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The effect of second-language vocabulary on word retrieval in the native language

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Abstract

When bilinguals produce words in one language, their translation equivalents in the other language are thought to be activated as well. A common assumption is that this parallel co-activation produces interference, which slows down word retrieval. The current study aimed to evaluate the assumption of lexical interference during word retrieval by testing whether late Portuguese–English bilinguals were slower to name pictures in their native language when they knew the word in their second language compared to when they only knew the native language label. Instead of interfering with production, knowing the second-language label facilitated speed of word retrieval in the native language for both cognate and non-cognate translation-equivalent pairs. We suggest that using the second language may provide an indirect frequency boost for translation-equivalent words in the native language. This frequency boost has both long-term and short-term effects, strengthening connections to native-language labels when the translation equivalent is retrieved.

Introduction

How do bilinguals speak in one language without tripping over words in the other language they know? Choosing which words to use during speech involves managing and selecting from a set of alternatives that have overlapping conceptual and/or phonological features. A commonly accepted assumption about language production is that words with similar semantic features compete for selection during language production (Levelt, Roelofs & Meyer, 1999). For bilingual speakers, this process may be complicated by the presence of multiple words that refer to the same concept (i.e., translation equivalents). Since translation equivalents for a concept overlap in their semantics completely (or nearly completely), bilinguals should experience constant competition between their two languages during word selection. The Inhibitory Control model (Green, 1998) posits that bilinguals experience cross-language lexical interference and deal with this interference by inhibiting competitors from the language not in use. Support for this model comes from language switching studies showing more difficulty switching into the stronger language than into the weaker language (e.g., Meuter & Allport, 1999; Misra, Guo, Bobb & Kroll, 2012). These findings are consistent with the idea that the dominant language must be inhibited more strongly than the non-dominant language and that the cost of overcoming this inhibition (as measured by longer response latencies), in order to once again use the dominant language, is relative to the amount of inhibition that was applied.

Other experimental paradigms, however, have provided little support for the idea that translation equivalents compete for selection. In fact, when translation equivalents are present, they appear to facilitate word retrieval in the target language (e.g., Costa, Miozzo & Caramazza, 1999; Dylman & Barry, 2018). This finding is counterintuitive given the reliability of semantic interference effects for words within a language and is difficult to explain using most models of language production based on monolingual data. Furthermore, if knowing two labels facilitates access to one of them, bilinguals should be faster to retrieve words than monolinguals. However, bilinguals tend to be slower than monolinguals to retrieve words, even for a language in which they are highly proficient (e.g., Gollan, Montoya, Cera & Sandoval, 2008; Ivanova & Costa, 2008). Perhaps most striking is that both the translation facilitation effect and the generally slower speed of lexical access are observed not only in bilinguals' non-dominant language but also in their dominant language. To explain the translation facilitation effect, researchers have proposed that unlike within-language lexical competitors, translation equivalents do not compete for selection, but rather they provide an additional source of activation to the target, aiding the target word's retrieval (the Language-Specific Selection account, Costa et al., 1999; see also Gollan, Montoya, Fennema-Notestine & Morris, 2005).

The current study addresses the discrepancy between studies showing cross-language facilitation and those showing cross-language interference. First, we tested the generalizability of the translation/interference facilitation effect by testing late second-language (L2) learners with varying levels of L2 proficiency in their native language (L1). Second, we employed a more specific test of the effect of cross-language lexical activation by identifying for each participant whether they knew each picture's label in one language or in two languages. Lastly, we tested predictions about the size of cross-language effects with regard to L2 proficiency and L1 lexical frequency.

Competition during lexical selection

Many models of language production assume that lexical selection involves competition from other lexical candidates. The speaker's preverbal message (communicative intention) activates a set of conceptual features that correspond to the concepts the speaker wants to express. This activation spreads in an automatic way from the conceptual to the lemma level and on to the phonological level of word representations (e.g., Caramazza, 1997; Morsella & Miozzo, 2002; Navarrete & Costa, 2005; Peterson & Savoy, 1998). If bilinguals use the same conceptual-semantic system when accessing words in either of their languages (Kroll & Stewart, 1994; Van Hell & De Groot, 1998), this should, in principle, send activation to lexical representations in both languages that are linked to those conceptual features. Activated semantic nodes spread activation to a set of words that share some degree of semantic overlap (Roelofs, 1992), which then compete to varying degrees for selection (Levelt et al., 1999).

There has been some debate about whether lexical competitors include semantically similar words in the other languages that the speaker knows (e.g., Costa et al., 1999; De Bot, 2004). Based on the assumptions of lexical selection by competition, words with more semantic overlap should compete with each other more than words with less semantic overlap (Finkbeiner, Gollan & Caramazza, 2006). Synonyms (such as *sofa* and *couch*) share all or nearly all of their semantic features. The time it takes to name a pictured object increases linearly as a function of the number of alternative names a picture has (Székely, D'Amico, Devescovi, Federmeier, Herron, Iyer, Jacobsen & Bates, 2003), suggesting that it takes time to select one word among several others that are highly matched in their meanings. Similarly, translation equivalents share conceptual features to the highest degree, and thus should be strong competitors with each other during selection. Within this model, bilinguals should experience strong interference from translation equivalents, effectively slowing down lexical access for them.

Empirical findings have not supported the prediction that synonyms and cross-language translation equivalents interfere with each other, however. Lexical competition is commonly studied using the picture-word interference paradigm. In this design, participants name a picture while ignoring a distractor word that is superimposed on the picture or is auditorily presented with the picture. When the distractor is semantically related to the target word, in either the same language or another language the participant knows (e.g., the word *cat* or *gato* presented with a picture of a dog), naming speeds are slower, which is in line with lexical competition accounts (Costa et al., 1999; for a review, see MacLeod, 1991). When synonyms or translation equivalents are presented as distractors, however, naming of the picture is *facilitated* relative to picture naming with distractors that are unrelated to the target name (Costa & Caramazza, 1999; Costa et al., 1999; Dylman & Barry, 2018; Giezen & Emmorey, 2016; Hermans, 2004; Roelofs, Piai, Rodriguez & Chwilla, 2016)[1]. Similar translation facilitation effects have been found for masked priming (Goral, Obler, Klein & Gitterman, 2001) and the bilingual version of the color-word Stroop task (Costa, Albareda & Santesteban, 2008; Tzelgov, Henik & Leiser, 1990). In each of these designs, the presentation of the translation equivalent is meant to boost the activation level of the translation equivalent relative to the target word. However, instead of interfering with target selection, the boost appears to aid the selection of the target word.

One criticism of the picture-word paradigm is that explicitly presenting distractor words makes lexical selection unlike what would occur normally (Finkbeiner et al., 2006; Spalek, Damian & Bölte, 2013). For example, the target word may receive an activation boost from the distractor because both the picture and the word activate the same semantic representation (Kleinman & Gollan, 2018). Translation distractors may also contribute to picture recognition speed (Hermans, 2000, 2004). Furthermore, it has been argued that the picture-word interference task cannot provide sufficient evidence to determine whether or not translation equivalents compete because the response time may reflect a combination of facilitation and competition (Hermans, 2004). Therefore, it is important to assess whether facilitation is also observed when bilinguals name in only one language and without the presence of cross-language distractors.

