The dynamics of language experience and how it affects language and cognition

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Abstract

Although research on bilingualism has attracted great scientific interest in recent decades, we still do not fully understand how bilinguals' language experience impacts language access and cognitive functioning. Our goal is to demonstrate that being exposed to one language, even for a short time, can influence the ability to use the other language and also affect how efficiently we process non-linguistic information. In this chapter, we focus on two types of effects related to the prior language experience of bilinguals (so-called language after-effects): (1) the impact of exposure to the second language on native language processing; (2) the impact of bilinguals' patterns of language use on cognitive control. For each topic, we review the available behavioral and neuropsychological evidence and discuss the possible sources of inconsistencies in the literature. Furthermore, we consider the implications of the available evidence for the current models of language "after-effects" and speculate about the possible convergence of mechanisms related to short- and long-term language experience.

1. INTRODUCTION: HOW DOES LANGUAGE EXPERIENCE MATTER FOR THE MIND AND WHY SHOULD WE CARE?

The use of more than one language is commonplace (e.g., Grosjean & Li, 2013). It is therefore crucial to identify the mechanisms that enable successful cooperation of languages in the human mind and the factors that contribute to language dynamics and language loss. Addressing these issues will help inform current models of human cognition, while taking into account the heterogeneity of language experiences across and within speakers. Although research on bilingualism[a] has attracted great scientific interest in recent decades, we still do not fully understand the mechanisms underlying the impact of bilinguals' language experience on language access and cognitive processing.

Our goal is to demonstrate that prior language experience can influence our ability to use language and how efficiently we process non-linguistic information. Based on the literature (Bialystok, 2011; Kroll, Dussias, Bice, & Perrotti, 2015; Kroll, Dussias, Bogulski, &

[a] Following the general usage in the literature, the term *bilingualism* is used here to refer to a phenomenon describing the language experience of a person who has knowledge of at least two languages (native and second) and uses each on a regular basis. This broad definition allows both early and late second-language learners as bilinguals to be taken into account, as long as the specific language learning history is clearly specified and taken into account.

Kroff, 2012), we assume that language use in bilinguals involves cognitive control, and this in turn may change the way the cognitive system operates. We consider factors that appear to modulate the magnitude and scope of these effects. We also argue that exposure to one language influences the use of another because it affects how much both languages are activated, relative to each other, in the bilingual mind. From now on, throughout the text, we will refer to the whole class of such phenomena as "language after-effects." We focus on two types of language "after-effects" by exploring how prior language experiences modify (1) the ways in which bilinguals access their native language, and (2) the ways in which cognitive processes are implemented. The effects observed in these two domains may in fact share a common underlying mechanism.

With respect to the question of the impact of one language on another, we will focus on lexical access, single-word recall, and in particular on the impact of second language exposure on native language processing. This topic has only recently attracted researchers (e.g., Linck, Kroll, & Sunderman, 2009; Sorace, 2019). With respect to the question of the impact of language experience on cognitive functioning, we will focus on the relationship between language use patterns (also called language context) and core cognitive processes such as switching, inhibition, goal maintenance and monitoring (Friedman & Miyake, 2017).

Two broad classes of prior language experience can be distinguished: *long-term* and *short-term*. Since there is no objective criterion to define short- vs long-term experience, any definition will be largely arbitrary. We take a pragmatic approach here and define the terms operationally. "Long-term experience" refers to a life event (i.e., migration) or a habitual pattern of language use. Studying this type of language experience involves contrasting participants who were exposed to a particular language environment for a long time, e.g., due to migration, against ones that did not. It also allows us to compare the same participants before and after prolonged exposure to a language. "Short-term experience" describes a situation in which a participant is exposed to a particular language in the form of experimental intervention. It involves contrasting performance across experimental conditions (e.g., with or without experimentally induced exposure).

For each topic, we present the available empirical evidence from both behavioral and brain neuroimaging approaches and discuss whether the different methods provide converging evidence. We will finish with speculations about possible convergence of mechanisms related to long-and short-term language experience and some concluding remarks about the challenges for future research.

2. IMPACT OF PRIOR LANGUAGE EXPOSURE ON NATIVE LANGUAGE RETRIEVAL

2.1. Identifying the focus and the underlying mechanism

Oftentimes, bilingual speakers experience difficulty in returning to their native language (L1) after using their second language (L2) for some time. Such an experience usually accompanies visits abroad, especially if the language of communication needs to be other than L1 (so-called L2 immersion). Fortunately, in most cases such difficulty is only temporary and, with some additional language exposure, a bilingual can regain their previous level of native language fluency.

In this section, we consider two different instances of this phenomenon that differ in the length of the exposure to L2. First, we will focus on L1 attrition, a difficulty of native language processing which comes as a consequence of long-term immersion in L2. Second, we will discuss the L2 after-effect, a temporary decrease of L1 lexical access caused by experimentally induced short-term exposure to a second language. We also discuss factors influencing the magnitude of the L2 after-effect and its persistence over time.

The difficulty of retrieving one's native language after exposure to L2 has been explained by two different accounts. The first one is the Inhibitory Control Model (IC model, Green, 1998). According to this proposal, the non-target language is inhibited whenever a bilingual wants to use another of her languages. A crucial assumption of the IC model is that the strength of inhibition applied over a given language is proportional to the baseline strength of its activation. Therefore, the stronger the language is, the stronger the inhibition applied over its representation. Since the baseline activation of the native language (L1) is usually higher than that of a second language (L2), L1 is strongly suppressed whenever bilinguals need to use L2. Therefore, after switching back to using L1, its representations continue to be inhibited for a while, thus dampening L1 performance.

We have recently proposed an extension of the IC model that is based on language balance (the IC-B), in which we point out that the amount of inhibition applied to L1 during L2 use depends on the relative balance between these two languages (Casado, Szewczyk, Wolna, & Wodniecka, 2020). Unbalanced speakers (L1 dominant) have asymmetric activation levels for L1 and L2. Therefore, to avoid L1 interference, unbalanced speakers need to apply larger amounts of inhibition to L1 during L2 use than balanced speakers, who have similar activation levels between L1 and L2 (see Fig. 1). This, in turn, implies that individual differences in a speaker's activation levels of each language should affect the magnitude of the L2 after-effect.

The second account explaining the source of difficulty when retrieving the native language after exposure to L2 is the Persisting Activation account. It proposes that the difficulty of lexical access in L1 is caused by increased interference between L1 and L2 due to the carry-over effects of L2 over-activation (Koch, Gade, Schuch, & Philipp, 2010). It assumes that whenever a bilingual uses L2, its representations get over-activated to surpass the activation of the native language. However, when after using L2 a bilingual switches back to L1, the carry-over effect of the prior over-activation of L2 results in an increase of between-language interference, thus dampening L1 performance (Koch et al., 2010; Philipp, Gade, & Koch, 2007; Yeung & Monsell, 2003).

Throughout the chapter, we will show how research so far has attempted to provide support for each of the accounts and discuss challenges in settling between the alternatives.

2.2. The influence of long-term immersion in the second language on native language processing

In recent years researchers have started to examine how the native language is affected by immersion, i.e., long-term exposure to the second language and its environment. In the following sections we will describe the outcome of studies exploring how long-term immersion in an L2 environment affects L1 production.[b]

2.2.1. Comparisons between L2-immersed and non-immersed speakers

The pioneering study on this topic (Linck et al., 2009) compared two groups of unbalanced English-Spanish bilinguals: an immersed group that spent one semester in Spain, and a classroom group that remained in their native language environment but attended L2 lessons. For language production, participants performed a semantic verbal fluency task.

[b] L1 attrition was also explored with respect to language comprehension (e.g., Kasparian, Vespignani, & Steinhauer, 2017), but as we focus on language production in the current chapter, comprehension studies are beyond our scope.

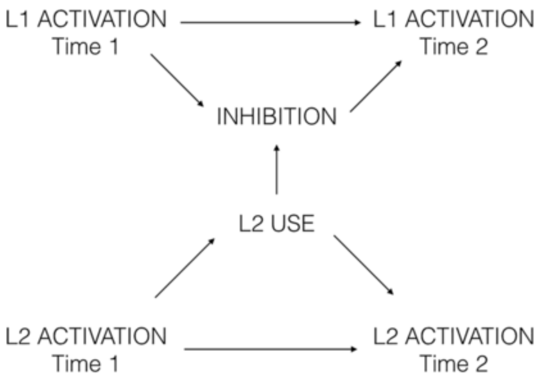

Fig. 1. The proposed IC-B model, showing the relationship between the relative balance of two languages, the involvement of inhibition, and change in L1 activation level between Time 1 and Time 2 of testing (Casado et al., 2020). It describes how L1 activation changes between two testing times (Time 1 vs Time 2) due to manipulations involving L2 use. At Time 1, when a participant arrives at the lab, she has a certain baseline level of activation of L1 and L2. If, at some point, the participant is asked to use her L2, this leads to an increased activation level of L2. In addition, speaking in L2 also triggers an inhibitory mechanism that dampens the activation of L1. The amount of inhibition depends on the current activation (measured at Time 1) of both L1 and L2. More specifically, it depends on the relative balance of L1 and L2. When the activation of L1 and L2 is balanced, the same amount of inhibition should be applied to each language (Meuter & Allport, 1999). The more L1 is activated compared to L2, the higher the amount of inhibition applied. When the activation of L1 and L2 is measured again after L2 use (Time 2), the activation of L1 should be lower, while L2 should be higher in comparison to a situation in which no L2 was used between Time 1 and Time 2.

The results showed differences between groups in terms of total number of words produced: the immersed group produced more L2 category members compared to the classroom group, even when controlling for proficiency between groups. Critically, the immersed group produced fewer L1 category members compared to the classroom group. The authors interpreted the results as suggesting that immersed learners inhibit L1, while in an L2 environment this facilitates L2 lexical access and evokes difficulties in L1 lexical access.

Another study exploring the influence of long-term exposure to L2 on L1 lexical access tested a group of German students spending a semester abroad in Spain (Baus, Costa, & Carreiras, 2013), during which they participated in a Spanish language course. The participants completed two testing sessions: just after arrival and just before departure. During both sessions they completed a picture-naming task and a semantic verbal fluency task. The results revealed that after the participants had been immersed in L2 for a couple of months, their naming latencies in L1 in the picture-naming task were significantly slower, but only for non-cognate and low-frequency words. Moreover, in the semantic fluency task, participants produced more cognate words in the second session. In general, these results indicate that immersion in L2 decreases the accessibility of L1 lexical representations (Baus et al., 2013).

Morales, Paolieri, Cubelli, and Bajo (2014) compared the performance of two groups of Spanish-English bilinguals: one immersed in an L1 environment (Spain) and another immersed in L2 (studying at a university in the USA for at least 2 years). Participants performed a picture-word interference task in which they named pictures in L2 and were instructed to ignore distractor words in L1. The distractor words were either congruent or incongruent in grammatical gender to the L1 name of the target picture. The results revealed that in the group immersed in L1, naming latencies for pictures paired with congruent distractors were longer compared to when they were paired with gender-incongruent distractors. However, a similar effect was not observed for the group immersed in L2. The authors interpreted their results as showing that immersion in L2 modulates lexical access in L1; for example, activation of the grammatical features of the native language decreases.

The effects of immersion in L2 on lexical access in the native language were also assessed in our recent study (Durlik, Bajo, & Wodniecka, 2019), in which we compared Polish-English late bilinguals immersed in L2 (living in the UK) or L1 (living in Poland). Participants performed a picture-naming task and a verbal fluency task. The results revealed that participants immersed in L2 were significantly slower at naming pictures in L1. They also produced less words in the verbal fluency task. This pattern of results supports the claim that long-term immersion in L2 results in a decrease in native language activation, thus dampening L1 lexical access.

2.2.2. Persistence of L1 retrieval difficulty under L2-immersion

So far we have discussed the evidence showing that long-term immersion in an L2 environment results in decreased activation of the native language. Decreased activation of L1 translates into difficulty in accessing L1 representations, as shown in the picture-naming and verbal fluency experiments (Baus et al., 2013; Durlik et al., 2019; Morales et al., 2014). But is L1 attrition a reversible process? Baus et al. (2013) proposed that decreased activation of L1 as a consequence of long-term immersion in L2 stems from reduced frequency of L1 exposure and use, and that it could be reversed by increasing exposure to L1. An argument to support this claim would be if short-term re-immersion in L1 could temporarily reverse L1 attrition effects. To the best of our knowledge, there have been only a few studies which have directly addressed this issue.

The first evidence comes from Linck et al. (2009), who investigated whether L1 retrieval difficulty under L2 immersion remained visible after returning to an L1 environment. A sample of participants who were immersed in Spanish (L2) while living abroad was re-tested 6 months after returning to their home country. Their language production ability was tested with the verbal fluency task. The results showed that performance in L1 was similar to that of the control group, which did not have the experience of immersion in L2. This shows that difficulty in L1 production caused by L2 immersion recovered after 6 months after returning to the L1 environment. However, because it is unclear in which language order the tasks were administered in the retest session, it cannot be ruled out that the influence of the long-term immersion was confounded with that of the short-term exposure to L2. As we will discuss in detail in Section 2.3, the order in which languages are used (L1 followed by L2 or L2 followed by L1) modulates the activation levels of both languages; for example, L1 accessibility is reduced immediately after L2 use.

