The cognate facilitation effect depends on the presence of identical cognates

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Abstract

Previous research has shown that the direction of the cognate facilitation effect (CFE) can disappear if identical cognate words are removed from the stimulus list while keeping task requirements constant (Comesaña, Ferré, Romero, Guasch, Soares & García-Chico, 2015). These results do not fit well with leading computational models of bilingual word recognition (BIA+, Multilink), according to which there are no top-down influences at early stages of word processing. Influences would be post-lexical in nature and would result from competition at the response level. This study aimed to examine this issue by manipulating stimulus list composition and examining its impact on cognate word recognition. We varied the proportion of identical cognates in the experimental lists with four ratios of identical vs. non-identical cognates (50-50; 25-75; 12-88, and 0-100, respectively). Results showed that the CFE gradually decreases as the proportion of identical cognates also decreases. These findings cannot be explained by mechanisms of response competition, but instead seem to imply a dynamic and language-specific top-down regulation of lexical activation.

Introduction

Cross-language influences during visual word recognition are very well documented in the literature. Indeed, when bilinguals are reading in their second language (L2), their native language (L1) is also activated and vice versa. These cross-language influences are due to parallel activation of lexical candidates from both languages, which compete for selection (Dijkstra & van Heuven, 2012). The so-called COGNATE EFFECT is one of the most robust experimental effects which has been considered as evidence for this parallel co-activation across-languages i.e., a differential processing for cognate words (translation equivalents that share form besides meaning; e.g., *papel*-paper in European Portuguese [EP] and English, respectively) vs. non-cognate words (translation equivalents which share only meaning; e.g., *casa*-house in EP and English, respectively). In addition to sharing meaning, cognate words also share form (i.e., they also present some level of orthographic and/or phonological overlap). As a consequence, the shared semantic representation receives more feed-forward activation (from simultaneously activated orthographic representations) compared to non-cognate words, which in turn feeds back and reinforces the form-meaning mapping, leading to facilitatory effects. However, although the majority of studies using different input modalities (e.g., visual and auditory), tasks (e.g., lexical decision, language decision, go/no-go, translation recognition, progressive demasking, sentence completion), paradigms (e.g., masked and unmasked priming), and techniques (e.g., eye-tracking, event-related potentials, pupillometry) have shown a cognate facilitation effect (CFE; e.g., Caramazza & Brones, 1979; Cristoffanini, Kirsner & Milech, 1986; de Groot & Nas, 1991; Dijkstra, Grainger & van Heuven, 1999; Dijkstra, Timmermans & Schriefers, 2000b; Guasch, Ferré & Haro, 2017; Lemhöfer & Dijkstra, 2004; Lemhöfer, Dijkstra, Schriefers, Baayen, Grainger & Zwitserlood, 2008; Midgley, Holcomb & Grainger, 2011; van Hell & Dijkstra, 2002; Soares, Oliveira, Comesaña & Costa, 2018a; Soares, Oliveira, Ferreira, Comesaña, Macedo, Ferré, Acuña-Fariña, Hernández-Cabrera & Fraga, 2019), recent studies have revealed that the CFE can vanish or can even be reversed if identical cognate words (i.e., cognates with complete orthographic overlap, e.g., *piano* in EP and English) are removed from the stimulus list (Comesaña, Sánchez-Casas, Soares, Pinheiro, Rauber, Frade & Fraga, 2012; Comesaña et al., 2015), or if the list contains non-target language words requiring a different response (Poort & Rodd, 2017; Vanlangendonck, Peeters, Rueschemeyer & Dijkstra, 2020). Thus, a thorough characterization of the representation and processing of cognate words in the bilingual mind requires an examination of how stimulus list composition influences cognate word recognition. This was precisely the aim of the present study, i.e., to further examine

the effect the stimulus list composition has on the CFE by manipulating the number of identical cognates in the list while keeping task requirements constant.

