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The after-effects of bilingual language production

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ABSTRACT

We explored the temporal course of bilingual language control after-effects to shed light on the scope of language control (local vs. global) and on the way in which language control is implemented (L1 inhibition or L2 over-activation). High-proficient bilinguals named objects across three blocks, first in their L1, then in their L2, and then again in their L1 (and conversely) while event-related brain potentials (ERPs) were recorded. Behaviorally we found only the L1 as being hindered by previous naming in the L2. In the ERPs we did not observe inhibitory effects in the N2 component time-window. However, the P2 component showed more positive-going deflections when the previous language slowed down naming latencies of the successive language. The P2 mean amplitude predicted naming latencies whereas the N2 did not. We conclude that in high-proficient bilinguals the P2 component is the marker of language control mechanisms other than inhibition, which are applied globally.

1. Introduction

The question of how bilingual speakers are able to control their two languages during speech processing has generated a substantial body of research in the last ten years. One of the most used paradigms to investigate bilingual language control has been the *language switching paradigm* (or *mixed naming task*) (Hernandez, Martinez, & Kohnert, 2000; Jackson, Swainson, Cunnington, & Jackson, 2001; Costa & Santesteban, 2004; Christoffels, Firk, & Schiller, 2007; Abutalebi et al., 2008; Verhoef, Roelofs, & Chwilla, 2009; Abutalebi et al., 2013; Meuter & Allport, 1999). In a mixed naming task, bilinguals are asked to name some pictures in their first language (L1) and some others in their second language (L2), with the presentation of those pictures mixed. Thus, participants continuously have to switch from one language to the other. So far, this research has been fruitful in highlighting the role of executive functions implicated in bilingual language control.

However, there are contexts in which bilingual language control is applied even though bilingual speakers do not switch from one language to the other so frequently. In these situations, that more closely resemble real life, it is likely that the way (the nature of the control mechanisms) and the extent (how broadly these mechanisms operate) to which bilingual language control is applied, is qualitatively different than in mixed naming contexts. One way to study how and to what extent bilingual language control is achieved in these situations, is to assess the after-effects of naming in one language upon the other language without mixing them. Addressing this issue is the main scope of the present study.

Several studies have already been conducted to investigate how performance in one language is affected by the previous use of a different language, without mixing them (e.g., Runnqvist & Costa, 2012; Levy, Mc Veigh, Marful, & Anderson, 2007; Lee & Williams, 2001). For instance, amongst the literature on memory, Levy et al. (2007) showed that naming pictures in L2 negatively affects the subsequent recall of the corresponding L1 translations (the *so-called* RIF effect across languages, retrieval-induced forgetting). The RIF effect was interpreted as reflecting an inhibitory mechanism that suppresses the strong interference of the L1 lexical entry when the L2 correspondent has to be retrieved from memory. As a consequence of this L1 inhibition during L2 retrieval, the subsequent recall of L1 is hindered. However, the existence of this effect was recently questioned by Runnqvist and Costa (2012). In their study, the authors tested three different groups of bilinguals (low, medium and high-proficient in the L2) in a RIF paradigm similar to the one used by Levy et al. (2007). They found an opposite result as compared to Levy et al. (2007): naming a picture in L2 facilitated the subsequent recall of the translation in the L1, so no RIF effect was present. Thus, the hypothetical inhibition of the L1 during L2 retrieval is still unresolved.

The two experiments described above investigated the after-effect of one language upon the other in a memory task. However,

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more relevant for the present purpose is a recent study in which the after-effects of one language on the other were measured during a blocked picture naming task (Misra, Guo, Bobb, & Kroll, 2012). Two groups of participants took part in this study: the first one was required to name a set of pictures in the L1 and then the same set of pictures in the L2. The second group instead was required to name a set of pictures in the L2 and then the same pictures in the L1. Hence, given authors were interested in evaluating whether or not L1 production was affected by previous naming in the L2, they compared across groups the same language (L1 or L2) before and after having used the other language. Results revealed facilitation effects when naming in the L2 followed naming the same items in the L1. This facilitation effect may be considered a classical priming effect, occurring when naming a picture that was already presented earlier in the same experiment. Interestingly, an inhibition effect was observed when naming in the L1 was preceded by naming in the L2. This inhibition effect was reflected both by the absence of priming effects in response times (RTs) and by an enhancement of the N2 component observed in event-related potential (ERP) measures. These results have been taken as evidence of persistent inhibition of the L1 during naming in the L2: inhibition has a negative after-effect when naming the same pictures later on in the L1.