Although the study by Chamorro, Sorace, and Sturt (2016) used a sentence comprehension task (and as such goes beyond single-word access, which is the focus of the current chapter), we decided to include it in our review as it directly discusses the consequences of a short-term re-immersion in L1 for L1 attrition. In this eye-tracking study, three groups of participants were tested: Spanish monolinguals, Spanish-English bilinguals immersed in L2, and Spanish-English bilinguals living in an L2 environment who had recently been re-immersed in their native language (during a minimum 1 week holiday in Spain). The study explored the sensitivity of the three groups to pronoun-antecedent mismatch in anaphoric sentences in Spanish (L1). The results revealed that while the monolingual and re-exposed group did show significant sensitivity to violation of the natural match of pronouns and antecedents, the participants who were immersed in L2 did not demonstrate such sensitivity. This suggests that the effects of L2 immersion can be reversed, at least to some extent, even by brief re-immersion in the native language.

Supporting evidence showing that difficulty in L1 lexical access due to long-term L2 immersion can be reversed after brief L1 re-immersion comes from a recent study conducted by our group (Walther, Casado, Wolna, Szewczyk, & Wodniecka, 2019). A group of Polish-English bilinguals who have lived in the L2 environment (UK) for at least 3 years was tested twice: after staying in the L2 environment continuously for at least 2 months and after a short holiday in Poland (at least 10 days), their native language environment. In both sessions, participants completed a block of picture naming in L1. The results revealed that the naming latencies were significantly shorter after brief re-immersion in their L1, suggesting that even a short visit in the native language environment can improve L1 lexical access.

All in all, the reviewed evidence suggests that the effects of attrition can be reversed even after short exposure to the L1 environment. Further evidence supporting this claim comes from an fMRI experiment showing that even short-term re-immersion in L1 results in robust neuroplastic changes in the language control network (Tu et al., 2015). Altogether, these findings demonstrate that the pattern of exposure to L1 and L2 leads to substantial reorganization of many domains of the language system, from single-word retrieval to language-control mechanisms. What is still to be established is the length of the re-immersion period that is necessary for the speakers to regain prior ease of L1 access.

2.3. The influence on native language processing of short-term exposure to the second language

One unresolved question concerns how long exposure to the second language needs to be to effectively disrupt native language retrieval. In the present section we will review studies that attempted to simulate the long-term L2 after-effect (discussed in Section 2.2) by introducing short-term experimental exposure to the second language. The studies reviewed below used a blocked picture-naming task to measure the ease of lexical retrieval in L1. The task requires participants to name pictures in language-consistent blocks. Because the consequences of using L2 for native language processing might be relatively long-lasting, the blocked designs provide an ecologically valid experimental model for exploration of the after-effect.[c] The review below discusses both behavioral and neuroimaging evidence and attempts to specify circumstances under

[c] Another task which has been frequently used in experiments exploring the effects of switching between languages and the asymmetry of switching costs is the Language Switching Task (e.g., Abutalebi & Green, 2008; Costa & Santesteban, 2004). However, as experiments using the language-switching paradigm have been extensively reviewed elsewhere (Bobb & Wodniecka, 2013; Declerck & Philipp, 2015), we will focus on the experiments using blocked designs, which make it possible to test the L2 after-effect in a longer time-scale and can provide a complementary perspective to that reported in the language-switching task.

which such short-term language after-effects can be observed in laboratory settings.

2.3.1. Behavioral evidence

Branzi, Martin, Abutalebi, and Costa (2014) tested two groups of highly proficient Catalan-Spanish bilinguals who named three blocks of pictures: L1–L2–L1. They found that naming latencies were much longer in the 3rd block than in the 1st block.[d] Degani, Kreiner, Ataria, and Khateeb (2019) used a similar experimental design to test Arabic-Hebrew bilinguals who use both languages on a regular basis. The participants were divided into two groups, both of which completed two picture-naming blocks in L1: in one group, L1 naming was interleaved with an L2 production task (reading a word list aloud); in the other group it was interleaved with a non-linguistic task (coloring mandalas). The results revealed that participants committed more within- and cross-language errors when the L1 naming was preceded by the L2 production task than when it was preceded by the non-linguistic task. We reported a similar effect (Wodniecka, Szewczyk, Kałamała, Mandera, & Durlik, 2020) in a study testing a group of late Polish-English bilinguals. The participants named pictures in two pairs of blocks: first L1–L1 and then L2–L1, separated by a 30-min break. The comparison of the second blocks of each pair (i.e., "L1 after L1" and "L1 after L2") revealed a slow-down of naming latencies in "L1 after L2" compared to "L1 after L1."

However, difficulties in accessing L1 following short-term exposure to L2 have not been observed consistently across all experiments using a blocked picture-naming design. In an experiment carried out by Strijkers, Baus, Runnqvist, FitzPatrick, and Costa (2013), two groups of early and highly proficient Spanish-Catalan bilinguals named pictures in two language-consistent blocks, each in different order: L1–L2 or L2–L1. Within each block, pictures were repeated three times. The results did not show differences between "L1 after L2" compared to the initial L1 naming block, suggesting that L2 use did not cause any lexical access difficulty to the native language. On the behavioral level, the L2 after-effect was also not observed in the experiment by Guo, Liu, Misra, and Kroll (2011), who tested highly proficient Chinese-English late bilinguals.

[d] Branzi et al. (2014) also tested another group of participants who completed the three naming blocks in different order: L2–L1–L2. Comparison of "L2 after L1" to "L1 after L2" revealed that the slow-down of naming latencies in the 3rd block only affected the L1–L2–L1 order but not L2–L1–L2. However, since the focus of this chapter is on the second-language influence on native language processing, we will not discuss the origins of the asymmetry between the two groups in detail.

The participants named pictures in two language-consistent blocks in different language order: L1–L2 or L2–L1. Importantly, each block used the same set of pictures. In line with Strijkers et al. (2013), the analysis of naming latencies did not reveal a slow-down in "L1 after L2" compared to naming in L1 in the first block. It might be argued that the lack of L1 naming slow-down after speaking in L2 in the aforementioned studies (Guo et al., 2011; Strijkers et al., 2013) was due to repetition priming. That is, the facilitation of the picture identification balanced out the difficulty in lexical access, thus leading to no differences between blocks in naming latencies. Nonetheless, using a similar design, Misra, Guo, Bobb, and Kroll (2012) showed that the L2 after-effect can still be observed in a design which repeated pictures between blocks. Chinese-English late bilinguals named a set of the same pictures in a series of four consecutive blocks. One group of participants first named two blocks in L1 (L1 first) followed by two blocks in L2 (L2 second), while another group named the first two blocks in L2 (L2 first) followed by two blocks of naming in L1 (L1 second). Even though no slow-down of naming latencies in L1 after L2 was observed, the L2 after-effect was manifested as a lack of facilitation in L1 naming after L2. Typically, repeating pictures speeds up their naming in the task. However, the facilitation of naming was only observed when the same picture was previously named in L1 (i.e., in L2 second), not L2 (L1 second). The authors interpreted the lack of facilitation in L1 naming following L2 naming as indicating that lexical access in the native language has been hampered by the previous use of L2.

We recently explored the inconsistency in finding the L2 after-effect in behavior in a series of experiments which aimed to assess how the details of the experimental design used could influence measurement of the L2 after-effect (Wolna, Szewczyk, Casado, & Wodniecka, 2020). The slow-down of naming latencies in L1 after naming in L2 was replicated in a simple two-session design in which Polish-English late bilinguals completed two blocks of naming (L1–L1) in the first session and another two blocks (L2–L1) in the second session. However, when the design included repetition of the pictures within blocks (analogous to the design of Strijkers et al., 2013, with each set of pictures being presented 3 times within a block but with new set of pictures being used in each block), the slow-down of L1 after naming in L2 was not observed. We also explored how splitting the experiment into two sessions (i.e., in one session participants complete the first pair of blocks, L1–L1, and in another they complete the second pair of blocks, L2–L1) in comparison to the experiment being completed in one session (i.e., all experimental blocks are completed in a sequence: L1–L1–L2–L1) affects measurement of the L2 after-effect (Wolna et al., 2020). The results revealed that in the one-session design, the L2 after-effect was seriously confounded by trial-related effects: the naming latencies were shown to consistently increase with each consecutive trial regardless of the language of naming. This was possibly due to the uncontrolled accumulation of semantic interference (Howard, Nickels, Coltheart, & Cole-Virtue, 2006; Runnqvist, Strijkers, Alario, & Costa, 2012), which results in systematically longer naming latencies in the “L1 after L2” block than in the “L1 after L1” block, which occurred earlier in the sequence. Importantly, the trial effect was shown to be independent of the L2 after-effect.

Apart from differences related to the details of the experimental design, individual differences between the participants may also influence measurement of the L2 after-effect. We explored how the magnitude of the L2 after-effect was affected by the relative balance of the two languages (L1 and L2), which is understood as the difference between the baseline activation levels of each language. The difference was measured as the mean naming latencies in the L1 and L2 blocks (Casado et al., 2020). We tested Polish-English bilinguals with different levels of balance between languages. The results showed a larger L2 after-effect (i.e., longer L1 naming latencies after L2 use) for the unbalanced bilinguals compared to the more balanced ones. According to the IC-B model (see Fig. 1), the more L1 dominant a participant is, the greater the amount of inhibition that is needed to resolve interference from L2 (caused by L2 use). Following the same idea of individual differences, in another experiment we explored how the differences in participants' cognitive performance between two sessions[e] could affect measurement of the L2 after-effect made during sessions (Wolna et al., 2020). Cognitive performance may influence measurement of the L2 after-effect in a picture-naming task as it can influence reaction times. In this experiment (Wolna et al., 2020), the individual processing speed was controlled with a choice reaction time task (CRT), as well as with baseline L1 naming latencies for each session. The results revealed that even though the reaction time speed and baseline naming latencies did influence the naming latencies in the “L1 after L1” and “L1 after L2” blocks, after controlling for their influence the L2 after-effect was still observed.

[e] Cognitive performance was shown to be prone to the daily variability in attention control (Engle, 2002), working memory capacity (Brose, Schmiedek, Lövdén, & Lindenberger, 2012) or biological factors such as circadian rhythms (Hasher, Zacks, & May, 1999).

2.3.2. Evidence from event-related potentials

Three of the studies reported in the previous section also included EEG recording while participants were naming pictures. All of them reported modulation of ERPs for L1 naming after L2. Two of them reported enhanced negativity (Misra et al., 2012; Wodniecka et al., 2020), and one reported enhanced positivity (Branzi et al., 2014). Although the precise pattern of the ERPs observed for the language after-effects differs across those studies (see Table 2 for details), the overall picture provides converging evidence for word-retrieval difficulty.

What is less clear from the ERP evidence is the exact mechanism that drives the word-retrieval difficulty. Misra et al. interpreted the enhanced negativity as direct evidence for L1 inhibition during L1 picture naming following L2. However, our interpretation of a similar ERP pattern (Wodniecka et al., 2020) is different: we proposed that rather than being a direct marker of inhibition, it reflects word-retrieval difficulty, which is a consequence of a language-control process that took place in the preceding block of L2 naming. On this basis, we argue that observing active L1 inhibition following L2 naming is unlikely because it would require making the rather problematic assumption that after the block of consistent naming in L2, an active inhibitory process takes place each time a speaker attempts to name a picture in L1. Branzi et al. (2014), on the other hand, reported this positivity and interpreted it as reflecting a carry-over effect of the over-activation of L2, which results in increased interference between the two languages, thus making lexical access in L1 more difficult.

As such, the results of experiments looking at the ERPs that accompany language after-effects seem to offer a very discrepant picture. We believe that despite the initial hopes, the ERPs so far have not been informative about the causal mechanism (Wodniecka et al., 2020). Further research is needed to disentangle the inhibitory and persisting activation accounts as the possible mechanisms driving the L2 after-effect.

2.3.3. Evidence from functional magnetic resonance imaging

The brain bases of the slow-down of L1 word retrieval that drives the L2 after-effect were also explored in two studies employing fMRI. Even though Guo et al. (2011) did not report a slow-down of naming latencies in “L1 after L2,” the neuroimaging results did identify increased activation in several brain structures. Compared to naming in L1 in the first block, naming in L1 after L2 resulted in enhanced activations in brain structures that are associated with interference suppression (left middle frontal gyrus, left inferior parietal gyrus), the maintenance of task-relevant information (left middle frontal gyrus) and attention shifts (left inferior parietal gyrus). The authors also argued that activations in the right postcentral gyrus might reflect the increased load for articulatory processes. All in all, although no effect was found on the behavioral level, the neuroimaging results of this study provided evidence that naming in "L1 after L2" is related to increased engagement of structures associated with language control and domain-general cognitive control mechanisms.

