What Cognates Reveal about Default Language Selection in Bilingual Sentence Production

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Abstract

When producing connected speech, bilinguals often select a *default-language* as the primary force driving the utterance. The present study investigated the cognitive mechanisms underlying default language selection. In three experiments, Spanish-English bilinguals named pictures out of context, or read aloud sentences with a single word replaced by a picture with a cognate (e.g., *lemon-limón*) or noncognate name (e.g., *table-mesa*). Cognates speeded naming and significantly reduced switching costs. Critically, cognate effects were not modulated by sentence context. However, switch costs were larger in sentence context, which also exhibited significant language dominance effects, asymmetrical switch costs, and asymmetrical cognate facilitation effects, which were absent or symmetrical respectively in bare picture naming. These results suggest that default-language selection is driven primarily by boosting activation of the default language, not by proactive inhibition of the nondefault language. However, relaxation of proactive control in production of connected speech leads to greater reliance on reactive control to produce language switches relative to out-of-context naming, a contextually driven dynamic tradeoff in language control mechanisms.

Keyword: bilingual language switching, cognate effects, sentence context

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Bilinguals seem to effortlessly produce words in the language that they intend to use and easily prevent interference from the other language (i.e., the nontarget language). However, producing this is not easy, as both languages are activated even when bilinguals intend to speak in just one language (e.g., Colomé, 2001; Hermans, Bongaerts, De Bot, & Schreuder, 1998; Moon & Jiang, 2012; Poulisse & Bongaerts, 1994; see de Groot, 2011, Kroll, Bobb, Misra, & Guo, 2008 for a review; but see Costa, Pannunzi, Deco, & Pickering, 2017). Much of what is known about how bilinguals choose one language for production comes from studies of language switching, in which bilinguals named pictures one at a time. These studies generally show that bilinguals speak more slowly when switching languages than when staying in the same language, a difference known as *switch costs* (Meuter & Allport, 1999; see Bobb & Wodniecka, 2013 for a review). While numerous studies have focused on switch costs in isolated word production, relatively little is known about how language control works when bilinguals produce full sentences. To fill this gap, the present study compared language switching in versus out of sentence context and examined how switches are modulated by cross-language overlap in phonology, or *cognate status*, which provides unique evidence on how dual-language activation is controlled with versus without supporting context.

Bilingual Language Control in Speech Production

Spoken word production begins with conceptual processing, lexical selection including retrieval of syntactic information, phonological encoding, and finally planning and articulation (Levelt, Roelofs, & Meyer 1999). For bilinguals, activation cascades from the concept level to the phonological level in the target language, and also in the nontarget language. Evidence for cascaded dual-language activation comes from cognate facilitation effects. Cognates are translation equivalents that overlap in meaning and form (e.g., *lemon-limón* in English and Spanish), whereas noncognates differ substantially in form (e.g., *table-mesa*). Bilinguals name pictures with cognate names more quickly and with fewer errors than noncognates (e.g., Costa, Caramazza, & Sebastian-Galles, 2000; Costa, Santesteban, & Caño, 2005; Gollan & Acenas, 2004; Hoshino & Kroll, 2008; Ivanova & Costa, 2008; Kohnert, 2004; Roberts & Deslauriers, 1999). These *cognate facilitation effects* are thought to arise at the phonological level due to cascading activation from lexical representations in both languages (Costa, et al., 2000). Cognate facilitation effects are stronger in the nondominant language, as automatic cascading of activation to the phonological is stronger from the dominant language (e.g., Christoffels, Firk, & Schiller, 2007; Costa et al., 2012). Alternative explanations of cognate effects have been proposed including that (a) cognates may simply be higher frequency words for bilinguals than noncognates (Strijkers, Costa, & Thierry, 2010; Titone, Libben, Mercier, Whitford & Pivneva, 2011), and (b) that cognates are easier to learn (e.g., Lotto & de Groot, 1998), and thus are represented more prominently than noncognates (Costa, Pannunzi, Deco & Pickering, 2017). Although there is still a debate about what drives cognate facilitation effects, the different accounts are not mutually exclusive. In the present study we assume the dual-language activation account and investigate if cognate effects are modulated by context. Some of the results we present herein, and additional findings reported in Li and Gollan (2018a) cannot be explained by the alternative accounts, which we consider in more detail in the General Discussion.

According to the widely adopted Inhibitory Control Model (ICM; Abutalebi & Green, 2007; Green, 1998) bilinguals select a language by inhibiting the nontarget language. Early evidence for this view came from an asymmetrical pattern of switch costs; language switch costs are often larger in the dominant language than in the nondominant language (e.g., Meuter &

Allport, 1999; for review see Declerck & Philippi, 2015a). This asymmetry may arise because baseline activation of the dominant language is stronger and needs to be inhibited more than the nondominant language. Thus, after speaking the nondominant language bilinguals must overcome more inhibition to enable switching back to the dominant language, eliciting larger costs than a switch to the nondominant language. Even more compelling evidence for inhibition is found in reversed language dominance effects, in which bilinguals produce the language that is usually dominant language more slowly than the nondominant language in mixed-language testing blocks (e.g., Christoffels et al., 2007; Costa & Santesteban, 2004; Declerck, Stephan, Koch, & Philipp, 2015; Declerck, Philipp, & Koch, 2013; Gollan & Ferreira, 2009; Guo, Liu, Misra, & Kroll, 2011; Li & Gollan, 2018a; Kleinman & Gollan, 2018; Philipp, Gade, & Koch, 2007; Philipp & Koch, 2009; Verhoef, Roelofs, & Chwilla, 2009). Normally, the dominant language is more active and elicits faster responses (for reviews, see Hanulová, Davidson, & Indefrey, 2011; Runnqvist, Strijkers, Sadat, & Costa, 2011). However, when bilinguals plan to switch back and forth between languages, they may proactively inhibit the dominant language globally (i.e., the whole-language), a control process implemented in *anticipation* of interference, a sustained control process that makes both languages about equally accessible throughout the mixed-language block, on both switch and nonswitch trials (see Declerck, 2020 for a review). In contrast, the switch-cost asymmetry reflects a more transient reactive control process that is initiated on switch trials. At different times, and with different constraints, bilinguals may rely more heavily on one of the two control processes (i.e., proactive vs. reactive control) given that the switch cost asymmetry and reversed language dominance effects tend not to be found in the same set of observations (for review see Declerck & Philipp, 2015a).

In addition to operating at different time-courses (i.e., proactive vs. reactive), inhibitory control might also be exerted at multiple processing levels (for review see Declerck & Philipp, 2015a). Cognate switch-facilitation effects provide strong evidence of dual-language activation and language control at the level of phonology, but relatively few studies tested if cognates facilitate switching, and revealed inconsistent findings. In cued language switching with picture naming, cognates sometimes elicited smaller (Declerck, Koch, & Philipp, 2012; Li & Gollan, 2018a), sometimes larger (Christoffels et al., 2007), and in other studies similar (Li & Gollan, 2018a; Santesteban & Costa, 2016; Verhoef et al., 2009) sized switch costs compared to noncognates. Li and Gollan (2018a) suggested that two factors may contribute to the inconsistency, including list composition and item repetition. When bilinguals produced only cognates or only noncognates in separate testing blocks, cognates reduced switch costs (in both languages, Declerck et al., 2012, or just in the dominant language Li & Gollan, 2018a, Experiment 1). This cognate switch-facilitation effect might be due to more nontarget language activation on switch than on nonswitch trials, given that the nontarget language had just been produced on the previous trial. However, when cognates and noncognates were intermixed in the same testing block – an experimental manipulation that likely has greater ecological validity – no cognate switch-facilitation effect was found unless the analysis was limited to the first presentation of each picture (in which case cognates reduced language switch costs in both languages; Li & Gollan, 2018a, Experiment 2). Finally, when a small number of pictures was repeated 12 times, responses to cognates slowed with repetition especially on switch trials, while repetition seemed to have little effect on noncognates, and also did not affect cognates on nonswitch trials, leading cognates to exhibit *larger* switch costs than noncognates (i.e., the opposite of switch-facilitation effects; Li & Gollan, 2018a, Experiment 3).[1]

Taken together, investigation of cognate effects on language switching to date suggest that cross-language overlap facilitates selection at the phonological level, but in special circumstances may interfere at the lexical level, and that the nature of cognate switch effects that will be observed depends on which processing level is targeted by the nature of task.

Language Control in Sentence Context

Studies of single word vs. sentence reading suggest that sentence context can reduce the extent to which both languages are active (e.g., Elston-Güttler, Gunter & Kotz, 2005; Schwartz & Arêas Da Luz Fontes, 2008; Schwartz & Kroll, 2006; Titone et al., 2011; but see Duyck, Van Assche, Drieghe & Hartsuiker, 2007; Libben & Titone, 2009; Van Hell & De Groot, 2008). An important consideration for speech production is how language control might be different when words are spoken in isolation versus in sentence context. In most studies of language switching with bare picture naming, bilinguals produced an equal number of responses in each language, a situation that is relatively rare in normal settings. By contrast, when bilinguals produce connected speech, they often select a single language as the primary or *default language* in which most words are produced and that drives syntactic structure (Gollan & Goldrick, 2018; see Matrix Language Framework model; Myers-Scotton & Jake, 2009). A striking demonstration of

[1] Li & Gollan (2018a) suggested that cognate interference effects can arise if selection occurs after activation has had time to flow from phonology back up to the lexical level (Cutting & Ferreira, 1999; Damian & Martin, 1999; Dell, 1988; Santésteban, Pickering, & McLean, 2010; Costa, Roelstraete, & Hartsuiker, 2006), increasing competition for selection at the lexical level especially for cognates. In normal circumstances, feedback effects might be relatively weak (Rapp & Goldrick, 2000), but repetition would speed activation flow both to the phonological level and back up to the lexical level. In naming blocked lists of cognates only, bilinguals might have focused attention strategically to eliminate feedback effects (see Li & Gollan, 2018a).

that power of default language selection is that while switching out of the default language is error prone, switching back to the default language appears to be very easy and elicits very few language selection errors (Gollan & Goldrick, 2018).

What cognitive mechanism(s) enable default language selection? Sentence context could boost activation of the default language, but according to some, does not completely prevent dual-language activation. Starreveld et al. (2014) compared picture naming in isolation, to picture naming in a task that presented sentences word by word and replaced one cognate or noncognate in the middle of each sentence with a picture. The replaced word was either predictable or not based on the sentence context, i.e., in high- vs. low-constraint context. Bilinguals were instructed to silently read the words and to produce the picture name as quickly and accurately as possible. Within a block, the words and pictures were always in the same language. Bilinguals named pictures more quickly in sentence context than in isolation, a result they attributed to boosted activation of the default language. However, cognates were produced more quickly than noncognates in both languages in low-constraint sentence context, possibly indicating the presence of dual-language activation even for words produced in sentence context. Additionally, cognate facilitation effects were significantly reduced in high-constraint sentences (smaller for the nondominant language, and entirely absent for the dominant language). Starreveld et al. suggested that high-constraint sentences elicited strong pre-activation of the objects depicted, which might be comparable to activating the picture itself. The pre-activation allowed bilinguals to prepare production of the target words even before pictures were presented, thus leaving little room to show cognate facilitation effects (i.e., a ceiling effect). The attenuation of cognate facilitation in high-constraint sentences was consistent with results reported in studies of bilingual language comprehension (e.g., Lagrou, Hartsuiker, & Duyck, 2015; Lauro &

Schwartz, 2017; Van Assche, Duyck, Hartsuiker & Diependaele, 2009). Alternatively, sentence context might have facilitated lexical retrieval in the default language via global inhibition of the nondefault language. However, this could not be tested because production of the two languages was tested in separate blocks. In addition, in Starreveld et al., sentences were read silently, and bilinguals produced single words only rather than full sentences - thus it is not clear to what extent bilinguals in this study selected a default language for production.

