With the shadow of a doubt: Waiting for cognitive science to tell you unequivocally to maintain two languages into old age? For now at least, still do it for the grandkids.

Review of *Growing Old with Two Languages: Effects of Bilingualism on Cognitive Aging* by Ellen Bialystok and Margot Sullivan (eds.), Amsterdam/Philadelphia, John Benjamins Publishing Company, 2017, 304 pp., ISBN 978 90 272 4195 5. Paperback, $54.00.

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There may be many reasons to sustain, even promote, life-long bilingualism. You may need two or more languages to carry out your day-to-day life successfully, such as to hold down an occupation that requires bilingual skills, to communicate with loved ones, or to complete the myriad quotidian chores of living in a wider multilingual society, in cities like Brussels, Montreal, Mumbai, Nairobi, even Los Angeles.

Certainly, the preservation of cognitive functioning in old age could be another reason to maintain bilingualism across one's life span. Finding a panacea for aging has always intrigued humans. It has also been surrounded by groundbreaking discoveries, myths, and counter arguments. Research examining the effects of bilingualism at both ends of the lifespan is full of promise and controversy. We know from a broad range of

research studies conducted over a number of years that children acquiring two languages appear to receive a boost to aspects of their cognitive development when compared with children acquiring just one language. For example, bilingualism, particularly in early primary-level students, is correlated with greater degree of working memory, attentional control (e.g., inhibiting focus on irrelevant stimuli), metalinguistic awareness (e.g., understanding the arbitrary relationship between language forms and meaning), and abilities in abstract thinking and symbolic representation (e.g., Adescope, Lavin, Thompson, & Ungerleider, 2010; Bailey, Griffin, Rivera-Torres & Mistry, 2015; Bialystok & Martin, 2004). Such cognitive advantages of bilingualism over monolingualism are found to be similar across groups of children acquiring different languages in tandem (e.g., Chinese-English, French-English and Spanish-English bilinguals, Barac & Bialystok, 2012).

This research is not without its detractors, however. A different line of research reporting contradictory results questions the credibility of these positive findings in children (e.g., Gathercole et al., 2014), or critiques the methodology of studies documenting the cognitive benefits of bilingualism (e.g., Morton, 2014). Antoniou (2019) suggests the field more generally is in a state of "impasse" (p.397). The methods of both proponents and opponents are mired in criticisms of internal and external validity, although the lure of bilingualism as a promise of cognitive gains in childhood or as a protective factor in cognitive aging (e.g., delaying the onset Alzheimer's disease and other forms of dementia) continues to enthrall both scholars and the general public.

The chapters in Ellen Bialystok and Margot Sullivan's edited volume *Growing Old with Two Languages: Effects of Bilingualism on Cognitive Aging* explore

connections between bilingualism and cognition in a range of older adults, adding new insights to this fascination. The complexities and nuances in findings and ideas successfully engage the reader around ways to approach the many challenges of doing research in this area and how to move the field forward. All the chapters address some aspect of the *bilingual advantage hypothesis* as either a "neural reserve" that preserves brain functioning, or as a "cognitive reserve" variable that protects against decline in certain behaviors or on cognitive performances. Bilingualism is one contender amongst others (e.g., playing chess or a musical instrument) for this role. Contradictions in findings, confounding distinctions among participants (e.g., age of second language exposure, length of residence, education level, immigration status, and intricate interactions among these factors), and discrepancies in the very definition of bilingualism in the empirical cases presented here and elsewhere (e.g., Antoniou, 2019; Sanders, Hall, Katz, & Lipton, 2012), suggest definitive evidence for a bilingual advantage to staving off the deleterious effects of old-age is also not yet in, but rather reflects a dynamic, intellectual field of study.

The thirteen chapters in this volume cover a broad swath of cognitive science. They examine the effects of aging on proficiency in two languages, as well as the titular effects of bilingualism on aging. This book helps to catalogue what is (and is not) special about speaking two or more languages when it comes to maintaining not just one's language faculties over time (e.g., Rossi & Diaz, Chapter 3), but also whether those very faculties are responsible for the structuring and functioning of a brain that can provide protections against the ravages of old age (e.g., Craik, Chapter 2, Gold, Chapter 9, and Chauvin, Duncan & Phillips, Chapter 11). It is possible that the continual need to control

the use of two or more languages simultaneously is a form of mental exercise for controlling one's attention when contemplating a host of other things in life, not just speaking and listening.

