



# Examining the effects of active versus inactive bilingualism on executive control in a carefully matched non-immigrant sample



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## ARTICLE INFO

### Article history:

Received 23 February 2015

revision received 6 July 2015

Available online 20 July 2015

### Keywords:

Bilingualism

Language use

Inhibitory control

Task switching

Immigrant status

## ABSTRACT

Bilinguals have been argued to show a cognitive advantage over monolinguals, although this notion has recently been called into question. In many studies, bilinguals and monolinguals vary on background variables. Moreover, most studies do not distinguish between potential effects of language knowledge and language use. We examined the effects of bilingualism on executive control in older adults by comparing active and inactive bilinguals and monolinguals matched on lifestyle, socio-economic status, education, IQ, gender, and age. In the Simon arrow task, no effect of bilingualism was observed on overall RTs or the Simon effect. In the task-switching paradigm, although there was a difference between active (but not inactive) bilinguals and monolinguals on raw switching costs, the groups did not differ on overall RTs and proportional switching or mixing costs. Thus, our findings do not reveal an overall cognitive advantage of bilingualism on executive control tasks in groups matched on background variables.

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## Introduction

Speaking two languages requires a constant control of both. Activating a word in the target language not only requires the speaker to activate that word, but also to inhibit the corresponding one from the non-target language (Green, 1998). This ongoing practice of language inhibition has been argued to lead to improved interference suppression in non-linguistic executive control tasks: the ability to suppress task-irrelevant information. Evidence for a bilingual advantage on inhibition tasks has been found for different age groups. Bilingual children have been found to outperform monolingual children on various inhibitory

control tasks (e.g., Bialystok & Viswanathan, 2009; Engel de Abreu, Cruz-Santos, Tourinho, Martin, & Bialystok, 2012; Martin-Rhee & Bialystok, 2008). Although more inconsistently, similar inhibitory advantages have also been observed for younger adults (e.g., Costa, Hernández, & Sebastián-Gallés, 2008; Pelham & Abrams, 2014; Treccani, Argyri, Sorace, & Della Sala, 2009). Several studies comparing younger to older adults have furthermore suggested that bilingual advantages on inhibition tasks may be larger in older adults. Bialystok, Craik, Klein, and Viswanathan (2004) compared middle-aged to older bilinguals and monolinguals on a Simon task. Participants were presented with blue and red squares that were associated with a left or right button press. Stimuli appeared on the left or right side of the screen, thus leading to incongruent (e.g., left button, right side screen) and congruent (e.g., left button, left side screen) trials. Reaction times (RTs) are generally shorter for congruent trials than incongruent

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trials (Simon effect), but this difference was found to be smaller for bilinguals than monolinguals. This bilingual advantage was furthermore greater for older than middle-aged adults. Similarly, using a Simon arrow paradigm, Bialystok, Craik, and Luk (2008) found that older bilinguals were better at suppressing irrelevant information than monolinguals. This advantage was not found for the younger adults tested in the same study. These advantages have also been found in verbal executive control tasks such as the Stroop task (e.g., Bialystok et al., 2008). However, to reduce the potentially confounding effects of lexical processing differences between bilinguals and monolinguals (cf., Bialystok, 2009), bilingual–monolingual differences have mainly been explored in non-verbal interference suppression tasks.

Other studies have challenged these findings. Testing participants across a range of inhibitory control tasks, several studies failed to observe a behavioural bilingual advantage in children (e.g., Antón et al., 2014; Duñabeitia et al., 2014), younger adults (e.g., Kousaie & Phillips, 2012a; Paap & Greenberg, 2013), and older adults (e.g., Kirk, Fiala, Scott-Brown, & Kempe, 2014; Kousaie & Phillips, 2012b).