The Present Study

The present study investigated the mechanisms underlying default language selection in bilingual speech production by examining language switches on cognates versus noncognates in production of full sentences. To elicit sentence production, we revised the paradigm used by Starreveld et al. (2014) by asking bilinguals to read each sentence aloud (instead of silently), and presented each picture simultaneously with a language cue, that half the time switched language out of the default language of the sentence.[2] To increase the probability of observing cognate effects we included only low-constraint sentences, and to further reveal the role of sentence context we conducted a third experiment with the same pictures but without sentence context. In all experiments, each critical picture was presented just 4 times so that each bilingual produced each picture name once in each language in each trial type (switch vs. nonswitch), while

[2] Reading aloud begins with reading comprehension which differs in obvious ways from normal speech production which is driven by intent to express thoughts. However, production of critical targets was always elicited by pictures in the present study, which involve only speech production, and note that speech produced in reading aloud engages the cognitive mechanisms underlying language production and bilingual language control. In turn, reading aloud enables study of connected speech with experimental control over the content of speech (e.g., Gollan, Schotter, Gomez, Murillo, & Rayner, 2014; Gollan & Goldrick, 2016, 2018, 2019; Li & Gollan, 2018b).

minimizing repetition. We planned a series of cross-experiment comparisons to reveal how default language selection functions according to the following logic:

First, whether bilinguals select a default language by boosting activation of the default language, or by inhibition the nondefault language, or both, switch costs should be larger in sentence context. On an activation account this would be because the switch words would be surrounded by words in the default language, making it harder to manage competition from the default language on switch trials, and easier to stay in the default language on nonswitch trials. By contrast, in single picture naming with an equal number of responses produced in each language, there would be no default language, making it easier to switch back and forth between languages. Similarly, if default language selection involves inhibition of the nondefault language then switch costs would also be larger in sentence context because producing a switch would require overcoming inhibition of the nondefault language.

Critically, if bilinguals select a default language solely by boosting activation of the default language without inhibiting the nondefault language, then we should find cognate effects (both cognate facilitation effects and cognate switch-facilitation; as found previously in out of sentence context picture naming with minimal repetition; Li & Gollan, 2018a). However, if the nondefault language is globally inhibited, then cognate facilitation effects should be reduced in sentence context on nonswitch trials because activation from the nondefault language would be reduced by inhibition. By contrast, on switch trials cognate effects should remain because inhibition of the nondefault language would be released to allow switching (and the activation which produces cognate effects would then come from the default language). Thus, cognate facilitation effects would be larger on switch than nonswitch trials in sentence context, increasing the extent to which cognates reduce switch costs in sentence context (compared to out of context).[3]

Experiment 1: Picture Naming in Sentence Context

In Experiment 1 we examined whether cognate status would influence language switch costs when bilinguals name pictures in sentence context.

Method

Participants. Thirty-two Spanish-English bilingual undergraduates at the University of California, San Diego participated for course credit. Table 1 shows participant characteristics and Multilingual Naming Test scores in both languages (MINT; Gollan, Weissberger, Runnqvist, Montoya, & Cera, 2012). Three participants were Spanish-dominant (i.e., they obtained higher picture-naming scores in Spanish than in English) and all others were English-dominant. Therefore, we used language dominance (dominant vs. nondominant) instead language (English vs. Spanish) in the analyses presented below.

Materials & Design. Forty-eight critical pictures (size 400 × 400 pixels) that were selected to be easy to name in both languages were selected, half of which have cognates names and the other half have noncognate names. The cognate versus noncognate pictures were matched on frequency, number of syllables, number of phonemes, visual complexity, and name agreement in both English and Spanish (*p*s > .24; see Table 2 for details). Another 48 pictures

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[3] Here we assume that inhibition of the nondefault language could be released in time to produce more robust cognate effects on switch than on nonswitch trials. We also assumed that this release does not automatically lead speakers to inhibit the most recently produced language more with default language selection than without. Whether these specific assumptions hold or not, the assumption that default language selection involves proactive inhibition of the nondefault language at the whole-language level (i.e., globally) would more easily explain changes in the nature of cognate effects found across contexts than the boosted activation-only account which predicts no such changes.

were selected as fillers. Each picture was embedded in a written sentence. Sentences were written either in English or in Spanish, and the pictures were named in the language corresponding to the language cue above the picture (i.e., a U.S.A. flag vs. a Mexican flag for English vs. Spanish, respectively). Thus, each picture was presented in four conditions: a) English nonswitch: sentence in English and picture named in English; b) English switch: sentence in Spanish but picture named in English; c) Spanish nonswitch: sentence in Spanish and picture named in Spanish; and d) Spanish switch: sentence in English but picture named in Spanish. The language of the sentence will henceforth be referred to as the *default language*. Each picture was repeated four times for each participant, once in each condition, but the sentence content was the same across the whole experiment (each picture appeared in the same default sentence, twice in English and twice in Spanish). See Table 3 for characteristics of critical sentences and examples, and see the Supplemental Materials for a list of all sentences. There were four testing blocks, so that each critical picture appeared in each condition for each subject distributed in even numbers across the four blocks between subjects in a Latin-square design. Thus, in each testing block, a participant would see each critical picture only once and always see 12 critical sentences in each condition, six with cognates and six with noncognates. Within each block, trials were randomized. In addition, the order of the four blocks was rotated across participants so that each picture appeared in each possible condition order.[4] For the 48

[4] We rotated sentences in the same order across the four conditions. As a result, for all pictures in switch trials in Blocks 2-4, the language that bilinguals used to name them in the previous block was different from that in the current block. Similarly, for all pictures in nonswitch trials in Blocks 2-4, the language that bilinguals used to name them in the previous block was the same as that in the current block. However, this was same across all the three experiments, and therefore did not affect cross-experiment comparisons. We explored the effects of repetition by comparing the first block (prior to any repetition of items) to the other three blocks in each experiment (see Appendix A). In these analyses, repetition elicited some significant effects, but did not interact with cognate effects.

sentences with filler pictures, one-third had pictures at the beginning of the sentence, one-third at the end of the sentence, and one-third in the middle of the sentence. All the above three types of the filler sentences were evenly distributed in the four blocks (i.e., four in each block).

Given that predictability may influence cognate effects (Starreveld, et al., 2014), all the sentences were low constraint, i.e., participants could not predict the upcoming target picture according to the preceding sentence context. Nine bilinguals who did not participate in the study completed a fill-in-the-blank test, in which they saw all the critical sentences with a blank instead of the picture, and were asked to complete the blank with an appropriate word (while being encouraged to use whatever word comes to mind first). For each sentence, only the words before the picture were presented, as participants would not see the words after it in the experiment itself. For example, for the critical sentence "The boy pretended to be a **[lion]** at the Halloween party", participants saw "The boy pretended to be a ____" and filled in the blank. The number of different answers was calculated — higher numbers refer to lower predictability which we aimed to have in the present study (if all participants provided the same answer, the sentence would be highly predictable). They provided an average of 7.67 vs. 7.75 different answers to cognate vs. noncognate sentences ($p = .84$), and the probability that target words were used to fill in the blank was 2.31% vs. 2.78% for cognate vs. noncognate sentences ($p = .75$), suggesting that the cognate and noncognate sentences were equally unpredictable.

Procedure. For each sentence, first a fixation ("+") was presented at the center of the screen for 400 ms, then the sentence was presented word by word. Each word was presented at the center of the screen until a response was given, then was immediately replaced by the following word, or by a 1,000ms blank, which was followed by the target picture and the language cue above the picture (i.e., the USA flag for English, and the Mexican flag for

Spanish). Each picture was presented 3,000 ms or until a response was given. A 1,000 ms blank was added before each picture presentation to prevent the production of the previous word (usually a very short function word, like *the, a, of*) to trigger the voice key of the picture; we did not have a blank between words to lead to coherent sentence production. There was a yes/no question after each filler sentence to examine whether participants would process the meaning of sentences. Each participant completed a practice with eight trials (2 trials in each condition with noncritical pictures) first.

Results

Analyses were carried out in R, an open source programming environment for statistical computing (R Core Team (2013) with the lme4 package (Bates et al., 2015) for linear mixed effects modeling (LMM) and general linear mixed effects modeling (GLMM). For all the pictures, response times (RTs) data for incorrect responses were excluded. Correct RTs were trimmed if any one or more of the following conditions were met: hesitation, disfluency, the correct answer failed to trigger the voice key, or noise or the utterance of the previous word triggered the voice key. Responses less than 250 ms were removed (as were any responses above 3,000 ms; these were not recorded). Following Li and Gollan (2018a), we also intended to remove responses that were four standard deviations larger or smaller than the means for each subject (collapsing all conditions), but found no outliers (i.e., all trials were within 4 SD*s*).

All the participants answered at least 10 out the 12 comprehension questions correctly, suggesting that they processed sentence meaning relatively well. For all the critical trials, we analyzed both error rates and response times (RTs). In both analyses, contrast-coded fixed effects included language (dominant vs. nondominant), trial type (switch vs. nonswitch), cognate status (cognates vs. noncognates), and all two-way and three-way interactions. Subjects and items were entered as random intercepts with related random slopes. The correlations among random effects were removed due to the failure to converge in both analyses. The significance of each fixed effect was assessed via likelihood ratio tests (Barr et al., 2013).

In the analysis of RTs, we removed 7.2% incorrect responses, and another 5.7% of trials due to trimming procedures. Figure 1 (Panel A) shows the mean RTs with the 95% confidence intervals of each condition. Bilinguals named pictures more slowly on switch than nonswitch trials (i.e., significant switch costs; M = 1015 ms vs. 931 ms; β = 86.40; SE β = 10.83; χ^2 *(1)* = 37.06, $p < .001$), in the nondominant than the dominant language (i.e., a language dominance effect; M = 992 ms vs. 954 ms; β = 50.84; SE β = 18.98; χ^2 *(1)* = 6.65, p = .010), and faster for cognates than noncognates (i.e., cognate facilitation; M = 937 ms vs. 1009 ms; β = -74.83; SE β = 28.39; χ^2 *(1)* = 6.94, p = .008).

Of greatest interest, switch costs, though significant for both cognates and noncognates (ps < .001), were smaller for cognates (M = 64 ms vs. 106 ms), a significant interaction between trial type and cognate status (i.e., a cognate switch-facilitation effect; β = -48.18; SE β = 18.25; χ^2 *(1)* = 6.58, p = .010). Stated differently, the cognate facilitation effect was only marginally significant on nonswitch trials (M = 906 ms vs. 957 ms; β = -50.19; SE β = 28.33; χ^2 *(1)* = 3.12, p = .077), but was significant on switch trials (M = 970 ms vs. 1063 ms; β = -94.90; SE β = 26.56; χ^2 *(1)* = 9.29, p = .002). In addition, the cognate facilitation effect was significant in the nondominant language (M = 944 ms vs. 1046 ms; β = -111.91; SE β = 38.77; χ^2 *(1)* = 7.96, p = .005), but was only marginally significant in the dominant language (M = 930 ms vs. 978 ms; β = -42.34; SE β = 25.11; χ^2 *(1)* = 2.83, p = .093), a significant language × cognate status interaction (β = 66.66; SE β = 29.78; χ^2 *(1)* = 4.94, p = .026). None of the other effects were significant (ps ≥ .64).

