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Cross-Language Activation Begins During Speech Planning and Extends Into Second Language Speech

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Abstract

Three groups of native English speakers named words aloud in Spanish, their second language (L2). Intermediate proficiency learners in a classroom setting (Experiment 1) and in a domestic immersion program (Experiment 2) were compared to a group of highly proficient English–Spanish speakers. All three groups named cognate words more quickly and accurately than matched noncognates, indicating that all speakers experienced cross-language activation during speech planning. However, only the classroom learners exhibited effects of cross-language activation in their articulation: Cognate words were named with shorter overall durations, but longer (more English-like) voice onset times. Inhibition of the first language during L2 speech planning appears to impact the stages of speech production at which cross-language activation patterns can be observed.

Keywords

second language speech; cognate effect; cross-language activation; cascading processing

Introduction

Recent studies provide compelling evidence that when bilinguals recognize and produce words in just one language, lexical representations in both languages are active in parallel (e.g., Dijkstra, 2005; Kroll, Bobb, & Wodniecka, 2006; Marian & Spivey, 2003). Such language nonselective activation is perhaps not surprising for learners at early stages of second language (L2) acquisition, for whom the more dominant first language (L1) can be expected to affect L2 processing at multiple levels of representation. The surprising observation is that, even for individuals who are highly proficient in the L2, many studies have demonstrated continued cross-language interaction, both from the L1 to the L2 and from the L2 to the L1 (Van Hell & Dijkstra, 2002). Moreover, such interaction has been

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observed for processes of lexical selection as well as grammatical encoding (Dussias, 2003; MacWhinney, 1997). The available evidence favors a system in which a bilingual's language boundaries are highly permeable.

The fundamental interactivity and plasticity revealed in bilingual processing has critical implications for understanding language performance more generally. In this article, we exploit the properties of L2 speech to examine an issue that remains unresolved in the literature on monolingual speech production: Can processes occurring at the lexical level of representation affect the articulatory realization of words? The answer to this question is crucial for understanding the flow of information during speech planning.

Theoretical Background

Speech Production: From Planning to Articulation

In strictly serial, discrete models of production, a selection must be made at the lexical level before articulation can be initiated (Levelt, 1989; Levelt, Roelofs, & Meyer, 1999). Such models therefore predict that lexical-level processes will not have articulatory consequences, because sublexical representations become active only after the target word has been selected. An alternative possibility is that the flow of information during speech planning is bidirectional and cascading (Dell, 1986; Rapp & Goldrick, 2000). Under this view, articulation may be initiated before competition between concurrently active representations has been fully resolved, with the result that variables affecting lexical selection may also influence the execution of the articulatory plan. The results of a study by Kello, Plaut, and MacWhinney (2000) support such a model. Using a Stroop paradigm, Kello et al. asked monolingual participants to name congruent and incongruent stimuli either at their own pace or under time pressure. In the time-stressed condition, Stroop effects were observed in reaction time data as well as articulatory (word duration) data, suggesting that competition among response alternatives extended into the production of speech. It should be noted, however, that Damian (2003) subsequently failed to replicate the Kello et al. results.

A study by Goldrick and Blumstein (2006) also reported spillover from planning to articulation, this time in the production of tongue twisters; erroneous productions of stop consonants were articulated more similarly to their competing alternatives than were accurate productions. In conjunction with Kello et al. (2000), these results suggest that speakers' articulatory realizations may reflect the influence of planning difficulty under stressed speaking conditions.¹ For L1 production, it is possible that planning must be highly or abnormally stressed for these spillover effects to be observed, perhaps explaining why relatively few studies have observed such effects. During L2 production, however, planning processes may consistently operate under high levels of stress, due to the relative weakness of L2 lexical and phonological representations and/or to a high level of competition from the more dominant L1.

The goal of the present study was to determine whether processes occurring during L2 speech planning can influence the execution of the L2 articulatory plan. Native English-

¹See Goldrick and Rapp (2007) for a related example from aphasic speech and Kawachi (2002) for evidence from speech errors.

speaking learners of Spanish were asked to name words in Spanish. Response time (RT) and accuracy were taken as indices of speech planning, and word duration and voice onset time (VOT) as indices of articulatory execution. The main question was whether the presence of language-ambiguous cognates—translation equivalents that share similar form across languages (e.g., *actor* or *hotel* in English and Spanish)—would influence both L2 speech planning and execution. Many studies have observed a cognate facilitation effect in bilinguals' and L2 learners' RTs (Dijkstra, Van Jaarsveld, & Ten Brinke, 1998; Kroll, Michael, Tokowicz, & Dufour, 2002; Schwartz, Kroll, & Diaz, 2007; Van Hell & Dijkstra, 2002). Relatively fewer studies have explored the consequences of cross-language activation for articulation. Recent work by Olson (2013) and by Goldrick, Runnqvist, and Costa (2014) provides evidence that processes occurring during planning can affect articulatory execution. In a language-switching paradigm, Spanish–English bilinguals in both studies produced VOTs with increased phonetic influence from the nontarget language on trials where they were required to switch languages, as compared to nonswitch trials. Olson's study additionally revealed an effect of language dominance (with only the more dominant language exhibiting cross-language phonetic influence), and Goldrick et al. additionally found an effect of cognate status (with cognates subject to greater influence from the nontarget language than noncognates). Amengual (2012) also examined the phonetic production of English–Spanish cognate words and also found greater cross-language phonetic influence from the nontarget language for cognates relative to noncognates, although the cognate effect was apparently unaffected by the language background of the speakers.

All of these results are consistent with a model of language production in which processes occurring during lexical access can spill over into articulatory execution. Crucially, however, none of these studies provide explicit data on both the planning stage and the articulatory stage of production; to our knowledge, no study to date has demonstrated simultaneous effects of cross-language activation on both naming times and speech articulation. Such a finding would constitute a significant contribution to the literature on bilingual speech articulation, a point to which we return below.

Articulatory Measures of Speech Production

First, a few words are in order concerning the articulatory variables examined here. We consider word duration as an index of general articulatory facilitation, but because the duration of a given word additionally depends on the segments with which it is composed, it is admittedly difficult to compare durations across words. The matching procedures used to identify noncognate control words will later be described in more depth, but for now we note that the absence of a cognate effect on word duration in some of the participant groups indicates that the matching procedures were effective. Stimulus matching for the VOT analysis was relatively more straightforward, but the precise contribution of this analysis to the literature on bilingual articulation deserves some additional elaboration.