Cognate word processing and stimulus list composition

The CFE supports the claim of a non-selective language access in bilinguals, which is a core assumption of models such as the BIA (Dijkstra & van Heuven, 1998), BIA+ (Dijkstra & van Heuven, 2002) or its recent extension, the Multilink (Dijkstra, Wahl, Buytenhuijs, van Halem, Aljibouri, de Korte & Rekké, 2019). According to these models, the languages known by bilinguals are represented in an integrated way in their minds, and the CFE arises from the form/semantic overlap between cognate and non-cognate words across those languages. Thus, when a given input word is presented, it would activate multiple word candidates as a function of their similarity to the input regardless of the language in use. In the case of cognates, two lexical representations (one for each language) would be activated and would send activation to the overlapping semantic representation, which, in turn, feeds back activation to the form level. As a result, the amount of activation they receive would be greater in comparison to non-cognates and processing is facilitated. Within this framework, it is further assumed that identical and non-identical cognates are differently represented and processed, as identical cognates are likely to share the same orthographic representation (e.g., *piano* in EP and American English) and two phonological representations (/pjɐnu/ and /piænoʊ/, respectively), while non-identical cognates present two orthographic and two phonological representations (e.g., *papel* - /pɐpɛl/ in EP and paper /peɪpəR/ in English). When the representations of a non-identical cognate become active, they compete with each other in the same way that other word candidates within and across languages do, through lateral inhibition. Higher competition delays processing: thus, explaining the reduced facilitation for non-identical cognates compared to identical cognates (Dijkstra, Miwa, Brummelhuis, Sappelli & Baayen, 2010), especially when there are mismatches between orthography and phonology (e.g., dança [dẽsɐ] - DANCE [dɑːns] > bomba [bõbɐ] - BOMB [bɒm]; although both pairs have the same degree of phonological overlap, the former has a lower degree of orthographic overlap; see Comesaña et al., 2012, 2015 for more details). The degree of competition seems to also vary as a function of variables that do not only depend on the internal representation of cognates. In particular, task demands and stimulus list composition seem to have an influence on how fast cognates are processed (Comesaña, Moreira, Valente, Hernández & Soares, 2019; Dijkstra et al., 2010; Elston-Güttler, Gunter & Kotz, 2005; Hoversten & Traxler, 2020; Jared & Kroll, 2001; Schwartz & Kroll, 2006; van Hell & de Groot, 2008; Vanlangendonck et al., 2020; Wu & Thierry, 2010).

The BIA+ model (and also the Multilink) allow characterizing modulations on word processing as either linguistic or non-linguistic due to the incorporation of two different systems: an identification system and a task/decision system. Only the task/decision system takes into consideration task requirements, the instructions given to the participants to perform the task, and the stimulus list composition. The identification system, on the other hand, is not influenced by non-linguistic contexts. As a consequence, top-down processes should not affect the early stages of bilingual visual word recognition or, with it, the relative activation level of each language. This postulate is not shared by its

predecessor model (BIA, Dijkstra and van Heuven, 1998). According to the BIA model, lexical selection of target words is directly influenced by feedback inhibition of the non-target words from language nodes that represent the language membership of an item. Hence, top-down effects over activation levels throughout the word recognition system are allowed in this model. Although language nodes still play a role within the architecture of BIA+ and Multilink, they no longer have feedback connections to the lexicon. Instead, inhibition of non-target lexical representations is said to take place by the separate task/decision system that operates on the output of the word identification system.