In another fMRI experiment, Branzi, Della Rosa, et al. (2016) explored how switching between languages disrupts S-R (stimulus-response) mapping. In this experiment, early German-Italian bilinguals completed a blocked picture-naming task in L1 and L2.[f] Each participant completed the task in two different orders: L1–L2 and L2–L1. The results revealed that naming in L1 after L2 elicited more activation in regions associated with control of interference and conflict resolution (left prefrontal cortex), response inhibition (right prefrontal cortex), and maintenance of task representations (left and right inferior parietal lobules). Importantly, in the L2 after L1 naming, these brain regions showed significant deactivation. According to the authors, these results indicate that establishing new S-R bindings after a change of language requires more control in L1 after L2 than in L2 after L1.

The last fMRI experiment that tested the mechanisms of bilingual language control in a blocked picture-naming task was carried out by Rossi et al. (2018). In their study, English-Spanish late bilinguals named pictures first in L1, followed by naming a set of different pictures in L2, and then six blocks of pictures in L1 were named. Three types of pictures were used in the six L1 blocks following the L2: (1) the same as those named in L2 (dog–dog), (2) new pictures from the same semantic category as those used in the previous L2 block (dog–cat), or (3) new pictures from completely new categories (dog–table). A group of English monolinguals was also tested (performing all the blocks of naming in L1) to provide a baseline for comparison of the effects of L2 exposure. The results revealed that compared to the first blocks of L1 naming, new items in the last L1 blocks (either from the same or different categories than those named in L2) elicited enhanced activations in the middle,

[f] The study also included a third condition in which participants were asked to perform a picture categorization task. However, since it is irrelevant from the perspective of this paper, only the design and results of the part using a picture-naming task in L1 and L2 will be discussed.

right and left cingulate gyrus and the left precuneus, all of which are regions associated with language control (Abutalebi et al., 2008). Moreover, naming new items in L1 after using L2 in bilinguals, as compared to naming the same pictures by monolinguals without a previous L2 exposure, resulted in enhanced activations in the brain regions associated with conflict monitoring (cingulate gyrus; Rossi et al., 2018) and switching between two sets of motor preparatory acts for picture naming (right precentral gyrus; Luk, Green, Abutalebi, & Grady, 2012). However, one interpretational limitation of this experiment is the fact that comparisons were made between two different groups: bilinguals and monolinguals. Therefore, it is difficult to dissociate the influence of short-term exposure to L2 (the experimental manipulation) from the fact that bilinguals' control the concurrent activation of both languages at all times (Costa, Miozzo, & Caramazza, 1999; Kroll, Bobb, & Wodniecka, 2006). The constant control of language activation likely results in functional adaptation of neural networks, especially those engaged in language control (e.g., bilinguals typically show less activity in brain structures linked to executive functions such as conflict monitoring (ACC; Abutalebi et al., 2013), while they outperform monolinguals in cognitive control tasks). This suggests that bilinguals use language control and domain-general control resources more efficiently. Therefore, in the study by Rossi et al. (2018) it might have been impossible to distinguish between the two sources of differences observed in brain activity: those related to short-term exposure to L2, and those related to the long-term consequences of bilingualism.

2.4. Summary and conclusions

We have shown that both long-and short-term exposure to L2 can severely affect production in the native language. First, we focused on studies exploring the consequences on the native language of long-term immersion in the L2 environment. The available evidence demonstrates that immersion in the L2 environment affects both lexical access and access to the syntactic structures of the native language. The fact that the detrimental effect of L2 immersion can be reversed after brief re-exposure to the native language environment (Chamorro et al., 2016; Walther et al., 2019) indicates rapid fluctuations in levels of language activation. As such, we conclude that L2 immersion results in a change in the relative activation between L1 and L2, which subsequently leads to difficulty of L1 lexical access and changes in the processing of L1 syntax. We propose that the reduced activation of L1 lies at the core of long-term L1 attrition.

Second, we have reviewed behavioral and neuropsychological evidence exploring the mechanisms of the L2 after-effect that were simulated in laboratory settings. We conclude that even very short exposure to L2 (~ 5 min) leads to substantial L1 retrieval difficulty in picture-naming tasks. Some experimental details may, however, make these effects more or less salient. Factors that can modulate the presence and magnitude of the L2 after-effect include whether or not items (pictures to name) are repeated, or whether the compared conditions are carried out in one session or not. Another factor which might influence the L2 after-effect is whether the tested participants are relatively balanced in the activation levels between their languages or not. As we have demonstrated, in line with the prediction of the IC-B model (Casado et al., 2020), L2 exposure affects subsequent performance L1 naming to a greater degree in unbalanced than in balanced bilinguals Additionally, measurement of the L2 after-effect can, to some extent, be influenced by day-to-day individual variability in overall cognitive performance (Wolna et al., 2020). Neuroimaging studies provide converging evidence that following a second-language exposure, native language production is associated with increased processing difficulty, although the precise mechanism driving this effect still needs to be established.

In conclusion, based on the experimental evidence discussed in this section, we propose that both long-term immersion and short-term exposure to L2 results in a temporary change in the balance between languages that could be caused either by L1 inhibition or by changes in L2 activation level. Further research is necessary to establish the exact nature of the mechanisms driving the modulation of the activation levels.

3. IMPACT OF PRIOR LANGUAGE USE ON COGNITIVE CONTROL

3.1. Identifying the focus and the underlying mechanisms

As demonstrated in the previous section, prior language experience does play an important role in native language access, but does it also affect cognitive mechanisms that do not involve language? We will now address this question while focusing on domain-general cognitive control.

We understand cognitive control as the set of cognitive processes responsible for goal-directed behavior in the face of distraction (Friedman & Miyake, 2004, 2017; Von Bastian et al., 2019). To exemplify the workings of cognitive control, imagine yourself driving home. Your attention can be captured by a billboard advertising a new pub. However, to pursue your main goal of safely driving home, your cognitive control redirects it to road traffic instead. Cognitive control comprises many different processes, including switching between different tasks (*task switching* or *shifting*), keeping track of changes in the environment (*goal maintenance*), and two processes related to inhibition: suppression of irrelevant information (*interference control*) and withholding a dominant or ongoing response (*response inhibition*). These processes can be measured by experimental paradigms which differ in the involvement of cognitive control. For example, in the flanker task, participants indicate the direction in which the central arrow is pointing while ignoring the direction of the surrounding arrows (i.e., flankers). If all of the arrows point in the same direction (e.g., → → → → →; congruent condition), little cognitive control is required. However, if the flanking arrows point in the opposite direction than the central arrow (e.g., → → ← → →; incongruent condition), participants need to exert more effort (i.e., more cognitive control) to resolve this interference in order to respond accurately. Smaller congruency effects (i.e., differences in performance between the incongruent and the congruent condition) are assumed to reflect more efficient interference suppression. In addition to contrasting performance between task conditions, sometimes overall performance (e.g., both congruent and incongruent condition) is investigated. Going back and forth between task conditions that are free of conflict (congruent) and those that require conflict resolution (incongruent) is more costly than having only one trial type. Constantly switching between trials involves a *monitoring* process that is necessary to react to conflict resolution when needed (e.g., Costa, Strijkers, Martin, & Thierry, 2009).

The cognitive control components mentioned above have been assumed to play a role in bilingual language control (BLC), but the extent to which cognitive control is related to BLC is still debated (Abutalebi & Green, 2007; Declerck, Koch, & Philipp, 2015). Much of the empirical evidence for this relationship comes from three lines of studies. The first line is correlational studies. The logic behind them is that measures of language control and cognitive control should correlate if these two types of control share some mechanisms. Most studies, however, did not find such correlations (e.g., Branzi, Calabria, et al., 2016; Calabria, Branzi, Marne, Hernández, & Costa, 2015; Declerck, Grainger, Koch, & Philipp, 2017; but see Cattaneo et al., 2015; Timmer, Calabria, Branzi, Baus, & Costa, 2018 for positive evidence). The second source of evidence comes from studies which compare the neural activation elicited by language control and cognitive control types of tasks within the same participant. The results showed partial overlap of activated brain areas between BLC and cognitive control (e.g., De Baene, Duyck, Brass, & Carreiras, 2015; Timmer, Grundy, & Bialystok, 2017a, 2017b). The third source of evidence for the cross-talk between language control and cognitive control comes from comparing bilinguals and monolinguals on performance in cognitive control tasks. The assumption is that if experience of using two languages trains cognitive control mechanisms, then bilinguals should outperform monolinguals. However, the results of these studies are mixed (e.g., for meta-analyses see Armstrong, Ein, Wong, Gallant, & Li, 2019; Donnelly, Brooks, & Homer, 2015; Lehtonen et al., 2018; Von Bastian et al., 2019).

The lack of consensus in the debate on the relationship between BLC and cognitive control has led to new and fruitful avenues of research. Recently, it has been proposed that the mere use of more than one language may not always impact cognitive control processes, but it depends on how bilinguals use their languages on a daily basis (e.g., Abutalebi & Green, 2016; Green & Wei, 2014; Gullifer & Titone, 2019; Yang, Hartanto, & Yang, 2016). These new theoretical proposals rely on the fact that bilinguals can employ their languages in different ways: some bilinguals may use their native language in most situations (e.g., at home and at work) and only sometimes use their second language (e.g., while traveling); others may switch frequently between their two (or more) languages or even mix them up. A bilingual individual can also move through different patterns of language use over time depending on the language context they are in. Crucially, all these patterns might engage different control processes to various degrees. The open question is how patterns of language use in bilinguals affect cognitive control. Methodologically, the role of the patterns of language use in shaping cognitive control can be tested either in a long-term scope (i.e., by evaluating the effect of long-lasting prior language experience), or in a short-term scope (i.e., by introducing a specific language context in the experimental setting). We review relevant empirical evidence for both scopes in the two subsequent sections (for an overview see Tables 3 and 4).

3.2. The influence of long-term patterns of language use on cognitive control

To examine the importance of bilinguals' lifelong language experience in shaping cognitive control, we focus on two widespread features of bilinguals' language use: tendency to use languages interchangeably (i.e., language switching) and tendency to mix elements of two languages, e.g., words, in single utterances; (i.e., language mixing; also called dense code-switching).

3.2.1. Habitual language switching and cognitive control efficiency

Bilinguals have a remarkable ability to quickly and accurately switch back and forth between their languages. Given research showing that language switching is cognitively effortful (for arguments see Blanco-Elorrieta & Pylkkänen, 2018), it is reasonable to expect that this ability should impact cognitive control mechanisms. Various studies investigated the relationship between self-reported language-switching tendencies and performance in different versions of the task-switching paradigm (e.g., Hartanto & Yang, 2016; Johnson, Sawi, & Paap, 2015; Jylkkä et al., 2017; Prior & Gollan, 2011; Soveri et al., 2011; see also Table 3). In this paradigm, participants switch between different rules of responding following a visual cue which informs about the correct response type (e.g., color or shape of stimulus). There are two measures that inform about the efficiency of cognitive control. Task-switch cost is the difference in performance between trials requiring switching between rules (i.e., switch trials) and non-switch trials; it is assumed to reflect the efficiency of *task-switching* ability. Task-mixing cost, on the other hand, refers to the difference in performance between non-switch trials in a mixed block and non-switch trials in a pure block in which only one decision has to be made. The latter is assumed to reflect individuals' ability to track changes in the environment (*goal maintenance*).

Prior and Gollan (2011) were the first to examine the role of frequent language switching in task-switching ability. They compared English monolinguals to Spanish-English and Mandarin-English bilinguals who differed in their self-assessed experience of language switching. Bilinguals who switched languages more frequently in daily life demonstrated smaller task-switch costs in RTs than the other groups. This suggests that alternating between languages involves a mechanism of switching which is domain general, not language specific.

Modulation of task-switching efficiency (indexed by task-switch costs) by a lifelong experience of language switching has also been reported in some subsequent studies (e.g., Hartanto & Yang, 2016; Prior & MacWhinney, 2010), but not in others (Soveri et al., 2011; see also Johnson et al., 2015; Jylkkä et al., 2017). For example, Soveri et al. (2011) did not find a relationship between language-switching and task-switch costs in a group of Finnish-Swedish bilinguals. Instead, the researchers found that higher rates of everyday language switches were related to a lower task-mixing cost in error rates. This effect was interpreted as evidence that switching between languages can be managed by a generic, non-switching cognitive process called goal maintenance. However, the task-mixing cost effect reported in this study was not replicated in a recent large-scale study on a sample from a similar population (Jylkkä et al., 2017; see also Johnson et al., 2015).

Habitual frequency of language switching has also been found to modulate inhibition skills (Verreyt et al., 2016; Woumans et al., 2015; see also Table 3). For example, Verreyt et al. (2016) investigated the efficiency of inhibition using the flanker task and the Simon task in three groups of Dutch-French individuals: unbalanced bilinguals, balanced non-switching bilinguals, and balanced switching bilinguals. Balanced switching bilinguals demonstrated smaller congruency effects in RTs in both tasks compared to the other groups, which did not differ in their performance. In the same vein, Woumans et al. (2015) showed that more fluent language switching is related to smaller congruency effects in the Simon task and the Attentional Network Task in RTs. However, others did not find a relationship between language-switching tendencies and inhibition skills (Paap & Greenberg, 2013; Soveri et al., 2011;). For example, Soveri et al. (2011), who reported the effect of language-switching frequency on task-mixing costs, did not observe a similar effect with regard to inhibition, as assessed by congruency effects in RTs and error rates in the Simon task and the flanker task.

