REVISTA DA **ABRALIN**

REVIEW

Bilingualism as a resource for neuroplasticity: a hypothesis to be considered

Mirela RAMACCIOTTI
University of Sao Paulo (USP)

ABSTRACT

This is a review of the lecture *Does Bilingualism Affect Cognitive and Brain Structures? Facts and Fictions* by Ellen Bialystok on June 30th, 2020 for Abralin. Aspects of bilingualism, inhibition and selective attention are examined to demonstrate where research shows positive correlations (life endpoints: infancy and old age) and where it remains unclear (young adults). Reasons for this are examined and the unity and diversity model upon which predictions have been made is disputed. A contention for a different outlook in research on bilingualism posits that better explanations can be found in looking at attentional network reconfiguration and neuroplasticity adaptations.

RESUMO

Esta é uma revisão da palestra *Does bilingualism affect cognitive and brain structures? Facts and Fictions* feita por Ellen Bialystok em 30 junho de 2020 para a Abralin. Aspectos do bilinguismo, inibição e atenção seletiva são examinados para mostrar onde pesquisas evidenciam correlações positivas (pontos extremos da vida: infância e velhice) e onde ainda permanecem dúvidas (adultos jovens). As razões para isso são examinadas e o modelo de unidade e diversidade sobre o qual as previsões foram feitas é contestado. A pesquisadora defende uma perspectiva diferente em pesquisas sobre bilinguismo e afirma que melhores explicações podem ser encontradas na busca de adaptações na reconfiguração das redes atencionais e na neuroplasticidade.

OPEN ACCESS

EDITED BY
Raquel Freitag

REVIEWED BY
Ingrid Finger

DATES
Received: 02/07/2020
Accepted: 23/09/2020
Published: 01/10/2020

HOW TO CITE
Ramacciotti, M. (2020). Bilingualism as a resource for neuroplasticity: a hypothesis to be considered. *Revista da Abralin*, v. 19, n. 2, p. 1-6, 2020.

KEYWORDS
Neuroplasticity. Bilingualism. Selective attention.

PALAVRAS-CHAVE
Neuroplasticidade. Bilinguismo. Atenção Seletiva.

This is a review of the lecture by Dr. Ellen Bialystok, distinguished Research Professor of Psychology at York University, who examines studies of cognitive development and decline across the lifespan with a focus on how these processes are modified by the selective attention that the bilingual experience engenders.

The talk addresses the title question by posing whether the concept of neuroplasticity, as a proxy for measurable changes in brain mechanisms and functions, can be also led by bilingualism. As language seems to be the most widely used brain activity, it promotes constant activation. For bilinguals, this means simultaneous and constant need for selection. She contends that a primary consequence is a reorganization in attentional networks. In so doing, bilingualism would lead to lifelong adaption of how attention is engaged.

Research developed with subjects from infancy to old age shows differences in their response to the effects of bilingualism. She draws attention to recent discussions on the discrepancies in the research. A vast majority of the controversy, though, relates to accuracy and response time (RT) by young adults.

A widely replicated article (BIALYSTOK; MCBRIDE-CHANG; LUK, 2005) relates how results for a Simon task (congruent and incongruent trials) show identical superior patterns for bilinguals (BL) compared to monolinguals (ML) across all age brackets. However, another study (PAAP; GREENBERG, 2013) with identical results gave an oppositional interpretation. And that started a series of disputes on the research basis so far. The contradictory effects found claim for an explanation, though.

With a track record of twenty years, cognitive differences found in tasks of executive functions (EF) abilities have been performed under the unity and diversity model (MIYAKI *et al.*, 2000). This structural model consists of three elements: updating, shifting and inhibition. Performance on the tasks reflects the engagement of each component separately. Within each component, several tasks are aligned to show its function. The integrity in the component reflects its independence, and the theoretical framing dictates the hypothesis generation and reporting of results for empirical predictions.

