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## Discussion forum

# Bilingual advantages in executive control – A Loch Ness Monster case or an instance of neural plasticity?

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In the 1990's, Michel Paradis (e.g., 1992) published several commentary articles, in which he likened reports of differential language lateralisation in bilinguals to sightings of the Loch Ness Monster: “Like the Loch Ness Monster, differential laterality is occasionally claimed to have been seen, under certain restricted conditions, but the purported evidence does not stand scrutiny; it either cannot be replicated or the reverse is found.” (p. 534).

Since 2012, Paap and colleagues have authored a set of commentaries, in which they question the existence of bilingual advantage in executive functioning (EF), a phenomenon that has attracted widespread interest in recent years. They conclude: “It is likely that bilingual advantages in EF do not exist” (Paap, Johnson, & Sawi, 2015, p.36). Are reported bilingual advantages in executive control just another case of Loch Ness Monster sightings?

Paap et al. (2015) have raised a number of important methodological and theoretical concerns. In many respects, these do not only specifically relate to the topic of bilingual advantages, but they are applicable to several (if not all) fields of experimental psychology and cognitive neuroscience. Above all, the pervasiveness of small sample sizes related to the low statistical power has been recently discussed and specific recommendations have been formulated (see Button et al., 2013).

One additional factor that could be considered when analysing differences in the existing findings on bilingual advantage is the usage of extreme group designs. A recent study by Unsworth et al. (2015) on the relation between video-gaming and cognitive abilities has demonstrated that

extreme-group analysis points to the cognitive advantages of video-gaming, while these effects are drastically reduced when a full range of participants is analysed. The usage of extreme group designs has been shown to be problematic, although this approach can be justified in the early, exploratory stages of research (Preacher, Rucker, MacCallum, & Nicewander, 2005; Unsworth et al., 2015).

A study by Paap and Greenberg (2013) suggests that even extreme group analysis does not point to bilingual advantages; however, they contrasted the most fluent bilinguals with the least fluent monolinguals. A potentially intriguing question is, which participants would be characterised by the most pronounced enhancements in executive control. Despite initial evidence that bilinguals with early age of acquisition (AoA) might be those who enjoy enhanced executive control (Luk, De Sa, & Bialystok, 2011), later studies rather suggest that it might be the late bilinguals that show the enhanced efficiency (Tao, Marzecová, Taft, Asanowicz, & Wodniecka, 2011; Vega-Mendoza, West, Sorace, & Bak, 2015). These bilingual groups were unbalanced in their proficiency of L2, while the late bilingual group from Tao et al. (2011) was balanced in the usage of two languages. It is plausible that demands to engage executive control are higher for bilinguals who acquired their L2 late, are unbalanced in the L2 proficiency, yet might be balanced in the use of both languages. The idea that bilinguals who experience “high bilingual management demands” – i.e., heightened demands on usage of executive control to appropriately manage two languages – might be the ones that show the expected advantages has been proposed by Macnamara and Conway

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(2013) in their longitudinal study with (predominantly late) bi-modal bilinguals (see also Christoffels, de Haan, Steenbergen, van den Wildenberg, & Colzato, 2015; for converging evidence on cognitive flexibility of late bilinguals attending a bilingual education program). Employing longitudinal designs to study effects of bilingualism on EF might provide the final answer in the quest of bilingual advantages. Bilingual experience is of a multi-faceted nature, and hardly falls into discrete categories. Therefore, treating different aspects of bilingual experience as continuous variables could prove useful.

The investigation into the case of bilingual advantages is further complicated by the fact that executive control is not a unitary phenomenon (see e.g., Parkin, 1998). Despite some evidence for the unity of interference control functions (Friedman & Miyake, 2004), there exists consistent evidence that different cognitive conflict tasks reflect functionally separable processes (Egner, Delano, & Hirsch, 2007; Nee, Wager, & Jonides, 2007). Nee et al.'s (2007) meta-analysis of neuroimaging studies that employed different cognitive conflict tasks (including tasks commonly used in research on bilingualism, such as the Flanker, Simon, and Stroop task) showed that each task is characterised by a differential pattern of activation of brain regions implicated in cognitive control. The authors propose that these tasks reflect separate interference resolution mechanisms present at different stages of processing. One should carefully consider mechanisms that each task entails along with the specific patterns of underlying brain activity in order to refine the hypothesis on differences associated with bilingualism. Additionally, it seems also necessary to account for differences in basic perceptual encoding of stimuli (see Krizman, Marian, Shook, Skoe, & Kraus, 2012). Employing the Attention Network Task (ANT; Fan, McCandliss, Sommer, Raz, & Posner, 2002) to study attentional functioning of bilinguals seemed promising, because ample behavioural and neuroimaging evidence supporting the theoretical model of three relatively independent attention systems indexed by the task has been accumulated. But so far, behavioural studies have brought mixed results. One potential explanation that has been put forward is that differences between bilinguals and monolinguals only become apparent when attentional demands of the task are sufficiently high (for a discussion, see Marzecová, Asanowicz, Krivá, & Wodniecka, 2013; see also Qu, Low, Zhang, Li, & Zelazo, in press).

Nevertheless, rather than asking if bilinguals outperform monolinguals in various tasks put under the umbrella of executive control, one could refine hypotheses on how bilingual experience, as an instance of experience-dependent plasticity, brings about changes in specific mechanisms and in the underlying functional and structural brain networks. Instead of looking at the Loch Ness Monster, one could be looking at an intriguing case of neural plasticity.

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