Currently set at over 10%, the proportion of the world's population aged 60 or older is rapidly increasing and expected to double by 2050 (Gold, Chapter 9). Additionally, we note that the World Health Organization estimates 50 million is also currently diagnosed with dementia (https://www.who.int). At the same time, popular estimates put the world's population of bilinguals at roughly 50% with some suggestion that this amount may be rising due to increasing displacement and trends in globalization (e.g., Ansaldo, Marcotte, Scherer, & Raboyeau, 2008). With these two demographics almost certain to collide, the time is ripe to bring together attempts by a range of researchers working in different traditions to help understand the connections between bilingualism and aging.

The volume comprises a combination of review chapters and chapters that present empirical research with older bilinguals in comparison with younger bilinguals and/or their younger and older monolingual counterparts. The research covered was conducted in different parts of the world and with a number of different languages in contact that constitute the bilingual experiences of study participants. The review chapters cite, for example, large-scale studies of bilinguals in Hyderabad, India and second language learners in Lothian, Scotland (Gold, Chapter 9, and Bak, Chapter 12). The authors of the empirical studies report their research with Dutch and English bilinguals in Melbourne, Australia (Keijzer & Schmid, Chapter 5), Spanish-English and English-Spanish bilinguals in San Diego, California (Ivanova, Murillo, Montoya, &

Gollan, Chapter 6, and Blumenfeld, Schroeder, Bobb, Freeman, & Marian, Chapter 7), and Swedish and predominantly English as a foreign language speakers in Umeå, Sweden (Ljungberg, Hansson, Adolfsson, & Nilsson, Chapter 10), as well as a study of individuals who spoke English along with being proficient in one of a host of additional languages (Sullivan, Prescott, Goldberg, & Bialystok, Chapter 8).

These chapters contribute innovative manipulations to established tasks of cognition and investigate important rival hypothesis to the legacy research of Bialystok and others (e.g., Bialystok, Craik, Klein, Viswanathan, 2004; Yim & Bialystok, 2012). The review chapters in the volume point out the complexities and possible shortcomings to approaches focused on evidence of behavioral differences in bilingual/monolingual and younger/older adults (e.g., reaction speed on compatibility/incompatibility tasks). The chapters focused on neuroimaging studies in particular offer an alternative approach, not looking at manifestations of cognitive differences on such tasks, but looking to the nervous systems of bilinguals and monolinguals to understand biological differences in brain structure and function.

This is a fairly technical book with not insignificant intellectual demands on the two aging bilinguals writing the current review. One must keep track of the wide array of different measurement techniques and their equivalencies across the different studies of the bilingual advantage hypothesis. Often these measures involved disparate areas of expertise, including novel executive functioning and working memory tasks, eye-tracking technology, neuro-imaging techniques, and various assessments of language proficiency. Ramifications of the study designs for obtaining clear and valid understandings of the impact of bilingualism on aging are implicitly and sometimes

explicitly raised by the chapter authors (e.g., Chauvin, et al. Chapter 11, Bak, Chapter 12; Titone, Gullifer, Subramaniapillai, Rajh, & Baum, Chapter 13). Moreover, specificity about who the bilinguals are in these studies and what experiences they have had during their lives that might distinguish them from younger bilinguals and/or aging monolinguals also varies by chapter and is sometimes not provided in detail. However, such information on the key comparison groups is paramount if contradictions in findings, both across the chapters in this volume as well as in the existing research field, are to be better understood as Higby and Obler (Chapter 4), Chauvin and his colleagues, Bak, and Titone and her colleagues also point out.

A key distinction made by many of the chapters is the language-specific effects of aging amongst bilinguals compared with the lack of effects of bilingualism on non-linguistic aspects of cognition. That is, does bilingualism only benefit the preservation of language(s) or does its preservative effects extend to other cognitive capacities? Or put yet another way, why would the inevitable redundancy in the linguistic systems of bilinguals lead to efficiencies in (for children and younger adults) or preservation of (for older adults) cognitive processing in areas other than language? For example, Ivanova and colleagues (Chapter 6) add to the body of research that documents such a disassociation between language-specific and domain-general executive control by examining the functioning of the aging bilingual brain on linguistic and non-linguistic tasks. Their study compared the performances of younger (21 years on average) and older (77 years on average) bilingual adults on verbal fluency tasks (e.g., producing exemplars of words starting with a specific letter or naming members of a semantic category), and non-linguistic flanker tasks (e.g., identifying the direction of a central

arrow accompanied by congruent and incongruent flanking arrows) in their two languages (Spanish and English).