Many previous studies have examined VOT production in bilinguals and L2 learners. The focus of such work has typically been to shed light on the ways in which language experience affects phonological category formation; given a L1 and L2 with significantly

different target VOTs, comparing a bilingual's realization of VOT to the monolingual category norms provides evidence as to whether the L1 and L2 phonological systems are merged or fully autonomous. A large body of work by Flege and colleagues (for VOT, see Flege, 1991; Flege & Eefting, 1988; Flege & Hillenbrand, 1984; for vowel production, see Flege, Schirru, & MacKay, 2003) has investigated the ways in which phonetic and phonological similarities between languages, in combination with factors related to L2 exposure, promote the establishment of separate L2 phonological categories. In a related vein, some researchers have asked whether factors such as explicit phonetic instruction (Lord, 2005) and the context of L2 learning (Díaz-Campos, 2004) impact learners' attainment of monolingual-like phonetic norms.

Importantly, these studies have focused on the nature of the L2 phonological system, with the underlying assumption that phonological categories exist in an abstract steady state, distinct from the words in which they appear, and divorced from the processing-related variables that have been shown to impact other aspects of bilingual language performance. The strength of the present investigation is that it explicitly asks whether variables known to affect online lexical processing are also associated with differences in articulatory execution and, if so, under what circumstances. We believe this to be a significant contribution to the literature on bilingual speech production, because it moves beyond the debate on merged versus autonomous phonological systems, and beyond the question of presence versus absence of cross-language activation during planning, to ask how far such interactivity extends into the planning process and which factors condition the types of interactivity we observe. Finally, to the extent that we believe bilingual speech production to be representative of speech production more generally, the present investigation brings new evidence to bear on the question of information flow during planning, which is relevant to monolingual populations as well.

The Current Studies

The rest of the article is organized as follows. Experiment 1 asks whether effects of cross-language activation can be observed during speech planning and execution by examining word naming in two groups of L2 Spanish speakers: a group of intermediate-proficiency classroom learners and a group of fluent, highly proficient Spanish language instructors, both at Pennsylvania State University. Word naming was chosen as the target task because even the least proficient learners are able to read words aloud in the L2. Based on previous findings, we predicted that cross-language activation would be generally facilitative for both groups of speakers; English–Spanish cognates should be named with faster RTs and greater accuracy when compared to noncognate Spanish words. With respect to the predictions for articulatory execution, we hypothesized that this general facilitation would extend to speakers' word durations, with greater phonological overlap for cognates resulting in both faster naming times and faster articulation. With respect to VOT, however, the increased activation of L1 English phonological representations could have a qualitative influence on the L2 production targets. We therefore hypothesized that VOTs would be longer (more English-like) for cognates as compared to noncognates.

A second question of interest in Experiment 1 was whether both groups would demonstrate cognate effects or whether the influence of cross-language activation would be modulated by language proficiency. While many studies have demonstrated cognate effects for bilinguals and proficient L2 learners (e.g., Van Hell & Dijkstra, 2002), there is evidence to suggest that cognate effects may become attenuated or nonexistent as L2 proficiency increases. Kroll et al. (2002), for example, argued that, as speakers gain L2 proficiency, L2 representations become more autonomous, L2 performance becomes increasingly automatized, and cognate effects may disappear under some circumstances. Particularly within the realm of speech articulation, a highly automatized process, it is reasonable to hypothesize that any cognate effects could diminish or disappear as speakers gain L2 proficiency.

Of course, L2 proficiency is often confounded with the development of inhibitory control mechanisms; as speakers become more proficient, they also gain practice inhibiting the more dominant L1. In Experiment 2, therefore, we extend our investigation to intermediate L2 learners participating in a domestic summer immersion program. Previous studies have indicated a reduced influence of the L1 in a L2 immersion context (e.g., Baus, Costa, & Carreiras, 2013; Linck, Kroll, & Sunderman, 2009). Our main hypothesis was therefore that, despite equivalent L2 proficiency for the classroom and immersed learners, the forced inhibition of the L1 in the summer immersion program would result in reduced L1 influence during L2 production. Reduced L1 influence could be reflected in any of the dependent measures we examine, but given the apparent pervasiveness of cognate effects on bilingual naming times (e.g., Schwartz et al., 2007), we predicted that the articulatory measures would be most sensitive to any effects of reduced L1 activation in the immersed group.

Experiment 1: Classroom Learners of Spanish Versus Advanced L2 Speakers

Method

Participants—Twenty-four L1 native English speakers were recruited from intermediate-level Spanish courses at Pennsylvania State University. A second group of 17 highly proficient advanced L2 Spanish speakers was recruited from the pool of native English-speaking Spanish instructors to provide a comparison. All participants completed a detailed language history questionnaire that included a self-assessment of their skill level in speaking, comprehension, reading, and writing, in both Spanish and English. As an online measure of lexical knowledge in Spanish, all participants also completed a Spanish lexical decision task. Spanish words and nonwords were presented one at a time and participants were asked to indicate whether each letter string was a real word by pressing a “yes” or “no” button. We report accuracy for the nonword trials as a measure of L2 proficiency.²

Materials—Fifty Spanish words with English cognates³ and 50 frequency-matched Spanish control words were used for RT and error-rate analysis. For the word duration

²Focusing on the nonword trials is a way of taking into account the false-alarm rate. An alternative option would be to calculate d' over all trials, but we report percentage accuracy for nonword trials as a more intuitive number.

³An anonymous reviewer points out that some of the cognate words had completely overlapping orthography (e.g., *piano* in Spanish and English), while some differed by one or more letters (e.g., *poeta* in Spanish, but *poet* in English). An earlier version of the

analysis, the same 50 cognates (plus one additional word) were compared to 51 phonetically matched noncognates. Phonetic control words were matched as closely as possible for phoneme identity and count, syllable count, and stress placement. Twenty total words were examined in the VOT analysis (10 cognates, 10 matched noncognates). Matching for the words in the VOT analysis took into consideration all of the factors listed above, with the additional constraint that control words must begin with the same consonant–vowel sequence as their matched cognate. In some cases it was possible to find a single phonetic control word that could be examined in both the word duration and VOT analyses (e.g., the duration and VOT for *cable* were compared to the duration and VOT for *cabe*). In some cases, however, it was necessary to pair the cognate word with different phonetic controls in the two analyses (e.g., for the cognate word *terror*, its duration was compared to *lector*, but its VOT was compared to that of *tercer*). All of the stimuli are included in Appendix S1 in the Supporting Information online.

Procedure—Participants first completed a speeded naming task: One Spanish word at a time appeared on a computer screen, and participants were instructed to simply name it as quickly as possible. Stimulus presentation and randomization were controlled by the E-Prime experimental software (Schneider, Eschman, & Zuccolotto, 2002). Participants completed a short practice block before continuing on to the experimental items. Naming latencies were recorded via a voice key, which triggered the next trial. After 1,000 milliseconds, if no response had been initiated, the word disappeared from the screen, and the next word appeared. Responses were recorded for acoustic analysis via a Shure SM-10A microphone and were digitized at 44.1 kHz with 16-bit sampling on a Marantz CDR300 professional CD recorder. Following the naming task, participants performed a Spanish lexical decision task to provide an objective measure of lexical proficiency. At the end of the experimental session, participants completed a language history questionnaire, yielding self-ratings for reading, writing, speaking, and auditory comprehension in Spanish and English.