Gollan and colleagues (2004; 2005) reported translation facilitation effects also in single-language picture naming contexts. Their pictures were classified according to whether most of their bilingual participants knew the word's translation equivalent or not (Gollan & Acenas, 2004; Gollan et al., 2005). They found that bilinguals were faster to retrieve the picture name for the high-translatable items compared to the low-translatable items (Gollan et al., 2005), and they experienced fewer tip-of-the-tongue states for high-translatable items (Gollan & Acenas, 2004), even after controlling for word-frequency and cognate effects.

To date, the translation facilitation effect has been observed mostly among bilinguals who have a high degree of proficiency in both languages (e.g., Costa et al., 1999; Gollan et al., 2005). It is still unclear whether bilinguals who are strongly dominant in one language experience cross-language lexical co-activation of the non-dominant language when operating in the dominant language only (Hermans, Ormel, van Besselaar & van Hell, 2011; Jared & Kroll, 2001; Kroll, Bobb & Wodniecka, 2006). Thus, in order to better understand the phenomenon of cross-language facilitation, it is important to assess whether the translation facilitation effect generalizes to other types of bilinguals, such as late learners of a second language naming in their dominant language.

Models of bilingual lexical selection

There are two prominent models of bilingual lexical selection: one proposes competition between translation equivalents and the other does not. The Inhibitory Control model (Green, 1998) has been used to explain a number of phenomena observed for bilingual language production. Bilinguals are slower to retrieve

[1]One exception comes from Geukes & Zwitserlood (2016), who taught participants new labels for 36 pictures. When naming in the L1, the presence of the novel object label interfered with naming compared to an unrelated distractor. The authors suggest that the new object labels may be treated like synonyms rather than translation equivalents or that the connections between the objects and their novel labels may not be strong enough to produce the typical pattern of facilitation.

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words in their dominant language after having just retrieved those words in their non-dominant language, suggesting that they had inhibited the dominant language while they were producing words in the non-dominant language because of interference (Misra et al., 2012). Additional evidence from language switching tasks demonstrates that bilinguals show longer response times when switching from their non-dominant language to their dominant language than for the opposite switching direction (e.g., Meuter & Allport, 1999), which has also been interpreted as reflecting inhibition of the dominant language. This inhibition is assumed to be the source of the advantage bilinguals show over monolinguals on certain tasks tapping cognitive control (e.g., Bak, Vega-Mendoza & Sorace, 2014; Bialystok, 2006, 2011; Bialystok, Craik & Luk, 2008; Colzato, Bajo, van den Wildenberg, Paolieri, Nieuwenhuis, La Heij & Hommel, 2008; Prior, 2012; Prior & MacWhinney, 2010; Soveri, Laine, Hämäläinen & Hugdahl, 2011; Soveri, Rodriguez-Fornells & Laine, 2011, but see, e.g., Kousaie & Phillips, 2012; Rosselli, Ardila, Lalwani & Vélez-Uribe, 2016). It is not currently clear, however, whether inhibition of this sort is applied to specific lexical competitors from the non-target language or to the lexicon as a whole.

A significant problem for a translation-interference account is that it makes the wrong predictions regarding translation-equivalent distractors. Any word in the non-target language is inhibited after activation spreads from the conceptual level, and this inhibition is presumed to have a cost (e.g., slower performance). If the amount of inhibition is proportional to the amount of interference, translation words should experience even greater suppression than semantically related words, and thus have an even greater negative effect on performance. However, rather than slowing down performance, presenting the translation word actually facilitates access to the target word in the picture-word interference paradigm.

The Language-Specific Selection account proposes that the lexical selection mechanism only considers candidates from the target language (Costa & Caramazza, 1999). Activation spreads to both languages, but words in the non-target language do not compete. Thus, the mechanism responsible for selecting the appropriate target word recognizes language membership, though how language membership is identified is still unknown.

Current study

The current study addresses the discrepancy between studies showing cross-language interference and those showing facilitation by assessing whether knowing two labels for an object (i.e., the name in the target language and its translation equivalent) facilitates or interferes with retrieval of the object's name in the native language. If translation equivalents interfere during naming, we expected our late bilinguals to be slower naming pictures in their L1, Portuguese, when they knew the L2 English name compared to naming pictures for which they only knew the Portuguese name. If, however, knowledge of the translation word facilitates access to the label in the native language, we expected speakers to be faster if they knew the label in both languages compared to when they only knew it in one. It is also possible that for late learners with low L2 proficiency the activation of the label in the non-dominant language is either too weak to influence lexical processing in the native language or is completely absent. In this case, we expected there to be no difference in speed of word retrieval whether they knew the English label or not. Alternatively, a null effect could also reflect facilitation and inhibition at different levels cancelling each other out.

We employed a simple picture naming task in the speakers' native language, Brazilian Portuguese, and later assessed speakers' knowledge of the English names of the same objects. Previous picture naming studies reporting a translation facilitation effect either explicitly presented the translation equivalent, using the picture-word interference paradigm (Costa & Caramazza, 1999), or used a group-level variable of lexical knowledge (e.g., dividing the stimulus items into high-translatable and low-translatable items) (Gollan & Acenas, 2004; Gollan et al., 2005) rather than assessing individuals' knowledge of specific lexical items. A clearer test of lexical competition would be to directly compare word retrieval speed in a single-language naming context for words that an individual knows in both languages, compared to words that they only know in the target language. Thus, we used the result of the English vocabulary test for each participant to compare Portuguese picture naming speed for pictures that they could name only in Portuguese with those the participant knew in both Portuguese and English. This provides a more nuanced look at how co-activation of translation equivalents affects word retrieval by permitting us to individualize the word retrieval measure based on each person's vocabulary knowledge.

Speakers were late learners of English who had a wide range of proficiency levels in English. This allowed us to test whether the translation facilitation or interference effect was a characteristic of highly proficient bilinguals only or whether it could also be seen for late L2 learners with a broader range of L2 proficiency levels. Moreover, we assessed the effect of L2 proficiency on cross-language effects. Both translation-interference and translation-facilitation models would predict stronger cross-language effects with higher L2 proficiency. If co-activation results in interference, stronger representations should interfere more than weaker ones, predicting that the interference effect should be greater for speakers with higher L2 proficiency. Similarly, for the translation-facilitation account, which proposes that the co-activation of translation equivalents boosts activation of the target through shared semantic representations, stronger L2 representations should provide a greater activation boost for the L1 targets.

