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Inducing asymmetrical switch costs in bilingual language comprehension by language practice

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ABSTRACT

The most widely discussed observation in the language control literature is the larger cost found when switching into the first than the second language (i.e., asymmetrical switch costs), which has been determined as a marker of persisting, reactive inhibition. While this is a common effect in bilingual language production, it generally does not occur in bilingual language comprehension. In this bilingual language comprehension study, we manipulated the relative activation of languages by letting participants practice in pure language blocks prior to a mixed language block. While no effect was found of practicing second-language words, asymmetrical switch costs were observed when practicing the same (Experiments 1 and 2) or different first-language words (Experiment 3) as in the following mixed language block. These findings indicate that, similar to bilingual production, bilingual comprehension relies on persisting, reactive language control.

According to several bilingual production models, language control, which is the process that makes sure that the target language is being processed and not the non-target language, is a persisting, reactive inhibitory process (e.g., Declerck, Koch, & Philipp, 2015; Green, 1998; Schwieter & Sunderman, 2008). Reactive inhibition means that a higher activation level of the non-target language will result in this language being suppressed to a higher degree. Persisting inhibition means that the inhibitory process will continue into the succeeding word(s). Whereas there is evidence for persisting, reactive inhibition during bilingual language production (e.g., asymmetrical switch costs), there is little evidence for such a process during bilingual language comprehension. This is puzzling, since there are models that postulate that production-based and comprehension-based language control rely on the same processes. Hence, in the current study we set out to investigate whether bilingual language comprehension relies on persisting, reactive inhibition by increasing the activation of a language through prior language practice and examining its effect on asymmetrical switch costs.

Asymmetrical switch costs are a measure found with the language switching task (for a review, see Declerck & Philipp, 2015). In this task bilinguals typically have to either name digits or pictures in one of two languages based on a language cue (production-based language switching; e.g., Costa & Santesteban, 2004; Meuter & Allport, 1999) or categorize written words of two languages (comprehension-based language switching; e.g., Grainger & Beauvillain, 1987; Thomas & Allport, 2000). A typical finding in both production-based (e.g., Fink & Goldrick, 2015; Meuter & Allport, 1999) and comprehension-based language switching (e.g., Orfanidou & Sumner, 2005; Thomas & Allport, 2000) is that performance is worse when the language of the current trial is different from that in the prior trial (switch trial) than when the same language was used in the current as in the prior trial (repetition trial), an effect typically referred to as switch costs.

Moreover, switch costs can be larger for the first language (L1) than for the second language (L2) during bilingual language production (e.g., Meuter & Allport, 1999; Peeters, Runnqvist, Bertrand, & Grainger, 2014; for reviews see, Bobb & Wodniecka, 2013; Declerck & Philipp, 2015). These asymmetrical switch costs have typically been explained with persisting, reactive inhibition between languages (Green, 1998; Meuter & Allport, 1999; for a persisting, reactive activation account, see Philipp, Gade, & Koch, 2007)[1]: while processing the target language on trial n-1, the non-target language will be inhibited. This inhibition is assumed to persist into the next trial (i.e., trial n). Hence, when the non-target language of trial n-1 becomes the target language of trial n (switch trial), the inhibition that was implemented on trial n-1 will persist into trial n. In turn, this persisting inhibition has to be overcome in order to select the word. No persisting inhibition has to be overcome when the same target language is used on trial n-1 and trial n

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[1] Other interpretations for asymmetrical switch costs have been proposed (Finkbeiner, Almeida, Janssen, & Caramazza, 2006; Verhoef et al., 2009). However, there is little evidence for these explanations (for reviews, see Bobb & Wodniecka, 2013; Declerck & Philipp, 2015).

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(repetition trial), making it harder to switch between languages than repeat the same language across trials due to persisting inhibition.

Reactive inhibition entails that a higher amount of activation will result in more inhibition of the non-target language. This can explain asymmetrical switch costs, since bilinguals typically have a higher activation for their L1 than their L2 due to more experience with L1. Hence, more inhibition on L1 is required during L2 production than L2 inhibition during L1 production. In turn, due to persisting inhibition, it will be more difficult to switch to L1 after previously having produced in L2 than switching to L2 after having produced in L1.

Whereas asymmetrical switch costs are generally observed in language switching studies that investigated bilingual language production (e.g., Declerck et al., 2015; Meuter & Allport, 1999; Philipp et al., 2007; Verhoef, Roelofs, & Chwilla, 2009; however, see e.g., Christoffels, Firk, & Schiller, 2007; Declerck, Koch, & Philipp, 2012; Gollan & Ferreira, 2009), typically no such asymmetrical switch costs are observed in bilingual language comprehension studies, such as studies that used a semantic categorization task (Macizo, Bajo, & Paolieri, 2012), a number categorization task (Hirsch, Declerck, & Koch, 2015; however, see Jackson, Swainson, Mullin, Cunnington, & Jackson, 2004), a lexical decision task (Aparicio & Lavaur, 2014; Orfanidou & Sumner, 2005; Thomas & Allport, 2000; Von Studnitz & Green, 2002), a picture-sentence matching task (Philipp & Huestegge, 2015), and with a visual world paradigm (Olson, 2017). In these bilingual language comprehension studies, the pattern generally shows similar L1 and L2 switch costs. This begs the question whether there is persisting, reactive inhibition during bilingual language comprehension.

