Published in final edited form as:

Cortex. 2015 December ; 73: 373–374. doi:10.1016/j.cortex.2015.06.010.

The importance of neuroscience in understanding bilingual cognitive control: A commentary on "Bilingual advantages in executive functioning either do not exist or are restricted to very specific and undetermined circumstances" by Paap et al. (2015)

Kelly A. Vaughn, **Maya R. Greene**, and **Arturo E. Hernandez**

University of Houston

The history of bilingual research has shifted from a bilingual disadvantage on general intelligence measures (e.g. Peal and Lambert, 1962) to a bilingual advantage on non-verbal cognitive control tasks (e.g. Bialystok, 2005). Recently, research suggesting that there is an advantage for bilinguals has been called into question by Kenneth Paap and his colleagues, among others (Costa, Hernández, Costa-Faidella, & Sebastian-Galles, 2009; Dunabieta et al., 2014; Paap, 2014; Paap & Greenberg, 2013; Paap, Johnson, & Sawi, 2014; Paap & Sawi, 2014; Paap, Sawi, Dalibar, Darrow, & Johnson, 2014). As evidence and reasonable arguments exist on both sides, we suggest it is time to stop regarding bilinguals as a group that is better or worse than monolinguals, and to focus on how their varied language experiences can contribute to our understanding of the relationship between language and cognition. In addition, we propose that neuroimaging techniques should be implemented in order to better understand how neurological development, structure, and function might serve as mechanisms connecting language and cognition—new and exciting hypotheses that cannot be examined with traditional behavioral methods. We agree with Paap and his colleagues that it is uninformative to attempt to support the idea of a bilingual advantage with neuroscience evidence, as it is still unclear whether more or less neural activity is better. Rather than focusing on a neurological advantage for bilinguals, we should conduct neuroimaging studies that investigate the relationship between language development, neurological development, and cognitive development within bilinguals in ways that may not be evident by only studying monolinguals.

In making sense of neuroimaging data, we disagree with the authors that behavioral differences between bilinguals and monolinguals must be established. Consider, as an analogy, a study on speech perception in bilinguals and monolinguals (Archila-Suerte, Zevin, & Hernandez, 2013). English monolingual children recruit, bilaterally, the superior temporal gyrus, a perceptual region of the brain, to perceive English speech sounds. Young Spanish-English bilingual children (ages 6–8) recruit the same regions when perceiving English speech sounds, but older bilingual children (ages 9–10) recruit additional regions of the brain commonly associated with cognitive control, such as the middle frontal gyrus and the inferior parietal lobule, to perform the same task. Bilingual children at this age do not differ from monolingual children when it comes to perceiving or producing English speech sounds, but their neural activity is different during this task. In other words, these findings are not indicative of an advantage or disadvantage for bilinguals, but they indicate that there

is something unique about the neural processes involved in bilingual language development, and understanding these can provide information about how the brain handles language more broadly.

The same may be true for cognitive control. Whether bilinguals have behavioral advantages or not, their neural activity during these tasks appears to be different than that of monolinguals, which indicates that the bilingual brain processes these tasks differently. For example, research in our lab focusing on differences in brain activity during the Simon task based on continuous measures of bilingualism (age of acquisition and proficiency across both languages) found that activity in cognitive control regions (the inferior parietal lobule, anterior cingulate cortex, and dorsolateral prefrontal cortex) during the incongruent condition of the task differs based on the age of second language acquisition and proficiency (Greene, Ramos Nuñez, Vaughn, & Hernandez, 2015). Specifically, later age of acquisition predicts greater activity in the left inferior parietal lobule, while better proficiency predicts less recruitment of the dorsolateral prefrontal cortex and anterior cingulate cortex. These findings are unrelated to better or worse behavioral performance on the Simon task, but they suggest that the age and extent to which a bilingual learns a second language can predict how the brain handles the task. In other words, variations in language experience can lead to variations in neural activity during non-verbal tasks, meaning that language plays a role in tasks that do not directly involve language.