We also considered how lexical co-activation might differentially affect high- and low-frequency words in the L1 based on these two bilingual lexical selection accounts. Low-frequency words should benefit more from an implicit cross-language activation boost than high-frequency words in the same way that repetition benefits low-frequency words more than high-frequency words (Forster & Davis, 1984; Ivanova & Costa, 2008; Scarborough, Cortese & Scarborough, 1977). This is because low-frequency words have more to gain in terms of activation levels. Highly frequent words may already be so accessible that additional activation does not make them much faster due to floor effects on word retrieval speed. Thus, if translations facilitate L1 lexical access, the effect of L1 lexical frequency (in other words, the difference in latencies between low- and high-frequency words) would be smaller for words whose translation equivalents are known compared to words known only in the L1 because of an indirect frequency boost for low-frequency words. By contrast, the cross-language lexical interference account would predict that interference would be stronger for high-frequency words than for low-frequency words because high-frequency translation equivalents may be more likely to become co-activated. This leads to a similar prediction as that of the indirect frequency boost account – words that are known in the L2 should

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Table 1. Participant and item characteristics (n = 41). Self-rated proficiency was assessed using a scale from 1 (very poor) to 7 (very good). The Can-Do Questionnaire items were rated using a scale from 1 (with difficulty) to 5 (with ease). MTELP = Michigan Test of English Language Proficiency

	Min	Max	Mean	SD	Median
Self-rated Proficiency (mean of 6 skills)	1.83	5.67	4.43	0.81	4.50
Reading	2.00	6.00	5.10	0.86	5.00
Writing	1.00	6.00	4.27	1.00	4.00
Listening comprehension	2.00	6.00	4.56	1.21	5.00
Speaking	1.00	6.00	4.20	1.21	4.00
Vocabulary	2.00	6.00	4.27	1.03	4.00
Grammar	1.00	6.00	4.17	1.12	4.00
English Vocabulary	22%	76%	52%	14%	53%
Can-Do Questionnaire (English)	1.72	4.61	3.55	0.71	3.61
MTELP	33%	98%	74%	17%	80%
Number of L2 Words Known (by participant, out of 140)	31	106	72.17	18.99	74
Number of Accurate Responses (by word, out of 41)	0	41	20.99	14.28	21
Portuguese Lexical Frequency	41	407036	15965	50088	3325

show a smaller frequency effect than words that are only known in the L1. However, it is possible that words that interfere more are more effectively inhibited, in essence neutralizing the effect of interference. This might result in similar frequency effects for L2-known words and L2-unknown words. Thus, we explored what effects translation equivalents have on L1 naming by comparing L2-known and L2-unknown words and by investigating how the L2-known effect interacts with L2 proficiency and L1 lexical frequency.

Method

Participants

The study included 42 adults aged 18–37 years (mean 26.05, SD 4.97). The sample included 30 females and 12 males. All participants had at least a high school education, and most had completed some college. All participants were native speakers of Brazilian Portuguese and had lived in Brazil almost their entire lives. Length of residence in the United States at the time of testing ranged from 2 weeks to 18 months, with mean length of residence 4.36 months (SD 4.92). The average age at which they began learning English was 11.8 years (SD 6.34, range 3–29). They reported using English between 15–95% of the time while in the U.S. (mean = 65%, SD 19%). One participant had to be excluded from the analysis due to a technical error. Group-level summary statistics for each of the proficiency variables are presented in Table 1.

None of the participants had learned another language before Portuguese or had spoken a language other than Portuguese at home growing up, nor had they lived in an English-speaking country for more than one year in the past or in the U.S. for more than 18 months at the time of testing. Additional exclusionary criteria included any history of stroke, head injury, concussion, or a major neurological or psychiatric problem.

Procedure

In order to put participants in a monolingual mode (Grosjean, 1998) to the greatest extent possible, the entire testing session was conducted in Portuguese by a native speaker of Brazilian Portuguese, all written materials were in Brazilian Portuguese, and no native English speakers were present in the room during testing. The experimenter had previously corresponded with the potential participants over the phone and by email in Portuguese, and they had been told that they would only be using Portuguese for the testing, which we expected would lead participants to believe prior to entering the lab that they would only be using their native language. At the end of the testing session, participants completed the English proficiency assessments. Participants were paid a small monetary compensation for their participation.

All participants gave informed consent before commencing with any of the tests. After signing the consent form, participants completed the language background questionnaire, which asked about all the languages they had studied, any foreign countries in which they had resided, their current studies in New York, and their use of English and Portuguese in various contexts. It also asked participants to rate their overall proficiency in both Portuguese and English using a Likert scale of 1 to 7. After the language background questionnaire, participants completed the Portuguese picture naming task, two tasks measuring English proficiency, and the English vocabulary test. The tests are described in more detail below.

All of the computer-based tasks were administered on a Toshiba laptop computer in a quiet, well-lit room using E-Prime presentation software version 2.0 (Psychology Software Tools, Inc.). Participants were seated comfortably about 20 inches from the computer screen and were asked to wear glasses for visual correction if necessary.

Measures of English Language Proficiency

English language proficiency was estimated using four different measures, which were later combined into a composite score.

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One measure was the Michigan Test of English Language Proficiency (MTELP). This is a test of grammar and auditory comprehension consisting of 45 questions. Participants heard a recorded question or statement spoken in clearly articulated, relatively slow speech by a female native speaker of American English. They were asked to choose the best response to what they had heard, from among three options that were printed on the computer screen. Overall accuracy was assessed on this task. Participants' performance on the proficiency measures is summarized in Table 1.

English vocabulary size was estimated using a 140-item test that asked participants to write the English name for the pictured item. These were the same pictures used previously in the picture naming task in Portuguese. Participants also completed a Can-Do Questionnaire designed to measure functional language abilities. The questionnaire consisted of 18 statements (in Portuguese) of language activities such as *I can give my opinion on a controversial topic and support it with examples and reasons*. Participants were asked to rate their level of ease in both Portuguese and English for each of the activities described in the statements on a scale from 1 (*com dificuldade*, i.e., with difficulty) to 5 (*com facilidade*, i.e., easily). The mean score was calculated separately for each language. The fourth measure of language proficiency included the self-rating of six language areas separately for Portuguese and English: reading comprehension, writing abilities, listening comprehension, speaking abilities, vocabulary, and grammar, using a Likert scale from 1 (*muito ruim,* i.e., very poor) to 7 (*muito bom,* i.e., very good).

A composite score was calculated for each participant to obtain a single comprehensive measure of English proficiency by averaging the standardized z-scores across the four proficiency measures.

Picture naming task

The picture naming task consisted of 140 black-and-white line drawings taken from the International Picture Naming Project database (http://crl.ucsd.edu/experiments/ipnp/). Items included both low frequency (e.g., *moose*) and high frequency (e.g., *waiter*) items. Forty of the 140 items (29%) were cognate words between English and Portuguese, meaning that they showed significant overlap in their word forms. Participants were told to name each pictured object as quickly as possible without erring and to avoid making any hesitation noises before saying the picture name. Reaction time to the beginning of each response was measured using a microphone with a voice-activated trigger recorded by E-Prime. Responses were transcribed after the testing session and coded for accuracy. Each trial began with a fixation cross for 500 ms, then the picture appeared until the voice key was triggered or a maximum of 3 seconds. Five practice trials were given, and one break occurred in the middle of the task.