Results

Participant Profile—Table 1 summarizes the characteristics of all three groups of participants in these experiments. The data from Experiment 1 comparing the classroom learners to the advanced speakers are in the leftmost and rightmost columns, respectively. Self-ratings on a scale of 1–10 are given for participants' speaking, spoken language comprehension, writing, and reading skills in both Spanish and English, where 1 is least proficient and 10 is most proficient. The table also provides the nonword accuracy scores for the Spanish lexical decision task. Participants' mean age and mean number of years learning Spanish are also given for each group.

A comparison of the groups revealed no significant differences overall for self-reported proficiency in L1 English, with mean L1 proficiency ratings of 9.6 versus 9.8 for the classroom learners versus advanced speakers, respectively, $t(39) = -1.40$, $p = .17$, $d = -.44$. The individual ratings for spoken English, $t(39) = .20$, $p = .84$, $d = .06$, English writing, $t(39)$

analyses presented here compared orthographically identical cognates to nonidentical cognates (Jacobs, 2007). Because the cognate effect was present independently of orthographic overlap, we have collapsed these categories here in order to simplify the analyses.

$= -1.16$, $p = .25$, $d = -.37$, and English reading, $t(39) = -1.05$, $p = .30$, $d = -.33$, were all not significantly different. The ratings for English comprehension were marginally different, $t(39) = -1.97$, $p = .06$, $d = -.63$, with slightly higher ratings given by the advanced L2 speakers (9.9 vs. 9.6). For L2 Spanish, the advanced proficiency group had significantly higher self-ratings for all measures relative to the classroom group: overall (8.0 vs. 6.3), $t(39) = 5.41$, $p < .001$, $d = 1.72$, speaking (7.8 vs. 5.8), $t(39) = 5.07$, $p < .001$, $d = 1.61$, spoken comprehension (8.5 vs. 6.6), $t(39) = 4.36$, $p < .001$, $d = 1.38$, writing (7.6 vs. 6.4), $t(39) = 3.09$, $p = .004$, $d = .98$, and reading (8.2 vs. 6.4), $t(39) = 5.89$, $p < .001$, $d = 1.87$. The advanced group was also more accurate in rejecting nonwords in the Spanish lexical decision task than the classroom learners (84.5% vs. 65.9% accuracy), $t(39) = 4.41$, $p < .001$, $d = 1.40$. The advanced L2 speakers were older than the classroom learners (mean ages of 33.4 vs. 20.3 years), $t(39) = 6.24$, $p < .001$, $d = 1.98$, and had also amassed significantly more experience with Spanish (18.6 vs. 6.9 years), $t(39) = 4.93$, $p < .001$, $d = 1.56$.

Naming Latency and Accuracy—Naming latencies that exceeded 2,000 milliseconds were considered outliers and excluded from the analyses. Latencies that were 2.5 standard deviations above or below each participant's mean were also considered outliers and excluded from subsequent analyses. False starts, mispronunciations, and missing responses were all considered errors, yielding naming accuracy data for each group. Word duration and VOT were hand-labeled based on a visual display of the acoustic waveform and spectrogram. For the word durations, boundaries were placed at the onset and offset of the acoustic energy associated with each word. For VOT, boundaries were placed at the stop burst and at the first zero crossing associated with the onset of vowel periodicity. The RT, accuracy, word duration, and VOT data were then averaged across items, yielding two values for each speaker (cognate vs. noncognate means).⁴ These means were submitted to two-way mixed analyses of variance (ANOVAs), with participant group (classroom learners vs. advanced speakers) as a between-subjects factor and word type (cognate vs. control) as a within-subjects factor. Post hoc comparisons were then carried out as warranted using paired t tests for the RT, accuracy, and word duration data and Wilcoxon's signed rank test for the VOT data; the former were reasonably normally distributed, while the latter followed a skewed distribution. We report Cohen's d as a measure of effect size for all comparisons (with the exception of the VOT data, for which we report r), where values up to .2 are considered a small effect, values between .2 and .5 are medium, and values above .5 are large.

The ANOVA examining RT revealed a significant main effect of word type, $F(1, 39) = 12.35$, $p = .001$, $d = 1.14$. For both participant groups, cognates were named faster than the frequency-matched, noncognate controls (643.5 vs. 662.6 milliseconds). There was no main effect of group on response latency, $F(1, 39) = 1.21$, $p = .28$, $d = .36$, and no significant interaction between word type and group, $F(1, 39) = .33$, $p = .57$, $d = .19$. The RT data for Experiments 1 and 2 are depicted in Figure 1; the participant groups are ordered from lowest to highest proficiency, such that the classroom learners are on the left, while the advanced speakers are on the right.

⁴Because the items in each condition were carefully matched according to multiple criteria, we follow the recommendations in Raaijmakers, Schrijnemakers, and Gremmen (1999) and report only by-subjects analyses.

Recall that two different sets of control words were necessary in the present investigation; one set of controls was matched on word frequency for the purpose of the RT and accuracy analysis, and a second set served as phonetic controls for the purpose of comparing word duration and VOT. It is possible that the focus on the phonetic properties of the second set of control words could have resulted in the selection of phonetic controls with abnormally high or low frequency or with other anomalous properties, which could in turn affect the way in which they were processed. To determine whether this was the case, we also performed an ANOVA comparing the RT data for the cognates and the phonetic controls. The results were qualitatively the same as in the analysis of the frequency-matched controls. A significant main effect was found for word type; cognates were named faster than their phonetic controls (643.5 vs. 678.0 milliseconds), $F(1, 39) = 31.16$, $p < .001$, $d = 1.81$. There was again no significant RT difference between the two participant groups, $F(1, 39) = 1.21$, $p = .28$, $d = .36$, and no significant interaction between word type and group, $F(1, 39) = .24$, $p = .63$, $d = .16$. These results demonstrate that the cognate facilitation effect is robust and that any significant differences in articulatory execution between cognates and their phonetic controls can likely be attributed to processes occurring during the planning phase.

The analysis of the accuracy data followed the same logic, comparing the cognates to both their frequency-matched and phonetically matched controls. In the ANOVA comparing cognates to their frequency-matched controls, there was a significant main effect of cognate status, with cognates named more accurately than controls (92% vs. 88% accuracy), $F(1, 39) = 26.51$, $p < .001$, $d = 1.67$. Unlike the RT analyses, there was a significant difference in overall accuracy between the two participant groups, with the more proficient group making fewer errors than the classroom learners (92% vs. 89% accuracy), $F(1, 39) = 9.77$, $p = .003$, $d = 1.02$. There was no significant interaction between word type and group, $F(1, 39) = .40$, $p = .86$, $d = .21$. The comparison with the phonetic controls revealed the same pattern.