Figure 1 (Panel B) shows the mean error rates with the 95% confidence intervals of each condition. The analysis of error rates showed switch costs (produced more errors on switch than nonswitch trials; M = 9.36% vs. 4.98%; β = .82; SE β = .13; χ^2 *(1)* = 28.28, p < .001), language dominance effects (more errors in the nondominant than the dominant language, M = 8.77% vs. 5.65%; β = .50; SE β = .23; χ^2 *(1)* = 4.14, p = .042). In addition, switch costs were asymmetrical, i.e., larger in the dominant than the nondominant language (M = 5.18% vs. 3.52%), a significant language × trial type interaction (β = .58; SE β = .22; χ^2 *(1)* = 6.25, p = .012). None of the other effects were significant (ps ≥ .12).

Discussion

The results of Experiment 1 replicated several effects previously reported in studies that examined bilingual word production in isolation, including switch costs (bilinguals named pictures less accurately and more slowly on switch than on nonswitch trials) and cognate facilitation (bilinguals named pictures with cognate names more quickly than pictures with noncognate names) especially in the nondominant language. Of greatest interest, like Li and Gollan (2018a), we found significant cognate switch-facilitation effects (smaller switch costs for cognates than for noncognates) — cognate facilitation was significant on switch trials (p = .002) but was only marginally significant on nonswitch trials (p = .077). The analysis of errors also revealed significant language dominance effects, but also asymmetrical switch costs (the asymmetry was not observed in the RTs). This combination of results could imply the absence of global inhibition of the dominant language (which sometimes leads language dominance to reverse), and the presence of reactive inhibition (leading to asymmetrical switch costs) – but the asymmetry was not found in the RTs, so we defer discussion of this possibility until after Experiment 2.

Although all the sentences were low constraint, a limitation of Experiment 1 was that the same target picture was presented in the same sentence context four times. As a result, bilinguals may have been able to predict the upcoming picture toward the end of the experiment. According to Starreveld et al. (2014), higher predictability may lead to pre-activation of the target word, thus reducing cognate effects. Therefore, we conducted Experiment 2 to test this possibility.

Experiment 2: Picture Naming in Different Sentence Context

Experiment 2 was a replication of Experiment 1, with a critical difference, that each time a picture was repeated it was presented in a different sentence to exclude the potential effects of increased predictability in later blocks.

Method

Participants. A total of 32 Spanish-English bilingual students from the same subject pool in Experiment 1 were recruited. Table 1 shows participant characteristics and MINT scores in both languages (Gollan et al., 2012), as well as the comparison across experiments. Five participants were Spanish-dominant, and all others were English-dominant.

Materials, Design & Procedure. The picture stimuli, research design, and procedure were same as those in Experiment 1, except that new sentences were created so that each picture was embedded in a different sentence in each of the 4 conditions (English nonswitch, English switch, Spanish nonswitch, and Spanish switch). The four sentences with the same critical picture rotated across conditions so that each sentence appeared in each condition for an equal number of times. Six bilinguals who did not participate the study completed a fill-in-the-blank test for all sentences. They provided an average of 5.24 vs. 5.13 different answers to cognate vs. noncognate sentences (p = .53), and the probability that target words were used to fill in the blank was 4.17% vs. 3.65% for cognate vs. noncognate sentences (p= .60). The number of words before the picture and the predictability across the four sentence sets were well matched (ps ≥ .67). See Table 4 for examples.

Results

Analyses were carried out in the same way as that in Experiment 1. As in Experiment 1, participants answered at least 10 out the 12 comprehension questions correctly. In the analysis of RTs, we removed 5.7% incorrect responses, and another 7.6% of trials due to trimming procedures. Figure 2 (Panel A) shows the mean RTs with the 95% confidence intervals of each condition. Bilinguals showed switch costs (longer RTs on switch than nonswitch trials; M = 1052 ms vs. 921 ms; β = 131.66; SE β = 10.14; χ^2 *(1)* = 62.98, $p < .001$), a language dominance effect (longer RTs in the nondominant than the dominant language; M = 1003 ms vs. 967 ms; β = 47.77; SE β = 16.17; χ^2 *(1)* = 8.39, $p = .004$), and a cognate facilitation effect (shorter RTs in cognates than noncognates; M = 951 ms vs. 1018 ms; β = -100.17; SE β = 26.51; χ^2 *(1)* = 14.04, $p < .001$).

Of greatest interest, switch costs were smaller for cognates than noncognates (M = 111 ms vs. 152 ms; ps < .001 for both word types), a significant cognate switch-facilitation effect (β = -41.56; SE β = 18.19; χ^2 *(1)* = 5.00, $p = .025$). Stated differently, while bilinguals produced cognate names faster than noncognates on both switch and nonswitch trials (ps < .05), the effect was stronger on switch trials (M = 88 ms vs. 48 ms). Switch costs were also asymmetrical (larger in the dominant than nondominant language; M = 149 ms vs. 110 ms; ps < .001 for both languages), a significant interaction between trial type and language (β = 37.84; SE β = 19.00; χ^2 *(1)* = 3.90, $p = .048$). Lastly, there was a significant language × cognate status interaction (β = 60.11; SE β = 25.37; χ^2 *(1)* = 5.37, $p = .020$), as the cognate facilitation effect was larger in the nondominant language (M = 956 ms vs. 1053 ms; β = 114.12; SE β = 35.00; χ^2 *(1)* = 10.09, p

= .001) than in the dominant language (*M* = 947 ms vs. 988 ms; β = 63.30; SE β = 25.06; χ^2 *(1)* = 6.36, *p* = .011). The three-way interaction was not significant (χ^2 < 1).

Figure 2 (Panel B) shows the mean error rates with the 95% confidence intervals of each condition. The analysis of error rates showed significant switch costs (more errors on switch than nonswitch trials; *M* = 7.79% vs. 3.56%; β = 1.08; SE β = .14; χ^2 *(1)* = 34.50, *p* < .001), a language dominance effect (more errors in the nondominant than the dominant language; *M* = 6.71% vs. 4.68%; β = .67; SE β = .23; χ^2 *(1)* = 7.88, *p* = .004), and switch-cost asymmetry (larger costs in the dominant than the nondominant language; *M* = 5.98% vs. 2.37%, β = 1.17; SE β = .26; χ^2 *(1)* = 15.79, *p* < .001). None of the other effects were significant (*p*s ≥ .14).

Discussion

Like in Experiment 1, in Experiment 2 we replicated switch costs（in both RTs and error rates) and cognate facilitation (in RTs only) which was stronger in the nondominant than the dominant language. Of greatest interest, in both experiments switch costs were smaller with cognates than with noncognates, i.e., cognates facilitated language switching. Interestingly, in the present study cognates were produced more quickly than noncognates even on nonswitch trials (marginally in Experiment 1, significantly in Experiment 2), while in our previous study cognates were produced more quickly than noncognates only on switch trials (Li & Gollan, 2018a, Experiment 2, analysis of first presentation). Additionally, like Experiment 1, in Experiment 2 we found asymmetrical switch costs and language dominance effects (in both RTs and error rates), two effects that were absent in Li and Gollan. Several methodological differences might account for the different pattern of results across studies. Most obvious was the inclusion of sentence context in the present study whereas in Li and Gollan bilinguals named bare pictures without sentence context. The present study also had fewer repetitions (4 instead of

12) and a larger number of pictures (48 instead of just 18). To examine the possible role of these differences in eliciting the different pattern of results we conducted Experiment 3.

Experiment 3: Picture Naming in Isolation

In Experiment 3, bilinguals named the same pictures with the same number of repetitions as in Experiments 1 and 2, but without sentence context. In addition, to otherwise maximize comparability to our previous out-of-context study, bilinguals were pre-exposed to pictures and their names as in Li and Gollan (2018a).

Method

Participants. A total of 32 Spanish-English bilingual students from the same subject pool in Experiments 1 and 2 were recruited. Table 1 shows participant characteristics and MINT scores in both languages (Gollan et al., 2012), as well as the comparison across experiments, which showed no significant difference between any combination of two experiments (ps > .12). Three participants were Spanish-dominant, and all others were English-dominant.

Materials & Design. The same 48 critical pictures as in Experiments 1 and 2 were presented 4 times each, in each of the four conditions: 1) English nonswitch, 2) English switch, 3) Spanish nonswitch, and 4) Spanish switch. The four presentations of the same picture were evenly and pseudo-randomly distributed in four blocks, so that participants saw a picture only once within a block. Each block contained equal number of pictures in each condition, and the order of the four blocks rotated across participants.

Procedure. Following Li and Gollan (2018a), each trial began with a fixation point (+) for 400 ms, followed by the target picture and the language cue above it (i.e., the USA flag for English, and the Mexican flag for Spanish), which were presented for a maximum of 3,000 ms or disappeared when a response was registered. The next trial began 150 ms after the picture disappeared. Pictures were presented at the center of the screen, and the language cue was presented above the picture. Each block always started with a dummy trial (i.e., a trial with a noncritical picture). Before the experimental trials, 16 practice trials were presented (using eight noncritical/filler pictures), followed by a familiarization session, in which bilinguals were instructed to use the target name to name each critical picture, once in English and once in Spanish. Correct names were provided by the experimenter if participants failed to name a picture or used an incorrect name.

Results

Analyses were carried out in the same way as in Experiments 1 and 2, except that RTs were also trimmed if the previous picture was named in the nontarget language, or if it was not named (a don't know or time-out) given that without sentence context, responses on the previous trial determined if the following trial was a switch trial or not (see also Li & Gollan, 2018a). In the analysis of RTs, we removed 3.2% incorrect responses, and another 8.3% of trials due to trimming procedures. Figure 3 (Panel A) shows the mean RTs with the 95% confidence intervals of each condition. Bilinguals showed significant switch costs (longer RTs on switch than nonswitch trials; M = 1022 ms vs. 924 ms; β = 97.46; SE β = 10.40; χ^2 (1) = 47.93, p < .001) and cognate facilitation (shorter RTs for cognates than noncognates; M = 938 ms vs. 1007 ms; β = -73.55; SE β = 22.07; χ^2 (1) = 10.36, p = .001). Switch costs were smaller for cognates than noncognates (M = 73 ms vs. 130 ms; ps < .001 for both word types), a significant cognate switch-facilitation effect (β = -59.89; SE β = 17.55; χ^2 (1) = 10.78, p = .001). Stated differently, while the cognate facilitation effect was significant on both switch and nonswitch trials (ps < .05), it was stronger on switch trials (M = 101 ms vs. 42 ms). None of the other effects were significant (χ^2s < 1).

Figure 3 (Panel B) shows the mean error rates with the 95% confidence intervals of each condition. The analyses of error rates showed significant switch costs (more errors on switch than nonswitch trials; $M = 4.58\%$ vs. 1.84%; $\beta = 1.02$; SE $\beta = .17$; $\chi^2\ (1) = 29.94$, $p < .001$), and a marginally significant language dominance effect (more errors in the nondominant than the dominant language; $M = 3.81\%$ vs. 2.61%; $\beta = .47$; SE $\beta = .25$; $\chi^2\ (1) = 3.32$, $p = .069$). None of the other effects were significant (ps $\geq .36$).