Data analysis

All analyses were carried out on log-transformed reaction times. Reaction times (RTs) were log-transformed because initial analyses produced highly skewed residuals. Trials were dropped for the following reasons: self-corrections ($n = 8$, $< 0.1\%$ of trials), trials for which the voice-key was triggered incorrectly ($n = 117$, 2% of trials), omissions ($n = 267$, 5% of trials), and inaccurate responses ($n = 488$, 9% of trials). Accurate responses for the Portuguese and English naming tasks included the target name, acceptable alternative names (e.g., *stone* for *rock*), misspellings that reflected the English or Portuguese phonology (e.g., *roch* for *rock*, or *violine* for *violin*), and compound nouns in the wrong order (e.g., *chair wheel* for *wheelchair* and *brush hair* for *hair brush*). Incorrect responses included omissions and incorrect labels for the picture, as well as responses whose spelling reflected a different phonological form (e.g., *zebral* for *zebra*), cognates that reflected the Portuguese form (e.g., *mapa* for *map* and *robo* for *robot*), and words that contained the target but reflected a different part of speech or semantic distinction (e.g., *waitress* for *waiter* and *cry* for *tear*).

RT outliers were defined according to a two-step method. First, all trials with RTs faster than 200 ms ($n = 15$, 0.2% of trials) were excluded as RTs shorter than 200 ms likely reflect recording errors. Second, observations that deviated from both their subject and item mean by more than two and a half standard deviations were dropped ($n = 30$, 0.4% of trials).

All models were linear mixed models with random effects by subject and item. Models' maximal random effects structure (Barr, Levy, Scheepers & Tily, 2013) generally yielded one or two implausible random effect estimates (for example, correlations of 1 or variances of 0), suggesting that the models were degenerate. Therefore, following the procedure of Bates, Kliegl, Vasishth, and Baayen (2015), we conducted principal components analyses on the random effect estimates from the full models to determine the maximum number of empirically identifiable random effects. We then fit models with simplified random effects structures. These models were compared to the full models using a likelihood ratio test. Unless explicitly stated, models with the simplified random effects structure did not differ from the maximal models. Moreover, we found that conclusions about fixed effects were unchanged by this simplification. Inferences about simple fixed effects were based on bootstrapped confidence intervals and *t*-tests using Sattherwaite-approximation of degrees of freedom. None of the predictors were highly collinear with each other; variance inflation factors for all models reported in the results section were below 2, suggesting the degree of collinearity was not problematic.

We examined the possible role of cognate status in our analyses due to possible facilitative effects of cognates (Costa, Caramazza & Sebastian-Galles, 2000). Cognates are typically measured categorically. However, the degree of overlap between words varies quite a bit, even for words that are considered to be cognates. Therefore, we included both continuous and categorical measures for cognates. Furthermore, cognates are usually determined based on orthographic overlap. Depending on the language pair, the same letter may have quite different pronunciations. For example, *real* in English is translated as *real* in Portuguese (an exact orthographic match), but the pronunciation in Brazilian Portuguese is [ʁi'aw]. Orthographically, these words are considered cognates but they are not very similar phonologically. Therefore, we calculated degree of overlap by including both orthographic and phonological similarity. For each pair of translations, we first calculated the Levenshtein distance based on orthographic overlap. The Levenshtein distance between two strings is the minimum number of subsititutions, deletions, and insertions required to turn one string into the other. Next, we took into account phonological overlap that wasn't captured in the orthographic comparison by manually modifying the Levenshtein distance calculation. For example, for the pair of words *microphone* and *microfone*, the Levenshtein distance is 2 because there is one substitution (p/f) and one addition (h) in order to turn one word into the other. However, English 'ph' and Portuguese 'f' are pronounced the same, so this part of the

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word should be considered overlapping in the two languages, reducing the Levenshtein distance to 0. However, the final 'e' in the Portuguese word is pronounced and adds a syllable to the word whereas the final 'e' in the English word is silent. So the modified Levenshtein distance for this pair was 1.

Lastly, the modified Levenshtein distance was normalized to account for differences in word length. The Levenshtein distance for short words is necessarily low (e.g., there is a maximum of 3 possible substitutions between two 3-letter words), and therefore this measure cannot be compared across shorter and longer words. A normalized Levenshtein distance takes word length into account by dividing the Levenshtein distance by the maximum number of letters in the two strings it is comparing and then subtracting the result from 1 (Schepens, Dijkstra & Grootjen, 2012). Because we had taken phonological overlap into account in the distance calculation, we used the number of phonemes instead of number of letters to calculate the normalized measure. In the Results section, we refer to this measure as "Overlap," and higher numbers on this measure reflect a higher degree of overlap.

All models included Portuguese lexical frequency and word length of the response (measured in number of syllables) as control variables because these variables are known to influence picture naming latencies. Lexical frequency values were obtained through the Corpus Brasileiro (http://corpusbrasileiro.pucsp.br). There may be other factors on which the items vary that make some items inherently easier to retrieve than others. In order to account for these unobserved and unidentified factors, we included a third control variable called L2-knowers. This was the percent of participants in our sample who knew the picture's name in English. Whatever it is that might make certain items in our stimulus set more likely to be known in English should be captured by this proxy variable.

Results

Naming accuracy on the Portuguese picture naming task was high (m = 88%, SD = 0.06%, range = 74–98%). The mean response time was 992.40 ms (SD = 367.71 ms). The median percent of L2 English words known by participants was 53% (SD = 14%, range = 22–76%) out of a possible total of 140. The median number of participants who knew the English equivalent of each Portuguese word was 21 out of a possible total of 41 (range = 0–41).

To test the effect of L2 knowledge, a linear mixed effects model was fit to the logarithm of RTs. Model 1 (see Table 2 for parameter estimates and full *t*-test results) included fixed effects for the centered log of frequency, a sum-coded variable indicating whether the L2 word was known (L2-known), and, as control variables, the median-centered number of Portuguese syllables and median-centered number of participants who knew the translation equivalent (L2-knowers). The simplified random effects structure included random intercepts with a correlated random slope for frequency by participant and a correlated random intercept and random slope for L2-known by item. The model revealed a significant negative effect of L2-known ($p = .001$) as well as a significant negative effect of L2-knowers ($p < .001$) and a significant positive effect of number of syllables ($p < .001$). Words for which an L2 translation equivalent was known by the participant were retrieved more quickly than those for which an L2 translation equivalent was not known, and words for which L2 translation equivalents were known by more participants were retrieved more quickly than words for which L2 translation equivalents were known by fewer participants. Words with more syllables were retrieved more slowly than words with fewer syllables.

To examine whether the effect of L2-known was moderated by frequency, Model 2 included an interaction between frequency and L2-known, in addition to the variables in Model 1. As can be seen in Table 2, neither frequency nor its interaction with L2-known was significant, but the effects of L2-known ($p = .001$) and L2-knowers ($p < .001$) remained significant[2]. Because we predicted that an interaction between frequency and L2-known may only exist among high-L2 proficiency participants, Model 3 included the same variables but was fit to the 20 high-L2 proficiency participants. As can be seen in Table 2, even for participants with high L2 proficiency, both frequency and its interaction with L2-known were non-significant.