3.2.2. Possible sources of discrepancies and the need for a more nuanced account

The relations between language-switching tendencies and language after-effects in cognitive control are inconsistent. It might be that in addition to language-switching tendency, other aspects of bilinguals' language experience also matter. When these aspects are not controlled for, they can confound the measurement of language after-effects. Taking this into account, Green and Abutalebi (2013) proposed the adaptive control hypothesis (ACH), in which they make a clear division between *language switching* and *language mixing* (i.e., mixing linguistic elements of two languages, e.g., words, in single utterances; dense code-switching in the paper). Importantly, the researchers argue that in contrast to language switching, language mixing is not cognitively effortful and hence mostly does not affect cognitive control. They distinguish between three basic patterns of language use in the bilingual population: dense code-switching, single-language context and dual-language context. Bilinguals who frequently mix elements of two languages within single utterances (i.e., representing dense code-switching context, DCS context) hardly ever engage in cognitive control because they utilize whichever language route is most readily available. In contrast, bilinguals who switch languages daily but do not mix them need to engage key cognitive processes. Such bilinguals might operate in either a single-language context (SL context), in which the person speaks only one language in each context (e.g., one language at home, another one at work), or a dual-language context (DL context), in which the person speaks two languages in one context but does not mix them in one and the same utterance (i.e., distinct languages are spoken with distinct speakers). Bilinguals in both SL and DL contexts are hypothesized to engage processes such as *goal maintenance* and *interference control*. However, only DL contexts require additional cognitive processes such as *task switching* (for arguments see Green & Abutalebi, 2013). Accordingly, both language switching and language mixing should be taken into account when exploring the relationships between language cognitive and cognitive control. Because the assessment of bilinguals' language experience in previous studies (e.g., BSWQ in Soveri et al., 2011; Jylkkä et al., 2017; see also Table 3) did not clearly distinguish between bilinguals who mix and do not mix their languages, the fact that the measurement of language after-effects in some studies was confounded by the participants' language-mixing tendencies cannot be dismissed, therefore it does not allow the expected effects to be observed.

3.2.3. Joint consideration of language switching and mixing

To the best of our knowledge, only a few studies so far have considered both language switching and language mixing when investigating language after-effects in cognitive control (Hartanto & Yang, 2016, 2019; Henrard & Van Daele, 2017; Kałamała, Szewczyk, Chuderski, Senderecka, & Wodniecka, 2019; Ooi, Goh, Sorace, & Bak, 2018; Pot, Keijzer, & de Bot, 2018).

Hartanto and Yang (2016, 2019) tested this issue in two consecutive experiments. In their first study, Singaporean bilinguals who used two languages interchangeably within the same context but did not mix them (i.e., representing DL context) showed a smaller task-switch cost during task switching than bilinguals who spoke only one language in one context (SL context). In their second study, the researchers focused on a wider range of cognitive control processes: not only task switching, but also goal maintenance and inhibition (also called interference control). Moreover, they employed the latent factor approach, which allowed more reliable and valid measurement of cognitive control constructs (for an overview of the measures see Table 3). Greater self-assessed exposure to the DL context was related to better task switching, whereas greater self-assessed exposure to the DCS context was associated with improved goal maintenance and interference control. While the relationship between DL context experience and task switching replicates the previous findings (Hartanto & Yang, 2016), the beneficial role of language mixing for both inhibition and goal maintenance contradicts the widely held notion that language mixing, which is cognitively less demanding, does not impact the cognitive control system (for arguments on why language mixing is cognitively undemanding see Blanco-Elorrieta & Pylkkänen, 2018; Green & Abutalebi, 2013; see also Green, 2018).

Further evidence for the effect of language mixing on inhibition efficiency comes from a German-English population (Hofweber et al., 2016). In order to measure language-mixing abilities (DCS in the article), Hofweber et al. (2016) tested bilinguals that frequently (5th-generation heritage speakers from South Africa) and less frequently mixed languages (1st-generation UK immigrants). The frequently mixing group demonstrated smaller congruency effects in RTs during a high-conflict condition of the flanker task.

Together, the studies by Hartanto and Yang (2019) and Hofweber et al. (2016) suggest that mixing of languages may involve some key cognitive control processes, such as inhibition (for more arguments see also Prior & Gollan, 2011; Green, 2018; Green & Wei, 2014; cf. Samuel, Roehr-Brackin, Pak, & Kim, 2018). Further research is necessary to clarify under which circumstances the tendency to mix languages may affect cognitive control.

Importantly, not all studies found support for the relationship between the patterns of language use proposed by the ACH and the efficiency of cognitive control (e.g., see Henrard & Van Daele, 2017, a version of the task-switching paradigm; Kałamała et al., in revision, four response inhibition tasks; Ooi et al., 2018, test of everyday attention; Pot et al., 2018, Wisconsin Card Sorting task). In our recent large-scale study (Kałamała, Szewczyk, et al., 2019), we tested whether greater intensity of DL context experience is related to greater efficiency of response inhibition in a large group of bilinguals living in Poland. Similarly, to Hartanto and Yang (2019), we adopted the latent factor approach to obtain a more reliable and valid measurement of constructs. The response inhibition construct was assessed by four response inhibition tasks including the go/no-go and stop-signal tasks (for details see Table 3). Contrary to expectations based on the ACH, we found that the self-assessed intensity of DL context experience was unrelated to the efficiency of response inhibition in bilinguals. As such, the results suggest either that bilinguals do not engage response inhibition to control language production, or all bilinguals engage this mechanism in the same way. One could argue that no evidence for modulation of inhibition in our study contradicts the inhibition effect reported in Hartanto and Yang (2019). We believe that this discrepancy results from the employment of different tasks that targeted different types of inhibition. This speculation is additionally supported by recent latent-factor studies that argue for heterogeneity of the inhibition construct (e.g., Rey-Mermet, Gade, & Oberauer, 2017; see also Friedman & Miyake, 2017; Von Bastian et al., 2019).

Taken together, the evidence suggests that both language switching and language mixing play an important role in shaping language after-effects in cognitive processes. However, there are several concerns that make it difficult to claim systematic evidence for the relationship between real-life patterns of language use and cognitive control efficiency. First, different studies focused on different cognitive constructs (e.g., task switching by Hartanto & Yang, 2016; response inhibition by Kałamała, Szewczyk, et al., 2019) and differed in the assessment of language-use patterns (even when the two studies were by the same research group: Hartanto & Yang, 2016, 2019, see also Table 3). Secondly, the life experience of bilinguals is remarkably heterogeneous since they play different social roles and represent different socio-demographic characteristics. It cannot be ruled out that this heterogeneity was not adequately controlled for in some studies (especially those that were conducted using relatively small sample sizes, e.g., Soveri et al., 2011) and thereby confounded the measurements. A promising approach to circumventing the problem of heterogeneity emerges from studies focusing on short-term language effects in the cognitive control domain, which we review in the next section.

3.3. The influence of short-term language context manipulations on cognitive control

Throughout life, bilingual individuals change their language environment frequently. Only recently have researchers started to consider how these short-term patterns of language use affect mechanisms of cognitive control. These studies introduce language context in the form of either trial-by-trial manipulations of language context or short-term language-switching training. Usually, the SL context, in which participants use only one language, is compared with the DL context, in which language switching is employed.

3.3.1. Trial-by-trial manipulations of language context

BLC involves several processes that have been suggested to be related to cognitive control. One of them is *interference control*, which helps suppress the irrelevant language. Another is *monitoring*, which in BLC refers to monitoring the language context for possible language changes. The results of studies that compare switching between languages against switching within one language, e.g., switching between word categories like nouns (e.g., chair) and verbs (e.g., sitting; Abutalebi et al., 2013; Cattaneo, Costa, Gironell, & Calabria, 2019; Khateb et al., 2007; Timmer, Wodniecka, & Costa, 2020b) suggest that only switching between languages involves *interference control*, while *monitoring* is engaged in both types of switching. Here we review studies involving trial-by-trial manipulations of language context and their evidence for either interference control or monitoring (for an overview see Table 4).

In their seminal paper, Wu and Thierry (2013) looked at the effect of trial-by-trial language context manipulations (monolingual/SL context versus bilingual/DL context) on the immediate change in the efficiency of interference control in the flanker task. The participants of the study were balanced Welsh-English bilinguals, and the language context manipulation was created by presenting words before each flanker trial. Participants read these words silently. Each participant received three different blocks of trials: (1) with Welsh words only (SL context), (2) with English words only (SL context), and (3) with words from both languages (DL context). The behavioral results showed that error rates were reduced in the DL context compared to the SL context, but only for the incongruent trials, which suggests improved interference control. These results were mimicked by ERP measures, which also showed a reduced congruency effect in the DL compared to the SL context. The authors interpreted this effect as an indication of enhanced interference resolution in the DL context. These findings were extended in a recent study with Cantonese-Mandarin-English bilinguals (Yang, Ye, Wang, Zhou, & Wu, 2018). Taken together, the available evidence suggests that the ability to resolve non-linguistic conflict can be modulated by a short-term language context.

However, two other studies that used a paradigm similar to that of Wu and Thierry (2013) showed a different pattern of results (Jiao et al., 2019; Timmer, Wodniecka, & Costa, 2020a; for a summary see Table 4). Jiao et al. (2019) conducted a replication of the study by Wu and Thierry (2013) with unbalanced Chinese-English bilinguals. The words were presented in either an SL context (i.e., only Chinese or only English) or a DL context (i.e., both languages). Unlike in the study of Wu and Thierry (2013), language context (SL vs DL) did not show a congruency effect modulation on either error rates or RTs. However, participants were faster overall in the DL than the SL contexts. This suggests that bilinguals were quicker in adjusting their responses, depending on the absence/presence of conflict in the DL context. Jiao et al. (2019) interpreted these behavioral adjustments as reflecting monitoring processes. The enhanced monitoring observed under the DL context may result from bilinguals' need to constantly monitor which language is required to achieve effective communication (Costa, Hernández, Costa-Faidella, & Sebastián-Gallés, 2009; Jiao et al., 2019). Also, Timmer et al. (2020a, 2020b) found neurophysiological evidence for more efficient monitoring in the DL compared to the SL context. More efficient monitoring in the DL context is in line with theoretical models of BLC which assume that bilingual speakers continuously monitor changes in their language environment so that they can adjust the relative activation levels of two languages depending on the language context (e.g., La Heij, 2005; Roelofs, 1998).

Why do some studies find language after-effects for *interference control* and others for *monitoring*? One possible explanation is that the compared studies differ with respect to the language combinations taken into account. For example, in some studies the two languages shared a writing system (e.g., both Latin alphabet in Wu & Thierry, 2013; Timmer et al., 2020a; L1–L3 and L2–L3 context in Yang et al., 2018), while in other studies they did not (e.g., Latin vs Sinitic in Jiao et al., 2019 and in L1–L2 context in Yang et al., 2018). One can argue that when the languages share a writing system, the same orthography might cause more interference and, in turn, it is harder to separate them. In contrast, when the language pairs have different writing systems, words are more distinct and interfere less with each other. In such cases, it may be sufficient to engage a general monitoring mechanism to keep track of the words in different languages. Evidence for this hypothesis also comes from a study on Cantonese-Mandarin-English trilinguals (Yang et al., 2018). Here, participants exhibited greater inhibitory efficiency in a Cantonese-Mandarin context when the writing systems were the same, compared to Cantonese-English and Mandarin-English contexts, in which the writing systems differed. However, in another recent study on Catalan-Spanish bilinguals in which the two languages shared scripts, the DL context also enhanced monitoring and not interference control (Timmer et al., 2020a). This indicates that language pairing is unlikely to fully account for the type of control processes engaged.

There is also another factor which may contribute to differences in the observed effects across studies. Most research discussed above introduces the DL context through tasks that involve comprehension, but passive comprehension requires less control than active language production (Kroll, Gullifer, & Rossi, 2013). Therefore, tasks that engage languages passively may impose different demands than those requiring active production. More specifically, comprehension may rely more on monitoring language context, while production may rely on resolving interference (Yang et al., 2018; but see Wu & Thierry, 2013 for contrasting results). Studies that have involved production as a way to introduce language context looked at the impact of short-term language-switching training on cognitive control. We discuss these in the next section.

