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The electrophysiological mechanism of joint language switching: Evidence from simultaneous production and comprehension

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ABSTRACT

Successful communicative language switching requires the finely orchestrated interaction between a speaker's production-based processes and a listener's comprehension-based processes. It is necessary to explore language switching mechanisms during simultaneous production and comprehension tasks. Pairs of bilinguals were asked to cooperatively complete a picture-naming task in two languages according to cues, leading to simultaneous production and comprehension. Results showed that switching to L2 elicited a larger LPC than switching to L1 during within-person switching in stimulus production processing, suggesting that inhibition may mainly play a role in suppressing the non-target lemma. This LPC pattern was also found at right hemisphere electrodes during within-person switching in stimulus comprehension processing, and occurred after the listener heard the speaker's utterance. Altogether, simultaneous language production and comprehension might both involve inhibitory control mechanism, and listeners compare the actual utterance of speaker with his/her own previous prediction after hearing what the speaker said.

1. Introduction

When attempting successful communication, bilingual speakers will sometimes switch between their two languages, especially when talking with a person who also speaks the same two languages. Most previous research on bilingual language switching has focused on the language production processes (e.g., Costa & Santesteban, 2004; Costa, Santesteban, & Ivanova, 2006; De Bruin, Roelofs, Dijkstra, & FitzPatrick, 2014; Declerck, Koch, & Philipp, 2015; Gollan, Schotter, Gomez, Murillo, & Rayner, 2014; Guo, Liu, Chen, & Li, 2013; Jackson, Swainson, Cunnington, & Jackson, 2001; Linck, Schwieter, & Sunderman, 2012; Liu, Liang, Dunlap, Fan, & Chen, 2016; Liu, Rossi, Zhou, & Chen, 2014; Wang, Xue, Chen, Xue, & Dong, 2007). Fewer

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studies have investigated language switching in language comprehension processes (Jackson, Swainson, Cunnington, & Jackson, 2004; Hosoda, Hanakawa, Nariai, Ohno, & Honda, 2012). The current study aims to adopt the joint language switching task to explore the interwoven between language production and comprehension in language communication. The task requires two bilinguals to cooperatively complete naming pictures in different languages according to cues, as a bilingual producing language, the other one comprehending the utterance simultaneously. The paired bilinguals will be affected by each other. That is, in addition to cross-language interference, there will be cross-person interference (for detailed explanations please refer to the section of *The relationship between language production and comprehension*) (Gambi & Hartsuiker, 2016; Kootstra, van Hell, & Dijkstra, 2010). Hence, this task approaches real-life communicative language switching.

1.1. Single-bilingual language switching mechanism

A prominent model of inhibitory control (Green, 1998) proposes that language switching involves two phases: the language task schema phase (i.e., selecting an appropriate language according to the language context, inhibiting the non-target language) and the lexical selection response phase (i.e., retrieving a target lemma while suppressing the non-target one). Previous studies suggest that inhibition might play a role during the first phase, the second phase, or both phases (Declerck et al., 2015; Jackson et al., 2001; Martin et al., 2013; Verhoef, Roelofs, & Chwilla, 2010).

Unbalanced bilinguals are more proficient in their dominant/first language (L1) than in their second language (L2). Regardless of which phase inhibition occurs in, L1 will always be more easily activated, causing more cross-language interference when switching to L2. In order to produce L2 successfully, the more dominant L1 would need to be suppressed, which requires extra cognitive effort. Such suppression is evidenced by longer naming latencies and increased error rates, producing language switching costs. The more effort is needed to inhibit L1, the more effort is needed in releasing inhibition of L1, which will lead to larger L1 switch costs than L2 ones (i.e., asymmetrical switch costs) (e.g., Declerck et al., 2015; Jackson et al., 2001; Liu et al., 2016). In contrast, balanced bilinguals are equally proficient in their two languages. For them, similar amount of inhibition of the two languages will be recruited and symmetrical switch costs will occur (e.g., Costa & Santesteban, 2004; Costa et al., 2006).

Recent research, using the fine-grained temporal resolution of the event-related potentials (ERP) technique, interpreted the N2 component as a sign of inhibition by conducting cued language switching in production tasks (Jackson et al., 2001; Verhoef, Roelofs, & Chwilla, 2009). For example, Jackson et al. (2001) presented cue and stimulus simultaneously to ask participants to do picture-naming. Switching to L2 elicited a more negative N2 than switching to L1 did, indicating strong inhibition of the dominant L1 when switching to L2. However, it may be hard for us to distinguish which phase caused N2 effects due to the simultaneous presentation of cue and stimulus. On the other hand, Verhoef et al. (2009) presented cue and stimulus picture separately. They found that participants could prepare their switching processes when they were given enough time to activate the language switching task schema. Specifically, a long interval between cue and stimulus (1250 ms) would induce a more negative N2 than a short interval (500 ms) and would result in symmetric language switching costs, whereas a short interval would result in asymmetrical language switching costs. To avoid confounding between cue switching and language switching, Verhoef et al. (2010) then controlled cue change in a different way, namely, by using two dimensions for each language within a single cue category (color) (e.g., L1: red or yellow; L2: green or blue). They found that L2 switch trials induced a more negative N2 than L2 repeat trials. This might suggest that the N2 component was endogenous and reflected attentional control of the task schema rather than inhibition of the non-target language. Misra, Guo, Bobb, and Kroll (2012) argued that inhibition functioned at the first phase of the language task schema. In their study, Chinese-English bilinguals were required to use one language to name pictures in a block, then subsequently to use the other language to name pictures in another block. A greater N2 component was observed for the L2 naming, suggesting that interference from L1 needed to be suppressed persistently. Yet, no such N2 effect was observed for L1 naming. Their results were consistent with a previous study (Verhoef et al., 2009) which found inhibition plays a role in suppressing interference from the dominant language (L1).

Recently, some language switching studies found not only an N2 component, but also a late positive component (LPC; Liu et al., 2014; 2016; Martin et al., 2013). These authors have proposed that the N2 reflects attentional control of the language task schema and the LPC represents inhibition of the non-target lemma. Martin et al. (2013) asked early bilinguals who learned their L3 later in life to perform a picture-naming task in L1 and L3 (i.e., L1-L3 early bilinguals), compared with early bilinguals who performed the task in L1 and L2 (i.e., L1-L2 early bilinguals) as well as late bilinguals who performed the task in L1 and L3 (i.e., L1-L3 late bilinguals). They found that during the picture-naming task, L1-L3 early bilinguals showed a more negative N2 component than L1-L3 late bilinguals, and switch trials elicited a larger LPC than repeat trials. However, L1-L3 early bilinguals and L1-L2 early bilinguals exhibited similar N2 components, but L1-L2 early bilinguals exhibited a larger LPC than L1-L3 early bilinguals, and L3 switch trials induced a larger LPC than L3 repeat trials. Altogether, they thought that the N2 reflected control of the language task schema and the LPC was associated with lexical access in the target language. However, it still remains unknown how these components reflect underlying cognitive processes during language production and comprehension.

Furthermore, the results of two ERP studies suggest that inhibition works at the lexical selection response phase. Liu et al. (2014) explored Chinese (L1)-English (L2) language switching mechanism of low proficient bilinguals by using a picture-naming task. Results showed that high inhibitory control bilinguals could more efficiently inhibit interference from the L1 lemma when switching to L2 compared to low inhibitory control bilinguals, and that inhibition was indexed by the LPC.