To examine whether the effect of L2-known was moderated by L2 proficiency, two models including L2 proficiency and its interaction with L2-known were fit to the data: one including proficiency as a continuous variable and one as a dummy-coded categorical variable defined on a median split of the continuous variable. Model 4 included L2 proficiency, coded categorically, and its interaction with L2-known, in addition to the variables in Model 1 (this model also accommodated a random slope for proficiency by item). As can be seen in Table 2, neither the main effect of L2 proficiency nor its interaction with L2-known was significant. The model using the continuous L2-proficiency variable (Model 5) revealed the same pattern of results, with a non-significant main effect of proficiency and a non-significant interaction between proficiency and L2-known. The effects of L2-known and L2-knowers remained significant in both of these models.

We used three methods to determine whether the effect of L2-known could be attributed to a cognate effect. First, in Model 6, we added mean-centered overlap and its interaction with L2-known to the base model (Model 1). As was the case before, the main effects of L2-known ($p = .002$) and L2-knowers were negative and significant ($p < .001$). The main effect of overlap was positive and marginally significant ($p = .08$), and its interaction with L2-known was non-significant. As can be seen in Figure 1, words with more overlap were named more slowly than words with less overlap, and this effect was smaller for L2-known than L2-unknown words, but not significantly so.[3]

We then examined whether the effect of L2-known remained significant when analyzing naming latencies for only the 100 non-cognates. We fit a linear mixed model with L2-known, L2-knowers, median-centered number of syllables and mean-centerered log frequency as fixed effects, random intercepts with correlated random slopes for syllables by subject and random intercepts with correlated random slopes for L2-known by item. For full results, see Model 7 in Table 2. In this model, the effect of L2-known was not significant ($p = .20$).

Third, since cognate and non-cognate pictures were not matched in the current stimulus set, we compared the 40 cognates with a matched subset of 40 non-cognates. The two sets were

[2]As a helpful reviewer pointed out, because log is a non-linear transformation, an interaction on the raw scale could potentially be destroyed by the transformation. We, therefore, fit the same model to raw RT data, and the interaction between frequency and L2-known remained non-significant ($p = .69$).

[3]To determine whether interactions were greatly affected by the log transformation, we fit the same model on the raw RT scale. The interaction between L2-known and Overlap was still non-significant ($p = .25$).

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Table 2. Parameter Estimates, *t*-values, and *p*-values for Linear Mixed Effects Models. Model 1: Base model to test the effect of L2-known. Model 2: Interaction of L2-known with log frequency (full sample). Model 3: Interaction of L2-known with log frequency (high-proficiency participants only). Model 4: Interaction of L2-known with L2 proficiency (categorical proficiency measure). Model 5: Interaction of L2-known with L2 proficiency (continuous proficiency measure). Model 6: Interaction of L2-known with degree of orthographic/phonological overlap (all items). Model 7: Effect of L2-known (non-cognates only). Model 8: Interaction of L2-known with cognate status (matched subset).
Note: * = p < .05, ** = p < .01, *** = p < .001

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Intercept	6.87*** $t(64) = 260.32$ $p < .001$	6.87*** $t(65) = 259.27$ $p < .001$	6.88*** $t(24) = 165.97$ $p < .001$	6.87*** $t(62) = 258.11$ $p < .001$	6.87*** $t(62) = 258.43$ $p < .001$	6.87*** $t(64) = 260.83$ $p < .001$	6.86*** $t(72) = 249.68$ $p < .001$	6.88*** $t(86) = 226.74$ $p < .001$
L2-Known	−.02** $t(111) = -3.15$ $p = .001$	−.02** $t(111) = -3.08$ $p = .003$	−.02* $t(99) = -2.46$ $p = .016$	−.02** $t(104) = -3.20$ $p = .002$	−.02** $t(101) = -3.08$ $p = .003$	−.02** $t(108) = -3.15$ $p = .002$	−.01 $t(74) = -1.29$ $p = .20$	−.04*** $t(258) = -4.94$ $p < .001$
L2-Knowers	−.01*** $t(150) = -4.77$ $p < .001$	−.01*** $t(150) = -4.77$ $p < .001$	−.00*** $t(163) = -4.13$ $p < .001$	−.01*** $t(150) = -4.75$ $p < .001$	−.01*** $t(150) = -4.73$ $p < .001$	−.01*** $t(148) = -5.04$ $p < .001$	−.01*** $t(104) = -4.33$ $p < .001$	
Portuguese Syllables	.04*** $t(351) = 3.93$ $p < .001$	.04*** $t(352) = 3.90$ $p < .001$	.03* $t(98) = 2.38$ $p = .019$	.04*** $t(351) = 4.00$ $p < .001$	.04*** $t(346) = 3.85$ $p < .001$	.04*** $t(349) = 3.99$ $p < .001$	.05*** $t(312) = 3.82$ $p < .001$	
Log Frequency	.00 $t(142) = 0.25$ $p = .80$	.00 $t(145) = 0.20$ $p = .84$	.00 $t(148) = 0.48$ $p = .63$	.00 $t(143) = 0.29$ $p = .77$	.00 $t(144) = 0.18$ $p = .86$	.00 $t(142) = 0.38$ $p = .71$	.00 $t(104) = 0.36$ $p = .71$	
L2-Known*Log Frequency		.00 $t(105) = 0.53$ $p = .53$	−.00 $t(118) = -0.82$ $p = .41$					
Proficiency				.01 $t(40) = 0.26$ $p = .80$	.00 $t(40) = 0.41$ $p = .69$			
L2-Known*Proficiency				.00 $t(423) = 0.46$ $p = .65$	−.00 $t(355) = -0.11$ $p = .91$			
Overlap						.07 $t(136) = 1.75$ $p = .08$		−.00 $t(74) = -0.15$ $p = .88$
L2-Known*Overlap						−.02 $t(85) = -1.17$ $p = .25$		−.00 $t(263) = -1.28$ $p = .20$

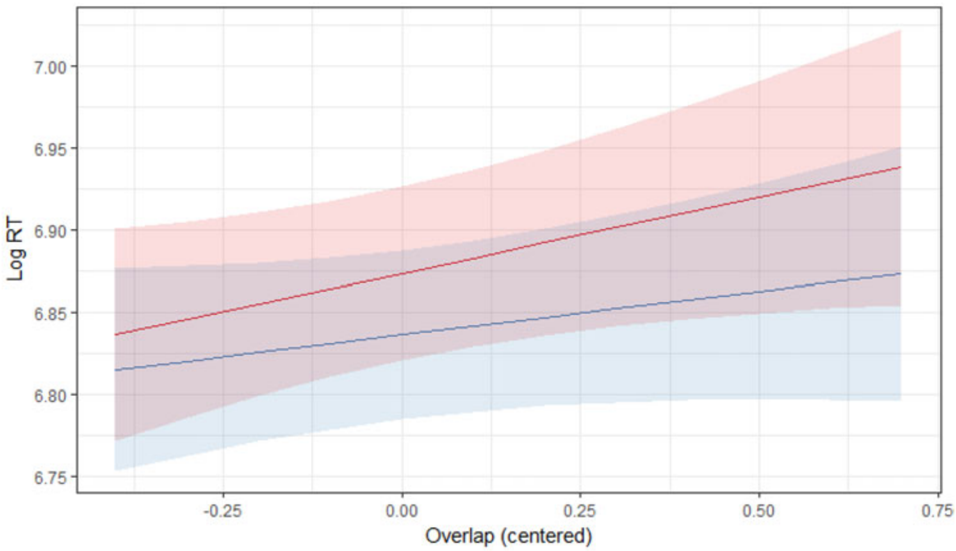

Fig. 1. Interaction between L2-known and Overlap. Blue line indicates L2-known words. Red line indicates L2-unknown words. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