The evidence in the literature regarding the locus of non-linguistic context effects (within or outside the lexicon) is mixed (see Hoversten & Traxler, 2020). Here, it is worth mentioning the studies in which these effects in lexical access were assessed through the manipulation of stimulus list composition. Although only few studies have manipulated this variable (Brenders, van Hell & Dijkstra, 2011; Comesaña et al., 2015; Dijkstra, Bruijn, Schriefers & Brinke, 2000a; Poort & Rodd, 2017; Titone, Libben, Mercier, Whitford & Pivneva, 2011; Vanlangendonck et al., 2020), they all report influences on cognate word processing, especially in the size and direction of the cognate effect. The underlying mechanisms put forward, however, vary across studies. Thus, whereas some authors consider mechanisms related to response competition (i.e., outside the lexicon; e.g., Poort & Rodd, 2017; Vanlangendonck et al., 2020), others point out mechanisms related to the cross-linguistic overlap of items or word language ambiguity, which modulate relative language activation during the early stages of word recognition (i.e., within the lexicon; e.g., Comesaña et al., 2012, 2015, 2016).

For example, Vanlangendonck et al. conducted two English (L2) lexical decision experiments with Dutch–English late bilinguals who had to decide whether or not a given string of letters was a real English word. Participants saw identical and non-identical cognates, interlingual homographs (words with an identical form across-languages, but a different meaning; e.g., *vast* which means *fixed* in Dutch), control words (non-cognates), and pseudowords. Crucially, in the second experiment, half of the pseudowords were replaced with Dutch words (requiring a "no" response). The results showed a CFE in the first experiment (restricted to identical cognates), which turned into inhibition in the second experiment. The authors explained the change in the direction of the cognate effect as a consequence of a response conflict. That is, in the first experiment, the fact that only L2 words were presented requiring a "yes" response (a "pure" stimulus list) facilitated the processing of identical and non-identical cognates (although only the effect for the former was significant) relative to control words due to their form overlap. However, in the second experiment, the inclusion of L1 words turned the "pure" list into a "mixed" list, with L2 words bounded to a "yes" response and L1 words bounded to a "no" response. This change increased response competition between cross-language competitors and led to the associated interference effect in cognate processing, especially for identical cognates since their two readings are ambiguous with respect to language membership. This explanation can account for the modulation of cognate effects in mixed lists but falls short of explaining modulations occurring in strictly "pure" lists conditions (i.e., when only L2 words were included in the stimulus list composition, as in Comesaña et al.'s 2015 study). Comesaña et al. carried out two lexical decision experiments with Catalan–Spanish bilinguals. They presented two lists: in each case, containing cognate

words, non-cognate words and pseudowords. While one list contained an equal number of identical cognates and non-identical cognates, the other contained only non-identical cognates. The results showed that the time it took participants to recognize non-identical Catalan–Spanish cognates (e.g., dutxa-ducha [shower]) was modulated by the presence (Experiment 1) or absence (Experiment 2) of identical cognates in the experimental list. Indeed, a CFE was only observed in Experiment 1 and restricted to identical cognates (as in Vanlangendonck et al., 2020; see also Guasch et al., 2017, for converging pupillometric evidence). Non-identical cognate words were recognized slightly faster than non-cognates but the effect was not significant. In Experiment 2, the effect was reversed, as non-identical cognates were responded to more slowly as compared to non-cognates (20 ms of inhibition). Because in both cases, all words were bounded to "yes" responses, the mechanism of response competition does not seem a plausible explanation for the observed differences. Instead, the authors explain their findings in terms of earlier influences of stimulus list composition on relative language activation. Specifically, in the absence of language ambiguous words (i.e., identical cognates), there is less activation of non-target language lexical candidates. Thus, any advantage of shared semantic representations for cognate words is reduced. Furthermore, since non-identical cognates have two orthographic and two phonological representations, they are proportionally more affected by lateral inhibition than non-cognate words, leading to the observed null CFE or its reversal. These results seem to indicate that non-linguistic context (via the manipulation of stimulus list composition) affects lexical access at earlier stages than those proposed by the authors of BIA+ and Multilink models. Assuming this, the question that follows now is how many language ambiguous words are necessary for the effect to be reduced or reversed.