3.3.2. Short-term language-switching training

In a typical experiment looking at how short-term language-switching training affects cognitive control, bilinguals perform various cognitive control tasks before and after a task that involves bilingual language switching in production. Usually the training has the form of a cued picture-naming task (Prior & Gollan, 2013; Liu, Jiao, Sun, & Wang, 2016; Liu et al., 2019; Timmer, Calabria, & Costa, 2019; Zhang, Kang, Wu, Ma, & Guo, 2015). So far, the results of this line of research seem inconsistent. Some studies found that language training improved task-switching ability as indexed by reduced task-switch costs (e.g., Timmer et al., 2019). Others found that language training improved proactive control,[g] as was reflected in reduced task-mixing cost (e.g., Liu et al., 2019). Zhang et al. (2019) also found evidence for more efficient proactive control as assessed by the AX-CPT task. However, there are also studies that did not find any effect of language-switching training on control process as assessed by task-switch and mixing costs (Prior & Gollan, 2013; for a summary see Table 4). There are several factors that could potentially explain the seeming discrepancies: the amount of language-switching training, the different types of cognitive control measured, and the type of control group employed as a baseline comparison. Below, we discuss each in turn.

The amount of language training appears to affect the presence or absence of cognitive control after-effects. Studies that involved language switching as training found increased efficiency of cognitive control (e.g., reduced task-switch costs or task-mixing costs) after training that included between 800 and 4800 trials divided over 1–10 days (Liu et al., 2019; Timmer et al., 2019; Zhang et al., 2015). However, no effects were found when the training session included only 160 trials, as in Prior and Gollan (2013; see also Table 4). Thus, it seems that a certain amount of training may be necessary to observe cross-talk from BLC to cognitive control.

Further, a straightforward explanation for why findings vary across studies is that studies used different experimental tasks that could target different cognitive control mechanisms. For example, Liu et al. (2019), Prior and Gollan (2013) and Timmer et al. (2019) employed the task-switching paradigm, while Zhang et al. (2015) used the AX-CPT task, and Liu et al. (2016) employed the faces task (Liu et al., 2016). It might well be that the processes targeted by these tasks are differently engaged during language switching.

Another reason for the discrepancy of results across different studies might be the choice of the control group that was selected as a baseline within each study. For example, Liu et al. (2019) revealed reduced mixing cost after language-switching training, but Timmer et al. (2019) did not. This might be because Liu et al. (2019) compared the language-

[g] The proactive control measure is related to the goal maintenance measure referred to in the studies using long-term language context. However, they are still dissociable as goal maintenance refers to keeping track of changes in the environment, while proactive control refers to maintaining (keeping track of) a goal while avoiding distractions.

switching training group to a control group that did not undergo any form of training. Therefore, the two groups differed in both interference control and monitoring (trained in the language-switching group). Timmer et al. (2019), on the other hand, compared the language-switching training group to a control group of bilinguals who performed blocks of single-language training, i.e., they named a block in one language and the next in another. In single-language block training, more general mechanisms of proactive control can be trained. Therefore, the language-switching training group only received additional training in conflict resolution (also called task switching) and consequently showed enhanced performance in this (interference control).

3.3.3. Ecological validity of short-term manipulations

One general problem with studies testing short-term language after-effects in cognitive control is the ecological validity of language manipulations employed in experimental research and their relation to the daily life experience of bilinguals. In order to increase ecological validity, we recently completed a study (Kałamała, Walther, et al., 2019) in which we experimentally induced specific patterns of language use in order to try to simulate the natural language environment. Highly proficient Polish-English bilinguals participated in a counterbalanced series of language games that mirrored the natural mechanisms of language use: L1 game, L2 game and DL game (requiring switching between L1 and L2). After each game, they performed the Stroop task. We found a reduced congruency effect in the Stroop task after the L2 game compared to the L1 game. These findings indicate that not only training in artificial language switching but also short-term intervention in the natural pattern of language use improves interference control.

Despite the seeming inconsistencies, the studies presented in this section suggest that trial-by-trial and short-term language-switching training manipulations impact several core processes of cognitive control which rapidly adjust to the language context. Which of the cognitive control mechanisms are modulated depends on the task that is employed, the conditions or language contexts that are compared, and the amount of language training that was employed.

3.4. Summary and conclusions

An increasing number of studies are converging on the idea that the relationship between BLC and cognitive control is modulated by bilinguals' language experience. Current research investigates this issue either by assessing bilinguals' language-use habits using questionnaires, or by inducing specific patterns of language use experimentally. Although these two bodies of research differ considerably in the methodological approach, they emerge with the seemingly coherent conclusion that certain patterns of language use—even if induced for a relatively short period of time—involve and modulate the specific mechanisms of cognitive control.

While early research focused mostly on the role of one aspect of language experience, i.e., language-switching tendency, recent research goes beyond language switching and attempts to define the set of conditions in which the lifelong language experience of bilinguals involves cognitive control mechanisms. Although the available evidence for the long-term effects is not clear-cut, two tentative conclusions emerge.

First, bilinguals who frequently reside in a DL context are more likely to practice cognitive control processes than bilinguals who come from a SL context (e.g., Hartanto & Yang, 2016, 2019; Ooi et al., 2018; Pot et al., 2018). Furthermore, in contrast to the widely held assumption in the literature, not only language switching (i.e., alternate use of languages; DL context) but also certain types of language mixing (i.e., mixing linguistic elements of two languages within single utterances; DCS) can modulate cognitive control (Hartanto & Yang, 2019; Hofweber et al., 2016). However, the precise role of language mixing in shaping cognitive control efficiency is not yet clear and should be addressed in future studies.

Second, daily patterns of language use influence task switching, goal maintenance, and interference control (e.g., Hartanto & Yang, 2016, 2019; see also Ooi et al., 2018; Pot et al., 2018), but not response inhibition (e.g., Kałamała, Szewczyk, et al., 2019). On this basis, we speculate that BLC does not involve inhibition in the form of stopping an ongoing response (as in the study by Kałamała et al.) but rather inhibition in the form of interference suppression (as in the study by Hartanto & Yang). Future research should exercise caution when interpreting results with regard to inhibition mechanisms and should systematically examine which aspects of inhibition are involved in BLC.

It is noteworthy that not only long-term language experience but also short-term changes between different types of language context within a bilingual individual exert an impact on the flexible cognitive control system. With regards to the evidence from trial-by-trial language context manipulation, the findings indicate that a DL context enhances either interference control (e.g., Wu & Thierry, 2013) or the global process of monitoring (e.g., Jiao et al., 2019). Monitoring of language context is more general and can also be applied in contexts in which only one language is used (i.e., SL context; Abutalebi et al., 2008; Cattaneo et al., 2019). This is supported by other studies, among which is a study showing that within-language switches (i.e., between nouns and verbs) reveal the same monitoring effects (Timmer et al., 2020b) as between-language switches (DL context). These findings are consistent with certain theoretical models which assume that bilingual speakers continuously monitor the changes in their language environment so that they can adjust the relative activation levels of the two languages depending on the language context (e.g., La Heij, 2005; Roelofs, 1998). Thus, both monitoring and interference control seem to play important roles in shaping the efficiency of cognitive control. Further investigation is needed to understand under which circumstances different mechanisms are critical and modulate the relation with BLC.

Evidence from language-switching training studies show a discrepancy with respect to which cognitive control processes are affected. This, however, can be easily explained by three factors: the amount of language-switching training, the type of task that is used and the related measurements, and, most importantly, the control group that is used in comparison to the language-switching training group. With these factors in mind, a clearer picture emerges that shows that a DL context requires a general mechanism of proactive control (also called goal maintenance) and a more specific mechanism that is related to language switching and can only be found when properly isolated from general monitoring, which can also be activated in within-language contexts (Timmer et al., 2019). Clearly, research investigating how patterns of language use modulate BLC is still in its infancy, but we are optimistic that new research will help to understand how bilingual language use affects the cognitive control system.

4. CONCLUSIONS, SPECULATIONS AND OUTSTANDING QUESTIONS

In this chapter, we have provided a quick tour through research that demonstrates the impact of long- and short-term language experience of bilinguals on subsequent language production and cognitive control (referred to in the text as "language after-effects"). As we have demonstrated throughout the chapter, the accumulated evidence shows that prior language experience does play an important role for both.

Being bilingual involves constantly managing the activation of two languages in the brain. Although both languages are always active to some degree, the level of activation fluctuates depending on which language is being used. The available behavioral and brain-imaging evidence converges on the conclusion that both long- and short-term exposure to L2 temporarily makes the native language more difficult to activate and thus harder to access. The need for temporary modulation of language activation is more apparent when there are larger differences between default activation levels, i.e., in more language-unbalanced speakers for whom one language is clearly more activated than the other (see Tables 1 and 2 for details). We speculate that a decrease of L1 activation is responsible for the experimentally observed L2 after-effect, but it also lies at the core of L1 attrition. We have discussed the evidence which shows that the effects of L1 attrition are reversible with re-exposure to the native language, which implies that the language system has a highly dynamic nature. A challenge for future research will be to establish the precise amounts of re-exposure that are required to reverse the temporary modulation of language activation.

In the literature two different cognitive mechanisms have been proposed as responsible for changes in language activation. One of them is inhibition of a currently irrelevant language; the other is an increase in activation of a currently used language. It has been hypothesized that these mechanisms are related to domain-general mechanisms of cognitive control. Such a theoretical perspective allows a bridge to be built between the evidence from the language after-effects that are observed in both the language- and the cognitive control domains. The current chapter reports some evidence to support such a proposal. Firstly, fMRI studies provide evidence that bilingual language control engages the same brain structures as critical cognitive control processes. Second, several studies have demonstrated that switching or mixing two languages in the long-term and short-term improves some aspects of cognitive control (e.g., interference control, monitoring, and switching). However, not all studies support the relationship between language experience and cognitive control. We believe that the discrepancy in the results stems from the fact that different studies use different experimental control tasks which engage different cognitive control processes (see Tables 3 and 4),

TABLE 1 Summary of experiments showing how long-term immersion in L2 influences processing in L1.

			Influence of long-term immersion in the second language for native language processing					
Authors	**Participants**		**Design**					**Effects o**
	Languages	Balance	Task	L2 exposure	Item repetition	Conditions of comparison	Manipulation	Behavior (effect of immersio
Baus et al. (2013)	German-Spanish	Late, unbalanced	Picture naming, verbal fluency	3 months	Between sessions	Before immersion in L2 After immersion in L2	Within participants	Yes, L1 retrieval difficult for non-cognate low-frequenc words

TABLE 1 (Continued)

	Influence of long-term immersion in the second language for native language processing							
Authors	**Participants**		**Design**					**Effects o**
	Languages	Balance	Task	L2 exposure	Item repetition	Conditions of comparison	Manipulation	Behavior (effect of immersio
Chamorro et al. (2016)	Spanish-English	Late, unbalanced-highly proficient	Reading comprehension	5 years	No	Immersed in L2 Re-immersed in L1 control group	Between groups	Yes, reduced sensitivi to L1 sy violatio decrease after re-immersi in L1
Durlik et al. (2019)	Polish-English	Late, unbalanced	Picture naming, verbal fluency	2 years	No	Immersed Control group	Between groups	Yes, L1 retrieval difficult

TABLE 1 (Continued)

	Influence of long-term immersion in the second language for native language processing							
Authors	**Participants**		**Design**					**Effects o**
	Languages	Balance	Task	L2 exposure	Item repetition	Conditions of comparison	Manipulation	Behavior (effect of immersio
Morales et al. (2014)	Spanish-English	Late, unbalanced	Picture-word interference in L2 with L1 distractors	2 years	Yes	Immersed group Control group	Between groups	Yes, reduced access o gramma features

TABLE 1 (Continued)

Influence of long-term immersion in the second language for native language processing								
Authors	**Participants**		**Design**					**Effects o**
	Languages	Balance	Task	L2 exposure	Item repetition	Conditions of comparison	Manipulation	Behavior (effect of immersio
Tu et al. (2015)	Cantonese-Mandarin	Early	Silent free-narration task	Comparable L1 and L2 exposure for at least 30 days	No	Condition (equal exposure to L1 and L2 vs intensified exposure to L1) × Language (L1 or L2)	Within participants	–

TABLE 1 (Continued)

Authors	Participants		Design					Effects o
	Influence of long-term immersion in the second language for native language processing							
	Languages	Balance	Task	L2 exposure	Item repetition	Conditions of comparison	Manipulation	Behavior (effect of immersio
Walther et al. (2019)	Polish-English	Late, unbalanced	Picture naming	3 years	No	Immersed in L2 Re-immersed in L1	Within participants	Yes, decrease after re-immersi in L1

Item repetition refers only to the crucial comparison. Each row describing the *Conditions of comparison* refers to either two sessions of measurements (for within-participant manipulations) or two experimental groups (for between-participant manipulations). The abbreviations used in the *Neuropsychological effect* section stand for: MFG, middle frontal gyrus; DLPFC, dorsolateral prefrontal cortex; ACC, anterior cingulate cortex.

TABLE 2 Summary of experiments showing how short-term exposure to L2 influences lexical processing in L1.

