No Coherent Evidence for Bilingual Advantges in Executive Functioning

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Introduction

During both comprehension and production there is overwhelming evidence that when bilinguals are conversing in one language, lexical entries in the other language are coactivated. This point of consensus diverges to contentious debates whether general inhibitory control is recruited to resolve competition from the nontarget lexicon and if so, is this ubiqutious practice sufficient to enhance general executive functioning (EF) and to transfer to nonverbal tasks where interference effects will be smaller in bilinguals compared to monolinguals. On the basis of a bibliometric analysis Sanchez-Azana, López-Penadés, Buil-Legaz, Aguilar-Mediavilla, & Androver-Roig (2017) identified Paap and Greenberg's (2013) *Cognitive Psychology* article as a "turning point" toward skepticism regarding the bilingual advantage in EF hypothesis. Nonetheless, there were still many proponents among the 22 commentaries when Paap, Johnson, and Sawi (2015, 2016) laid out a full indictment of the bilingual advantage hypothesis in a target article for a *Cortex* forum. Furthermore, in an extensive counterarguement Bialystok (2017) reiterated her strong belief in the bilingual advantage hypothesis, but shifted its locus from EF to "selective attention" (SE). This revised hypothesis was supported by bilingual advantages in conjunctive visual search (Friesen, Larman, Calvo, & Bialystok, 2014) and an ambiguous figures task (Chung-Fat-Yim, Sorge, & Biallystok, 2017).

Meta-Analyses of EF

Recent meta-analyses of studies testing for bilingual advantages in EF reveal meager support for the phenomena.

Working Memory

Bialystok (2017) asserts that working memory (WM) capacity, conceptualized not as storage space, but as the extent to which resources are available to control attention *"…is compatible with the evidence found across the life span for bilinguaism-dependent plasticity"* p. 249. A recent meta-analysis by von Bastian, de Simoni, Kane, Carruth, and Miyake (2017) evaluated this conceptualization of EF for bilingual advantages. A set of 88 studies with 108 independent comparisons were included. The average effect size was g = +0.11 [+0.03, +0.19]. Considering the Bayes Factor associated with each effect size there was a high degree of heterogeneity, mostly null effects, and little evidence for the alternative hypothesis. Neither age (children, younger adults, older adults) nor task mode (verbal versus nonverbal) moderated the variability in effect sizes. Lehtonen, Soveri, Laine, Järvenpääl, de Bruin, & Antfolk (2018) also examined the WM domain and their meta-analysis of 243 effect sizes yielded a mean effect size of g = +0.07 [0.00, +0.13] that shifted to a disadvantage when corrected for bias, g = -0.07 [-0.17, +0.03]. The Lehtonen et al. meta-analysis reinforces the conclusion of von Bastian et al. that the findings *"challenge executive-attention accounts of bilingual advantages"*.

Interference Control

Two recent meta-analyses converge on the conclusion that significant bilingual advantages in inhibitory control are relatively rare (15% of all comparisons), that the average effect sizes are small, and that there is evidence for publication bias, which when taken into account, appears to completely eliminate the effect.

In Paap (2019) the mean advantage across all 146 comparisons was +4.4 ms. If the 146 effect sizes are treated as a single sample the Bayes Factor (using the JZS prior and Rouder's calculator) favoring the alternative is 2.87, an odds ratio that according to Jeffrey's (1961) guidelines is "barely worth mentioning".

Lehtonen, et al. (2018) used a wider definition of inhibitory control tasks and identified a more heterogeneous set of 212 effect sizes compared to Paap (2019). Furthermore, Lehtonen et al. only included datasets that were both independent and allowed standardized effect sizes. However, the Lehtonen et al. meta-analysis was restricted to studies using participants 18 years and older, whereas the Paap meta-analysis includes participants 6 years and older. The mean effect size for inhibitory control in Lehtonen et al. was Hedge's g = +0.11 [+0.05, +0.18], but when corrected by the PET-PEESE method the mean was no longer significant, g = -0.02 [-0.12, +0.08]. Because the two meta-analyses accepted different trade-offs, they are complementary. They converge on the same outcome and the most straightforward conclusion is that they provide no compelling evidence that bilingualism enhances inhibitory control.

Switching

In a seminal study Prior and MacWhinney (2010) were the first to report a bilingual advantage in switching cost. The advantage in switching costs looked like one that should easily replicate given that the estimated effect size was d = .52 (with 44 participants in each group) and that the estimated power for a one-tailed test with an alpha equal to .05 was .78. However, Paap's (2019) update of the meta-analysis first reported by Paap, Myuz, Anders, Bockelman,

Mikulinsky & Sawi (2017) shows that the bilingual-advantage obtained by Prior and MacWhinney has replicated twice, but yielded null results 25 times. These results converge with Lehtonen et al.'s meta-analysis of 77 effect sizes of which 45 were derived from a color-shape switching task. A small significant bilingual advantage was present in the uncorrected analysis, g = +0.15 [+0.06, +0.24], but this advantage was not sustained when corrected for bias, g = +0.02 [-0.09, +0.14]. Again, despite many differences in selection criteria and methods the two meta-analyses converge on the outcome that there is very little evidence for a bilingual advantage in switching ability.

Selective Attention

The revised hypothesis that bilingual language control recruits and enhances selective attention thereby producing far transfer to the visual search and ambiguous figures was retested in our lab by Anders-Jefferson (2018). Although the construction of the search displays closely followed the descriptions provided in Friesen et al. and produced overall mean search times almost identical to the original study, there were no significant differences between the language groups in the critical low-discriminability, conjuctive-search condition, $F(1,115) = .034$, p=.854, partial $\eta^2 = .0003$. Likewise, although we used the set of ambiguous figures provide by Chung-Fat-Yim et al. in their supplementary materials and the overall mean transition point was the same in both studies, there were no significant differences between the bilinguals and monolinguals, $t(131) = -0.58$, p=.563, BF=3.9. Consistent with our previous studies using EF tasks (Paap, Johnson, & Sawi, 2014) performance on the SE tasks were unrelated to the L2/L1 ratio, L2 age of acquisition, percentage of L2 use, frequency of daily switching, frequency of switching within utterances. number of languages used per context, and language similarity.

Why Doesn't Bilingualism Enhance EF or SE?

The impetus for predictions of bilingual advantages in cognitive control rest on the assumption that bilingual language control recruits general domain-free control processes and that the ubiquitous practice afforded by using two languages enhances the control processes of bilinguals relative to monolinguals. There are three plausible reasons why there may be a break in this chain of events: (1) Normally functioning individuals engaged in everyday life may receive sufficient "practice" to reach their genetically determined upper limit of ability without special experiences such as bilingualism. (2) As a corollary, bilingual language control may not require sufficiently greater levels of control beyond those required by speaking a single language. (3) Complex cognitive skills such as coordinating two languages may require effortful control in early stages, but then give way to automatic processes that exploit domain-specific learning (Paap, 2018).

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