The present study

The aim of this work was to directly answer the above question. Specifically, to address how the characteristics of the stimuli composing the lists, regarding the number of identical and non-identical cognate words, affect the magnitude and the direction of the CFE. To this end, we manipulated the number of identical cognates in the experimental lists according to four different ratios: (i) 50% identical cognates and 50% non-identical cognates (as in the Experiment 1 of Comesaña et al., 2015); (ii) 25% identical cognates and 75% non-identical cognates, (iii) 12% identical cognates and 88% non-identical cognates; and (iv) 0% identical cognates and 100% non-identical cognates (as in the Experiment 2 of Comesaña et al., 2015).

Task requirements were the same across the lists and all real words were bounded to "yes" responses. Hence, any observed effects of the number of identical cognates on the CFE cannot be attributed to mechanisms at the response level. Instead, assuming an earlier effect of stimulus list composition on lexical access, as the BIA model holds, we expected to find any facilitatory cognate effects to gradually decrease (and potentially disappear) as the number of identical cognates decreases in the list. We recognize that a lexical decision task does not enable us to establish with precision how much earlier is the effect of stimulus list composition in the CFE. More sensitive paradigms or techniques would be ideal to examine its locus. Nevertheless, we can assure with our design that any observed effect cannot be attributed to response competition and, thus, it is necessarily earlier than the

authors of Multilink model hold. The CFE would be greater in the first list (i.e., when half of the cognates are identical), and null in the list where there are no identical cognates, as previous studies have shown (see Comesaña et al., 2012, 2015 for more detail).

General Method

Ethics statement

The experiment was conducted with the approval of the Ethics Committee for Human Research of the Research Center on Psychology (CIPsi) at the University of Minho (Braga, Portugal). Written consent was obtained from all the participants.

Materials

The materials consisted of four stimulus lists with 160 EP-English word pairs in each list/experiment (half cognates and half non-cognates). Stimulus lists were created by gradually decreasing the number of identical cognates within the lists. This resulted in four different ratios of identical vs. non-identical cognates: 50-50; 25-75; 12-88; and 0-100, respectively. The four experimental lists shared a varying number of common words ranging from a minimum of 56% up to 88% of shared words (see the stimuli for the four lists in the Appendix). Thus, identical cognates from List 1 that were not included in the other lists were replaced with non-identical cognates with similar values of frequency and length. Also, some non-cognate words were changed to guarantee the perfect match.

In each list, English cognates and non-cognates were matched in logarithmic word frequency and length in number of letters (all $ps > .14$; see Table 1 for mean and std). Frequency measures and data for length were obtained from the N-Watch database (Davis, 2005). Also, when considering EP words, there were no differences between cognates and non-cognates in each list regarding the logarithmic frequency and length values (all $ps > .13$, see Table 1). These values were taken from the Procura-PALavras lexical database (P-PAL; Soares, Iriarte, de Almeida, Simões, Costa, Machado, França, Comesaña, Rauber, Rato & Perea, 2018b). In addition, there were no differences in logarithmic frequency and length across lists for both English and EP words (all $ps > .28$, see Table 1).

The degree of orthographic (O) similarity was calculated based on the Normalized Levenshtein Distance (NLD) with values ranging from 0 (no overlap) to 1 (total overlap). Non-identical cognates were selected such that orthographic similarity was maximized while also matching identical cognates on factors word length, phonological & orthographic neighbours and logarithmic frequency. The minimum cut-off in orthographic similarity was 0.43 for non-identical cognates and the maximum cut-off was 0.34 for noncognates with only few word pairs close to the cut-off boundaries. Table 1 contains both mean and range of orthographic similarity for the different lists and per condition. As expected, there were statistically significant differences in orthographic similarity between cognate and non-cognate words, as well as between identical and non-identical cognates within all lists (all $ps < .001$). Importantly, neither identical, non-identical cognates nor noncognates differed across lists in terms of their orthographic overlap (all $ps > 0.4$). For phonological (P) similarity, we relied on the analysis of the degree of overlap of the phonemic transcriptions. Those transcriptions were used to

Table 1. Mean values of log frequency, length, and O and P NLD (standard errors are in round parentheses range is in square parentheses).