The findings suggest older bilingual adults preserve an intact ability after switching between their two languages to inhibit language intrusions for one language task (letter fluency) but not another language task (semantic fluency); they have poorer performances on the latter task than younger bilingual adults. These results are interpreted to suggest bilinguals may be able to "flexibly modulate the degree of inhibition when they can benefit from semantic priming between languages" (p.99) even though aging is found to still negatively impact that ability. Additionally, their performance on non-linguistic tasks appears to be in much steeper decline with age. This result points to the existence of a language control component independent of general executive control.

Other studies appear to generate contradictory results for the claim of dissociation between tasks of linguistic and non-linguistic functioning. For example, Blumenfeld and colleagues (Chapter 7) extend the line of research that explores the nuances of linguistic and non-linguistic cognitive processes to include comparisons amongst younger and older adults, both bilingual and monolingual. The authors speculate whether or not life-long bilingual experiences would "reconfigure" both linguistic and non-linguistic cognitive processing. Using eye-tracking techniques for a picture selection task that measures lexical access (in English only), the authors measured participants' abilities to inhibit the erroneous selection of pictures representing phonologically similar "competitor" words to the target words they heard.

A non-linguistic Stroop task (e.g., inhibiting arrow location on a screen to select direction of the arrowhead) measured domain-general cognitive functioning.

In apparent contrast with the findings of Ivanova and her colleagues, the results of the study suggest that inhibition mechanisms are similar in linguistic and non-linguistic tasks for both younger and older bilinguals. This is also in contrast with the performances of both the younger and older monolinguals who have weaker inhibition in linguistic and non-linguistic tasks in this study. Bilinguals also demonstrate more consistent resolution for competing linguistic forms and exhibit greater cognitive control across their lifespans than do monolinguals across theirs. When processing speed is considered, age is less impactful on word activation and inhibition for bilinguals than it is for monolinguals.

Gold (Chapter 9) provides an overview of neuroimaging techniques that can indicate bilinguals do not demonstrate cognitive impairments in the presence of significant damage to the memory system (Alzheimer's disease, specifically). While such techniques still possess a coarseness according to Gold, it appears that the effects of bilingualism, as a cognitive reserve variable (more strictly perhaps, as a neural reserve mechanism), are operating somewhere other than in the medial temporal lobe regions of the brain that contain the neural circuitry for declarative memory and that can be compromised by disease. Rather, Gold suggests, the bilingual advantage is likely related to executive control circuits because they are thought to be strengthened by regular bilingual activation. We understand this work to suggest there is a neural "workaround" by bilingual brains (i.e., they have the neuroplasticity to co-opt alternate circuits as necessary) that can contribute to the delay in Alzheimer's disease onset—as

much as by four and a half to six years according to some of the studies reviewed here.

This is truly a remarkable time delay in a disease with incalculable personal and financial costs to individuals, families, and societies all around the globe. This approach to the bilingual advantage hypothesis is important because it can inform us about the biological effects of bilingualism and monolingualism that may afford hope for future medical intervention. The approach also brings modern, biotechnical techniques (including attempts to account for genetic risk factors for dementia, Ljungberg, et al. Chapter 10) to the debate, with some in the field touting the neuroscience area as contributing the most convincing evidence of the bilingual advantage in cognitive aging (Antoniou, 2019).

Perhaps presaging the criticisms of Bak (Chapter 12), Gold's chapter also tackles the likely confounds associated with bilingualism as a cognitive reserve variable, citing studies that have controlled for such factors as childhood IQ, verbal fluency, and immigration status, all of which may have cognitive reserve effects of their own for staving off declines in old age. Ljungberg and colleagues also speculate whether the delay is as a result of a cognitive reserve built up by bilingualism or more a cessation of bilingual language usage at the point of retirement. Neurological approaches are thus not inured from methodological criticisms and need to include well-defined comparison groups and measure rival factors in order to reveal for which bilinguals and under what conditions there is a bilingual advantage.

Bak's chapter challenges the seemingly immaculate research designs and linear causal links presented in some studies, and examines the causes of controversies in bilingualism and cognitive aging research through the lens of an historical and social

context, exposing societal prejudices against bilinguals and bilingualism (including underplaying the widespread nature of bilingualism as justification by some not to fund research in this area). Citing some of the same studies already reviewed by Gold in Chapter 9, Bak attributes the mixed findings of bilingualism research to the multitude of confounding variables associated with the construct, and addresses the most common amongst them: 1) group heterogeneity, 2) migration, 3) social factors (e.g., education level, leisure activities), and 4) variability in cognitive abilities.