The RT and accuracy results replicate previous studies in demonstrating that cognates are named more rapidly and accurately than noncognates in the L2 (Kroll et al., 2002; Schwartz et al., 2007). The presence of a significant cognate effect for both groups of participants indicates that cross-language activation was not restricted to learners at early stages of L2 acquisition. This is consistent with past studies demonstrating that both learners and more proficient speakers are sensitive to the influence of the language not in use (Guo, Misra, Tam, & Kroll, 2012; Kroll & Gollan, 2014; Sunderman & Kroll, 2006; Thierry & Wu, 2007). Having demonstrated that this was the case for both participant groups in the present experiment, we now turn our attention to the analysis of the articulatory data. The question of interest is whether the evidence for cross-language activation extends from the planning stages into the articulatory realization of L2 speech. If the flow of information during planning is discrete and modular, then processes occurring at the lexical level of representation (such as cross-linguistic activation of cognate words) should not affect the realization of articulatory gestures.

Word Duration—The word duration data were submitted to a 2×2 mixed ANOVA examining the effects of participant group (classroom learners vs. advanced speakers) and word type (cognate vs. phonetically matched control). There was a significant main effect of cognate status, with shorter durations for cognates than phonetic controls (558.8 vs. 566.1

milliseconds), $F(1, 39) = 10.94$, $p = .002$, $d = 1.08$. There was also a significant main effect of group, such that the advanced speakers produced shorter overall durations than the classroom learners (533.0 vs. 591.9 milliseconds), $F(1, 39) = 9.93$, $p = .003$, $d = 1.02$. Critically, and unlike the analyses of RT and accuracy, there was a significant interaction between cognate status and group, $F(1, 39) = 7.70$, $p = .008$, $d = .90$. Post hoc comparisons revealed that the main effect of cognate status on word duration was highly reliable for the classroom learners (585.2 vs. 598.5 milliseconds), $t(23) = 4.59$, $p < .001$, $d = .21$, but nonexistent for the advanced speakers (532.4 vs. 533.6 milliseconds), $t(16) = .06$, $p = .95$, $d = .022$. The word duration data are depicted in Figure 2.

VOT—A 2×2 mixed ANOVA targeting the VOT data indicated that the main effect of cognate status was marginally significant (27.5 vs. 26.5 milliseconds), $F(1, 39) = 3.44$, $p = .071$, $d = .60$, with slightly longer (i.e., more English-like) VOTs in cognates than in control words. There was a main effect of speaker group (22.4 vs. 31.5 milliseconds), $F(1, 39) = 9.96$, $p = .003$, $d = 1.03$, with the advanced speakers produced significantly shorter (i.e., more Spanish-like) VOTs than the classroom learners. However, these main effects were qualified by a significant interaction between cognate status and speaker group, $F(1, 39) = 7.04$, $p = .01$, $d = .86$. Post hoc comparisons again revealed that the cognate effect on articulation was driven entirely by the classroom learners (32.7 vs. 30.3 milliseconds), $W = 242$, $Z = 2.63$, $p = .007$, $r = .54$, and was not significant for the advanced speakers (22.2 vs. 22.6 milliseconds), $W = 64$, $Z = -.59$, $p = .58$, $r = -.14$. The VOT data are depicted in Figure 3.

Discussion

In Experiment 1, two groups of native English speakers—one highly proficient in L2 Spanish and the other at an intermediate level of L2 Spanish proficiency—were asked to simply name Spanish words as they appeared on a computer screen. The crucial manipulation was whether the Spanish words were cognates with the speakers' L1, English. Consistent with previous findings, all speakers revealed cognate facilitation during the planning stages of production, as reflected in both RTs and accuracy. Critically, an analysis of the acoustic properties of speakers' productions revealed significant differences in cross-linguistic influence depending on speakers' proficiency level. Classroom learners, but not advanced speakers, produced cognate words with significantly shorter total durations, but significantly longer (more English-like) VOTs, presumably due to the coactivation of English phonological representations.

In previous work on cognate effects in bilingual language production, two main accounts of cognate facilitation have emerged. The “weaker links” hypothesis posits that the relative frequency of use of the bilingual speaker's two languages is in some cases responsible for slowed lexical retrieval for the less frequently accessed items (Gollan, Montoya, Cera, & Sandoval, 2008; Baus et al., 2013). Under this account, representations that are similar in L1 and L2, such as cognates, may partially inherit the frequency of their other-language counterpart. Access to noncognates is therefore predicted to be noticeably slower, especially in the less frequently used language, while access to cognates should be relatively spared.

An alternative explanation appeals to the way in which activation spreads throughout the network of lexical and phonological representations as the speaker prepares to articulate the target word. Under this account, cognates become more active than noncognates during retrieval due to their phonological and semantic connections to the nontarget language. While the spreading activation and weaker links hypotheses are not mutually exclusive, we favor an activation-based account of the Experiment 1 results for several reasons. First, a frequency-based account predicts that cognate effects in the L2 should generally decrease over time, as greater experience with noncognates allows them to catch up with cognates. However, we found no difference in the size of the cognate effect as a function of L2 proficiency. This suggests that, at least for these speakers, the cognate effect on RTs is more likely to have been the result of automatic cross-language activation, the magnitude of which was unaffected by L2 proficiency. Second, the weaker links hypothesis does not make a clear prediction with respect to the articulatory data. Even if the strength of the connections associated with cognates versus noncognates is responsible for the observed differences in RT, at present it is not obvious how connection strength maps on to articulatory execution. It would be possible to stipulate that greater connection strength is associated with faster articulation, but because the effect of cognate status on Spanish VOT was a qualitative blending of English and Spanish phonological targets, an activation-based account provides a more parsimonious explanation of both the RT and articulation data.