There is still the possibility, as the authors suggest, that any differences between bilinguals and monolinguals are not a result of bilingualism, but are confounded by other variables, such as SES, intelligence, or genetics. For example, findings from our lab at the University of Houston suggest that there may be genetic differences between college-aged Spanish-English bilinguals and English monolinguals. In our sample, bilinguals carried the A1+ allele of the ANKK1 gene in higher proportions than monolinguals (Hernandez et al., 2015). The A1+ allele has been previously shown to be related to better cognitive control performance, and different recruitment of the inferior frontal gyrus during task-switching (Stelzel et al., 2013). Again, research suggesting that genetics and bilingualism, or language ability in general, are each related to neural activity during cognitive control tasks present an opportunity to explore the relationship of language experience and genetic factors in the development of these important cognitive abilities.

In sum, we, like the authors, are hesitant in claiming that bilinguals have better cognitive control than monolinguals, and further, that learning a second language improves cognitive control. Regardless, studying bilinguals, without positing them as better or worse than monolinguals, can provide insight into the ways in which age of acquisition of a language and language use or abilities relates to cognitive abilities. Unlike monolinguals, whose language history is relatively homogenous, bilinguals have diverse language histories and experiences, and can demonstrate how these language experiences and abilities relate to functioning in other cognitive domains. It may be time to give up the claim of a “bilingual advantage,” but it is not time to slow down research on bilingual cognitive control.

References

Archila-Suerte P, Zevin J, Ramos AI, Hernandez AE. The neural basis of non-native speech perception in bilingual children. Neuroimage. 2013; 67:51–63. DOI: 10.1016/j.neuroimage.2012.10.023 [PubMed: 23123633]

Bialystok EM, Viswanathan MMM. Bilingualism across the lifespan: The rise and fall of inhibitory control. International Journal of Bilingualism. 2005; 9(1):103–119.

Costa A, Hernández M, Costa-Faidella J, Sebastian-Galles N. On the bilingual advantage in conflict processing: now you see it, now you don't. [Research Support, Non-U.S. Gov't]. Cognition. 2009; 113(2):135–149. DOI: 10.1016/j.cognition.2009.08.001 [PubMed: 19729156]

Dunabeitia JA, Hernandez JA, Anton E, Macizo P, Estevez A, Fuentes LJ, Carreiras M. The inhibitory advantage in bilingual children revisited. Experimental Psychology. 2014; 61(3):234–251. DOI: 10.1027/1618-3169/a000243 [PubMed: 24217139]

Hernandez AE, Greene MR, Vaughn KA, Francis DJ, Grigorenko EL. Beyond the bilingual advantage: The potential role of genes and environment on the development of cognitive control. Journal of Neurolinguistics. 2015; 35:109–119. DOI: 10.1016/j.jneuroling.2015.04.002

Greene, MR., Ramos Nuñez, AI., Vaughn, KA., Hernandez, AE. Bilingual proficiency and age of acquisition are independently related to non-verbal cognitive control: Evidence from an fMRI study. Poster presented at the annual meeting of the Cognitive Neuroscience Society; San Francisco, CA. 2015 Mar.

Paap KR. The role of componential analysis, categorical hypothesising, replicability and confirmation bias in testing for bilingual advantages in executive functioning. Journal of Cognitive Psychology. 2014; 26(3):242–255. DOI: 10.1080/20445911.2014.891597

Paap KR, Greenberg ZI. There is no coherent evidence for a bilingual advantage in executive processing. Journal of Cognitive Psychology. 2013; 66(2):232–258. DOI: 10.1016/j.cogpsych.2012.12.002

Paap KR, Johnson HA, Sawi O. Are bilingual advantages dependent upon specific tasks or specific bilingual experiences? Journal of Cognitive Psychology. 2014; 26(6):615–639. DOI: 10.1080/20445911.2014.944914

Paap KR, Sawi O. Bilingual advantages in executive functioning: problems in convergent validity, discriminant validity, and the identification of the theoretical constructs. Frontiers in Psychology. 2014; 5:962.doi: 10.3389/fpsyg.2014.00962 [PubMed: 25249988]

Peal E, Lambert WE. The relation of bilingualism to intelligence. Psychological Monographs: General and Applied. 1962; 76(27):1–23.

Paap RK, Sawi MO, Dalibar C, Darrow J, Johnson AH. The Brain Mechanisms Underlying the Cognitive Benefits of Bilingualism may be Extraordinarily Difficult to Discover. AIMS Neuroscience. 2014; 1(3):245–256. DOI: 10.3934/Neuroscience.2014.3.245