Influence of short-term exposure to the second language for native language processing									
Authors	**Participants**		**Design**					**Effects observed**	
	Languages	Balance	Task	L2 exposure	Item repetition	Conditions of comparison	Manipulation	Behavioral (slow-down of L1 after L2)	Neuropsycholo
Branzi, Calabria, Boscarino, and Costa (2016); Branzi, Della Rosa, Canini, Costa, and Abutalebi (2016)	German-Italian	Early, balanced	Picture naming	Naming pictures	Yes	**L1–L2** **L2–L1**	Within participants	–[a]	Increased activation in: PFC, right PF left and right

TABLE 2 (Continued)

Influence of short-term exposure to the second language for native language processing									
Authors	**Participants**		**Design**					**Effects observed**	
	Languages	Balance	Task	L2 exposure	Item repetition	Conditions of comparison	Manipulation	Behavioral (slow-down of L1 after L2)	Neuropsycholo
Branzi et al. (2014)	Catalan-Spanish	Early, balanced	Picture naming	64 trials	No	**L1–L2–L1**	Within participants	Yes (RT)	P2 (140–220 fronto-central distribution
Casado et al. (2020)	Polish-English	Late, unbalanced	Picture naming	Naming pictures	No	**L1–L1–L1** **L1–L2–L1**	Within participants	Yes (RT)	–
Degani et al. (2019)	Arabic-Hebrew	Late, unbalanced	Picture naming	Reading aloud	Yes	**L1–L2–L1**	Between groups	Yes (ER: within- and cross-language errors)	–

TABLE 2 (Continued)

Influence of short-term exposure to the second language for native language processing									
Authors	**Participants**		**Design**					**Effects observed**	
	Languages	Balance	Task	L2 exposure	Item repetition	Conditions of comparison	Manipulation	Behavioral (slow-down of L1 after L2)	Neuropsycholo
Guo et al. (2011)	Chinese-English	Late, unbalanced	Picture naming	Naming pictures	Yes	**L1–L2** **L2–L1**	Within participants	No (RT)	Increased activation in: MFG, left MT left IPG, precuneus an right postcent gyrus
Misra et al. (2012)	Chinese-English	Late, unbalanced	Picture naming	144 trials	Yes	**L1–**L1–L2–L2 L2–L2–**L1–**L1	Between groups	Yes, reduced repetition priming	N2 (250–375 ms broadly distributed

TABLE 2 (Continued)

Influence of short-term exposure to the second language for native language processing									
Authors	**Participants**		**Design**					**Effects observed**	
	Languages	Balance	Task	L2 exposure	Item repetition	Conditions of comparison	Manipulation	Behavioral (slow-down of L1 after L2)	Neuropsycholo
Rossi, Newman, Kroll, and Diaz (2018)	English-Spanish	Late, unbalanced	Picture naming	Naming pictures	Yes	**L1–L2–L1**	Between groups	–[a]	All items: enhanced activations in middle, right left cingulate gyrus and left precuneus New items: ri precentral gyı and central cingulate gyrı

TABLE 2 (Continued)

Influence of short-term exposure to the second language for native language processing									
Authors	**Participants**		**Design**					**Effects observed**	
	Languages	Balance	Task	L2 exposure	Item repetition	Conditions of comparison	Manipulation	Behavioral (slow-down of L1 after L2)	Neuropsy
Strijkers et al. (2013)	Spanish-Catalan	Early, balanced	Picture naming	Naming pictures	yes, within blocks	**L1**–L2 L2–**L1**	Between groups	No (RT)	–[a]
Wodniecka et al. (2020)	Polish-English	Late, unbalanced	Picture naming	Naming pictures	50% new 50% repeated	**L1–L1** **L2–L1**	Within participants	Yes (RT)	N3 (240 central distribut
Wolna et al. (2020)	Polish-English	Late, unbalanced	Picture naming	Naming pictures	No	L1–**L1**–L2–**L1**	Within participants	No (RT)	–
					No	CRT–L1–L1–**L1** CRT–L1–L2–**L1**	Within participants	Yes (RT)	–

TABLE 2 (Continued)

Influence of short-term exposure to the second language for native language processing									
Authors	**Participants**		**Design**					**Effects observed**	
	Languages	Balance	Task	L2 exposure	Item repetition	Conditions of comparison	Manipulation	Behavioral (slow-down of L1 after L2)	Neuropsycholo
					Yes, within blocks	L1–**L1** L2–**L1**	Within participants	No (RT)	–

Item repetition refers only to the crucial comparison. In short-term exposure section, the blocks used for the comparisons reported in *Effects observed* are marked in bold. Each row describing the *Conditions of comparison* refers to either two sessions of measurements (for within-participant manipulations) or two experimental groups (for between-participant manipulations). The abbreviations used in the *Neuropsychological effect* section stand for: MFG, middle frontal gyrus; MTG, middle temporal gyrus; IPG, inferior parietal gyrus; PFC, prefrontal cortex; IPL, inferior parietal lobule.

[a]Even though a study did report a behavioral (Branzi et al., 2016; Rossi et al., 2018) or neuropsychologival (Strijkers et al., 2013) effect, they do not provide evidence for a crucial comparison when analyzing the L2 after-effect, therefore they were not discussed in this review.

TABLE 3 Summary of experiments showing how long-term exposure to different language context influence cognitive control.

Influence of long-term language context exposure on cognitive control							
Authors	**Participants**		**Design**			**Effects observed**	
	Languages	Balance	Pattern of language use measure/group comparison	Language after-effect task	Process (dependent measure)	Behavioral	Neuropsych
Hartanto and Yang (2016)	Singaporeans with different combinations of languages	Early, balanced	Composite score of DLC bilingualism	Task switching	Task switching (switch cost)	Yes (RT)	–
			Index of SLC bilingualism			Yes (RT)	
			Frequency of intrasentential code-switching			–	
			Frequency of intersentential code-switching			Yes (RT)	

TABLE 3 (Continued)

Influence of long-term language context exposure on cognitive control							
Authors	**Participants**		**Design**			**Effects observed**	
	Languages	Balance	Pattern of language use measure/group comparison	Language after-effect task	Process (dependent measure)	Behavioral	Neuropsych
			Index of intrasentential code-switching			Yes (RT)	
			Index of intersentential code-switching			Yes (RT)	
Hartanto and Yang (2019)	Singaporeans with different combinations of languages	Early, balanced	SLC index, DLC index, DCS index	3 versions of task switching	Task switching (latent factor based on switch costs)	Yes for DLC index	–

TABLE 3 (Continued)

Influence of long-term language context exposure on cognitive control							
Authors	**Participants**		**Design**			**Effects observed**	
	Languages	Balance	Pattern of language use measure/group comparison	Language after-effect task	Process (dependent measure)	Behavioral	Neuropsych
			SLC index, DLC index, DCS index	3 versions of task switching	Goal maintenance/ shifting (latent factor based on mixing costs)	Yes for DCS index	
			SLC index, DLC index, DCS index	3 versions of flanker task	Inhibition (latent factor based on congruency effects)	Yes for DCS index	
Hofweber, Marinis, and Treffers-Daller (2016)	German-English	Early, balanced	Frequent dense code-switchers vs infrequent dense code-switchers	Flanker task	Inhibition/interference control (congruency effect)	Yes (RT), no (ER)	–

TABLE 3 (Continued)

Influence of long-term language context exposure on cognitive control							
Authors	**Participants**		**Design**			**Effects observed**	
	Languages	Balance	Pattern of language use measure/group comparison	Language after-effect task	Process (dependent measure)	Behavioral	Neuropsych
Jylkkä et al. (2017; experiment 1)	Finnish-Swedish	Early, balanced	Frequency of language switching (derived from BSWQ)	Task switching	Task switching (switch cost)	No (RT, ER)	–
					Goal maintenance/ shifting (mixing cost)	No (RT, ER)	
				Flanker task	Inhibition/interference control	No (RT, ER)	
				Simon task	Inhibition/interference control	No (RT, ER)	

TABLE 3 (Continued)

Influence of long-term language context exposure on cognitive control							
Authors	**Participants**		**Design**			**Effects observed**	
	Languages	Balance	Pattern of language use measure/group comparison	Language after-effect task	Process (dependent measure)	Behavioral	Neuropsych
Jylkkä et al. (2017; experiment 2)	Finnish-Swedish	Early, balanced	Frequency of language switching (derived from BSWQ)	Task switching	Task switching (switch cost)	Yes (RT), no (ER)	–
					Goal maintenance/ shifting (mixing cost)	No (RT, ER)	
				Flanker task	Inhibition/interference control	No (RT, ER)	
				Simon task	Inhibition/interference control	No (RT, ER)	

TABLE 3 (Continued)

Influence of long-term language context exposure on cognitive control							
Authors	**Participants**		**Design**			**Effects observed**	
	Languages	Balance	Pattern of language use measure/group comparison	Language after-effect task	Process (dependent measure)	Behavioral	Neuropsych
Kałamała, Szewczyk, et al. (2019)	Polish-English	Early, unbalanced	Intensity of dual-language context	Stroop task	Inhibition/response inhibition (latent factor*)	No	–
				Antisaccade task			
				Stop-signal task			
				Go/no-go task			
Prior and Gollan (2011)	English, Spanish-English, Mandarin-English	Early, balanced	Frequency of language switching during a typical day	Task switching	Task switching (switch cost)	Yes (RT)	–

TABLE 3 (Continued)

Influence of long-term language context exposure on cognitive control							
Authors	**Participants**		**Design**			**Effects observed**	
	Languages	Balance	Pattern of language use measure/group comparison	Language after-effect task	Process (dependent measure)	Behavioral	Neuropsych
Soveri, Rodriguez-Fornells, and Laine (2011)	Finnish-Swedish	Early, balanced	Frequency of language switching (derived from BSWQ)	Task switching	Goal maintenance/ shifting (mixing cost)	No (RT)	–
					Task switching (switch cost)	No (RT, ER)	
				Flanker task	Goal maintenance/ shifting (mixing cost)	No (RT), yes (ER)	
					Inhibition/interference control (congruency effect)	No (RT, ER)	

TABLE 3 (Continued)

Influence of long-term language context exposure on cognitive control							
Authors	**Participants**		**Design**			**Effects observed**	
	Languages	Balance	Pattern of language use measure/group comparison	Language after-effect task	Process (dependent measure)	Behavioral	Neuropsych
				Flanker task	Inhibition/interference control (congruency effect)	No (RT, ER)	
Verreyt, Woumans, Vandelanotte, Szmalec, and Duyck (2016)	Dutch-French	Early, different balance	Unbalanced vs balanced non-switching vs balanced switching	Flanker task	Inhibition/interference control (congruency effect)	Yes (RT), no (ER)	–
				Simon task		yes (RT), no (ER)	

TABLE 3 (Continued)

Influence of long-term language context exposure on cognitive control							
Authors	**Participants**		**Design**			**Effects observed**	
	Languages	Balance	Pattern of language use measure/group comparison	Language after-effect task	Process (dependent measure)	Behavioral	Neuropsych
Woumans, Ceuleers, VanderLinden, Szmalec, and Duyck (2015)	Dutch-French	Different	Unbalanced vs balanced non-switching vs balanced switching	ANT	Monitoring (overall performance)	Yes (RT), no (ER)	–
				Simon task	Inhibition/interference control (congruency effect)	Yes (RT), no (ER)	

The abbreviations used in *pattern of language use* section stand for: DLC, double-language context; SLC, single-language context; DCS, dense code-switching.

TABLE 4 Summary of experiments showing different types of short-term language influence cognitive control.