In summary, the aforementioned study reveals that L1 production is hindered when the same items are previously named in the L2. Nevertheless, there are still two major unresolved issues: (1) whether the hindered L1 naming affects only those specific items that have been named previously in the L2, or whether naming in the L2 hinders subsequent production in L1 in a global way (i.e., whether language control operates just locally or globally), and (2) whether such control is implemented through inhibition of the non-target language or not. These two main questions are the focus of the present study. Before going into the details of the present study, we will briefly expose the current debate on each of these key questions on bilingual language control.

1.1. The scope: Local versus global control

Control mechanisms applied during bilingual speech production could occur in at least two different ways. On one hand, language control might be restricted to the task-relevant lexical items (*local control*). On the other, control mechanisms could affect the entire non-target lexicon (*global control*; De Groot & Christoffels, 2006). Both processes might be required for efficient language selection and there is some evidence indicating that they are carried out differently. In a recent functional magnetic resonance imaging (fMRI) study, Guo, Liu, Misra, and Kroll (2011) observed the recruitment of different brain systems for *global* control[1] (dorsal left frontal gyrus and parietal cortex) and *local* control (dorsal anterior cingulate cortex and supplementary motor area). Regardless of the merits of revealing a functional dissociation between the brain areas involved in these two types of control, it is important to notice that in this study the effects related to *global* control were tested just considering repeated items[2]. A way to further deepen our knowledge on how broad these *global* inhibition processes are, is to examine the control effects on items not previously encountered. In the present study, we investigated the scope of bilingual language control by asking high-proficient bilinguals to name *repeated* and *new* items in the two languages. Through this manipulation, we were able to explore if language control is applied only on the critical items used in a naming block, or if it is exerted on the entire lexicon of the non-target language.

1.2. The mechanisms: Inhibition versus activation

Levy et al. (2007) and Misra et al. (2012) interpreted their findings as evidence of L1 inhibition during L2 naming. Indeed, their results find a straightforward explanation in the Inhibitory Control model that explicitly predicts such inhibitory effects (IC model, Green, 1998). The main claim of this model is that, because both languages are active even when naming in only one language, a control mechanism is necessarily operating to suppress or reduce the interference of non-target lexical items (Green, 1998; Hermans, Bongaerts, de Bot, & Schreuder, 1998). The inhibition of lexical representations is supposed to be proportional to the amount of activation and potential interference of a given language. That is, the more interference from the non-target language, the greater the amount of inhibition that needs to be applied. Therefore, naming in the L2 requires a strong inhibition of the L1. Subsequently, naming in the L1 is hindered because it requires more resources to override a strong inhibition (*see* Meuter & Allport, 1999).

However, the cost of naming in the L1 after naming in the L2 might also be interpreted under an alternative account, i.e., the persisting activation account. The persiting activation account (e.g., Yeung & Monsell, 2003; Philipp, Gade, & Koch, 2007) is based on the hypothesis that the stronger language (L1) is normally more active than the weaker one (L2). Thus, the L2 has to be over-activated (relative to the L1) during naming in the L2. When successively naming L1 items, this operation would cause a strong interference because of the carry-over effect of the previously over-activated language (L2; Philipp et al., 2007; for a review, *see* Koch, Gade, Schuch, & Philipp, 2010). This interference from previous L2 over-activation would increase the time necessary to retrieve the name of the picture in the target language: L1.

The fact that two opposite accounts can explain the same phenomenon (slower L1 naming after L2 naming) may make it difficult to consider inhibition as a key feature of bilingual language control. This concern was actually acknowledged by Misra et al. (2012), who discussed that negative effects of a previous L2 naming over L1 naming could be explained by the persistent inhibition of L1 (Green, 1998; Meuter & Allport, 1999), but also by the persisting over-activation of L2 (e.g., Yeung & Monsell, 2003; Philipp et al., 2007). In the present study, we will test these two theoretical alternatives by evaluating not only the after-effects of naming in one language on the successive naming in the other language, but also the after-effects of returning to a previously abandoned language.

1.3. Present study

In this study, we explored whether naming pictures in one language exerts after-effects on the successive other language with two purposes: to investigate to what extent bilingual language control mechanisms are applied (locally versus globally) and how these mechanisms are implemented (through inhibition versus activation).

We conducted an ERP experiment in which participants were asked to name pictures in the L1 in the first block, and then to name pictures in the L2 in the second block (or conversely). In order to explore *local* after-effects of language control, we measured naming latencies and ERPs on items of the second block *repeated* from the first block. In order to explore *global* after-effects of language control, we measured naming latencies and ERPs on

[1] Note that in Guo et al. (2011) *global* and *local* control referred specifically to inhibitory processes.

[2] Note that the scope of language control was not addressed either by Misra et al. (2012), who presented participants only with *repeated* items, thus testing exclusively what we call here *local* language control.