carefully matched on Portuguese frequency, number of syllables of the target response in Portuguese, the picture's visual complexity, percent name agreement in the sample, and percent of omissions in the sample (all p's > .81 based on Wilcoxon signed-rank tests). The two word lists also had a similar distribution of initial phonemes. The average degree of overlap for the cognates was 0.74, and the average degree of overlap for the non-cognates was 0.17. We fit a linear mixed model with cognate status (sum coded), L2-known, and their interaction as fixed effects. Given the smaller number of data points, the model could only accommodate random intercepts by subject and by item. See Model 8 in Table 2 for full results (note, in order to keep the table concise, the row Overlap refers to the categorically coded cognate variable in this model). The effect of L2-known was significant in this model. However, neither the main effect of cognate status nor its interaction with L2-known was significant.

Discussion

The current study investigated the nature of cross-language lexical co-activation in bilingual word retrieval. We found that knowing the picture's label in the second language facilitated naming speed in the native language, after we controlled for word frequency, word length, form overlap, and the percent of participants who knew the item's name in English. This finding is in line with previous studies using different experimental paradigms (Costa et al., 1999; Gollan & Acenas, 2004; Gollan et al., 2005) and supports the idea that the facilitation effect can be found even in an experimental paradigm that does not present an explicit translation word and when the experimental session is conducted solely in the native language.

One of the strengths of this study is that it considered L2 lexical knowledge on an item-by-item basis for each participant. This permits a more careful investigation of predictions made by two well-known hypotheses regarding the effect of bilingualism. According to models of cross-language interference, words in both languages are activated in parallel and compete for selection, thus requiring the active suppression of one of them for correct selection of the target word. This competition can only arise when the speaker knows more than one label for the object because the translation equivalents are assumed to interfere with selection of the target word. This hypothesis predicts that, when they know the L2 label for an object, speakers will be slower to retrieve the L1 label due to this competition compared to objects for which they know only the L1 label. Our findings, however, do not support the assumption that translation equivalents are always competing for selection. Instead, this study extends previous work showing that translation equivalents facilitate word retrieval. Here we show that the effect can even be observed for late bilinguals naming in a single-language context in their dominant language.

Sources of cross-language facilitation

The mechanism by which translation words facilitate word retrieval is not entirely clear. Several models have been proposed to account for the patterns observed in the picture-word paradigm (e.g., the interlexical translation connection hypothesis, Dylman & Barry, 2018; and the response exclusion hypothesis, Mahon, Costa, Peterson, Vargas & Caramazza, 2007), but it is not immediately apparent whether these models can account for effects of translation equivalents in a simple picture naming experiment without distractors. It is fairly easy to account for the translation facilitation effect in terms of priming at the conceptual or lexical level. There is a good deal of evidence that bilinguals have a unitary conceptual system and that activation spreads from conceptual representations to words in both languages during comprehension or production, even when the speaker is in a monolingual context (e.g., Marian & Spivey, 2003; Marian, Spivey & Hirsch, 2003; Martin, Dering, Thomas & Thierry, 2009; Spivey & Marian, 1999). If we assume that activation spreads throughout the system in both forward and backward directions (i.e., from conceptual to lexical representations and back to the conceptual level), the co-activation of the translation word might then spread activation back to the conceptual representation, providing a 'boost' in activation. This additional activation is then likely to spread to the target word, facilitating its retrieval (e.g., Gollan et al., 2005). This explanation is similar to that proposed to account for semantic priming effects (e.g., Roelofs, 1992).

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Another possibility is that translation words are directly connected to each other at the lexical level, as proposed in some models (e.g., Dylman & Barry, 2018; Kroll & Stewart, 1994). The activated words should then boost each other directly at the lexical level (Gollan et al., 2005) with the size of the boost proportional to the strength of the lexical connection (for a discussion of asymmetric lexical links, see Kroll & Stewart, 1994). However, studies investigating the timing of this facilitation suggest that it has a semantic locus – the translation facilitation effect is largest when the translation-equivalent is presented before the picture, shows a small amount of facilitation when it is presented simultaneously with the picture, and disappears when it is presented with a short delay after picture onset (Costa et al., 1999), similar to the timing found for semantic interference effects (Starreveld & La Heij, 1996).

The present study's findings are consistent with the Language-Specific Selection account of Costa et al. (1999). This account was proposed to explain the facilitatory effects of translation equivalents in the picture-word task. In this hypothesis, translation equivalents are co-activated with the target, producing priming of the target; but, because they are identified as belonging to the non-target-language lexicon, they do not compete with the target for selection. Although the model was designed to explain picture-word effects, if we assume automatic co-activation of translation equivalents even in a single-language picture naming task, it could extend to bilingual word retrieval more generally. However, this model has difficulty explaining other evidence of cross-language interference. For example, using the picture-word paradigm, Hermans, Bongaerts, De Bot and Schreuder (1998) found that same-language distractor words that were phonologically related to the target word's translation equivalent interfered with target word selection. They argued that this demonstrates that words from the non-target language can and do compete for lexical selection. Furthermore, it is difficult to reconcile a language-specific selection mechanism with evidence suggesting language inhibition, such as the finding that word retrieval in the dominant language is impaired immediately after word retrieval in the non-dominant language (e.g., Misra et al., 2012; Van Assche, Duyck & Gollan, 2013).

The explanation that we find most plausible for the current findings is that parallel co-activation of translation equivalents raises the resting activation level of both the target and its translation equivalent. In other words, if translation equivalents are activated in parallel no matter which language is used (e.g., Marian et al., 2003), this activation should boost the resting activation level of not only the target word but also its translation equivalent. This is based on the mechanism used to explain the well-known effect of word frequency on lexical access in monolinguals, whereby the more frequently a word is comprehended or uttered, the stronger the connection between the conceptual and lexical representations, making it easier to access the word from the mental lexicon (e.g., Bybee, 2006). The frequency with which a word is encountered or used influences the resting level of activation in a cumulative way. If the labels for a given concept are activated in parallel in both languages whenever one of them is used, both labels should experience the "frequency boost" associated with language use, which should increase the word's resting activation level in each language, as suggested by Poulin-Dubois, Kuzyk, Legacy, Zesiger and Friend (2018). We propose calling the frequency boost associated with target word retrieval a DIRECT frequency effect and the frequency boost associated with the target's translation equivalent an INDIRECT frequency effect. In other words, the typical frequency effect reflects a faster retrieval process based on the strengthened connections between the concept and the lexical unit. Parallel co-activation of the translation equivalent may facilitate retrieval in a similar way. Both the target and the translation-equivalent word are strengthened when one of them is retrieved, though the indirect frequency effect may be weaker than the direct frequency effect.