Influence of short-term language context exposure on cognitive control								
Authors	**Participants**		**Design**					**Effects obse**
	Languages	Balance	Group comparison	Type of language exposure	Length of exposure	Language after-effect task	Process (dependent measure)	Behavioral
Jiao et al. (2019)	Chinese-English	Late, unbalanced	SLC vs DLC	Language context	Trial-by-trial	Flanker task	Interference control (congruency effect)	No (RT, ER)
							Monitoring (overall performance)	Yes (RT)
Kałamała, Walther, et al. (2019)	Polish-English	Late, unbalanced	DLC vs SLC in L1 vs SLC in L2	Language game	1 day (2 h)	Stroop	Interference control (congruency effect)	Yes (RT)
Liu et al. (2019)	Chinese-English	Late, unbalanced	DLC vs no task or vs SLC	Language switching training	4 days (approx. 800 trials)	Task switching	Proactive control (mixing cost)	Yes (RT)

TABLE 4 (Continued)

Influence of short-term language context exposure on cognitive control								
Authors	**Participants**		**Design**					**Effects obse**
	Languages	Balance	Group comparison	Type of language exposure	Length of exposure	Language after-effect task	Process (dependent measure)	Behavioral
						Antisaccade task	Inhibition/response inhibition (congruency effect)	Yes (RT)
Liu et al. (2016)	Chinese-English	Late, unbalanced	SLC vs DLC	Language switching training	1 day (128 trials)	Faces task	Inhibition (not specified)	Yes (RT)
							cognitive flexibility	No (RT)
Prior and Gollan (2013)	Spanish-English	Early, balanced	Task vs language	Language switching training	1 day (160 trials)	Task switching	Proactive control (mixing cost)	No (RT, ER)
	Mandarin-English	Early, balanced					Reactive control (switch cost)	No (RT, ER)

TABLE 4 (Continued)

Authors	Participants		Design					Effects obse
	Influence of short-term language context exposure on cognitive control							
	Languages	Balance	Group comparison	Type of language exposure	Length of exposure	Language after-effect task	Process (dependent measure)	Behavioral
Timmer et al. (2020a)	Catalan-Spanish	Early, balanced	SLC vs DLC	Language context	Trial-by-trial	Attentional Network Test	Alerting (cue vs no-cue)	Yes (RT, ER)
							Interference control (congruency effect)	Yes (RT, ER)
Timmer et al. (2020b)	Catalan	Early, balanced	Single vs mixed (noun/verb)	Language context	Trial-by-trial	Attentional Network Test	Alerting (cue vs no-cue)	Yes (RT, ER)
							Interference control (congruency effect)	Yes (RT, ER)

TABLE 4 (Continued)

Influence of short-term language context exposure on cognitive control								
Authors	**Participants**		**Design**					**Effects obse**
	Languages	Balance	Group comparison	Type of language exposure	Length of exposure	Language after-effect task	Process (dependent measure)	Behavioral
Timmer et al. (2019)	Catalan-Spanish	Early, balanced	SLC vs DLC	Language switching training	2 days (1536 trials)	Task switching	Proactive control (mixing cost)	No (RT)
							Reactive control (switch cost)	Yes (RT)
Wu and Thierry (2013)	English-Welsch	Early, balanced	SLC vs DLC	Language context	Trial-by-trial	Flanker task	Interference control (congruency effect)	Yes (ER)
Yang et al. (2018)	Cantonese-Mandarin-English	Early Can + Man, late English	DLC in L1–L2, L1–L3, L2–L3	Language context	Trial-by-trial	Flanker task	Interference control (congruency effect)	Yes (ER)

TABLE 4 (Continued)

Authors	Participants		Design					Effects obse
			Influence of short-term language context exposure on cognitive control					
	Languages	Balance	Group comparison	Type of language exposure	Length of exposure	Language after-effect task	Process (dependent measure)	Behavioral
Zhang et al. (2015)	Chinese-English	Late, unbalanced	DLC vs no task	Language switching training	10 days (4800 trials)	AX-Continuous Perf Test	Goal maintenance (shift index)	Yes (RT)

The abbreviations used in *pattern of language use* section stand for: DLC, double-language context; SLC, single-language context; DCS, dense code-switching.

and that not all patterns of bilingual language use engage these processes to the same degree.

By bringing together the available evidence from the two research domains (language and cognitive processes), we hope to have illustrated that the mind is highly susceptible to nuances of the linguistic environment. Converging evidence supports the idea that both language and cognitive systems are subject to rapid changes. The language system modulates relative activation of L1 and L2 in order to optimize performance to the ongoing demands. The cognitive system flexibly adjusts to the current communication demands imposed by a prior language experience; however, the precise mechanisms underlying this phenomenon are yet to be established. Many questions remain open: What is the *time-course* of the adaptive processes? What is the exact *nature* of the *preceding language context*? How *permanent* and *reversible* are the changes in the language- and cognitive control systems?

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REFERENCES

Abutalebi, J., Annoni, J.M., Zimine, I., Pegna, A.J., Seghier, M.L., Lee-Jahnke, H., et al., 2008. Language control and lexical competition in bilinguals: An event-related fMRI study. Cerebral Cortex 18 (7), 1496–1505. https://doi.org/10.1093/cercor/bhm182.

Abutalebi, J., Della Rosa, P.A., Ding, G., Weekes, B., Costa, A., Green, D.W., 2013. Language proficiency modulates the engagement of cognitive control areas in multilinguals. Cortex 49 (3), 905–911. https://doi.org/10.1016/j.cortex.2012.08.018.

Abutalebi, J., Green, D., 2007. Bilingual language production: The neurocognition of language representation and control. Journal of Neurolinguistics 20 (3), 242–275 https://doi.org/10.1016/j.jneuroling.2006.10.003.

Abutalebi, J., Green, D.W., 2016. Neuroimaging of language control in bilinguals: Neural adaptation and reserve. Bilingualism: Language and Cognition 19 (04), 689–698 https://doi.org/10.1017/S1366728916000225.

Armstrong, B.A., Ein, N., Wong, B.I., Gallant, S.N., Li, L., 2019. The effect of bilingualism on older adults' inhibitory control: A meta-analysis. The Gerontologist

Baus, C., Costa, A., Carreiras, M., 2013. On the effects of second language immersion on first language production. Acta Psychologica 142 (3), 402–409.

Bialystok, E., 2011. Reshaping the mind: The benefits of bilingualism. Canadian Journal of Experimental Psychology/Revue canadienne de psychologie expérimentale 65 (4), 229.

Blanco-Elorrieta, E., Pylkkänen, L., 2018. Ecological validity in bilingualism research and the bilingual advantage. Trends in Cognitive Sciences 22 (12), 1117–1126 https://doi.org/10.1016/j.tics.2018.10.001.

Bobb, S.C., Wodniecka, Z., 2013. Language switching in picture naming: What asymmetric switch costs (do not) tell us about inhibition in bilingual speech planning. Journal of Cognitive Psychology 25 (5), 568–585 https://doi.org/10.1080/20445911.2013.792822.

Branzi, F.M., Calabria, M., Boscarino, M.L., Costa, A., 2016. On the overlap between bilingual language control and domain-general executive control. Acta Psychologica 166, 21–30 https://doi.org/10.1016/j.actpsy.2016.03.001.

Branzi, F.M., Della Rosa, P.A., Canini, M., Costa, A., Abutalebi, J., 2016. Language control in bilinguals: Monitoring and response selection. Cerebral Cortex 26 (6), 2367–2380.

Branzi, F.M., Martin, C.D., Abutalebi, J., Costa, A., 2014. The after-effects of bilingual language production. Neuropsychologia 52, 102–116.

Brose, A., Schmiedek, F., Lövdén, M., Lindenberger, U., 2012. Daily variability in working memory is coupled with negative affect: The role of attention and motivation. Emotion 12 (3), 605.

Calabria, M., Branzi, F.M., Marne, P., Hernández, M., Costa, A., 2015. Age-related effects over bilingual language control and executive control. Bilingualism: Language and Cognition 18 (1), 65–78 https://doi.org/10.1017/S1366728913000138.

Casado, A., Szewczyk, J., Wolna, A., Wodniecka, Z., 2020. How does language balance affects L2-after effects?. [manuscript in preparation] Department of Experimental Psychology, Jagiellonian University.

Cattaneo, G., Calabria, M., Marne, P., Gironell, A., Abutalebi, J., Costa, A., 2015. The role of executive control in bilingual language production: A study with Parkinson’s disease individuals. Neuropsychologia 66, 99–110 https://doi.org/10.1016/j.neuropsychologia.2014.11.006.

Cattaneo, G., Costa, A., Gironell, A., Calabria, M., 2019. On the specificity of bilingual language control: A study with Parkinson's disease patients. Bilingualism: Language and Cognition 1–9.

Chamorro, G., Sorace, A., Sturt, P., 2016. What is the source of L1 attrition? The effect of recent L1 re-exposure on Spanish speakers under L1 attrition. Bilingualism: Language and Cognition 19 (3), 520–532.

Costa, A., Hernández, M., Costa-Faidella, J., Sebastián-Gallés, N., 2009. On the bilingual advantage in conflict processing: Now you see it, now you don’t. Cognition 113 (2), 135–149.

Costa, A., Miozzo, M., Caramazza, A., 1999. Lexical selection in bilinguals: Do words in the bilingual's two lexicons compete for selection?. Journal of Memory and Language 41 (3), 365–397.

Costa, A., Santesteban, M., 2004. Lexical access in bilingual speech production: Evidence from language switching in highly proficient bilinguals and L2 learners. Journal of Memory and Language 50 (4), 491–511.

Costa, A., Strijkers, K., Martin, C., Thierry, G., 2009. The time course of word retrieval revealed by event-related brain potentials during overt speech. Proceedings of the National Academy of Sciences of the United States of America 106 (50), 21442–21446.

De Baene, W., Duyck, W., Brass, M., Carreiras, M., 2015. Brain circuit for cognitive control is shared by task and language switching. Journal of Cognitive Neuroscience 27 (9), 1752–1765 https://doi.org/10.1162/jocn_a_00817.

Declerck, M., Grainger, J., Koch, I., Philipp, A.M., 2017. Is language control just a form of executive control? Evidence for overlapping processes in language switching and task switching. Journal of Memory and Language 95, 138–145 https://doi.org/10.1016/j.jml.2017.03.005.

Declerck, M., Koch, I., Philipp, A.M., 2015. The minimum requirements of language control: Evidence from sequential predictability effects in language switching. Journal of Experimental Psychology: Learning, Memory, and Cognition 41, 377–394 https://doi.org/10.1037/xlm0000021.

Declerck, M., Philipp, A.M., 2015. A review of control processes and their locus in language switching. Psychonomic Bulletin & Review 22 (6), 1630–1645.

Degani, T., Kreiner, H., Ataria, H., Khateeb, F., 2019. The impact of brief exposure to the second language on native language production: Global or item specific?. Applied PsychoLinguistics 41, 1–31.

Donnelly, S., Brooks, P.J., Homer, B.D., 2015. Examining the bilingual advantage on conflict resolution tasks: A meta-analysis. In: CogSci, the Annual Meeting of the Cognitive Science Society, July 22–25.

Durlik, J., Bajo, M.T., Wodniecka, Z., 2019. Two L1's or two L2's? The consequences of L2 immersion for lexical access and cross-language interference in bilinguals. In: 21st Conference of European Society for Cognitive Psychology, Tenerife, Spain, September 25–28 [Poster presentation]. https://rb.gy/q6ja47.

Engle, R.W., 2002. Working memory capacity as executive attention. Current Directions in Psychological Science 11 (1), 19–23.

Friedman, N.P., Miyake, A., 2004. The relations among inhibition and interference control functions: A latent-variable analysis. Journal of Experimental Psychology: General 133 (1), 101–135 https://doi.org/10.1037/0096-3445.133.1.101.

Friedman, N.P., Miyake, A., 2017. Unity and diversity of executive functions: Individual differences as a window on cognitive structure. Cortex 86, 186–204 https://doi.org/10.1016/j.cortex.2016.04.023.

Green, D.W., 1998. Mental control of the bilingual lexico-semantic system. Bilingualism: Language and Cognition 1 (2), 67–81 https://doi.org/10.1017/S1366728998000133.

Green, D.W., 2018. Language control and code-switching. Language 3 (2), 8 https://doi.org/10.3390/languages3020008.

Green, D.W., Abutalebi, J., 2013. Language control in bilinguals: The adaptive control hypothesis. Journal of Cognitive Psychology 25 (5), 515–530 https://doi.org/10.1080/20445911.2013.796377.

Green, D.W., Wei, L., 2014. A control process model of code-switching. Language, Cognition and Neuroscience 29 (4), 499–511 https://doi.org/10.1080/23273798.2014.882515.

Grosjean, F., Li, P., 2013. The psycholinguistics of bilingualism. John Wiley & Sons.

Gullifer, J.W., Titone, D., 2019. Characterizing the social diversity of bilingualism using language entropy. Bilingualism: Language and Cognition 1–12 https://doi.org/10.1017/S1366728919000026.

Guo, T., Liu, H., Misra, M., Kroll, J.F., 2011. Local and global inhibition in bilingual word production: fMRI evidence from Chinese–English bilinguals. NeuroImage 56 (4), 2300–2309.

Hartanto, A., Yang, H., 2016. Disparate bilingual experiences modulate task-switching advantages: A diffusion-model analysis of the effects of interactional context on switch costs. Cognition 150, 10–19.

Hartanto, A., Yang, H., 2019. The role of bilingual interactional contexts in predicting interindividual variability in executive functions: A latent variable analysis. Journal of Experimental Psychology: General https://doi.org/10.1037/xge0000672.

Hasher, J., Zacks, R.T., May, C.P., 1999. Inhibitory control, circadian arousal, and age. In: Gopher, D., Koriat, A. (Eds.), Attention and performance XVII. Cognitive regulation of performance: Interaction of theory and application. MIT Press, Cambridge, MA, pp. 653–675.

Henrard, S., Van Daele, A., 2017. Different bilingual experiences might modulate executive tasks advantages: Comparative analysis between monolinguals, translators, and interpreters. Frontiers in Psychology 8, https://doi.org/10.3389/fpsyg.2017.01870.

Hofweber, J., Marinis, T., Treffers-Daller, J., 2016. Effects of dense code-switching on executive control. Linguistic Approaches to Bilingualism 6 (5), 648–668 https://doi.org/10.1075/lab.15052.hof.

Howard, D., Nickels, L., Coltheart, M., Cole-Virtue, J., 2006. Cumulative semantic inhibition in picture naming: Experimental and computational studies. Cognition 100 (3), 464–482.

Jiao, L., Liu, C., Liang, L., Plummer, P., Perfetti, C.A., Chen, B., 2019. The contributions of language control to executive functions: From the perspective of bilingual comprehension. Quarterly Journal of Experimental Psychology 72, 1747021818821601.