		EN_Log freq	EN_length	PT_Log freq	PT_length	NLD_O	NLD_P
Experiment 1 (List A)	CG_Iden	1.11 (.55)	5.78 (.89)	1.16 (.63)	5.78 (.90)	1 (0)	.58 (.25)
	CG_NI	1.12 (.51)	6.05 (.85)	1.08 (.54)	5.98 (.95)	.76 (.12) [.43 −.86]	.55 (.23)
	CG	1.11 (.52)	5.91 (.87)	1.11 (.57)	5.88 (.92)	.88 (.15)	.57 (.24)
	NCG	1.16 (.67)	6.11 (.81)	0.96 (.67)	5.97 (1.03)	.09 (.10) [0 −.36]	0 (.00)
Experiment 2 (List B)	CG_Iden	.97 (.52)	5.8 (.77)	1.01 (.61)	5.8 (.77)	1 (0)	.57 (.23)
	CG_NI	1.15 (.58)	6.17 (.88)	1.15 (.60)	6.07 (.92)	.75 (.11) [.5 −.86]	.52 (.26)
	CG	1.10 (.56)	6.08 (.87)	1.11 (.60)	6.00 (.89)	.82 (.14)	.53 (.25)
	NCG	1.20 (.64)	6.13 (.79)	0.96 (.64)	5.90 (1.06)	.09 (.10) [0 −.34]	0 (.00)
Experiment 3 (List C)	CG_Iden	.74 (.37)	5,9 (.88)	.94 (.62)	5,9 (.88)	1 (0)	.56 (.19)
	CG_NI	1.18 (.63)	6.11 (.88)	1.17 (.66)	6.04 (.92)	.75 (.10) [.5 −.86]	.52 (.26)
	CG	1.12 (.61)	6.09 (.87)	1.14 (.65)	6.02 (.91)	.78 (.13)	.53 (.25)
	NCG	1.27 (.66)	6.04 (.83)	1.04 (.66)	5.91 (1.08)	.09 (.09) [0 − 0.34]	0 (.00)
Experiment 4 (List D)	CG_NI	1.18 (.59)	5.92 (.99)	1.19 (.63)	5.91 (.96)	.75 (.10) [.5 −.86]	.53 (.25)
	NCG	1.31 (.64)	5.92 (.91)	1.05 (.63)	5.82 (1.12)	.09 (.10) [0 −.34]	0 (.00)

Note: EN and EP stand for English and European Portuguese, respectively; NLD_O and NLD_P stand for the Normalized Levenshtein Distance between English and EP translations regarding orthography and phonology, respectively. Values are reported for noncognates (NCG) and cognates (CG). Cognates are further split into non-identical cognates (CG_NI) and identical cognates (CG_Iden).

compute the NLD between pairs of words. Each phoneme was characterized according to a set of standard binary distinctive features. Thus, only those features that are necessary to minimally distinguish the sounds of EP and American English were included: syllabic, sonorant, consonantal, continuant, delayed release, lateral, nasal, voice, anterior, coronal, distributed, high, back, low, mid, and stress. In the computation of P similarity between a given pair of phonemes, the algorithm took into account the feature values that were shared by the two phonemes (see Gooskens & Heeringa, 2004, for a similar approach). As was the case with O similarity, P similarity varied from 0 to 1. As expected, there were statistically significant differences between cognate and non-cognate words within all lists (all $ps < .001$). Overall, no differences were found regarding the degree of P overlap either between identical and non-identical cognates in each list or across lists (all $ps > .372$).

In addition to the cognate and non-cognate experimental words, we created 160 pseudowords per list using the Wuggy software (Keuleers & Brysbaert, 2010) for the purposes of the lexical decision task.

