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Bimodal language switching: New insights from signing and typing ☆

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ABSTRACT

Language switching typically refers to unimodal switching between two spoken languages. In bimodal language switching, one language is produced vocally and the other language is produced manually (e.g., a sign language). We compared unimodal language switching with two different kinds of bimodal language switching for non-signers. In Experiment 1a and 1b participants switched between speaking and newly learned signs. Participants of Experiment 2 switched between two originally spoken languages in a bimodal way: One language was produced vocally and the other language was produced manually (by typing). Interestingly, switch costs were reduced for bimodal compared to unimodal switching in Experiment 1a and 1b but not in Experiment 2. This speaks for different language control mechanisms. We assume less costly output channel inhibition for switching between speaking and signing (Experiment 1a and 1b) and more costly lexical inhibition for switching between speaking and typing (Experiment 2).

Introduction

In the last decades, there has been growing interest in the study of bimodal bilingualism to generate new insights into language control mechanisms (for a recent review see Emmorey, Giezen, & Gollan, 2016). Bimodal bilinguals are mostly hearing individuals who are proficient in a spoken and a sign language. They represent a unique group of bilinguals because they are able to perform two languages simultaneously due to the fact that their languages are produced via different articulators or motor modalities (i.e., the vocal modality for spoken language and the manual modality for sign language).[1] The simultaneous production of a spoken language and a sign language is termed code-blending. Code-blending can be observed when hearing bimodal bilinguals communicate with other bimodal bilinguals (e.g., Emmorey, Borinstein, Thompson, & Gollan, 2008) or when they communicate with non-signers (Casey & Emmorey, 2009). In contrast, unimodal bilinguals (i.e., bilinguals who are proficient in two spoken languages) perform both languages via the same motor modality (i.e., vocally). Thus, as regards the combination of the two languages, unimodal bilinguals cannot produce the two languages at the same time – they have to switch between them sequentially. The comparison of unimodal and bimodal bilinguals can reveal important information about possible influences on language control, as will be argued below.

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[1] Different articulators correspond to different motor modalities. In the following, we will refer to the articulators as motor modalities because it is consistent with speaking about uni*modal*/ bi*modal* language switching.

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Language control enables bilinguals to cope with competition between their languages. It helps them to keep the languages separate and to restrict their language production to the target language (for a review about language control see Declerck & Philipp, 2015a). The study of bimodal bilinguals allows conclusions about modality-specific influences on language control. Are there different mechanisms of language control when the two languages are produced via different motor modalities? Emmorey, Luk, Pyers, and Bialystok (2008) provide initial evidence that language control mechanisms of bimodal bilinguals differ from that of unimodal bilinguals. In their study, they describe enhanced functions of executive control for unimodal bilinguals but not for bimodal bilinguals in a flanker task. This advantage for unimodal bilinguals is interpreted as a result of life-long extensive practice with more challenging demands on cognitive control during language processing. That is, their languages are referred to the same motor modality and, thus, the irrelevant language has to be continuously inhibited to avoid speech errors. In contrast, for bimodal bilinguals the conflict and control demands might be reduced due to the separation of the languages by different motor modalities.

Further evidence for differences in language control mechanisms between unimodal and bimodal bilinguals stems from studies about language switching. The language switching paradigm is an established method to investigate cognitive control mechanisms (e.g., Declerck & Philipp, 2015a). The most common version is the cued language switching paradigm, in which participants typically name visually presented pictures or digits and switch sequentially between two or more languages depending on a visually presented language cue (e.g., a colored frame). This results in language repetition trials, in which the target language is the same language as in the previous trial, and in language switch trials, in which the target language differs from that in the preceding trial. An important finding from studies about language switching is that reaction times (RTs) and error rates are increased in switch trials compared to repetition trials (i.e., switch costs; for reviews see e.g., Bobb & Wodniecka, 2013; Kroll, Bobb, Misra, & Guo, 2008).

Language switch costs are considered as a marker of language control (e.g., Green, 1998) and they are often associated with inhibition processes (for a review see Kroll et al., 2008). In the inhibitory control model (ICM; Green, 1998; see also Abutalebi & Green, 2008, for a neurocognitive adaption of the model), switch costs are explained by persisting inhibition of the previous trial. More precisely, it is assumed that processing a concept in a bilingual context (e.g., seeing a picture in trial n-1 during a language-switching experiment) always leads to a parallel activation of both possibly relevant languages, which is followed by the inhibition of the non-target language. If afterwards (i.e., in trial n) the same language as in trial $n - 1$ has to be produced (i.e., repetition trial), the inhibited language remains inhibited. In turn, when the previously inhibited language has to be produced (i.e., language switch trial), the inhibition from the previous trial will still exist in the current trial and has to be overcome. This overcoming of inhibition leads to language switch costs (i.e., longer RTs and higher error rates in language switch compared to language repetition trials; Meuter & Allport, 1999). Language switch costs are a very stable and often described finding in research about unimodal language switching (Declerck & Philipp, 2015a).

Language switching studies including sign language, however, indicate a remarkable pattern regarding language switch costs. Emmorey, Petrich, and Gollan (2014) examined switching between speaking and code-blending as well as switching between signing and code-blending. Interestingly, they found neither switch costs for switching from speaking into code-blending nor for switching from signing into code-blending (see also Kaufmann & Philipp, 2015, for reduced switch costs for switching into code-blending compared to switching into speaking or signing in isolation). In another condition of their study, they investigated switching between American Sign Language (ASL) and English. In this condition they found significant switch costs for switching into English but, again, not for switching into ASL. In a follow-up study they could replicate the absence of switch costs for switching between English and one-handed gestures during digit naming. Kaufmann, Mittelberg, Koch, and Philipp (in press) directly compared unimodal switching (switching between German and English) to bimodal language switching (switching between German and German Sign Language) using the cued language switching paradigm. This comparison revealed shorter RTs, lower error rates and, most importantly, decreased switch costs for bimodal compared to unimodal language switching. Even if it cannot be ruled out that switch cost differences between the unimodal and the bimodal condition of the study by Kaufmann et al. (in press) might have been influenced by language proficiency (i.e., the unimodal condition consisted of switching between two languages with a high proficiency and the bimodal condition consisted of switching between a language with high proficiency and a language with low proficiency; see also Philipp, Gade, & Koch, 2007, for evidence that language proficiency can influence language switch costs), the studies reported above suggest that there should be differences in language control for switching between a spoken and a sign language compared to switching between two spoken languages (see Emmorey et al., 2016, for an overview of similarities and differences between unimodal and bimodal bilingualism).

So far, the specific nature of bimodal language switching has been associated with a different locus of cognitive control due to the assignment of the two languages to different motor modalities. That is, considering language processing as a staged process (e.g., Levelt, 1989; Levelt, Roelofs, & Meyer, 1999), inhibition processes can occur at different processing levels. The locus of cognitive control for unimodal language switching is mostly assigned to the lexical level (e.g., Declerck, Koch, & Philipp, 2015; Declerck & Philipp, 2016; Grainger, Midgley, & Holcomb, 2010; Green, 1998; Hirsch, Declerck, & Koch, 2015). It is assumed that the lemmas of both possibly relevant languages are activated and this activation is followed by a lexical inhibition of the not relevant lemma before the articulation process starts (e.g., Kroll et al., 2008). If lexical inhibition fails, phonological information from both