Johnson, H., Sawi, O., Paap, K.R., 2015. Language switching frequency in bilinguals is inconsistently linked to executive functioning. In: Poster presented at Annual Meeting of the Cognitive Neuroscience Society, San Francisco, CA, March.

Jylkkä, J., Soveri, A., Wahlström, J., Lehtonen, M., Rodríguez-Fornells, A., Laine, M., 2017. Relationship between language switching experience and executive functions in bilinguals: An Internet-based study. Journal of Cognitive Psychology 29 (4), 404–419 https://doi.org/10.1080/20445911.2017.1282489.

Kałamała, P., Szewczyk, J., Chuderski, A., Senderecka, M., Wodniecka, Z., 2019. Patterns of bilingual language use and response inhibition: A test of adaptive control hypothesis. [manuscript submitted] Department of Experimental Psychology, Jagiellonian University.

Kałamała, P., Walther, J., Senderecka, M., Zhang, Z., Diaz, M., Wodniecka, Z., 2019. How short-term language context modulates efficiency of inhibitory control: ERP investigation. [manuscript in preparation] Department of Experimental Psychology, Jagiellonian University.

Kasparian, K., Vespignani, F., Steinhauer, K., 2017. First language attrition induces changes in online morphosyntactic processing and re-analysis: An ERP study of number agreement in complex Italian sentences. Cognitive Science 41 (7), 1760–1803.

Khateb, A., Abutalebi, J., Michel, C.M., Pegna, A.J., Lee-Jahnke, H., Annoni, J.M., 2007. Language selection in bilinguals: A spatio-temporal analysis of electric brain activity. International Journal of Psychophysiology 65 (3), 201–213.

Koch, I., Gade, M., Schuch, S., Philipp, A.M., 2010. The role of inhibition in task switching: A review. Psychonomic Bulletin & Review 17 (1), 1–14.

Kroll, J.F., Bobb, S.C., Wodniecka, Z., 2006. Language selectivity is the exception, not the rule: Arguments against a fixed locus of language selection in bilingual speech. Bilingualism: Language and Cognition 9 (2), 119–135.

Kroll, J.F., Dussias, P.E., Bice, K., Perrotti, L., 2015. Bilingualism, mind, and brain. Annual Review of Linguistics 1 (1), 377–394.

Kroll, J.F., Dussias, P.E., Bogulski, C.A., Kroff, J.R.V., 2012. Juggling two languages in one mind: What bilinguals tell us about language processing and its consequences for cognition. In: Psychology of learning and motivation. Vol. 56, Academic Press, pp. 229–262.

Kroll, J.F., Gullifer, J.W., Rossi, E., 2013. The multilingual lexicon: The cognitive and neural basis of lexical comprehension and production in two or more languages. Annual Review of Applied Linguistics 33, 102–127 https://doi.org/10.1017/S0267190513000111.

La Heij, W., 2005. Selection processes in monolingual and bilingual lexical access. In: Kroll, J.F., de Groot, A.M.B. (Eds.), Handbook of bilingualism: Psycholinguistic approaches. Oxford University Press, pp. 289–307.

Lehtonen, M., Soveri, A., Laine, A., Järvenpää, J., De Bruin, A., Antfolk, J., 2018. Is bilingualism associated with enhanced executive functioning in adults? A meta-analytic review. Psychological Bulletin 144 (4), 394.

Linck, J.A., Kroll, J.F., Sunderman, G., 2009. Losing access to the native language while immersed in a second language: Evidence for the role of inhibition in second-language learning. Psychological Science 20 (12), 1507–1515.

Liu, C., Jiao, L., Sun, X., Wang, R., 2016. Immediate effect of language switch on non-proficient bilinguals' cognitive control components. Acta Psychologica Sinica 48 (5), 472–481.

Liu, C., Yang, C.L., Jiao, L., Schwieter, J.W., Sun, X., Wang, R., 2019. Training in language switching facilitates bilinguals' monitoring and inhibitory control. Frontiers in Psychology 10, 1839.

Luk, G., Green, D.W., Abutalebi, J., Grady, C., 2012. Cognitive control for language switching in bilinguals: A quantitative meta-analysis of functional neuroimaging studies. Language & Cognitive Processes 27 (10), 1479–1488.

Meuter, R.F., Allport, A., 1999. Bilingual language switching in naming: Asymmetrical costs of language selection. Journal of Memory and Language 40 (1), 25–40.

Misra, M., Guo, T., Bobb, S.C., Kroll, J.F., 2012. When bilinguals choose a single word to speak: Electrophysiological evidence for inhibition of the native language. Journal of Memory and Language 67 (1), 224–237.

Morales, L., Paolieri, D., Cubelli, R., Bajo, M.T., 2014. Transfer of Spanish grammatical gender to English: Evidence from immersed and non-immersed bilinguals. Bilingualism: Language and Cognition 17 (4), 700–708.

Ooi, S.H., Goh, W.D., Sorace, A., Bak, T.H., 2018. From bilingualism to bilingualisms: Bilingual experience in Edinburgh and Singapore affects attentional control differently. Bilingualism: Language and Cognition 21 (4), 867–879 https://doi.org/10.1017/S1366728918000020.

Paap, K.R., Greenberg, Z.I., 2013. There is no coherent evidence for a bilingual advantage in executive processing. Cognitive Psychology 66 (2), 232–258 https://doi.org/10.1016/j.cogpsych.2012.12.002.

Philipp, A.M., Gade, M., Koch, I., 2007. Inhibitory processes in language switching: Evidence from switching language-defined response sets. European Journal of Cognitive Psychology 19 (3), 395–416.

Pot, A., Keijzer, M., de Bot, K., 2018. Intensity of multilingual language use predicts cognitive performance in some multilingual older adults. Brain Sciences 8 (5), 92 https://doi.org/10.3390/brainsci8050092.

Prior, A., Gollan, T.H., 2011. Good language-switchers are good task-switchers: Evidence from Spanish–English and Mandarin–English bilinguals. Journal of the International Neuropsychological Society 17 (04), 682–691 https://doi.org/10.1017/S1355617711000580.

Prior, A., Gollan, T.H., 2013. The elusive link between language control and executive control: A case of limited transfer. Journal of Cognitive Psychology 25 (5), 622–645.

Prior, A., MacWhinney, B., 2010. A bilingual advantage in task switching. Bilingualism: Language and Cognition 13, 253–262.

Rey-Mermet, A., Gade, M., Oberauer, K., 2017. Should we stop thinking about inhibition? Searching for individual and age differences in inhibition ability. Journal of Experimental Psychology. Learning, Memory, and Cognition 44, 501–526 https://doi.org/10.1037/xlm0000450.

Roelofs, A., 1998. Lemma selection without inhibition of languages in bilingual speakers. Bilingualism: Language and Cognition 1 (2), 94–95 https://doi.org/10.1017/S1366728998000194.

Rossi, E., Newman, S., Kroll, J.F., Diaz, M.T., 2018. Neural signatures of inhibitory control in bilingual spoken production. Cortex 108, 50–66.

Runnqvist, E., Strijkers, K., Alario, F.X., Costa, A., 2012. Cumulative semantic interference is blind to language: Implications for models of bilingual speech production. Journal of Memory and Language 66 (4), 850–869.

Samuel, S., Roehr-Brackin, K., Pak, H., Kim, H., 2018. Cultural effects rather than a bilingual advantage in cognition: A review and an empirical study. Cognitive Science 42 (7), 2313–2341 https://doi.org/10.1111/cogs.12672.

Sorace, A., 2019. L1 attrition in a wider perspective. Second Language Research0267658319895571.

Soveri, A., Rodriguez-Fornells, A., Laine, M., 2011. Is there a relationship between language switching and executive functions in bilingualism? Introducing a within group analysis approach. Frontiers in Psychology 2, 183 https://doi.org/10.3389/fpsyg.2011.00183.

Strijkers, K., Baus, C., Runnqvist, E., FitzPatrick, I., Costa, A., 2013. The temporal dynamics of first versus second language production. Brain and Language 127 (1), 6–11.

Timmer, K., Calabria, M., Branzi, F.M., Baus, C., Costa, A., 2018. On the reliability of switching costs across time and domains. Frontiers in Psychology 9, 1032 https://doi.org/10.3389/FPSYG.2018.01032.

Timmer, K., Calabria, M., Costa, A., 2019. Non-linguistic effects of language switching training. Cognition 182, 14–24.

Timmer, K., Grundy, J.G., Bialystok, E., 2017. Earlier and more distributed neural networks for bilinguals than monolinguals during switching. Neuropsychologia 106, 245–260 https://doi.org/10.1016/j.neuropsychologia.2017.09.017.

Timmer, K., Grundy, J.G., Bialystok, E., 2017. Earlier and more distributed neural networks for bilinguals than monolinguals during switching. Neuropsychologia 106, 245–260.

Timmer, K., Wodniecka, Z., Costa, A., 2020. Where to look? The influence of language context on attention processing. [manuscript in preparation], Department of Experimental Psychology, Jagiellonian University.

Timmer, K., Wodniecka, Z., Costa, A., 2020. Where to look? The influence of within-language context on attention processing. [manuscript in preparation], Department of Experimental Psychology, Jagiellonian University.

Tu, L., Wang, J., Abutalebi, J., Jiang, B., Pan, X., Li, M., et al., 2015. Language exposure induced neuroplasticity in the bilingual brain: A follow-up fMRI study. Cortex 64, 8–19.

Verreyt, N., Woumans, E., Vandelanotte, D., Szmalec, A., Duyck, W., 2016. The influence of language-switching experience on the bilingual executive control advantage. Bilingualism: Language and Cognition 19 (01), 181–190 https://doi.org/10.1017/S1366728914000352.

Von Bastian, C.C., Blais, C., Brewer, G., Gyurkovics, M., Craig, H., Kałamała, P., et al., 2019. Advancing the understanding of individual differences in attentional control: Theoretical, methodological, and analytical considerations. [manuscript in preparation] Department of Experimental Psychologu, Jagiellonian University.

Walther, J., Casado, A., Wolna, A., Szewczyk, J., Wodniecka, Z., 2019. Visiting your country of origin: Impact of recent re-immersion to a home country on native language lexical access. In: 21st conference of European Society for Cognitive Psychology, Tenerife, Spain, September 25–28 [poster presentation]. https://rb.gy/i5kjxo.

Wodniecka, Z., Szewczyk, J., Kałamała, P., Mandera, P., Durlik, J., 2020. When a second language hits a native language. What ERPs (do and do not) tell us about language retrieval difficulty in bilingual language production. Neuropsychologia 107390. https://doi.org/10.1016/j.neuropsychologia.2020.107390.

Wolna, A., Szewczyk, J., Casado, A., Wodniecka, Z., 2020. Now you see, now you don't. How does the experimental design impact the measurement of L2 after-effect in L1 production?. [manuscript in preparation] Department of Experimental Psychology, Jagiellonian University.

Woumans, E., Ceuleers, E., VanderLinden, L., Szmalec, A., Duyck, W., 2015. Verbal and nonverbal cognitive control in bilinguals and interpreters. Journal of Experimental Psychology. Learning, Memory, and Cognition 41, 1579–1586. https://doi.org/10.1037/xlm0000107.

Wu, Y.J., Thierry, G., 2013. Fast modulation of executive function by language context in bilinguals. Journal of Neuroscience 33 (33), 13533–13537.

Yang, H., Hartanto, A., Yang, S., 2016. The complex nature of bilinguals' language usage modulates task-switching outcomes. Frontiers in Psychology 7, https://doi.org/10.3389/fpsyg.2016.00560.

Yang, J., Ye, J., Wang, R., Zhou, K., Wu, Y.J., 2018. Bilingual contexts modulate the inhibitory control network. Frontiers in Psychology 9, 395.

Yeung, N., Monsell, S., 2003. Switching between tasks of unequal familiarity: The role of stimulus-attribute and response-set selection. Journal of Experimental Psychology: Human Perception and Performance 29 (2), 455.

Zhang, H., Kang, C., Wu, Y., Ma, F., Guo, T., 2015. Improving proactive control with training on language switching in bilinguals. Neuroreport 26 (6), 354–359.

FURTHER READING

Abutalebi, J., Della Rosa, P.A., Green, D.W., Hernandez, M., Scifo, P., Keim, R., et al., 2012. Bilingualism tunes the anterior cingulate cortex for conflict monitoring. Cerebral Cortex 22 (9), 2076–2086.

Schwieter, J.W., Sunderman, G., 2008. Language switching in bilingual speech production: In search of the language specific selection mechanism. The Mental Lexicon 3 (2), 214–238 https://doi.org/10.1075/ml.3.2.06sch.

Van den Noort, P.D.M., Struys, E., Bosch, P., Jaswetz, L., Perriard, B., Yeo, S., et al., 2019. Does the bilingual advantage in cognitive control exist and if so, what are its modulating factors? A systematic review. Behavioral Science 9 (3), 27. https://doi.org/10.20944/preprints201902.0038.v1.

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