The model served as a starting point for bilingualism research and has shaped predictions issued by research since then. But problems emerged: the predicted correlations reflecting inhibitions were not accurately found; and across a wide range, research kept showing a higher RT for BLs (BIALYSTOK *et al.*, 2004; MARTIN-RHEE; BIALYSTOK, 2008; EMMOREY *et al.*, 2008; CHUNG-FAT-YIM; HIMEL; BIALYSTOK, 2019). This led to the conclusion that the issue may not relate to inhibition.

Additionally, this issue pointed to a conflation of inhibition. Research with developmental and fMRI data showed that there are two kinds of inhibition: the one used to execute a response (response inhibition) and another that requires interference suppression (BUNGE *et al.*, 2002; MARTIN-RHEE; BIALYSTOK, 2008). In bilingual research, response inhibition shows no group differences. However, for interference suppression, BLs are faster than MLs. Taken together, research establishes that there is no general inhibition process.

Choices to resolve the issue fall between two possibilities: either that predictions are wrong and there is no cognitive effect of bilingualism, or that the model is wrong. In revisiting the model, relations between components are indeed questionable and problematic if predictions be taken seriously. Alternatively, a look at a common denominator – attention - is of use as where it is placed answers for performance on the tasks. Thus, the effect of bilingualism may be better found in the processes that modulate attention.

A revision of studies for all age brackets was then performed to separate information about RT from attention mechanisms (COMISHEN; BIALYSTOK; ADLER, 2019; GRUNDY; ANDERSON; BIALYSTOK, 2017). Taken together, results point towards a higher RT for MLs (a sequential congruent effect), i.e., MLs take longer to switch between tasks, meaning that BLs surpass monolinguals in allocating their attention.

Statistically meticulous research performed by Zhou and Krott (2018) investigated RT distribution and attention with exponential gaussian analysis. They examined performance of MLs and BLs in the three big tasks for EF function (Stroop, Flanker and Simon). Results show that, regarding RT, MLs performed the same as BLs. However, for attention, MLs took longer than BLs. This gives the modulation of attention hypothesis a robust basis.

To examine language processing, data from a recent study by Bialystok *et al.* (2020) show that BLs fare worse than MLs in linguistic tasks (vocabulary scores). However, when combining linguistic benefits for MLs and executive function benefits for BLs, data show that even linguistic tasks requiring selection and attention yield results similar to nonverbal EF tasks.

The controversy then lies in determining why, among so many positive bilingual effects, a consistent pattern (within the component model) does not emerge. To choose between a rock and hard place, some points had to be analyzed, such as confounding factors (like socioeconomic status or SES), publication bias and sample sizes in relation to positive results rejections.

To confront SES and bilingualism confounding effects, a study by Hartanto and colleagues (2018) shows that, besides SES being the most important predictor of EFs, there is an interaction effect, i.e., bilingualism is especially helpful for those in the lower SES strata. Another study by Brito and Noble (2018) examined cortical brain volume. Results show that bilingualism boosts brain development in the most disadvantaged groups. Regarding publication bias, as it does not challenge the validity of the results, it is not a validity check. And for sample size, method emerges as more important than size. As for null results, a definition of bilingualism needs more scrutiny.

Bilingualism is taken as an independent variable and contended as being a continuum that encompasses a full range of experiences. These in turn could depict analyses of degrees in relation to

outcomes with more granularity. Many studies show complex non-linear relations (brain/behavior) that reflect how different bilingual experiences are important for outcomes (ANDERSON *et al.*, 2018; BIALYSTOK; CRAIK; LUK, 2008; CHUNG-FAT-YIM *et al.*, 2020; DELUCA *et al.*, 2019; GUERRERO; SMITH; LUK, 2016). In examining reasons to reject null results, the type of tasks used are demystified as demands on processing matter more than their classification per se. And finally, relative to the context of language use, adaptive control models showing how languages are used in context could provide better answers (such as the one by GREEN; ABUTALEBI, 2013).