Besides inhibitory control, bilingual advantages may also be related to task switching. Bilinguals were found to be faster at switching between non-verbal tasks than monolinguals in groups of children (e.g., Barac & Bialystok, 2012; Bialystok & Viswanathan, 2009), younger adults (e.g., Prior & MacWhinney, 2010), and older adults (e.g., Gold, Kim, Johnson, Kryscio, & Smith, 2013). Prior and MacWhinney (2010) presented participants with stimuli that had to be responded to according to colour or shape. In the blocked condition, participants were presented with shape or colour stimuli only. In the mixed condition, participants had to switch between colour and shape decisions. The mixed condition consisted of both switch trials (switching between colour and shape) and non-switch trials (two consecutive colour or shape decisions). Bilingual participants were found to be better at switching than monolinguals. No difference was observed for the mixing costs: the difference between non-switch trials in the mixed condition and the blocked condition. These mixing costs have been argued to reflect more global mechanisms needed to maintain two competing tasks in a mixed condition (Rubin & Meiran, 2005). This suggests that the bilingual advantage is related to switching specifically rather than more global task control. Comparing younger to older adults on a switching task, Gold et al. (2013) only found a bilingual switching advantage for the older but not the younger group. Yet bilingual switching advantages have been challenged too (e.g., Paap & Greenberg, 2013; Hernández, Martín, Barceló, & Costa, 2013).

Effects of bilingualism have predominantly been tested in inhibitory control and task-switching paradigms. However, if an advantage is found, its exact nature remains debated. Bilingual advantages have been found on inhibition costs such as the Simon costs (e.g., Bialystok et al., 2008), suggesting that the bilingual advantage concerns incongruent trials specifically. Yet bilingual advantages have not only been found on incongruent trials, but also on both congruent and incongruent trials (e.g., Bialystok,

2006). In 2011, Hilchey and Klein reviewed 31 experiments examining effects of bilingualism on executive control tasks. They concluded that there was hardly any evidence to support the hypothesis that bilinguals have an advantage on inhibitory control. Rather, they concluded, that bilinguals may have a more global advantage in monitoring conflict and regulating task demands. If bilinguals indeed have a more global monitoring advantage, this should be reflected in faster overall RTs on both congruent and incongruent trials in inhibition tasks and both switch and non-switch trials in switching tasks. Other studies have confirmed the suggestion that a bilingual advantage may be more widespread than just inhibition or switching, stating that the bilingual advantage may be found in conflict monitoring (Costa, Hernández, Costa-Faidella, & Sebastián-Gallés, 2009) or general mental flexibility (Kroll & Bialystok, 2013).

However, the idea of a bilingual advantage on either inhibitory control or switching specifically or on a more global level has been challenged in several recent studies. Paap, Johnson, and Sawi (2014) analysed 76 studies conducted after Hilchey and Klein's review (2011). They included tasks measuring specific interference suppression and switching costs or global monitoring effects and mixing costs. The majority of studies did not observe a significant effect of bilingualism neither on interference suppression and switching costs nor monitoring and mixing costs, especially for larger sample sizes. Similarly, in an update to their 2011 review, Hilchey, Saint-Aubin, & Klein (2015) conclude that the evidence for a bilingual advantage on inhibitory control is still weak. Contrary to the 2011 review, however, they now also argue that evidence for a more global bilingual advantage has evaporated since their initial review. Thus, whereas initial studies showed evidence supporting a bilingual advantage, more recent studies have challenged the reliability and even existence of this effect (a process that is known as the 'decline effect', see de Bruin & Della Sala, 2015).

A recent meta-analysis of studies on bilingualism and executive control (de Bruin, Treccani, & Della Sala, 2015) showed an average effect size of  $d = .30$ , suggesting a significant but small and inconsistent effect of bilingualism across studies. However, this meta-analysis was based on published studies only. The same study showed that the interpretation of the current literature may be distorted by a publication bias: The tendency that studies with positive findings are more likely to be published than papers with null or negative findings. An analysis of publication rates of conference abstracts found that 63% of results supporting a bilingual advantage were published in a scientific journal compared to only 36% of results challenging a bilingual advantage. The current literature of published studies may thus overestimate the actual effects of bilingualism on domain-general cognitive processes.

Thus, the current literature shows an inconsistent pattern of results (see Baum & Titone, 2014; Valian, 2015; Paap, Johnson, & Sawi, 2015, for recent overviews). Whereas several studies have found a cognitive effect of bilingualism, this is challenged in more recent studies. Two key issues may affect the type of results found in studies on bilingualism and executive control: the extent

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