Journal of Memory and Language 86 (2016) 35–59

Contents lists available at ScienceDirect

Journal of Memory and Language

journal homepage: www.elsevier.com/locate/jml

Reactive and proactive control in bilingual word production: An investigation of influential factors

Fengyang Ma [b], Shengcao Li [a,d], Taomei Guo [a,c,*]

[a] State Key Laboratory of Cognitive Neuroscience and Learning & IDG/McGovern Institute for Brain Research, Beijing Normal University, PR China
[b] School of Education, University of Cincinnati, United States
[c] Center for Collaboration and Innovation in Brain and Learning Sciences, Beijing Normal University, PR China
[d] School of Preschool Education, Shandong Yingcai University, PR China

ARTICLE INFO

Article history:
Received 21 October 2013
revision received 9 July 2015
Available online 14 October 2015

Keywords:
Inhibitory control
Reactive control
Proactive control
Bilingual language production

ABSTRACT

The present study examined how reactive control (indexed by switching costs) and proactive control (indexed by mixing costs) during bilingual language production was modulated by three factors reflected by different time-courses of stimulus presentation. In three experiments, unbalanced Chinese–English bilinguals named digits in Chinese or English according to a naming cue. In Experiment 1, switching costs reduced when participants had longer preparation time to select the target language to name digits (during the Cue-Stimulus interval, CSI), indicating that longer preparation time helps overcome reactive inhibition. In addition, mixing costs declined drastically at a longer preparation time, indicating that a tiny amount of preparation time allows bilinguals to overcome costs associated with proactively preparing two languages. In Experiment 2, the stimuli were presented prior to the cues, so that participants were given different amounts of time to activate the target lexical nodes in both languages before they were informed of the naming language (during the Stimulus-Cue interval, SCI). Symmetrical switching and mixing costs were observed, indicating that bilinguals can strategically boost activation of the target lexical item in the second language (L2) and attempt to equalize it with its translation equivalent in the native language (L1), when they know previously the specific lexical items to be prepared in two languages. In Experiment 3, different Response-Cue intervals (RCIs) were provided after participants named a digit. It was found that the switching cost asymmetry was more prominent when the time to resolve competition was shorter, while the mixing cost asymmetry emerged only with the longest waiting time. These findings provide the first piece of evidence for the dissipation of the reactive inhibition over time, and suggest that longer preparation would allow the proactive control mechanism to be sensitive the relative proficiency levels of the two languages, leading to stronger proactive control on the dominant language. Taken together, the findings in the present study suggest the dynamic nature of reactive and proactive control in unbalanced bilinguals and have important implications for the current models of bilingual language production, which do not explicitly distinguish the two types of control or address how they adapt to the fine-grained time course of the situation.

Introduction

Bilinguals are able to choose the appropriate language to produce according to specific communicative contexts. In the past decade, there has been growing interest in

* Corresponding author at: State Key Laboratory of Cognitive Neuroscience and Learning, Beijing Normal University, Beijing 100875, PR China. Fax: +86 10 58806154.
E-mail address: guotm@bnu.edu.cn (T. Guo).

http://dx.doi.org/10.1016/j.jml.2015.08.004
0749-596X/

how bilinguals manage to produce words in the intended language. A number of studies have shown that even when bilinguals perform production tasks in one language, information in both languages is activated (e.g., Colomé & Miozzo, 2010; Costa & Caramazza, 1999; Costa, Caramazza, & Sebastian-Galles, 2000; Costa, Miozzo, & Caramazza, 1999; Guo & Peng, 2006; Hermans, Bongaerts, de Bot, & Schreuder, 1998; Hoshino & Kroll, 2008). Thus, one important issue in bilingualism research is how bilinguals select the correct word in the appropriate language for a certain context. It has been proposed that bilinguals need to inhibit the activation of the non-target language to ensure error-free production. However, such control mechanisms might not be an "all or none" phenomenon: first, there might be several types of control (proactive and reactive); and second, the way those types of control are exercised might depend on the fine-grained time course of the situation at hand. These issues have been largely under-investigated, and the present study aimed to examine the language control mechanisms of unbalanced bilinguals in particular.