According to several models, bilingual language comprehension should rely on persisting, reactive inhibition if bilingual language production does, since they assume similar control processes in both modalities (however, see Blanco-Elorrieta & Pylkkänen, 2016). The BIA-d model (Grainger, Midgley, & Holcomb, 2010), for example, proposes that both production-based and comprehension-based language control rely on the same inhibitory processes governed by language nodes (Grainger & Dijkstra, 1992; van Heuven, Dijkstra, & Grainger, 1998) that determine the relative activation levels of word representations in each language. The BIA+ (Dijkstra & van Heuven, 2002), also assumes that production-based and comprehension-based language control rely on similar language control processes, since they proposed that comprehension-based language control occurs between task schemas, similar to those proposed in bilingual language production models (cf. Green, 1998; Schwieter & Sunderman, 2008). Finally, several results obtained in bilingual language comprehension studies (e.g., Thomas & Allport, 2000; Von Studnitz & Green, 2002) have been explained with production-based language control models.

In the current study we set out to investigate whether comprehension-based language control persists and is reactive by implementing pure language blocks prior to the mixed language block. During these pure language blocks, activation of the practiced language would be increased and the language that was not practiced would be inhibited (Declerck & Philipp, 2017; Van Assche, Duyck, & Gollan, 2013). Hence, practicing a language should result in a relatively higher activation of that language in comparison to the language that was not practiced. In turn, if bilingual language comprehension relies on persisting, reactive language control, we should find larger switch costs for the practiced language than for the language that was not practiced, since the higher amount of activation for the practiced language should result in more inhibition for that language, which then persists into the next trial, and thus should be harder to overcome.

1. Experiment 1

In Experiment 1, we investigated whether asymmetrical switch costs could be affected by prior language practice. To this end, we let participants first practice a size categorization task with eight written French words in pure language blocks. Afterwards, a size categorization task with the same eight written French words and their English translation had to be performed in a mixed language block. In line with the idea of persisting, reactive inhibition one would expect larger French switch costs than English switch costs, due to the French practice which should have increased the activation of French and the specific French words.

2. Method

2.1. Participants

16 French-speaking participants took part that spoke English as their second language (8 male, mean age = 23.9). Prior to the experiment, the participants filled in a questionnaire about their French and English proficiency and completed a French (Brysbaert, 2013) and English (Lemhöfer & Broersma, 2012) vocabulary test. The questionnaire consisted out of questions about their age-of-acquisition, the average percentage of language use during childhood and current language use, and the bilinguals had to rate their level of spoken, written, and reading skills in French and English on a 7-point scale, with one being very bad and seven being very good (see Table 1).

2.2. Material and task

Participants had to classify eight written French words and their translation equivalent English words, none of which were cognates or contained diacritics, as larger or smaller than 1 meter (for an overview of the written words in French and English, see Appendix). The participants indicated their size classification by pressing the key "j" or "f" on a keyboard (the mapping of the response keys to the two sizes [i.e., smaller or larger than 1 m] was counterbalanced across participants).

2.3. Procedure

Prior to the experiment, the instructions were presented in French (L1) both orally and visually, with an emphasis on speed and accuracy. Following the instructions, the participants performed seven pure French blocks of 80 trials each, after which they had to perform one mixed language block of 80 trials. The mixed language block contained the same written French words as those used in the pure French blocks, and their English translation equivalent.

In the pure French blocks, each of the eight words was presented ten times, whereas in the mixed language blocks, each of the sixteen words was presented five times. The same word or its translation equivalent never followed each other. Moreover, in the mixed language blocks an equal amount of French and English trials were presented, both of which consisted out of 50% switch trials and 50% repetition trials.

Each trial started with a written word presented in the center of the screen, which stayed visible until a response was recorded. After the participant's response there was a 200 ms interval until the next written word would be presented.

Table 1
Overview of the demographic information for Experiments 1–3. The information consists of the average age-of-acquisition of both languages and the average percentage of time the participants spoke either language during childhood and currently. Furthermore, the average self-rated scores for speaking, writing and reading both languages is given, as is the average LexTALE scores for both languages.

	Experiment 1		Experiment 2		Experiment 3	
Effects	French	English	French	English	French	English
Age-of-acquisition	0.3	9.4	0.6	8.5	0.9	8.7
% used during childhood	87.5	12.5	85.0	15.0	80.6	19.4
% currently used	75.6	24.4	80.0	20.0	68.7	31.3
Spoken	6.3	4.1	6.5	4.4	6.3	4.1
Written	6.0	4.1	6.3	4.5	5.9	4.0
Reading	6.8	4.6	6.5	5.0	6.3	4.1
LexTALE	91.6	68.9	90.4	71.5	89.3	72.3