Cross-Experiment Comparison. To investigate the influence of sentence context on cognate switch-facilitation effects, we compared Experiments 2 and 3 in the same models for both RTs and error rates. Contrast-coded fixed effects included experiment number, cognate status, language, trial type, and all of their two-way, three-way, and four-way interactions. Subject and item were entered as two random intercepts with related random slopes. The correlations among random effects were removed due to a failure to converge. Figure 4 plots the mean RTs (Panel A) and error rates (Panel B) across experiments.

Of greatest interest, cognates facilitated production to the same extent in sentence context (in Experiment 2) as in bare picture naming (in Experiment 3), a nonsignificant interaction between experiment and cognate status (M= 67 ms vs. 69 ms; $\beta = -5.01$; SE $\beta = 21.77$; $\chi^2\ (1) < 1$). In addition, cognates reduced switch costs to the same extent in sentence context as in bare picture naming (M= 41 ms vs. 63 ms; $\beta = 18.49$; SE $\beta = 24.67$; $\chi^2\ (1) < 1$). Stated differently, cognate facilitation effects were similar in size in sentence context and in bare picture naming on both nonswitch and switch trials (ps $\geq .42$). The pattern of results remained the same when we repeated these comparisons collapsing Experiments 1 and 2 to increase power (all ps $\geq .43$).

Bilinguals named pictures equally quickly in sentence context and bare picture naming (M = 984 ms vs. 971 ms; $\beta = 19.22$; $SE\ \beta = 32.61$; $\chi^2\ (1) < 1$), named pictures more slowly on switch than nonswitch trials (*M* = 1036 ms vs. 921 ms; β = 114.42; SE β = 7.15; χ^2 *(1)* = 256.37, p < .001), and named cognates faster than noncognates (*M* = 943 ms vs. 1012 ms; β = -93.63; SE β = 21.84; χ^2 *(1)* = 18.38, p < .001). Cognate facilitation effects were smaller in the dominant than the nondominant language, a marginally significant language × cognate status interaction (*M* = 53 ms vs. 86 ms; β = 37.42; SE β = 19.18; χ^2 *(1)* = 3.81, p = .051). Cognate effects were stronger on switch than on nonswitch trials (*M* = 94 ms vs. 45 ms) — or stated differently, switch costs were smaller for cognates than noncognates, a significant trial type × cognate status interaction (i.e., cognate switch-facilitation; *M switch costs* = 90 ms vs. 139 ms; β = -50.49; SE β = 11.85; χ^2 *(1)* = 18.15, p < .001).

While cognate effects did not vary across experiments, other analyses did reveal significant differences between experiments illustrating sufficient power to observe such effects. Consistent with the predictions outlined in the Introduction section, switch costs were larger in sentence context than in bare picture naming (*M* = 131 ms vs. 98 ms, *p*s < .001 in both experiments), a significant trial type × experiment interaction (β = 33.71; SE β = 14.70; χ^2 *(1)* = 5.26, p = .022).[5] Additionally, bilinguals named pictures more quickly in the dominant than the nondominant language in sentence context (*M* = 967 ms vs. 1003 ms, p = .004), but showed no language dominance effects in bare picture naming (means were even in the opposite direction, i.e., towards reversed dominance, dominant, *M* = 977 ms vs. nondominant, 965 ms, p = .49), a language × experiment interaction (β = -55.83; SE β = 18.43; χ^2 *(1)* = 8.88, p = .003). Lastly, switch costs were significantly larger in the dominant than the nondominant language in sentence

[5] This appeared to be driven more by cognates than noncognates. The trial type × experiment interaction was significant for cognates (p = .002) but not for noncognates (p = .34), which could be seen as evidence for the hypothesis that default language selection entails inhibition of the nondefault language. However, the 3-way interaction between cognate status, trial type, and experiment did not approach significance (p = .45).

context (*M* = 149 ms vs. 110 ms, $p = .048$), but switch costs were symmetrical in bare picture naming (*M* = 92 ms vs. 103 ms, $p = .64$), a marginally significant trial type × language × experiment interaction ($\beta = 47.57$; SE $\beta = 26.31$; χ^2 *(1)* = 3.32, $p = .069$). None of the other effects were significant (*p*s ≥.10). See Table 5 for full results. In the additional analysis that combined data from Experiments 1 and 2 and compared to Experiment 3, the cognate status × language × experiment 3-way interaction became significant while all other results remained unchanged. That is, cognate facilitation effects were asymmetrical in sentence context (stronger in the nondominant than the dominant language; *M*= 100 ms vs. 44 ms), but symmetrical in bare picture naming (*M* = 78 ms vs. 65 ms) ($\beta = 49.87$; SE $\beta = 24.25$; χ^2 *(1)* = 4.23, $p = .046$).[6]

In the analysis of error rates cognate facilitation effects and cognate switch facilitation effects were not significant (χ^2s < 1). Nevertheless, bilinguals produced more errors in sentence context than in bare picture naming (a small but significant effect that might have been caused by our pre-exposure procedure in Experiment 3, in which correct names were provided when participants failed to name a picture; *M* = 5.7% vs. 3.2%; $\beta = -.68$; SE $\beta = .20$; χ^2 *(1)* = 10.32, $p = .001$), more errors in the nondominant than dominant language (*M* = 5.2% vs. 3.6%; $\beta = .54$; SE $\beta = .18$; χ^2 *(1)* = 8.84, $p = .003$), and more errors on switch than nonswitch trials (*M* = 6.2% vs. 2.7%; $\beta = -1.05$; SE $\beta = .11$; χ^2 *(1)* = 85.16, $p < .001$). Switch costs were larger in the dominant than the nondominant language (*M* = 4.3% vs. 2.6%, *p*s < .001 for both languages), a significant interaction between language and trial type ($\beta = -.73$; SE $\beta = .21$; χ^2 *(1)* = 12.22, $p < .001$). However, this two-way interaction was mainly driven by sentence context. Switch costs

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[6] While this interaction was consistent with the results reported within each experiment separately (i.e., smaller cognate facilitation for the dominant than the nondominant language only in sentence context), additional post-hoc analyses showed that cognate facilitation effects were similar across experiments in both the dominant and the nondominant languages (no cognate status × experiment interaction in either language; *p*s > .26).

were larger in the dominant than the nondominant language with sentence context in Experiment 2 (M = 5.98% vs. 2.38%; $p < .001$), but were symmetrical (similar across the two languages) in bare picture naming in Experiment 3 (M = 2.62% vs. 2.85%, $p = .37$), a significant trial type × language × experiment 3-way interaction ($\beta = -.90$; SE $\beta = .41$; $\chi^2(1) = 4.12$, $p = .042$), in the same direction as results in the RT analysis. None of the other effects were significant (ps $\geq .25$). See Table 6 for full results.

Discussion

Like Li and Gollan (2018a), in Experiment 3 we replicated switch costs, cognate facilitation that was equally strong in two languages, and cognate switch-facilitation effects in bare picture naming with a larger set of pictures than in Li and Gollan, and with minimal repetition of items. Unlike in Experiments 1-2, in Experiment 3 we found symmetrical switch costs, no significant effects of language dominance, both were consistent with Li and Gollan. Of great interest, and consistent with our predictions, cross-experiment comparisons showed larger switch costs in sentence context than in bare picture naming, and critically, cognates facilitated language switching to the same extent with versus without sentence context.

General Discussion

The present study investigated how cross-language overlap in phonology (i.e., cognates) influences language control in versus out of sentence context. Spanish-English bilinguals named pictures with cognate versus noncognate names in repeated sentence context (Experiment 1), in non-repeated sentence context (Experiment 2), or in isolation (Experiment 3). Results replicated several previously reported findings including switch costs and cognate facilitation effects. In addition, all three experiments showed cognate facilitation and cognate switch-facilitation effects of equal magnitude, though switch costs were significantly larger in versus out of sentence context. Finally, language dominance effects were significant, and switch costs and cognate facilitation effects were asymmetrical in sentence context, while all these effects were absent in bare picture naming. These findings reveal the cognitive mechanisms underlying default language selection in bilingual speech production.

Language Switching in vs. out of Sentence Context

We asked whether default language selection in sentence context is implemented exclusively via boosting activation of the default language or if it also involves inhibition of the nondefault language. Both accounts predict larger switch costs in sentence context relative to bare picture naming, because boosted activation leads to stronger competition from the default language when attempting to switch, and with increased inhibition additional efforts would be needed to overcome inhibition of the nondefault language on switch trials. Our cross-experiment comparison confirmed this prediction.

Cognate effects, however, seem more consistent with the proposal that default language selection exclusively involves boosting activation of the default language. On this view, cognates should facilitate production to the same extent in sentence context vs. in bare picture naming because activating the default language leaves the magnitude of dual-language activation unchanged (i.e., does not change activation of the nondefault language, and cognate effects reflect the extent to which the nontarget language is active). By contrast, the inhibition account predicted reduced cognate facilitation in sentence context, assuming proactive inhibition is applied to the nondefault language as a whole (i.e., globally), and would need to be released on switch trials to enable switches to occur (reintroducing the benefits from overlapping phonology for cognates on switch trials). By the same token, inhibition of the nondefault language could also increase cognate switch-facilitation effects (because cognate facilitation would be more robust on switch trials when inhibition is released). Inconsistent with these predictions, cross experiment comparisons revealed that cognates facilitate naming, and reduced switching costs, to the same extent in versus out of sentence context. Further analyses showed that cognate effects were similar across all three experiments for both switch trials and nonswitch trials, in both the dominant and nondominant languages (*p*s > .26), further suggesting no global inhibition of the nondefault language is involved in selecting a default language, thus supporting the boosted-activation-only account.

These conclusions rest on the assumption that cognate effects are caused by dual-language activation. This is justified because alternative accounts of cognate effects cannot explain why cognates modulate switch costs. Specifically, assuming cognates are higher in frequency and represented more prominently than noncognates (Costa et al., 2017; Strijkers et al., 2010; Titone et al., 2011), we would then have to assume that it is easier to switch languages when naming pictures with high-frequency rather than low-frequency names. Although few studies examined this possibility, von Studnitz and Green (1997) showed German-English bilinguals' switch costs in lexical decision did not differ between high- versus low-frequency words. In addition, other evidence suggests that factors that speed responses (as should high frequency and prominent representation) increase rather than reduce switch costs — e.g., English monolinguals showed larger switch costs on faster words relative to slower words in a Stroop switching task, particularly in word naming (Finkbeiner, Almeida, Janssen, & Caramazza, 2006).[7] Lastly, the alternative cognate accounts cannot explain why cognate switch facilitation effects were eliminated and even reversed after many repetitions of the same pictures in Li and

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[7] Further support comes from data from an unpublished picture-naming study (work in progress) in which 48 Spanish-English bilinguals named pictures with high-frequency (n=100) or low-frequency names (n=100), while switching languages 1/3 of the time and exhibited smaller switch costs on low-frequency targets.

Gollan (2018a). Thus, it appears that cognate effects, at least in language switching paradigms, are better explained by assuming dual-language activation, and therefore the results of the present study support the boosted-activation-only hypothesis (even if frequency and/or representation prominence also play a role in explaining cognate effects in other types of speaking tasks when bilinguals do not switch languages).