If we accept the spreading activation account of the Experiment 1 results, we are then faced with the question of why only the less proficient classroom learners exhibited cognate effects in their L2 articulation. One interpretation of this finding is that, at lower levels of L2 proficiency, speakers encounter more difficulty resolving or inhibiting cross-linguistic activation patterns during planning, allowing the influence of the nontarget language to spill over into the articulatory realization of phonologically related words. Recent studies focusing on inhibitory control during proficient bilingual language use suggest that bilinguals develop control mechanisms in both comprehension (e.g., Martín, Macizo, & Bajo, 2010) and production (e.g., Misra, Guo, Bobb, & Kroll, 2012) in order to regulate the language not in use and enable fluent performance. Blumenfeld and Marian (2011) demonstrated that both bilinguals and monolinguals activate competing within-language alternatives (e.g., when hearing *plu-*, both groups experienced competition between the lexical items *plum* and *plug*), but that proficient bilinguals are able to control the consequences of such lexical activation more efficiently. Similarly, the pattern of results in Experiment 1 may demonstrate that, during speech planning in the L2, both learners and proficient speakers activate lexical representations in the L1, but the more proficient speakers are better able to control the consequences of that activation. A second interpretation, not necessarily mutually exclusive with the first, is that such effects may be compounded by the relatively high demands placed on the bilingual production system; on analogy with Kello et al. (2000), it is possible that cross-linguistic activation during bilingual production continually puts speakers in the position of articulating before planning is entirely complete.

In either case, the Experiment 1 results complicate the picture of cognate learning. Although cognates may in some sense be easier to learn than noncognates (e.g., De Groot & Keijzer, 2002), accurate phonetic production of L2 cognates may ultimately be more difficult due to

cross-language activation patterns. The finding that classroom learners' productions of VOT and word duration differed for cognates versus phonetic controls suggests that accurate L2 production requires not only acquiring L2 lexical and phonological representations, but also controlling the influence of the L1 during planning.

If the cognate effects on articulation in Experiment 1 are the result of controlling the influence of the L1, then it should be possible to isolate the role of inhibitory control in this process. Because more proficient L2 speakers will generally have accumulated more experience regulating the L1, Experiment 1 does not allow us to distinguish between the possibility that inhibition of the L1 versus general proficiency in the L2 were responsible for the results. The goal of Experiment 2 was therefore to isolate the role of L1 inhibition during L2 production by examining the performance of another group of L2 Spanish learners who were immersed in a summer program in which they were not permitted to speak English. We hypothesized that the forced inhibition of the L1 in the immersion setting would result in reduced cognate effects for the learners in Experiment 2. If this prediction is borne out, it would suggest that the differences between the two L2 speaker groups in Experiment 1 can be attributed in part to the control of L1 activation during speech planning.

Experiment 2: Immersed Learners of Spanish Versus Advanced L2 Speakers

Recent studies indicate that increased L2 use is associated with reduced availability of the L1 in both a laboratory setting (Levy, McVeigh, Marful, & Anderson, 2007) and during actual language immersion in the L2 (Baus et al., 2013; Linck et al., 2009), shown through measures of both comprehension and production. Experiment 2 examined the performance of a group of intermediate learners of Spanish who were immersed in a domestic summer program. Perhaps surprisingly, it is not uncommon for participants in domestic immersion programs to be under a stricter requirement to inhibit their L1 than participants in foreign immersion programs; the participants in Experiment 2, for example, all signed a contract promising not to use their L1 (English) for the duration of the program, whereas speakers immersed in a foreign environment are not necessarily subject to the same absolute requirement to suppress the L1 at all times. If differences in the strength of L1 inhibition are responsible for the effect of cognate status on the articulatory measures reported in Experiment 1, then participants in Experiment 2 may pattern with the more advanced learners rather than with their proficiency-matched peers. Indeed, if the forced inhibition of the L1 that is legislated by the domestic immersion context affords learners significant control over their L1, then we might not expect to see cognate effects in any of the measures for the immersed learners.

Method

Participants—Fifty L1 native English-speaking, intermediate-level learners of Spanish were recruited from the Middlebury summer language program, an intensive domestic immersion program in which participants sign an agreement to speak exclusively in Spanish for the duration of the program. Testing took place approximately halfway through the 7-week immersion program. In the analysis of Experiment 2, the Middlebury participants'

performance was compared to that of the same advanced proficiency Spanish speakers who served as the comparison in Experiment 1. The prediction was that, contrary to the classroom learners in Experiment 1, the Middlebury learners would pattern with the advanced Spanish speakers in terms of their ability to inhibit L1 English. We therefore predicted no significant interactions between cognate status and participant group in the analysis of Experiment 2.

Materials and Procedure—The materials and procedure for Experiment 2 were exactly the same as in Experiment 1. The only difference between the two experiments is the participant groups being compared.

Results

Participant Profiles—A comparison of the two groups revealed that the advanced Spanish speakers generally rated their L1 English abilities slightly higher than the immersed participants, with average composite L1 ratings of 9.8 vs. 9.3, $t(65) = 2.29$, $p = .03$, $d = .64$. The differences for L1 reading (9.7 vs. 9.4), $t(65) = 1.37$, $p = .17$, $d = .39$, and speaking (9.8 vs. 9.2), $t(65) = 1.38$, $p = .17$, $d = .39$, were not significant; the difference in L1 comprehension was marginally significant (9.9 vs. 9.6), $t(65) = 1.96$, $p = .05$, $d = .55$, and the difference in L1 writing was significant (9.6 vs. 9.0), $t(65) = 2.47$, $p = .02$, $d = .69$. It is possible that, in the context of controlled immersion, the lower ratings for the immersed group reflected suppression of their L1 skills. This stands in contrast with the same comparison for the classroom learners, whose L1 ratings were more similar to those of the advanced Spanish speakers. This result may be akin to other findings suggesting that L2 immersion affects speakers' access to the L1 (e.g., Baus et al., 2013; Linck et al., 2009).

As expected, the high-proficiency speakers rated themselves significantly higher for all four dimensions of L2 Spanish proficiency: speaking (7.8 vs. 5.6), $t(65) = 5.54$, $p < .001$, $d = 1.56$; comprehension (8.5 vs. 6.9), $t(65) = 3.60$, $p < .001$, $d = 1.01$; writing (7.6 vs. 5.9), $t(65) = 3.89$, $p < .001$, $d = 1.09$; and reading (8.2 vs. 6.1), $t(65) = 5.33$, $p < .001$, $d = 1.50$. Given these differences in measures of individual skills, it is not surprising that the difference between overall L2 ratings was also significant (8.0 vs. 6.1), $t(65) = 5.10$, $p < .001$, $d = 1.43$. The high-proficiency group also performed better on the Spanish lexical decision task, exhibiting significantly higher nonword accuracy than the immersed learners (84.5% vs. 68.7%), $t(65) = 3.09$, $p = .003$, $d = .87$. The advanced speakers were also significantly older than the immersed group (33.4 vs. 26.3 years), $t(65) = 2.55$, $p = .01$, $d = .72$, and had significantly more experience with L2 Spanish (18.6 vs. 9.8 years), $t(65) = 3.95$, $p < .001$, $d = 1.11$.