In sum, EFs remains central to cognitive processing and development, academic achievement, and long-term wellbeing. Additionally, they are associated with mental resilience. But the biggest payoff, argued by Bialystok, lies in old age; in the face of normal cognitive decline for which there is no effective intervention (as in dementia), the single resource is cognitive reserve. This means maintaining high levels of cognitive function through sustained use, and it implies a dissociation between what is happening in the brain (decline) as compared to what happens in the mind (cognitive function preservation). The brain can show some atrophy, but that may not hold for cognitive function.

A clear indication of this is the age of diagnosis for dementia and, across studies, MLs show signs earlier than BLs (KOWOLL *et al.*, 2016; PERANI *et al.*, 2017). A proxy for dementia advancement is in the levels of metabolic glucose uptake, which get lower as dementia increases. By this measure, BLs take longer in showing dementia. When examining bilingual countries in relation to dementia rates, another study by Klein *et al.* (2016) which held life-expectancy as the independent variable, shows a lower incidence of dementia for more BL countries.

The last argument posited by Bialystok loops back to the mechanism in the unity and diversity model to examine transfer versus adaptation. She argued that a bilingual experience modifies selective attention. That, in turn, would impact language and non-verbal selection in different ways independently and in differing degrees, i.e., neuroplasticity in action. Considering that there is no transfer for BLs in infancy nor in old age, a single conclusion remains: research must look elsewhere. And this outlook should consider bilingualism both as reconfiguring attentional networks and as a source of neuroplasticity leading to adaptations both in brain and behavior.

REFERENCES

ANDERSON, John AE *et al.* The language and social background questionnaire: Assessing degree of bilingualism in a diverse population. *Behavior research methods*, v. 50, n. 1, p. 250-263, 2018. DOI: 10.3758/s13428-017-0867-9

BIALYSTOK, Ellen; CRAIK, Fergus; LUK, Gigi. Cognitive control and lexical access in younger and older bilinguals. *Journal of Experimental Psychology: Learning, memory, and cognition*, v. 34, n. 4, p. 859-873, 2008. DOI: 10.1037/0278-7393.34.4.859

BIALYSTOK, Ellen; MCBRIDE-CHANG, Catherine; LUK, Gigi. Bilingualism, language proficiency, and learning to read in two writing systems. *Journal of educational psychology*, v. 97, n. 4, p. 580-590, 2005. DOI: 10.1037/0022-0663.97.4.580

BIALYSTOK, Ellen *et al.* Bilingualism, aging, and cognitive control: evidence from the Simon task. *Psychology and Aging*, v. 19, n. 2, p. 290-303, 2004. DOI: 10.1037/0882-7974.19.2.290

BIALYSTOK, Ellen *et al.* Using the DRM paradigm to assess language processing in monolinguals and bilinguals. *Memory & Cognition*, p. 1-14, 2020. DOI: 10.3758/s13421-020-01016-6

BRITO, Natalie H.; NOBLE, Kimberly G.; PEDIATRIC IMAGING, NEUROCOGNITION, GENETICS STUDY. The independent and interacting effects of socioeconomic status and dual-language use on brain structure and cognition. *Developmental Science*, v. 21, n. 6, p. e12688-e12693, 2018. DOI: 10.1111/desc.12688

BUNGE, Silvia A. *et al.* Dissociable contributions of prefrontal and parietal cortices to response selection. *Neuroimage*, v. 17, n. 3, p. 1562-1571, 2002. DOI: 10.1006/nimg.2002.1252

CHUNG-FAT-YIM, Ashley; HIMEL, Cari; BIALYSTOK, Ellen. The impact of bilingualism on executive function in adolescents. *International Journal of Bilingualism*, v. 23, n. 6, p. 1278-1290, 2019. DOI: 10.1177/1367006918781059

CHUNG-FAT-YIM, Ashley; SORGE, Geoffrey B.; BIALYSTOK, Ellen. Continuous effects of bilingualism and attention on Flanker task performance. *Bilingualism: Language and Cognition*, p. 1-6, 2020. DOI: 10.1017/S1366728920000036

COMISHEN, Kyle J.; BIALYSTOK, Ellen; ADLER, Scott A. The impact of bilingual environments on selective attention in infancy. *Developmental science*, v. 22, n. 4, p. e12797-12799, 2019. DOI: 10.1111/desc.12797