While cognate effects produced a pattern of results that seems more consistent with the boosted-activation-only account of default language selection, other aspects of the results seemed to reveal some modulation of inhibitory control processes in sentence context relative to bare picture naming. First, cognate facilitation effects were stronger in the nondominant than the dominant language in sentence context, consistent with the results in single language context (e.g., Christoffels et al., 2007), as automatic cascading of activation to phonology is stronger from the dominant language thus providing more extra activation (i.e., the source of cognate facilitation). However, we found symmetrical cognate facilitation in bare picture naming. In addition, we found significant language dominance effects (i.e., faster responses in the dominant than nondominant language) in sentence context but no dominance effects in bare picture naming. Together these results suggested that in bare picture naming, activation levels of the dominant and the nondominant languages were similar, while in sentence context the dominant language was more active than the nondominant language. In other words, in bare picture naming, bilinguals globally inhibited the dominant language aiming to reach about equal levels of activation of the two languages to facilitate switching (Declerck, Kleinman, & Gollan, 2020; Kleinman & Gollan, 2018). For this reason, switch costs were also asymmetrical in sentence context (larger in the dominant than the nondominant language; Meuter & Allport, 1999; for review see Bobb & Wodniecka, 2013; Declerck & Philipp, 2015a), but symmetrical in bare picture naming. Thus, these seemingly opposed indices of inhibitory control suggest that different forms of inhibition are affected differently by selection of a default language that is triggered by sentence context. While default language selection does not appear to entail global inhibition of the nondefault language, instead it appears to reflect a relaxed exertion of proactive control of the dominant language, thereby eliciting greater need for reactive inhibition to implement language switches (Green, 1998; Abutalebi & Green, 2007).

The trade-off between different types of inhibitory control in versus out of sentence context may reflect a couple of factors. First, in sentence context, most of words were in the default language, which may reduce anticipation of disruption from the non-default language and elicit a mode of processing with more relaxed proactive control. Second, although bilinguals produced exactly the same number of picture names and language switches in all 3 experiments in the present study, if considering all the words produced in each sentence in the baseline (i.e., including all the words that were read aloud not just the pictures for which switching rate was identical across experiments), the rate of language switches was much higher in bare picture naming than it was in sentence context. Of note, while the possibility of selecting a default language in the present study was limited to Experiments 1-2 which had sentence context, the inclusion of sentences might not be necessary to elicit a change in control mechanisms. For example, Olson (2016) asked Spanish-English bilinguals to name pictures in monolingual context (95% English 5% Spanish or 95% Spanish 5% English, low switch rate) vs. in bilingual context (50% English 50% Spanish, high switch rate), and found asymmetrical switch costs in monolingual context but symmetrical costs in bilingual context. Olson proposed these findings reflect a modulation of the amount of reactive control across contexts such that reactive inhibition is applied equally to both languages when switch rates are high (e.g., 50%) and equal numbers of words in each language are produced. Our interpretation is similar but differs in the assumption that the trade-off occurs between two different forms of inhibitory control (proactive vs. reactive) that is applied at different processing levels (whole-language vs. lexical levels; for review see Declerck, 2020).

A question that remains open concerns how language dominance effects vary in different contexts. Comparing the results of Experiment 3 (bare picture naming) to several other studies that tested bilinguals recruited from the same population on cued language switching out of context, reveals mixed findings with respect to dominance effects. While we found reversed dominance effects in some previous studies (Gollan & Ferreira, 2009; Gollan, Kleinman, & Wierenga, 2016; Kleinman & Gollan, 2016; Li & Gollan, 2018a; Weissberger, Wierenga, Bondi & Gollan, 2013), in others we found no difference between the two languages (e.g., Experiment 3 in the present study, Prior & Gollan, 2011; Stasenko, Matt, & Gollan, 2017). However, none of our previous studies of language switching with repeatedly presented bare pictures revealed significant language dominance effects as found herein in sentence context (Experiments 1 and 2). Extensive repetition of items could reduce, eliminate, or reverse language dominance effects either because of inhibition of the dominant language, or because the nondominant language benefits more from repetition than the dominant language (Francis, Augustini, & Sáenz, 2003; Francis, & Sáenz, 2007), or both (Kleinman & Gollan, 2018). Note however that the effects of context in the present study could not have been caused by differences in repetition, as the number of repetitions of each picture was identical across experiments (see Appendix A for analyses of repetition effects).

The first two experiments and Experiment 3 did differ on several methodological aspects other than in versus out of sentence context, which were necessary to implement reading aloud full sentences before each picture. First, the interval between the target picture and the previous trial was longer in Experiments 1 and 2 than Experiment 3. We included a 1,000 ms blank before each target picture appeared in sentence context to prevent the voice key being triggered by the production of previous words. In Experiment 3, there was only a 400 ms interval (i.e., fixation) between two trials in addition to the 150 ms blank after each response, consistent with previous research (i.e., Li & Gollan, 2018a). However, our critical findings are unlikely to have been caused by this difference. If anything, longer response-to-stimulus interval (in Experiments 1 and 2) should lead to *smaller* switch costs, as it provides more time for inhibition to dissipate, and for response preparation (Kiesel et al., 2010; also see Ma, Li, & Guo, 2016). However, switch costs were larger in sentence context.

Another possible difference was that in sentence context the word produced before target pictures was most often a function word like *the* and *a* (see Supplemental Materials), while it was always a noun out of sentence context. However, Olson (2016) found similar modulations of the switch cost asymmetry based on frequency of switches in single picture naming when words produced before target pictures were always nouns, suggesting that part of speech was not the critical factor that modulated the switch cost asymmetry. In addition, function words are typically retrieved more automatically than content words in sentence context (Schotter, Li, & Gollan, 2019). As a result, if anything, bilinguals would not have needed to inhibit the nontarget language before the target pictures in sentence context, and this should have elicited smaller switch costs and a smaller switch-cost asymmetry in sentence context, but this is the opposite of what we found.

Finally, in Spanish sentences we used both masculine and feminine determiners (e.g., *el* versus *la*) to match the gender of picture names in both switch and nonswitch trials. In some bilingual communities, Spanish-English bilinguals tend to use masculine determiners by default before switching to an English noun (e.g., Jake, Myers-Scotton, & Gross, 2002; Pfaff, 1979; also see Valdés Kroff, Dussias, Gerfen, Perroti, & Bajo, 2016). Switch costs in sentence context might have been increased if violation of this habitual constraint on switching is more difficult than producing bare picture names. However, the percentage of cognate versus noncognate trials with feminine determiners was equivalent in both Experiments 1 (25.0% vs. 20.8%) and 2 (22.9% vs. 17.7%) (*p*s $\geq$ .37; see Supplemental Materials), thus cognate switch-facilitation effects should not be affected by this factor. Confirming this conclusion, after removing all items with feminine-marked nouns in all experiments (22.9% of the data were removed), the critical results remained the same. Specifically, the cross-experiment comparison between Experiments 2 and 3 still showed larger switch costs in sentence context ($p = .022$), a cognate switch-facilitation effect ($p < .001$), and a nonsignificant cognate status × trial type × experiment interaction ($p = .87$); in sentence context language dominance effects were significant ($p = .006$) and switch costs were asymmetrical ($p = .018$), two effects that were absent in bare picture naming (*p*s $\geq$ .40).

The Real Story on How Cognates Affect Switching

While cognates reduced switch costs in Experiments 1-3 in the present study (both in and out of sentence context), previous research revealed every possible outcome with respect to how cognates affect switch costs (i.e., cognates showed smaller, larger, or the same size switch costs as noncognates). To date, all studies that failed to show cognate switch-facilitation effects in picture naming had many repetitions (12 in Li and Gollan, 2018a; 16 in Christoffels et al., 2007; 47 or 48 in Santesteban & Costa, 2016; 32 in Verhoef et al., 2009). Other studies that failed to show cognate switch-facilitation effects used written words to elicit spoken or typed responses

(Dijkstra, Van Hell, & Brenders, 2015; Filippi Karaminis, & Thomas, 2014; Gollan et al., 2014; Li & Gollan, 2018b; Muscalu & Smiley, 2019). For example, in Gollan et al. (2014) and Li and Gollan (2018b), bilinguals read aloud paragraphs primarily written in either the dominant or nondominant language, in which a handful of words were replaced with translation equivalents words, or *switch-out* words. In this task, bilinguals sometimes automatically translated switch-out words to avoid switching in their speech, an error that resembles *cross-language intrusion errors* and occurred significantly more often with cognates than with noncognates even without item repetition. What may be the critical variable in common in all these cases is that phonology can be accessed very quickly (as explained in detail in Li & Gollan, 2018a). In picture naming (i.e., concept-driven production), fast access to phonology resulted from many repetitions, while in production elicited by reading aloud), the written words provided more rapid access to phonology (for the same reason word naming (i.e., reading aloud) is usually faster than picture naming even with extensive training; Theios & Amrhein, 1989; Ferrand, 1999).[8] Studies focusing on phonetic processing also consistently showed cognate switch-interference effects, that articulation was more accented for cognates than noncognates on switch trials (Amengual, 2012; Goldrick, Runnqvist, & Costa, 2014; Olson, 2013). These studies also had many repetitions (16 in Goldrick et al, 2014) or used written words to elicit spoken responses (Amengual, 2012; Olson, 2013). However, the mechanisms of cognate switch-interference effects on phonetic processing could be different (a topic for further research).

Conclusion

[8] Although cognates were also orthographically similar for some language pairs (e.g., English-Spanish), more intrusion errors when producing cognates in reading aloud it is unlikely this merely reflects failure a to identify the correct language given that written Chinese-English cognates are visually very distinct but also elicit more errors in reading aloud than noncognates (Li & Gollan, 2018b).

The present study showed that cognates facilitated production on both switch and nonswitch trials, and facilitated language switching to the same extent in versus out of sentence context. By contrast, switch costs were larger in sentence context, and switch costs and cognate effects were asymmetrical only in sentence context which also exhibited normal language dominance effects. These results are consistent with previous conclusions that bilinguals activate both languages even in production of full sentences (e.g., Brown & Gullberg 2008; Declerck & Philippi, 2015b; Hartsuiker, Pickering, & Veltkamp, 2004; Hatzidaki, Branigan, & Pickering, 2011; Starreveld et al., 2014). Of greatest interest, our findings imply trade-offs in control mechanisms across contexts. In connected speech, default language selection primarily entails boosted activation of the target language. In turn, cued switching in sentence context must rely more heavily on reactive inhibition. By contrast, when there is no default language (as in bare-picture naming with 50% of responses are in each language), bilinguals proactively inhibit the dominant language to make both languages about equally accessible which leads to symmetrical switch costs and cognate facilitation effects, and either no language dominance effects or significantly reversed language dominance effects. This trade-off between proactive and reactive inhibitory control in bilingual speech production depending on the presence or absence of contextual support is generally consistent with notions of “adaptive control” mechanisms (Abutalebi & Green, 2013), and illustrates similar principles in operation even within more narrow and carefully controlled experimental settings.