Some researchers have already suggested that this same kind of additive frequency effect occurs for cognates (Baus, Costa & Carreiras, 2013; Strijkers, Costa & Thierry, 2010). In comparison, Strijkers et al. (2010) have suggested that non-cognate translation equivalents do not produce the same frequency boost. However, we would argue that this explanation of cognate facilitation ignores the fact that parallel activation should boost resting activation of translation equivalents for all words, not just cognates. Cognates may still have some kind of special status or may produce even greater cross-language effects than non-cognates, but the facilitatory effect of parallel co-activation should in theory exist for all translation equivalents. Indeed, we found that the facilitative effect of knowing the L2 word was largest for cognates and was no longer significant when the analysis was restricted to just the non-cognates (although numerically, L2-known words were still faster than L2-unknown words). This suggests that the indirect frequency effect resulting from parallel co-activation is stronger for cognates than non-cognates.

The facilitative effect of cognates has been interpreted as operating primarily at the phonological level but may actually facilitate selection at both the lexical and phonological levels, as suggested by Strijkers et al. (2010). Non-cognate translation equivalents should produce facilitation only at the lexical level since they do not share phonology. If parallel co-activation of translation equivalents results in an indirect frequency boost for the non-target label, overlapping phonology (i.e., cognates) would enhance this effect by spreading activation from both the target and non-target lexical representations to overlapping phonological nodes (Costa et al., 2000), or even by back-propagating activation from phonological representations to lexical representations (Strijkers et al., 2010). Thus, the cognate facilitation effect is expected to enhance the translation-equivalent facilitation effect because cognates get an extra boost at both the lexical and phonological levels while non-cognate translation equivalents only get the boost at the lexical level through shared semantic representations or direct lexical connections.

Despite the fact that the facilitative effect of L2-known words was larger for cognates in the full stimulus set, when we compared response times for the set of forty cognates with a carefully matched set of forty non-cognates, there was no significant effect of cognate status, and the effect of L2-known was found for both cognates and non-cognates. These results are difficult to reconcile. However, in the overall stimulus set, non-cognates were faster than cognates, contrary to the pattern that is normally seen, in which cognates facilitate word retrieval. Cognate facilitation is not always observed in the dominant language (Ivanova & Costa, 2008; Silverberg & Samuel, 2004; Van Hell & Dijkstra, 2002) or for late L2 learners (Silverberg & Samuel, 2004). Van Hell and Dijkstra's (2002) data from trilinguals suggest that only proficient languages produce cognate effects in the dominant language (but see Spivey & Marian, 1999 for a case of immersed bilinguals). These patterns might reflect the inability of the non-dominant language to prime the dominant language in certain conditions. Thus, the majority of non-cognates in our set may have been very easy to retrieve, relative to the cognates and matched non-cognates. This may also

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partially explain why the L2-known effect may have been weaker for the non-cognates: an indirect frequency boost will have less effect on words that are already highly accessible.

One of the possible reasons that we found effects of knowing the L2 word but no cognate facilitation effect is because these processes may operate at different time scales. Consider the effects of parallel co-activation in the short-term and in the long-term. The facilitative effects of translation equivalents and cognates are typically interpreted as occurring during one or more stages of word processing. For example, Gollan et al. (2005) proposed that the translation facilitation effect might be the result of activation coming from two sources: the target lexical node receives activation from the activated conceptual nodes, and, because the target word's translation equivalent gets activated as well, additional activation to the target might come from the translation equivalent either through shared conceptual nodes or through direct lexical links. Similarly, the cognate facilitation effect is thought to reflect activation that spreads from the translation equivalent to semantic and phonological nodes that are shared with the target word (e.g., Gollan & Acenas, 2004). This explanation of facilitation is based on the notion of spreading activation across a set of connected nodes in the lexical network. This model implies that the effect is transient: it operates only until the point of decision or articulation.

However, we suggest that our findings more likely reflect the long-term effect of parallel co-activation for connection weights between levels of representation in each language. A broadly-accepted explanation for the well-known frequency effect is that more frequent words have stronger connections between levels of representations than do less-frequent words (e.g., Levelt, 1999). In other words, the strength of the connections increases each time the word is retrieved in connection with that concept. One way this connection strength has been conceptualized is in terms of a word's resting activation level (Dell, 1988). More frequent words have a higher resting activation level than less frequent words, making them easier to access. Indeed, we would suggest that the lack of an interference effect of L2-known words or a facilitative effect of cognates argues against the notion that L2 words were activated during the experiment to a high enough degree to interfere with L1 naming. Moreover, we explicitly attempted to reduce or eliminate L2 activation during the experiment by having all interactions with the participants in Portuguese by a native speaker of Brazilian Portuguese, both before and during the experiment, with no other individuals around who would provide cues to activate English. Kroll et al. (2006) suggested that while parallel co-activation is nearly always present, one situation where bilinguals may be able to restrict co-activation is when processing a highly-skilled L1 in an L1 context, which is the type of context we set for the bilinguals in our study. This may be achieved by the activation of specific language-task schemas that restrict activation of the lexicon to items with specific language tags (Green, 1998).

A similar learning-based account of cross-language effects in the L2 was recently posited by Costa, Pannunzi, Deco and Pickering (2017). According to their account, evidence that has been interpreted as reflecting automatic co-activation of translation equivalents can be explained in terms of the way connections between semantic and lexical representations were formed during L2 learning. They concede that parallel co-activation occurs during early stages of L2 learning, but claim that, after a certain level of proficiency is reached, accessing L2 words no longer activates their L1 translation equivalents. While this hypothesis may be able to account for characteristics of the L2 lexicon that resemble those of the L1 lexicon, it does not extend well to effects found in the other direction, i.e., characteristics of the L1 that resemble the L2. Their explanation of cross-language effects as reflecting connection strengths that emerge over long-term language use, however, is compatible with our account of the translation facilitation effects.

The indirect frequency effect we describe here should be sensitive to use effects, just like typical (direct) frequency effects are. This allows us to make some additional predictions about the magnitude of the indirect frequency effect that can be tested in future research. For example, the indirect frequency boost for L1 words should be larger for L2 words that are used more often. Moreover, L2 words with earlier ages of acquisition should have a larger indirect frequency boost due to cumulative use over time. One way that age of acquisition effects could be tested is with beginning L2 classroom learners where the point at which each word is learned is known. In terms of amount of L2 use, a measure of overall amount of L2 use may not be sensitive enough to capture the proposed effects on specific lexical items. Measuring the amount of use of specific words is challenging, as these data likely rely on self-reporting, and it is unclear how accurate introspection about amounts of use for specific words would be.