DELUCA, Vincent *et al.* Redefining bilingualism as a spectrum of experiences that differentially affects brain structure and function. *Proceedings of the National Academy of Sciences*, v. 116, n. 15, p. 7565-7574, 2019. DOI: 10.1073/pnas.1811513116

DOES Bilingualism Affect Cognitive and Brain Structures? Facts and Fictions. Lecture presented by Ellen Bialystok. [s.l., s.n], 2020. 1 video (1h 39min 11s). Published by Associação Brasileira de Linguística. Available at: https://www.youtube.com/watch?v=DpuqI9pa_5U . Accessed on July 1st, 2020.

EMMOREY, Karen *et al.* The source of enhanced cognitive control in bilinguals: Evidence from bimodal bilinguals. *Psychological Science*, v. 19, n. 12, p. 1201-1206, 2008. DOI: 10.1111/j.1467-9280.2008.02224.x

GREEN, David W.; ABUTALEBI, Jubin. Language control in bilinguals: The adaptive control hypothesis. *Journal of Cognitive Psychology*, v. 25, n. 5, p. 515-530, 2013. DOI: 10.1080/20445911.2013.796377

GRUNDY, John G.; ANDERSON, John AE; BIALYSTOK, Ellen. Neural correlates of cognitive processing in monolinguals and bilinguals. *Annals of the New York Academy of Sciences*, v. 1396, n. 1, p. 183-201, 2017. DOI: 10.1111/nyas.13333

GUERRERO, Sibylla Leon; SMITH, Sara; LUK, Gigi. Home language usage and executive function in bilingual preschoolers. *Cognitive Control and Consequences of Multilingualism*. John Benjamins Publishing Company, v. 2, p. 351-374, 2016.

HARTANTO, Andree; YANG, Hwajin; YANG, Sujin. Bilingualism positively predicts mathematical competence: Evidence from two large-scale studies. *Learning and Individual Differences*, v. 61, p. 216-227, 2018. DOI: 10.1016/j.lindif.2017.12.007

KLEIN, Eva M. *et al.* The German version of the Perceived Stress Scale–psychometric characteristics in a representative German community sample. *BMC Psychiatry*, v. 16, n. 1, p. 159-169, 2016. DOI: 10.1186/s12888-016-0875-9

KOWOLL, Magdalena Eva *et al.* Bilingualism as a contributor to cognitive reserve? Evidence from cerebral glucose metabolism in mild cognitive impairment and Alzheimer's disease. *Frontiers in Psychiatry*, v. 7, p. 62-67, 2016. DOI: 10.3389/fpsyt.2016.00062

MIYAKE, Akira *et al.* The unity and diversity of executive functions and their contributions to complex "frontal lobe" tasks: A latent variable analysis. *Cognitive Psychology*, v. 41, n. 1, p. 49-100, 2000. DOI: 10.1006/cogp.1999.0734

MARTIN-RHEE, Michelle M.; BIALYSTOK, Ellen. The development of two types of inhibitory control in monolingual and bilingual children. *Bilingualism*, v. 11, n. 1, p. 81-93, 2008. DOI: 10.1017/S1366728907003227

PAAP, Kenneth R.; GREENBERG, Zachary I. There is no coherent evidence for a bilingual advantage in executive processing. *Cognitive Psychology*, v. 66, n. 2, p. 232-258, 2013. DOI: 10.1016/j.cogpsych.2012.12.002

PERANI, Daniela *et al.* The impact of bilingualism on brain reserve and metabolic connectivity in Alzheimer's dementia. *Proceedings of the National Academy of Sciences*, v. 114, n. 7, p. 1690-1695, 2017. DOI: 10.1073/pnas.1610909114

ZHOU, Beinan; KROTT, Andrea. Bilingualism enhances attentional control in non-verbal conflict tasks–evidence from ex-Gaussian analyses. *Bilingualism: Language and Cognition*, v. 21, n. 1, p. 162-180, 2018. DOI: 10.1017/S1366728916000869