Supplemental Materials

A list of sentence materials and the data of all three experiments can be found at

https://osf.io/ujwnq/

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Table 1. Means and standard deviations of participant characteristics

	Experiment 1		Experiment 2		Experiment 3	
Characteristic	*M*	*SD*	*M*	*SD*	*M*	*SD*
Age	19.72	1.69	20.63	2.89	19.75	1.46
Age of Acquisition of English	3.5	2.08	3	2.64	3.3	2.18
Age of Acquisition of Spanish	0.58	1.09	0.53	1.5	0.25	0.44
Self-rated spoken English proficiency[a]	6.67	0.62	6.63	0.75	6.5	0.72
Self-rated spoken Spanish proficiency[a]	6.41	0.8	6.34	0.9	6.06	1.09
Current percent of English use	80.25	14.03	76.34	16.67	81.15	17.03
Percent of English use during childhood	47.42	16.67	51.56	12.21	52.72	21.19
Primary caregiver English proficiency[a]	3.28	1.63	4.38	1.98	3.97	2.07
Primary caregiver Spanish proficiency[a]	6.97	0.18	6.94	0.36	6.94	0.35
Secondary caregiver English proficiency[a]	3.62	1.83	3.81	2.13	3.68	1.97
Secondary caregiver Spanish proficiency[a]	6.92	0.27	6.97	0.18	6.93	0.26
Years lived in Spanish-speaking country	6.56	5.6	8.1	5.42	5.3	4.76
MINT score in English[b]	60.56	3.3	59.94	3.9	61.47	3.45
MINT score in Spanish[b]	49.09	7.05	48.22	8.97	47.59	9.9
MINT score in the dominant language[b]	60.66	3.15	60.69	2.75	61.91	3.09
MINT score in the nondominant language[b]	49	6.96	47.47	8.3	47.16	9.34

Note. None the characteristics showed significant difference between any two experiments (*ps* > .12).
a Proficiency-level self-ratings were obtained using a scale from 1 (almost none) to 7 (like a native speaker).
b The maximum possible MINT score is 68

Table 2. Means and standard deviations of critical pictures' characteristics

		Cognates		Noncognates	
		M	*SD*	*M*	*SD*
Picture	Visual Complexity[a]	1.18	0.28	1.13	0.16
English Name	Number of syllables	2.21	0.78	1.96	0.69
	Number of Phonemes	4.92	1.61	4.96	1.49
	Frequency[b]	55.78	111.95	54.21	132.9
	Naming Agreement[c]	9.88	0.45	9.96	0.2
Spanish Name	Number of syllables	2.79	0.83	2.88	0.9
	Number of Phonemes	5.83	1.66	6.17	1.55
	Frequency[b]	43.27	61.63	60.75	150.45
	Naming Agreement[c]	9.88	0.45	9.96	0.2

a Visual Complexity scores were obtained using a scale from 1 (very easy to recognize the picture) to 4 (in the middle) to 7 (too complex to recognize the picture) from 10 Spanish-English bilinguals who did not participate in any of the three experiments.
b Word frequency information was acquired from the Subtlexus (Brysbaert & New, 2009) and Subtlex-ESP (Cuetos et al., 2011) database for English and Spanish words, respectively.
c Ten Spanish-English bilinguals who did not participate in any of the three experiments were recruited to name the critical pictures in English and Spanish. The scores referred to how many bilinguals used the target name to name the pictures (e.g., 10 means all the participants used the target name to name the corresponding picture).

Table 3. Examples of critical sentences used in Experiment 1. The word in brackets is presented in the form of the picture to be named.

Condition	Cognate Status	Mean # of words before the picture	Example Sentence
English Nonswitch	Cognate	6.71 (0.95)	The boy pretended to be a **[lion]** at the Halloween party.
	Noncognate	6.58 (1.32)	I want to print a picture of a **[tooth]** and use it in the next class.
English Switch	Cognate	6.67 (1.05)	El niño fingió ser un **[lion]** en la fiesta de Halloween.
	Noncognate	6.75 (1.19)	Quiero imprimir la imagen de un **[tooth]** y usarla en la próxima clase.
Spanish Nonswitch	Cognate	6.67 (1.05)	El niño fingió ser un **[león]** en la fiesta de Halloween.
	Noncognate	6.75 (1.19)	Quiero imprimir la imagen de un **[diente]** y usarla en la próxima clase.
Spanish Switch	Cognate	6.71 (0.95)	The boy pretended to be a **[león]** at the Halloween party.
	Noncognate	6.58 (1.32)	I want to print a picture of a **[diente]** and use it in the next class.

Note. The number of words before the picture was well matched between cognates vs. noncognates in both languages (*p*s > .64)

Table 4. Examples of critical sentences used in Experiment 2. The word in brackets is presented in the form of the picture to be named.

Condition	Cognate Status	Mean # of words before the picture	Example Sentence
English Nonswitch	Cognate	6.63 (1.26)	The boy pretended to be a **[lion]** at the Halloween party.
	Noncognate	6.50 (1.40)	I want to print a picture of a **[tooth]** and use it in the next class.
English Switch	Cognate	6.63 (1.35)	El niño quiere que el pintor dibuje un **[lion]** en su mano izquierda. *(The boy wants the painter to draw a **[lion]** on his left hand.)*
	Noncognate	6.66 (1.59)	La pesadilla era sobre la extracción de su **[tooth]** por una bruja. (*The nightmare was about his **[tooth]** being removed by a witch.*)
Spanish Nonswitch	Cognate	6.63 (1.35)	Fue desafortunado que no pudimos ver un **[león]** en el safari. *(It was unfortunate that we couldn't see a **[lion]** on the safari.)*
	Noncognate	6.66 (1.59)	Yo tengo un nervio dañado en mi **[diente]** que me causa dolor. *(I have a damaged nerve in my **[tooth]** that causes me pain.)*
Spanish Switch	Cognate	6.63 (1.26)	The hunters used a net to trap the **[león]** even though it was illegal.
	Noncognate	6.50 (1.40)	I promise to not touch your **[diente]** until the pain goes away.

Note. The number of words before the picture was well matched between cognates vs. noncognates in both languages (*p*s > .74)

Table 5. Full results of RT analysis of cross-experiment comparison (Experiment 2 vs. 3)

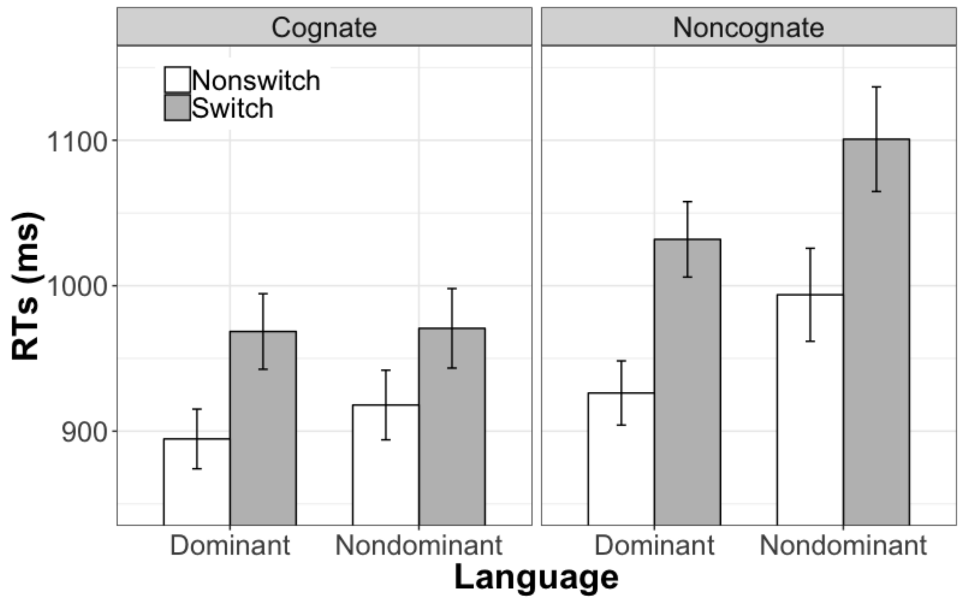
	β	SE β	χ^2	p value
Experiment	19.22	32.61	0.35	0.555
Cognate Status	-93.63	21.84	18.38	< 0.001
Language	-19.03	11.48	2.75	0.097
Trial Type	114.42	7.15	256.37	< .001
Experiment × Cognate Status	-5.01	21.77	0.05	0.818
Experiment × Language	-55.83	18.43	8.88	0.003
Experiment × Trial Type	33.71	14.70	5.26	0.022
Cognate Status × Language	37.42	19.18	3.81	0.051
Cognate Status × Trial Type	-50.49	11.85	18.15	< 0.001
Language × Trial Type	14.67	13.90	1.11	0.291
Experiment × Cognate Status × Language	44.50	27.14	2.69	0.101 [a]
Experiment × Cognate Status × Trial Type	18.49	24.67	0.56	0.454
Experiment × Language × Trial Type	47.57	26.31	3.32	0.069
Cognate Status × Language × Trial Type	-9.27	25.96	0.13	0.721
Experiment × Cognate Status × Language × Trial Type	7.26	48.74	0.02	0.882

[a] This effect was significant after we collapsed Experiments 1 and 2 and compared to Experiment 3 (p = .046).

Table 6. Full results of error rates analysis of cross-experiment comparison (Experiment 2 vs. 3)

	β	SE *β*	χ^2	*p* value
Experiment	-0.68	0.21	10.32	< 0.001
Cognate Status	0.17	0.19	0.88	0.348
Language	0.54	0.18	8.84	0.003
Trial Type	-1.05	0.11	85.16	< 0.001
Experiment × Cognate Status	-0.08	0.26	0.10	0.750
Experiment × Language	0.23	0.29	0.62	0.432
Experiment × Trial Type	-0.02	0.21	0.01	0.914
Cognate Status × Language	-0.29	0.34	0.73	0.393
Cognate Status × Trial Type	-0.05	0.23	0.06	0.808
Language × Trial Type	-0.73	0.21	12.22	< 0.001
Experiment × Cognate Status × Language	-0.63	0.55	1.31	0.253
Experiment × Cognate Status × Trial Type	0.04	0.41	0.01	0.915
Experiment × Language × Trial Type	-0.90	0.41	4.12	0.042
Cognate Status × Language × Trial Type	0.27	0.42	0.42	0.515
Experiment × Cognate Status × Language × Trial Type	0.81	0.82	0.96	0.327

(A)



(B)