Naming Latency and Accuracy—As in Experiment 1, two-way mixed ANOVAs, with participant group (immersed learners vs. high-proficiency speakers) and word type (cognate vs. control) as factors were performed on the measures of response time (RT), percent accuracy, word duration, and VOT. Summary data are illustrated in Figures 1–3, where the performance of the immersed learners can be compared to that of the classroom learners and advanced speakers.

The ANOVA revealed a significant main effect of cognate status on RT, with cognates named faster than the frequency matched, noncognate controls (622.5 vs. 638.5 milliseconds), $F(1, 65) = 15.68, p < .001, d = 1.13$. As in Experiment 1, there was no significant difference between the two groups with respect to overall response latency, $F(1, 65) = .17, p = .68, d = .12$, and no significant interaction between word type and participant group, $F(1, 65) = 0, p = .99, d = 0$. The same pattern of results held when comparing the accuracy of cognates and their noncognate frequency- matched controls. Cognates exhibited significantly fewer errors (90% vs. 88% accuracy), $F(1, 65) = 36.08, p < .001, d = 1.71$; advanced learners committed significantly fewer errors (92% vs. 86%), $F(1, 65) = 12.65, p = .001, d = 1.01$; and there was no significant interaction between word type and group, $F(1, 65) = 0, p = .99, d = 0$. The RT data are shown in Figure 1.

Also as in Experiment 1, we wished to exclude the possibility that RT and accuracy for the phonetic control words was in some way anomalous. A two-way mixed ANOVA comparing the RT data for the cognates to those of the phonetic controls indicated the same pattern of results as for the frequency-matched controls. A significant main effect was found for word type; cognates were named faster than their phonetic controls (622.5 vs. 655.2 milliseconds), $F(1, 65) = 36.90, p < .001, d = 1.73$. There was again no significant difference between the participant groups with respect to response latency, $F(1, 65) = .16, p = .69, d = .11$, and no significant interaction between word type and participant group, $F(1, 65) = 0, p = .97, d = 0$. The ANOVA comparing accuracy of cognates to the phonetic controls again indicated a significant main effect for word type, with cognates named more accurately than their phonetic controls (89% vs. 83%), $F(1, 65) = 36.1, p < .001, d = 1.71$. There was a significant main effect of participant group, with high proficiency speakers committing fewer errors than immersed learners (91% vs. 84% accuracy), $F(1, 65) = 12.6, p < .001, d = 1.01$. There was no significant interaction between word type and participant group, $F(1, 65) = .57, p = .45, d = .22$.

Word Duration—A two-way mixed ANOVA examining word duration returned no significant main effect for participant group (533.0 vs. 553.3 milliseconds), $F(1, 65) = 1.55, p = .22, d = .36$. There was also no significant main effect for cognate status; cognates were not shorter in duration than noncognate controls (541.7 vs. 544.6 milliseconds), $F(1, 65) = 1.70, p = .20, d = .37$, and in contrast to Experiment 1, there was no significant interaction between cognate status and group, $F(1, 65) = .59, p = .45, d = .22$. The word-duration data are plotted in Figure 2.

VOT—The analysis of VOT indicated a significant main effect of speaker group; the advanced speakers produced significantly shorter VOTs than the immersed learners (22.4 vs. 28.5 milliseconds), $F(1, 65) = 9.81, p = .003, d = .89$. There was no significant main effect of cognate status (25.3 vs. 25.6 milliseconds), $F(1, 65) = 1.26, p = .27, d = .32$, and as in the analysis of word duration, there was no significant interaction between cognate status and participant group, $F(1, 65) = .08, p = .78, d = .08$. The VOT data are plotted in Figure 3.

Discussion

As in Experiment 1, the analyses of RT and accuracy in Experiment 2 revealed a cognate facilitation effect during speech planning. Both the high-proficiency L2 speakers and the immersed L2 learners in Experiment 2 were faster and more accurate when naming Spanish cognate words as compared to a set of frequency-matched noncognate controls. This result is consistent with Experiment 1, in which RT and accuracy for a group of L2 classroom learners also exhibited a cognate facilitation effect on planning.

In contrast to Experiment 1, in Experiment 2 the cognate facilitation effect was not evident in measures of the immersed learners' articulation.⁵ In Experiment 1, the classroom learners produced cognates with longer VOTs and shorter total word duration, as compared to a set of phonetically matched noncognates. In the interpretation of Experiment 1, we argued that significant differences in the processing of cognate versus noncognate words (as revealed in the RT and accuracy results) could be attributed to cross-linguistic activation during planning and that the influence of this cross-linguistic activation extended into the classroom learners' articulation. This interpretation is consistent with spreading activation models of speech production in which processes occurring at the lexical and phonological levels of planning can cascade down to affect the articulatory realization of speech (e.g., Dell, 1986).

Because the classroom learners in Experiment 1 and the immersed learners in Experiment 2 were of comparable L2 proficiency levels, the fact that only the classroom learners exhibited an effect of cognate status on articulation suggests that this spillover effect should not be attributed to a difference in L2 proficiency alone.⁶ Indeed, the immersed learners still produced significantly longer (more English-like) VOTs than the advanced speakers. The finding that neither the high-proficiency speakers nor the immersed learners in Experiment 2 exhibited a cognate effect on articulation suggests that the ability to inhibit the nontarget language was the operative factor rather than proficiency. In line with this suggestion, it is interesting to note that the immersed learners had the shortest RTs overall—considerably shorter even than the RT of advanced speakers—despite the fact that they were of significantly lower proficiency than the advanced speakers according to all metrics. Taken together, these results provide evidence for a dissociation between L2 proficiency and L1 inhibition. Outside of the immersion context, it is likely that proficiency and inhibitory control tend to be correlated; more proficient L2 speakers will generally also have acquired more practice regulating their L1. However, the L2 immersion setting appears to have resulted in a qualitative similarity between the immersed learners and the advanced speakers

⁵For the sake of completeness, we include here the omnibus analyses of the two experiments. For RT, a 3 (subject group) $\times 2$ (cognate status) repeated-measures ANOVA returned a significant main effect of cognate status only, $F(2, 88) = 27.45$, $p < .001$, $\eta_p^2 = .24$. There was no main effect of group, $F(2, 88) = 1.52$, $p = .23$, $\eta_p^2 = .03$, and no interaction, $F(2, 88) = .40$, $p = .67$, $\eta_p^2 = .009$. For word duration, a 3×2 ANOVA returned a significant main effect of cognate status, $F(2, 88) = 13.06$, $p = .001$, $\eta_p^2 = .13$, a significant main effect of group, $F(2, 88) = 5.56$, $p = .005$, $\eta_p^2 = .11$, and a significant interaction, $F(2, 88) = 3.92$, $p = .02$, $\eta_p^2 = .08$, reflecting the fact that the cognate effect was only reliably present for the classroom learners (see text for discussion). For VOT, a 3×2 ANOVA returned no significant effect of cognate status, $F(2, 88) = 3.09$, $p = .08$, $\eta_p^2 = .08$, but a significant main effect of group, $F(2, 88) = 6.31$, $p = .003$, $\eta_p^2 = .13$, and a significant interaction, $F(2, 88) = 9.63$, $p < .001$, $\eta_p^2 = .18$, again reflecting the fact that the cognate effect was reliable only for the classroom learners.