Interacting forces: Inhibition and facilitation

An important consideration is that the bilinguals tested in the current study were immersed in an L2 context outside of the testing situation. Research on the effects of L2 immersion on language processes has shown that access to the L1 lexicon is reduced after a period of immersion in the L2 (Linck, Kroll & Sunderman, 2009) and that the suppression of the dominant language in an immersion context reduces competition of the L1 during L2 production (Jacobs, Fricke & Kroll, 2016). Based on previous research, the consequences of this suppression would be reduced L1 interference (perhaps by restricting co-activation of the L1 during L2 use) with a negative impact on L1 access (Jacobs et al., 2016; Linck et al., 2009). It would be useful to compare bilinguals on the same task before they came to the U.S. and again after several months of immersion to better understand how L1 immersion might impact the translation facilitation effect. The immersion situation affecting these bilinguals may explain why we were able to detect L2 effects on the L1 for L2-known words. If bilinguals' L1 is being suppressed in order to acquire and use the L2, this may lower the resting activation level for L1 words. When an L2 word is used and the L1 translation equivalent is activated in parallel, the L1 word experiences a tiny boost in activation, putting it at a slight advantage over the L1 words whose equivalents are not being used in the L2 because the L2 equivalents have not yet entered their vocabulary.[4]

[4]For speakers who engage in code-switching, particularly to retrieve a word in the L1 when they do not know the L2 equivalent, we would predict the opposite effect – those code-switched words would receive a direct frequency effect on account of being used in place of the L2 word. Unfortunately, we did not include any questions about participants' code-switching practices in our language background questionnaire and thus cannot determine the degree to which they did or did not code-switch. However, since most English speakers in New York City do not know Portuguese, it is unlikely that our participants would have been successful in communicating in English by bringing in Portuguese words. If they code-switch at all, it is more likely to be when speaking in Portuguese with other Portuguese–English bilinguals.

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It is not clear whether L1 suppression is applied to the whole non-target language system or to specific lexical items, but the scope of inhibition may depend on the task demands: which language is being used, the type of bilingual, and/or the degree of bilingualism (Green & Abutalebi, 2013; Van Assche et al., 2013). At least for the type of bilinguals we tested – L1-dominant bilinguals with a wide range of L2 proficiencies performing a word retrieval task in their L1 – we did not find evidence that individual L2 lexical items interfered and were suppressed during L1 retrieval. Nevertheless, there might be more global language suppression, especially given the immersion context in which they were living, which would reduce the speed of access to L1 words globally.

Thus, we posit that the translation facilitation effect we observed reflects the existence of interacting forces, some of them facilitatory and others inhibitory (see La Heij, Van der Heijden & Schreuder, 1985 for a similar argument). A general effect of L1 suppression might be counteracted by an indirect frequency boost from parallel co-activation during L2 use, allowing the words that are used in the L2 to be slightly more accessible in the L1 than the rest of the lexicon. That is, while the L1 lexicon as a whole has reduced accessibility, the use of specific L2 items activates their L1 equivalent, giving them an advantage over L1 words that have not been used in the L2.

Remaining concerns

A few issues remain unresolved with explaining the translation facilitation effect in terms of an indirect frequency effect. First, if we make certain assumptions that have been made in the literature, e.g., that the frequency effect accumulates over instances of repeated use (e.g., Dell, 1988), that using the L2 necessarily means using the L1 less (e.g., Gollan et al., 2008) and that the indirect frequency boost is smaller than the direct effect of retrieving the target word itself (an assumption made in computational models such as that of Costa et al., 2017), this predicts that words which are always retrieved in the L1 (i.e., L2-unknown words) will be retrieved more quickly than words that are sometimes retrieved in the L1 (direct boost) and sometimes in the L2 (indirect boost). Even if the indirect frequency effect were just as strong as the direct use of the word, this would result in a null effect for L2-known words – using the word in the L1 or in the L2 would be equivalent. However, if we do not assume that every instance of L2 retrieval reduces the instances of L1 retrieval, the findings can be adequately explained in terms of an indirect frequency boost.

A paradox arises: if parallel co-activation results in a boost in resting activation levels for the target words, bilinguals should be just as fast as monolinguals at word retrieval in their dominant language. However, several studies have shown that bilinguals are slower than monolinguals not only on picture naming tasks but also on other word retrieval tasks like verbal fluency (Bialystok et al., 2008; Gollan, Montoya & Werner, 2002; Portocarrero, Burright & Donovick, 2007; Rosselli, Ardila, Araujo, Weekes, Caracciolo, Padilla & Ostrosky-Solís, 2000; Sandoval, Gollan, Ferreira & Salmon, 2010). If we assume that the activation boost for the nontarget word is weaker than that for the target, then you would expect that the indirect frequency boost would not raise resting activation levels as much as a direct frequency boost, and over time this may result in the type of 'frequency-lag' effect proposed by Gollan and colleagues. They propose that connections between the semantic and phonological representations of a given word in either language are weaker in bilinguals than in monolinguals because bilinguals do not use each language as much as monolinguals do. Thus, equivalent lexical representations in bilinguals' and monolinguals' lexicons will have different accumulated frequency effects, with bilinguals 'lagging behind' the monolinguals in their accumulation of use. An indirect frequency effect that is weaker than the direct frequency effect would be expected to produce similar effects.

The current study also tested some of the predictions that the indirect frequency boost account might make for words with different levels of lexical frequency and for speakers with different levels of L2 proficiency. An indirect frequency boost is likely to have a greater effect on low-frequency words than on high-frequency words because low-frequency words benefit more from use. However, we found no difference in the size of the frequency effect for L2-known and L2-unknown words. Furthermore, we expected that speakers with higher L2 proficiency would have stronger L2 lexical representations than less proficient speakers and that stronger representations could result in a stronger indirect frequency boost for the L1. However, there was no effect of L2 proficiency on the size of the L2-known effect.

It is difficult to interpret these null findings; we thus refrain from drawing strong conclusions about them. As with any null result, it is possible that the current study lacked sufficient power to detect what may be very subtle effects. While we did have a relatively wide range of L2 proficiency levels (from barely conversational to advanced), we had few participants who would be considered near native-like, and overall our participants were generally less proficient in their second language than those in most other current bilingual studies. Another possibility is that late bilinguals who are L1-dominant have not yet taken a big enough "hit" on their L1 that it can be detected in an experimental setting of this type. Our participants, recall, averaged only 4 months in the U.S. Lastly, language proficiency can be measured in numerous ways. We combined the measures from four different proficiency assessments, including both subjective and objective measures, in order to capture participants' L2 proficiency in a comprehensive way. However, much debate still surrounds the best method for testing language proficiency, and different measures may result in different characterizations of the sample. Another possibility is that these two null results are due to faulty assumptions about how the indirect frequency effect works or may indicate that the facilitation found here has a different source. Further research is needed to test these possibilities.

Conclusion

The current study aimed to clarify a discrepancy in the literature regarding whether L2 translation equivalents interfere with or facilitate L1 word retrieval. We used participants' knowledge of specific lexical items in the L2 in order to test this, providing a more specific test of the lexical interference account than previous studies. We did not find support for cross-language lexical interference but, rather, our findings support the notion that translation equivalents facilitate processing. Pictures whose labels were known in the L2 were named faster in the L1 than pictures whose names were only known in the L1, irrespective of lexical frequency, word length, and L2 proficiency, and the effect was larger for cognates than noncognates. These findings extend previous work to a sample of late bilinguals naming in the dominant language and suggest that the translation-facilitation effect may be due to an indirect frequency effect of L2 use on L1 word representations through automatic co-activation of labels in both languages.

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