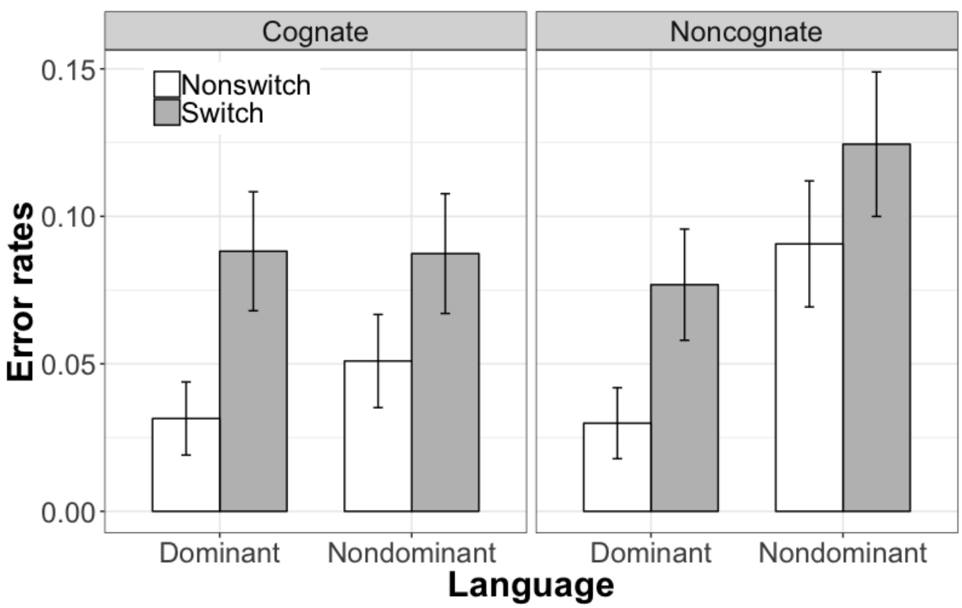
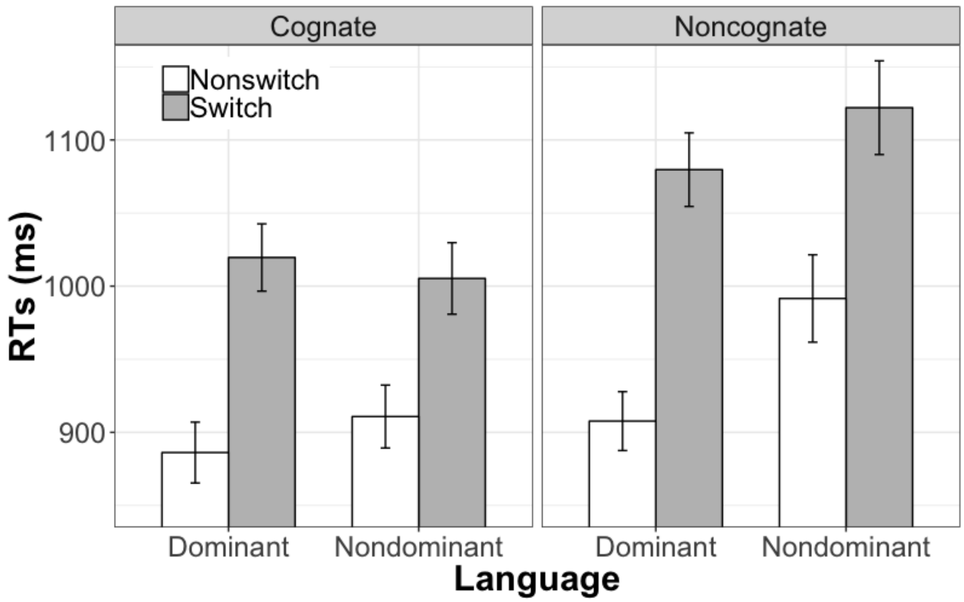


Figure 1. Mean picture naming response time (Panel A) and error rates (Panel B) for each trial type (switch vs. nonswitch) and language (dominant vs. nondominant) for cognates and noncognates in Experiment 1. Error bars represent 95% confidence interval.

(A)



(B)

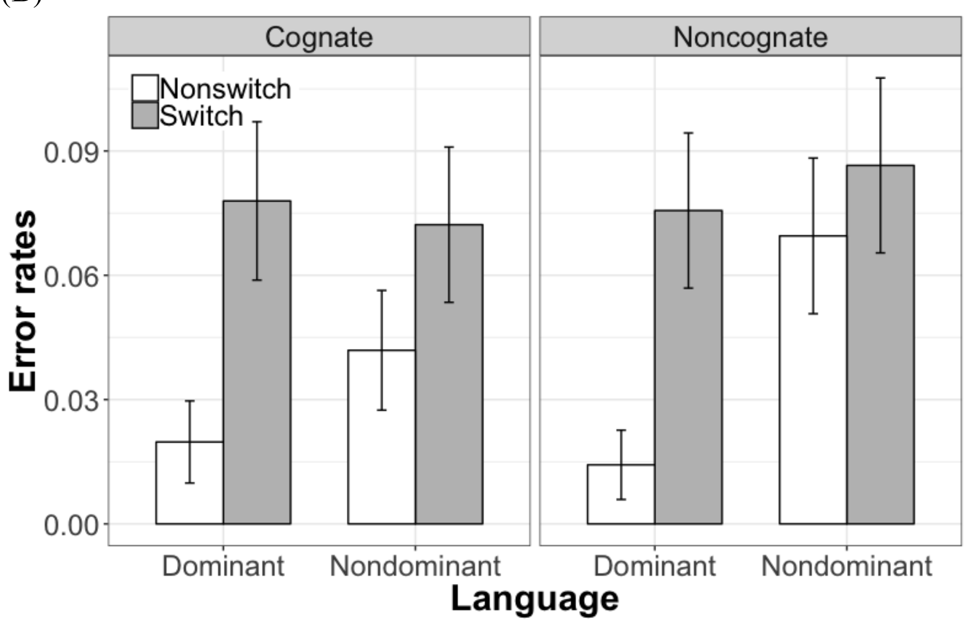
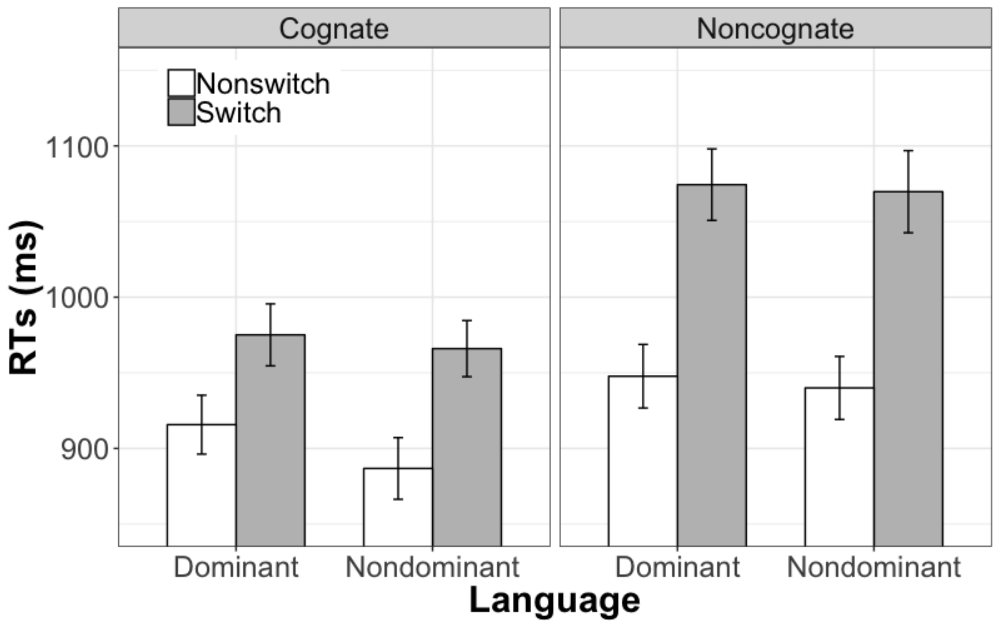


Figure 2. Mean picture naming response time (Panel A) and error rates (Panel B) for each trial type (switch vs. nonswitch) and language (dominant vs. nondominant) for cognates and noncognates in Experiment 2. Error bars represent 95% confidence interval.

(A)



(B)

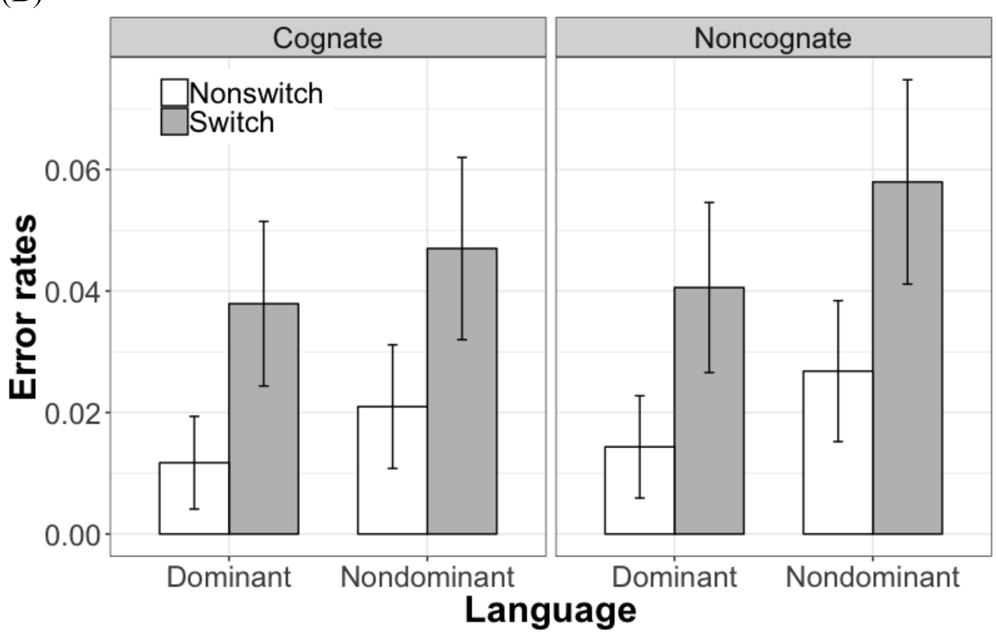
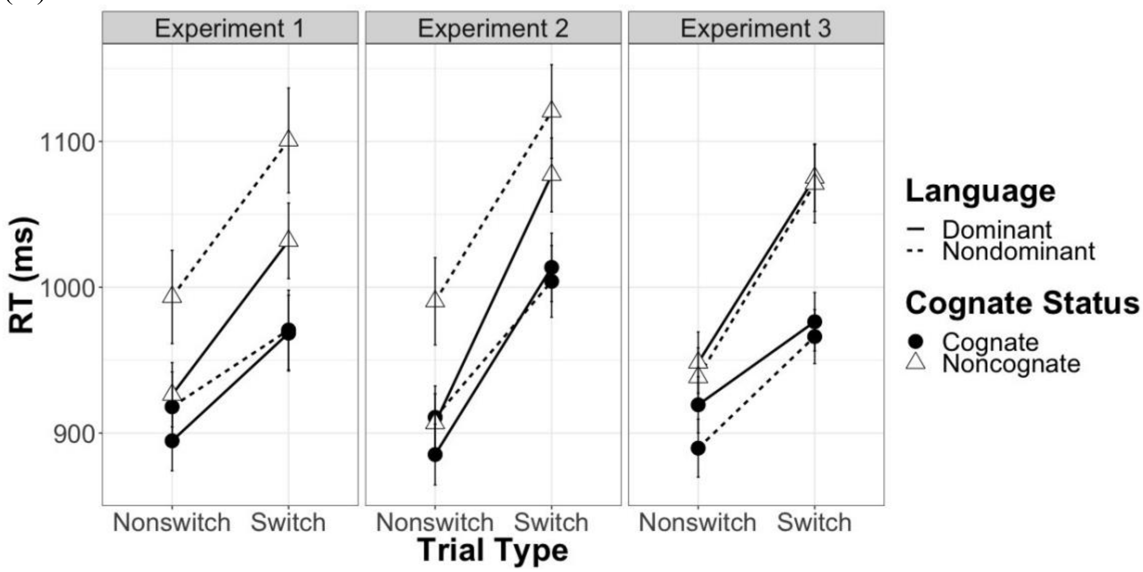


Figure 3. Mean picture naming response time (Panel A) and error rates (Panel B) for each trial type (switch vs. nonswitch) and language (dominant vs. nondominant) for cognates and noncognates in Experiment 3. Error bars represent 95% confidence interval.