⁶An anonymous reviewer points out that the immersed group was older than the classroom group and had amassed more L2 experience at the time of testing, making it difficult to exclude the possibility that these factors contributed to the between-group differences. We conducted an additional set of analyses using data from a subset of the immersed ($n = 22$) and classroom learners ($n = 22$) that were perfectly matched in both age and L2 experience, and the results were qualitatively identical. We therefore conclude that suppression of the L1 was the crucial determinant of whether the cognate effects spilled over into articulation.

with respect to articulation; without producing any substantial gains in proficiency, the requirement to suppress the L1 eliminated the articulatory spillover effect obtained for the classroom learners in Experiment 1.

The existence of cross-linguistic activation during planning is largely accepted in the literature on bilingual production. That this activation could produce the pattern of effects that we have observed at the articulatory stage of production, however, may be somewhat surprising and has important implications for models of speech production more generally. We consider these implications in more depth below.

General Discussion

The present study is part of a recent uptick in work relating online processing considerations to cross-language phonetic influence. Whereas many previous studies have examined the long-term consequences of cross-language activation for bilingual phonetic production (e.g., Flege & Hillenbrand, 1984; Flege, 1987; Flege et al., 2003; Sancier & Fowler, 1997), only recently have researchers begun to home in on the precise mechanisms that relate the early stages of bilingual language selection to their eventual behavioral outcome in speech articulation (Amengual, 2012; Goldrick et al., 2014; Olson, 2013). Taken together, the two experiments reported here indicate that all bilingual speakers experience cross-linguistic activation during speech planning. The present results additionally suggest that, for bilinguals who are less adept at managing this activation, its effects may extend from planning to articulation. It is important to note that the speech articulation data reported here significantly enrich and complicate our understanding of the processes involved in bilingual speech production; were we to consider naming latencies alone, we would simply conclude (as many studies have) that bilingual speakers of all proficiency levels and in all speaking contexts experience cross-linguistic activation to a certain extent. However, the articulation data reveal that the time course of cross-language activation and inhibition during planning may be more susceptible to modulation than the presence of activation and inhibition.

Inhibitory Control in Speech Production

With respect to the inhibitory processes involved, it appears that the ability to regulate the L1 is an important determinant of whether cross-language activation spills over into the execution of L2 speech. The crucial finding was that immersed learners of relatively low proficiency did not demonstrate evidence of L1 English activation during their articulation of L2 Spanish, but nonimmersed learners of comparable proficiency did. As noted above, this indicates that, to a certain extent, L2 proficiency and inhibitory control over the L1 are potentially dissociable. Indeed, the pattern observed for the immersed learners in the present study suggests a level of language control similar to that of highly proficient bilinguals (e.g., Misra et al., 2012). Based on previous work, it stands to reason that the dissociation between proficiency and control of the L1 would be most evident in an immersed population. Several recent studies are consistent with the idea that the L2 immersion setting induces rapid and strong effects on speakers' L1 activation levels (e.g., Baus et al., 2013) and that these effects are likely to be the result of active L1 suppression (Linck et al., 2009). We take the reduced L1-to-L2 phonetic transfer in our immersed speakers as an index of reduced L1 activation,

and we interpret the dissociation between the naming times and articulatory measures as an index of active L1 suppression. What is not yet known is whether the language control observed in a L2 immersion setting interacts in some way with executive function more generally. The present study cannot address this question, because no measures of domain-general inhibitory control were collected from the participants in our study.

While our results for the immersed learners are consistent with a pattern of suppressed L1 activation, it is not clear that L1 suppression for this group was stronger. It is possible that, in the context of L2 immersion, control over the L1 essentially “comes for free” due to increased L2 exposure and/or reduction in L1 activation. Given that research on learning and memory suggests that imposing demands during learning may produce later benefits to performance (e.g., Bjork & Kroll, 2015), a prediction for future research would be that, for learners who achieve similar L1 control in classroom versus immersed contexts, the classroom learners might reveal more extensive benefits to cognitive control than the immersed learners. In effect, the classroom learners may need to work harder to achieve the same outcome, and the increased demands on the control system may spill over from language-specific control to domain-general control processes.

With respect to the time course of production planning, the present results additionally indicate a partial dissociation between processes involved in word retrieval versus phonological planning. While all speakers demonstrated evidence of cross-linguistic activation in their naming latencies, the differential activation for cognates versus noncognates only spilled over into speech execution for the classroom learners. Because the main difference between the classroom and immersed learners concerns the extent to which their L1 was inhibited, it is likely that some difference in the strength or the time course of L1 inhibition may have affected the tendency of cross-linguistic activation to persist from planning stages into articulation. A study by Blumenfeld and Marian (2011) on spoken word recognition may be relevant here: In that experiment, monolinguals' and bilinguals' eye movements were tracked as they listened to words in L1 English. On critical trials, a within-language phonological competitor was present in the display (e.g., listeners saw a plum, a plug, and two unrelated pictures). Critically, each picture identification trial was immediately followed by a priming probe trial to index the residual activation of targets and competitors: Participants were asked to identify the location of a star symbol that appeared in the same position as the target, the competitor, or one of the unrelated objects. The main finding was that while both monolingual and bilingual participants experienced competition between the target and the competitor during picture identification, inhibition of the location of the competitor persisted into the probe trials for monolinguals only. Additionally, a significant correlation was found between bilinguals' performance on a nonlinguistic Stroop task and the strength of their inhibitory response to lexical competitors. Both findings suggest that proficient L2 speakers make use of quantitatively (and perhaps qualitatively) different, more efficient inhibitory mechanisms during auditory word recognition as compared to monolinguals.

While our study concerned production rather than comprehension, it is possible that an analogous difference between groups in the efficiency of inhibitory processing was responsible for the differential pattern we have reported. More efficient inhibitory processing

may be associated with better control of cross-language competition. Under this interpretation, cross-language activation will only spill over into articulation for speakers whose inhibitory mechanisms are not yet efficient enough to shut it down quickly. Future work should explicitly address the question of whether individual differences in nonlinguistic inhibitory control are related to the existence of cross-language phonetic influence in bilingual speech. What is clear at present is that the dissociations between proficiency and immersion, and across the production measures we report here, will require a more nuanced account of language regulation during speech planning.