Lexical selection in bilingual language production

One prominent viewpoint of the mechanism of lexical selection in bilingual language production is the language non-specific selection hypothesis (Green, 1998; La Heij, 2005; Poulisse, 1997; Poulisse & Bongaerts, 1994; but see Costa, 2005; Costa, Albareda, & Santesteban, 2008; Costa & Caramazza, 1999; Costa et al., 1999). According to this hypothesis, lexical information in each language is activated and competes for production against candidates from within and across languages, and the most activated lexical item gets selected. Based on this hypothesis, Green (1998) put forward the Inhibitory Control (IC) model. According to this model, an inhibitory mechanism is required to resolve conflicts between two simultaneously activated languages and inhibit the non-target language to ensure production in the target language. Moreover, the amount of inhibition is determined by the speaker's relative proficiency in each language, such that the dominant language is inhibited to a larger extent than the weaker language. Previous empirical studies have mainly employed the language-switching task to test the IC model. In a pioneering study by Meuter and Allport (1999), unbalanced bilinguals were asked to name Arabic digits in either their L1 or L2, cued by the background color of the digits. The trials fell into two categories: switch trials in which two successive digits were named in different languages (e.g., L2 followed by L1), and non-switch trials in which two successive digits were named in the same language (e.g., L1 followed by L1). Meuter and Allport (1999) found that switch trials were named more slowly than non-switch trials, yielding switching costs. In addition, it was found that the switching costs in the L1 were larger than switching into the L2, resulting in an asymmetry of the switching cost. This pattern supports the IC Model's assumption that the dominant language requires stronger inhibition. Specifically, compared to the weaker L2, the stronger L1 was inhibited to a larger extent when it serves as the non-target language in the switch condition. Therefore, it needs more efforts to overcome the residual inhibition after the switch, leading to larger switching costs.

This asymmetric pattern of switching costs in unbalanced bilinguals was replicated in some later studies (e.g., Costa & Santesteban, 2004, Experiment 1; Fink & Goldrick, 2015, Experiment 2; Philipp, Gade, & Koch, 2007, Experiment 1; Linck, Schwieter, & Sunderman, 2012). However, other studies have challenged the IC model's assumption that relative language proficiency determines the magnitude of inhibition. For instance, Gollan and Ferreira (2009) did not observe asymmetric switching costs in unbalanced bilinguals who voluntarily switched between languages. Interestingly, they also reported reversed language dominance, i.e., faster naming in the less proficient L2 than that in the more proficient L1, which has been taken as strong evidence for inhibition of the dominant language (e.g., Christoffels, Firk, & Schiller, 2007; Costa & Santesteban, 2004, Experiment 2 and 5; Costa, Santesteban, & Ivanova, 2006, Experiment 1; Gollan & Ferreira, 2009; Gollan, Schotter, Gomez, Murillo, & Rayner, 2014; Kroll, Bobb, Misra, & Guo, 2008; Philipp & Koch, 2009, Experiment 1; Verhoef, Roelofs, & Chwilla, 2009, 2010). These findings led the authors to conclude that consistent inhibition is exerted on the dominant language for both switch and non-switch trials when unbalanced bilinguals voluntarily switch between languages. In addition, symmetrical switching costs were observed in trilinguals with a native-like L2 when switching between their weaker L3 and L1, despite a significant proficiency difference (Costa & Santesteban, 2004; Costa et al., 2006). Based on these findings, the researchers concluded that bilinguals do not need to inhibit the non-target language when they are highly proficient in two languages.

Although it is still open to debate whether asymmetrical switching costs observed in unbalanced bilinguals are behavioral indices for inhibition during bilingual language production (see Philipp et al., 2007; Verhoef et al., 2009 for related discussions), evidence drawn from recent Event-Related Potential (ERP) investigations (e.g., Christoffels et al., 2007; Guo, Liu, Misra, & Kroll, 2011; Jackson, Swainson, Cunnington, & Jackson, 2001; Misra, Guo, Bobb, & Kroll, 2012; Verhoef et al., 2010; for a review see Kroll et al., 2008) and functional magnetic resonance imaging (fMRI) studies (e.g. Chee, Soon, & Ling Lee, 2003; Crinion et al., 2006; Hernandez, Dapretto, Mazziotta, & Bookheimer, 2001; Price, Green, & von Studnitz, 1999; Rodriguez-Fornells et al., 2005; Wang, Kuhl, Chen, & Dong, 2009) support the notion of inhibitory control during bilingual word production from the neurological perspective. For instance, it was found that when bilinguals switched between their languages, the switch trials elicited more negative-going ERP waves than the non-switch trials around 300 ms post stimulus onset (Christoffels et al., 2007; Jackson et al., 2001; Verhoef et al., 2010), producing an N2 effect, which has been taken to reflect interference suppression (e.g., Nieuwenhuis, Yeung, & Cohen, 2004). In addition, fMRI studies (e.g. Chee et al., 2003; Hernandez et al., 2001; Price et al., 1999; Wang et al., 2009) showed increased activation in brain areas related to attentional