(A)



(B)

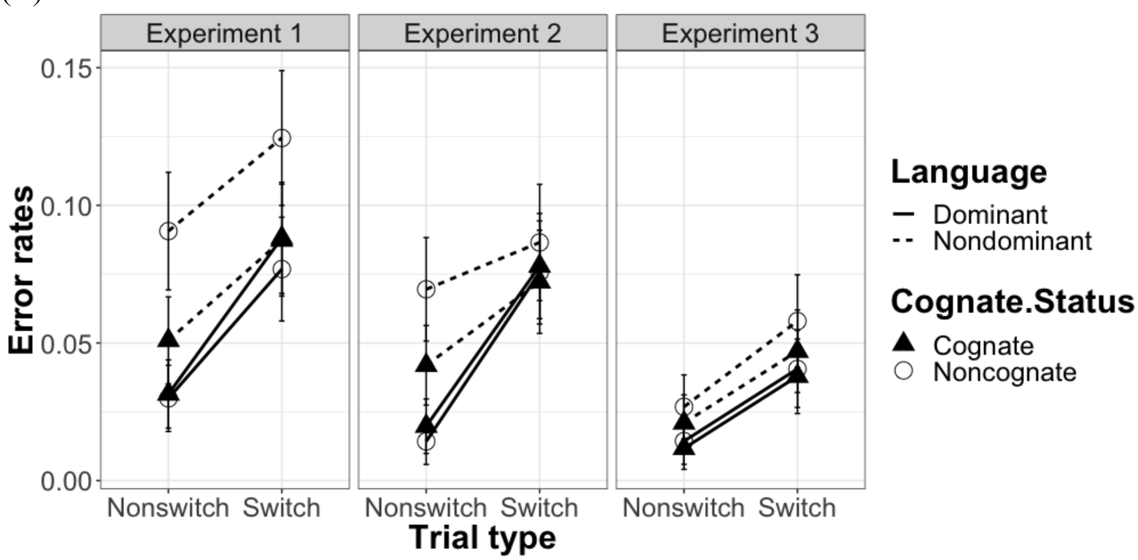


Figure 4. Mean picture naming response time (Panel A) and error rates (Panel B) for each trial type (switch vs. nonswitch) and language (dominant vs. nondominant) for cognates and noncognates in all experiments. Error bars represent 95% confidence interval.

Appendix A

In the present study, we minimized the number of repetitions (just four of each picture, 1 repetition in each language) to ensure each item appeared once in each trial type and each language. However, since Li and Gollan (2018a) found a difference between first presentations vs. when including all 12 repetitions, we ran a final set of analyses to check if even minimal repetitions might have modulated the results. For each experiment, we compared the results found in the first presentation to the repeated trials in an analysis with block number (Block 1 vs. the average of Blocks 2 to 4), trial type, cognate status, language, and all their interactions as fixed effects. Of greatest interest, all the above-reported effects held, and block number did not interact with cognate effects or cognate switch effects in any of the three experiments (i.e., nonsignificant block × cognate status × trial type interactions in all three experiments, *p*s > .11). See Table A1-A3 for the full results.

While repetition did not modulate the effect of greatest interest, we did observe some significant effects. With sentence context (in Experiments 1 and 2), bilinguals named pictures more quickly and with fewer errors in the later three blocks than in the 1st block (Experiment 1 RTs: M = 938 ms vs. 1078 ms; Experiment 1 error rates: M = 6.6% vs. 8.8%; Experiment 2 RTs: M = 960 ms vs. 1059 ms; Experiment 2 error rates: M = 5.1% vs. 7.3%; *ps* < .001). In addition, switch costs were larger in later blocks than the 1st block for both RTs and error rates (Experiment 1 RTs: M = 91 ms vs. 58 ms; Experiment 1 error rates: M = 5.0% vs. 2.4%; Experiment 2 RTs: M = 152 ms vs. 78 ms; Experiment 2 error rates: M = 5.0% vs. 2.0%; *p*s < .05), a result that is likely an artifact of our experimental design in which repeated blocks always switched the target language relative to the previous block (note that usually, if anything, switch costs *decrease* not increase with repetition; e.g., Kang et al., 2007, Kang, Ma, & Guo, 2017; Strobach, Liepelt, Schubert, & Kiesel, 2011; Timmer, Calabria & Costa, 2019) . By contrast, language dominance effects (i.e., slower responses in the nondominant than in the dominant language) were smaller in later blocks than the 1st block (Experiment 1: $M = 21$ ms vs. 89 ms; Experiment 2: $M = 27$ ms vs. 64 ms; ps < .05). Lastly, although cognates facilitated production more in the nondominant than dominant language overall, cognate facilitation effects were more symmetrical in later blocks (Experiment 1: $M = 104$ ms vs. 60 ms in the nondominant vs. dominant language respectively; Experiment 2: $M = 87$ ms vs. 45 ms) than the 1st block (Experiment 1: $M = 100$ ms vs. 7 ms in the nondominant vs. dominant language; Experiment 2: $M = 130$ ms vs. 29 ms), i.e., block × cognate status × language interactions (ps < .052). All other block number effects were not significant (ps > .10).

Without sentence context (i.e., in Experiment 3), block number did not show a significant main effect or interaction with any other predictors for RTs or error rates (ps > .20), except a block × trial type interaction for RTs that suggested switch costs in later blocks were larger than the 1st block ($M = 115$ ms vs. 45 ms; $p = .002$), which was consistent with the results in Experiments 1 and 2. The only repetition effects that were consistently shown in all experiments were that switch costs increased significantly after the first time that pictures were named, which was likely caused by our counterbalancing procedure (see footnote 4), and was consistent across all three experiments for both cognates and noncognates, and the dominant and nondominant languages. Critically, these repetition effects therefore did not influence the main questions we intended to investigate (and the results that we reported above).

Table A1. Full results of RT and error rates analysis of block/repetition effects in Experiment 1

	RTs				Error rates			
	β	SE β	χ^2	*p* value	β	SE β	χ^2	*p* value
Block	147.08	19.78	55.31	< 0.001	-0.40	0.12	10.67	< 0.001
Cognate Status	-76.93	28.67	7.20	0.007	0.21	0.22	0.86	0.354
Language	-52.09	19.05	7.48	0.006	0.51	0.24	4.59	0.032
Trial Type	82.93	11.02	56.64	< 0.001	-0.85	0.13	42.13	0.000
Block × Cognate Status	15.50	30.94	0.25	0.616	0.29	0.24	1.45	0.229
Block × Language	-62.81	20.28	9.59	0.002	-0.49	0.24	4.10	0.043
Block × Trial Type	-45.11	22.09	4.17	0.041	0.57	0.24	5.59	0.018
Cognate Status × Language	70.86	31.01	5.22	0.022	-0.67	0.45	2.24	0.134
Cognate Status × Trial Type	-44.24	18.84	5.52	0.019	-0.20	0.23	0.74	0.389
Language × Trial Type	14.30	22.16	0.42	0.519	-0.60	0.23	6.86	0.009
Block × Cognate Status × Language	80.97	36.26	4.99	0.026	-1.14	0.48	5.54	0.019
Block × Cognate Status × Trial Type	66.05	40.72	2.63	0.105	-0.31	0.48	0.41	0.522
Block × Language × Trial Type	32.62	42.44	0.59	0.442	-0.58	0.49	1.42	0.234
Cognate Status × Language × Trial Type	7.07	39.86	0.03	0.859	-0.05	0.45	0.01	0.913
Block × Cognate Status × Language × Trial Type	-22.46	101.37	0.05	0.825	-0.26	0.97	0.07	0.791

Table A2. Full results of RT and error rates analysis of block/repetition effects in Experiment 2

	RTs				Error rates			
	β	SE β	χ^2	*p* value	β	SE β	χ^2	*p* value
Block	103.15	20.52	25.27	< 0.001	-0.52	0.14	13.33	< 0.001
Cognate Status	-83.12	26.62	9.75	0.002	0.11	0.25	0.19	0.659
Language	-48.81	16.60	8.65	0.003	0.65	0.23	7.78	0.005
Trial Type	131.54	9.38	196.69	< 0.001	-1.15	0.16	53.72	< 0.001
Block × Cognate Status	-14.32	27.66	0.27	0.605	-0.21	0.28	0.53	0.465
Block × Language	-44.20	20.53	4.64	0.031	0.37	0.28	1.74	0.187
Block × Trial Type	-98.62	22.51	19.20	< 0.001	0.85	0.28	9.11	0.003
Cognate Status × Language	67.53	26.08	6.70	0.010	-0.70	0.44	2.52	0.112
Cognate Status × Trial Type	-39.51	16.62	5.65	0.017	-0.04	0.31	0.02	0.894
Language × Trial Type	46.52	17.76	6.86	0.009	-1.12	0.28	16.11	< 0.001
Block × Cognate Status × Language	82.34	42.38	3.78	0.052	-0.12	0.57	0.05	0.830
Block × Cognate Status × Trial Type	27.69	41.79	0.44	0.508	-0.50	0.57	0.80	0.372
Block × Language × Trial Type	-0.23	44.82	0.00	0.996	-0.09	0.57	0.03	0.873
Cognate Status × Language × Trial Type	-0.53	31.03	0.00	0.986	0.80	0.56	2.09	0.148
Block × Cognate Status × Language × Trial Type	63.27	83.40	0.58	0.448	-1.17	1.14	1.06	0.303

Table A3. Full results of RT and error rates analysis of block/repetition effects in Experiment 3

	RTs				Error rates			
	β	SE β	χ^2	*p* value	β	SE β	χ^2	*p* value
Block	22.26	14.06	2.51	0.113	-0.19	0.19	0.97	0.324
Cognate Status	-73.36	22.04	11.08	< 0.001	0.20	0.20	0.97	0.324
Language	9.02	13.48	0.45	0.503	0.49	0.26	3.62	0.057
Trial Type	97.16	10.50	85.67	< 0.001	-1.04	0.17	35.46	< 0.001
Block × Cognate Status	20.38	16.15	1.59	0.207	-0.28	0.38	0.55	0.459
Block × Language	-0.03	18.26	0.00	0.999	0.13	0.38	0.11	0.736
Block × Trial Type	-72.86	23.10	9.95	0.002	0.09	0.38	0.05	0.817
Cognate Status × Language	17.54	22.28	0.62	0.431	0.00	0.49	0.00	0.992
Cognate Status × Trial Type	-60.10	17.60	11.66	< 0.001	-0.11	0.35	0.10	0.753
Language × Trial Type	-8.80	19.08	0.21	0.645	-0.34	0.36	0.88	0.347
Block × Cognate Status × Language	-22.81	33.01	0.48	0.490	-0.64	0.77	0.69	0.407
Block × Cognate Status × Trial Type	62.14	45.25	1.89	0.170	0.99	0.77	1.66	0.198
Block × Language × Trial Type	38.23	38.92	0.96	0.326	0.38	0.77	0.25	0.620
Cognate Status × Language × Trial Type	-12.36	37.72	0.11	0.743	-0.19	0.69	0.08	0.780
Block × Cognate Status × Language × Trial Type	-77.43	70.91	1.19	0.275	0.86	1.54	0.31	0.575