Inhibition and Learning Context

In the present study, the nature of the immersion context in Experiment 2 made it impossible to collect data on production in English, the learners' L1, because the immersed learners were not permitted to speak English. While we cannot directly speak to this issue with the present data, other recent studies suggest that our immersed learners may have been the most likely to evince effects of L2 immersion on their L1 phonetic production. Chang (2012) demonstrated that immersed learners of L2 Korean showed rather dramatic changes in their production of L1 English within just a few weeks of entering the immersion environment. Chang (2013) subsequently argued that the magnitude of L1 phonetic drift was related in part to the novelty of the L2 experience, because learners with the least amount of previous exposure to Korean demonstrated the strongest effects. However, it may be possible to relate Chang's findings to the present results and to previous work demonstrating differential language switching costs for the more dominant L1 (e.g., Meuter & Allport, 1999). In cases where L1 proficiency is considerably greater than L2 proficiency, strong inhibition of the L1 appears to be required in order to enable access to the L2. For the learners in the present study, this inhibition appears to have been more effectively achieved in an immersion setting than in a classroom setting, a result that is consistent with previous reports on the consequences of immersion (e.g., Linck et al., 2009). For Chang's immersed learners, the difference in L2 proficiency between the experienced and inexperienced groups could explain why the inexperienced learners demonstrated the greatest L1 phonetic drift: The inhibition applied to the L1 may be greatest for low-proficiency L2 learners placed in an immersion setting, somewhat paradoxically resulting in greater L2-to-L1 phonetic influence for speakers of lower L2 proficiency.

A recent line of research investigating speech planning in highly proficient bilinguals has additionally reported evidence for inhibition when bilinguals are required to switch from speaking the L2 to speaking the L1 after an extended period of naming (e.g., Misra et al., 2012; Van Assche, Duyck, & Gollan, 2013). Like trial-to-trial language switching (e.g., Goldrick et al., 2014; Meuter & Allport, 1999), the blocked naming paradigm reveals an inhibitory effect on the L1 when it follows the L2. Curiously, under blocked conditions where there is ample opportunity to recover from momentary inhibition, there is persistent inhibition of the L1, suggesting multiple components of inhibitory control that are engaged during speech planning (e.g., Abutalebi & Green, 2007; Guo et al., 2012). In a recent study, Fricke, Scharf, Martín-García, Rossi, and Kroll (2014) found that inhibition during blocked picture naming also spilled over into L1 word duration and that the specific pattern of results was affected by whether proficient L2 speakers were immersed in a L1 or L2 environment.

Demonstrating that the context of speech planning affects the degree of inhibition in production in even highly proficient L2 speakers again suggests a dynamic system that reflects not only the automaticity that might be associated with skilled speech, but also the coordination of the regulatory mechanisms that control cross-language activation to enable fluency.

The present study with L2 learners is unique in demonstrating that inhibition of the L1—independently from L2 proficiency—is an important factor modulating the dynamics of this system. While this result in itself is important for understanding the time course of processes occurring during bilingual speech planning, it also has important implications for how we understand the speech production process more generally. We conclude with an overview of these implications.

Conclusion

As noted earlier, spreading activation models of speech production do not all agree on the way in which activation flows between representations during planning. In serial, discrete models (e.g., Levelt et al., 1999), processes that affect lexical selection cannot affect processes occurring at subsequent levels of representation (e.g., articulation). Once a word reaches the threshold for selection, the phonological segments associated with it become active; there is no mechanism allowing greater or lesser degrees of lexical activation to affect the activation levels of individual phonemes. Lexical variables, such as word frequency or perhaps cognate status, would therefore be predicted to affect the latency or accuracy with which a word can be produced, but not its phonetic realization.

In a cascading model (e.g., Dell, 1986; Goldrick & Blumstein, 2006), activation can flow from lexical representations to phonological and phonetic representations before a selection is made at any given level. In this way, ongoing processes of feedback and inhibition can potentially influence the amount of activation that reaches phonological representations and subsequent articulatory processes. Much of the controversy surrounding the question of discrete versus cascading activation flow comes from the fact that some studies have found differences in articulatory duration as a function of processing difficulty (e.g., Goldrick & Blumstein, 2006; Kello et al., 2000), while others have not (e.g., Damian, 2003). In this respect, the present study is no different: In Experiment 1, we found significant effects of cognate status on articulation, while in Experiment 2, we did not. However, we believe that this difference in experimental outcomes brings a unique and important perspective to the question of information flow during planning. The finding that cross-linguistic activation only had articulatory consequences for the group of nonimmersed, relatively low-proficiency L2 learners is consistent with Kello et al.'s claim that the speech production system is fundamentally cascading, but that it exhibits apparently staged versus cascading behavior as a function of task difficulty. Under this view, when speakers produce their L1 under normal speaking conditions, they are essentially at ceiling. However, as the task of speaking becomes more difficult—for example, when a nonnative speaker struggles to inhibit strongly competing L1 representations—the fundamentally cascading nature of the planning system becomes apparent. Our results, in concert with other recent studies, indicate that the

examination of bilingual phonetic production provides a unique and rich source of data on the time course and coordination of processes that must occur during speech planning.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1. Mean naming latencies for cognate versus control words in Experiments 1 and 2. The error bars represent ± 1 SE from the mean.

Figure 2. Mean total word durations for cognate versus control words in Experiments 1 and 2. The error bars represent ± 1 SE from the mean.

Figure 3. Mean voice onset time (VOT) for cognate versus control words in Experiments 1 and 2. The error bars represent ± 1 SE from the mean.

Table 1
Summary of participant profiles in Experiments 1 and 2

Variable	Classroom learners (<i>n</i> = 24)	Immersed learners (<i>n</i> = 50)	Advanced speakers (<i>n</i> = 17)
Age (years)	20.3 (1.0)	26.3 (9.7)	33.4 (10.2)
Spanish experience (years)	6.9 (1.8)	9.8 (6.4)	18.6 (11.5)
L1 speaking	9.8 (0.4)	9.2 (1.6)	9.8 (0.4)
L1 understanding	9.6 (0.7)	9.6 (0.7)	9.9 (0.2)
L1 writing	9.4 (0.8)	9.0 (0.9)	9.6 (0.6)
L1 reading	9.5 (0.9)	9.4 (0.8)	9.7 (0.5)
L2 speaking	5.8 (1.4)	5.6 (1.6)	7.8 (0.9)
L2 understanding	6.6 (1.6)	6.9 (1.8)	8.5 (0.9)
L2 writing	6.4 (1.2)	5.9 (1.7)	7.6 (1.2)
L2 reading	6.4 (1.1)	6.1 (1.6)	8.2 (0.8)
Accuracy (Spanish lexical decision)	65.9 (14.3)	68.7 (19.8)	84.5 (11.7)

Note. Standard deviations appear in parentheses.