The chapter problematizes causal links between bilingualism and later cognitive differences by suggesting the possibility of reverse causality of *initial* cognitive differences that result in bilingualism. This possibility, Bak argues, must be examined further. Ultimately, Bak sees the complex and messy nature of bilingualism as "an opportunity for scientific progress" (p.259). The chapter calls for groundbreaking new directions of research that would tackle the construct of "imperfect bilingualism" and challenge the unilateral study approach that can fail to measure the multidimensionality of bilingualism.

In total, the volume presents a comprehensive set of reviews and original research that provides us with a good cross section of the varied methods and much to contemplate about the current "state of the science." Not surprisingly, given there is much being debated within and across these chapters, many questions remain. Several are raised by the volumes' authors themselves; questions such as: *Are there separate and/or shared executive control mechanisms for linguistic and non-linguistic brain functioning? Are the brains of bilinguals able to compensate for the ravages of old age because they use different neural circuitry to accomplish the tasks of a disease-*

compromised working memory, for example? Will prospective, longitudinal research designs that take account of confounding variables such as educational level and well-defined individual differences provide answers that are more conclusive? And, how early must an additional language experience occur for a bilingual advantage to emerge? This is a fast moving field, and already the work of Estanga and colleagues (2017) suggests that early bilingualism (i.e., before formal schooling starts around age six) but not later bilingualism is associated with the existence of necessary proteins found in the neurons of a healthy central nervous system (i.e., Alzheimer's disease biomarkers), as well as being associated with the lower prevalence of preclinical Alzheimer's disease. Explaining *why* this and other emerging biological associations are the case (given early bilinguals were no more proficient in their two languages than later bilinguals in this study) will be an additional important line of questioning. Here the field can be encouraged to explore advances in Big Data research approaches that can reveal new connections in the medical data and be set up to delve into the multitude of confounding variables in patient backgrounds (Chauvin et al., Chapter 11). We add to this a suggestion to leverage the power of deep neural networks and artificial intelligence to model the workings of bilingual and monolingual brains in order to simulate the effects of the lifespan on cognition (perhaps sidestepping insurmountable issues with randomized controlled trials with human brains).

Just as the language development literature focused on the start of the lifespan has been plagued by methodological (and sometimes mythological) ills (e.g., Morton & Harper, 2007) and has been viewed as lacking definitive cognitive outcomes for bilingual students (e.g., McCardle, 2015), so too has the focus on the impact of

bilingualism on cognition at the opposite end of the lifespan (e.g., Paap, Johnson, & Sawi, 2014). Indeed, discrepant or null effects of bilingualism on aging are also evident to some degree across the chapters in this volume, as illustrated in descriptions of several findings above. (See also Antoniou, 2019, for a review of cognitive benefits that includes research on bilinguals at both ends of the lifespan, and De Bruin, Treccani, & Della Sala, 2015, on possible publication biases toward studies reporting positive results for bilinguals on executive control tasks).

The final chapter goes to Titone and colleagues who fear that the fractious debate about the role of bilingualism on cognitive aging will negatively affect how researchers in this field will be viewed as scientists (those rejecting the bilingual advantage hypothesis have yet to come up with a replacement hypothesis according to Titone and colleagues), and possibly even counter-productively demoralize a new generation of researchers. Final remarks by Bialystok and Sullivan would have been most welcome in order to put the criticisms by Titone and colleagues into context for the reader, sort through contradictions in findings across the studies, posit possible implications for future interventions, and conclude the book with an expanded version of the roadmap that Titone and colleagues begin in their chapter: a systemic treatment of what the next decade of research in this fascinating and increasingly crucial arena should strive for.

If slowing the decline in cognition were to be the only rationale for maintaining two languages into old age, the lack of robust findings across studies and the doubts and debates in the field more generally might lead one to rethink that decision. Given that parents of (potentially) bilingual children are not choosing bilingualism solely for the cognitive boost it may or may not provide their children, so too must adult (potential)

bilinguals realize that their motivation to 1) maintain the languages they have, or 2) intentionally acquire an additional language later in life, cannot be solely derived from the hope that their language practices will lead to neural/cognitive reserves and the slowing of the deleterious effects of dementia. Maintaining close linguistic and hence personal ties with our children and grandchildren may be the most efficacious and obvious bilingual advantage for aging bilinguals for now, for the very tangible supports families can provide us in old age (and the chance bilingualism will pass on to our grandchildren). However, the work of the current volume has highlighted the enormity and methodological complexities of coming to definitive answers about the effects of bilingualism on cognitive aging and, along the way, it has deepened our appreciation and understanding of the many facets that either impact or are impacted by growing old with two (or more) languages.

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