Procedure

The same procedure was applied for all the four experiments. Participants were tested individually in separate soundproof booths and randomly assigned to one of the four stimulus list conditions. Participants were asked to decide as quickly and accurately as possible whether the string of letters presented on the computer screen corresponded or not to a real word in English (i.e., to perform a lexical decision task). Participants indicated their decisions by pressing one of two response buttons ("M" for "yes" and "Z" for "no") of the keyboard. The experiment was run using the DMDX software (Forster & Forster, 2003). Prior to the experiment, there was a practice block consisting of 16 randomized trials (eight words plus eight pseudowords) to familiarize participants with the task. The practice block included

identical cognates in those experiments, where the experimental stimulus list included cognates as well. Each trial started with a fixation cross at the center of the screen. After 500 ms, the fixation cross was replaced by the target stimulus presented in uppercase, which remained on the screen until participants responded or until 2,500 ms had elapsed. The experimental session consisted of 320 trials presented in randomized order. There were breaks during each session after every 80 trials. Participants decided when to continue after a break by pressing the space bar of the keyboard. The whole session lasted around 45 minutes to be completed.

Prior to the experiment, participants filled in the Language History Questionnaire (LHQ, Li, Zhang, Tsai & Puls, 2013) and, at the end of the lexical decision task, they performed three tests evaluating their lexical and spelling knowledge in the English language, in order to assess their L2 proficiency and to guarantee the homogeneity of the sample. In the LHQ, they were asked to provide the age at which they began to learn each of their languages and to estimate their proficiency on a 7-point Likert scale (1 = very poor, 7 = native-like) regarding reading, writing, speaking, and listening skills. In the first test administered at the end of the lexical decision task, participants performed a recognition task on all the 160 experimental items to ensure they knew their meaning. In the second test, participants were asked to translate 150 EP words into English (see Casalis, Commissaire & Duncan, 2015 for more details about this test), and, in the last test, they were asked to choose the correct spelling out of two different spellings for a total of 20 pairs of words. The 20 English words were nouns, adjectives or adverbs, from four to fifteen-letters long, with a mean frequency of 29.6 and few orthographic neighbors ($M = 1.05$). These values were taken from the N-Watch database (Davis, 2005).

We recorded a sample of 95 participants (26, 24, 23 and 22 participants for Lists 1 to 4 respectively). Of those 95 participants, we excluded the data from 23 participants in order to guarantee homogeneity in their language proficiency. Data from five of those participants were excluded, because their native language

Table 2. Mean age of acquisition and mean of L2 proficiency (7-point Likert scale) based on the LHQ and average performance (percentage correct) on the three background tests per experiment (standard errors are in parentheses).

	AoA of L2	L2 proficiency	% unfamiliar words	% translated words	% spelled words
Experiment 1 (List A)	9.4 (1.7)	5.4 (0.7)	8 (5.0)	76 (11.2)	90 (6.7)
Experiment 2 (List B)	10.3 (3.8)	5.5 (0.8)	8.4 (4.5)	67 (15.1)	84 (8.0)
Experiment 3 (List C)	11 (2.4)	5.1 (1.0)	8.8 (5.9)	66 (17.5)	83 (11.6)
Experiment 4 (List D)	9.6 (2.2)	5.3 (0.6)	9.7 (5.0)	70 (12.4)	84 (11.6)

Note: AoA stands for Age of Acquisition; L2 stands for second language.

was not European Portuguese and data from an additional 11 participants were excluded because they scored less than 50% in any of the English language proficiency tests. The data from the remaining seven participants were excluded in order to balance proficiency levels of the population samples across lists. After exclusion, the data obtained from the LHQ and from the three language tests showed no differences between groups of participants across the four experimental list conditions (all *ps* > .14; see Table 2). Considering the results of the different tasks used to evaluate their proficiency, we can state that the final sample had intermediate to high L2 proficiency.

Experiment 1 (50-50 Condition)

Participants

Eighteen EP (L1)–English (L2) undergraduate students from the University of Minho (Braga, Portugal) participated in the experiment, in exchange for academic credits (all of them signed an informed consent). They were unbalanced bilinguals (14 females) with ages ranging from 19 to 38 years ($M = 23.8$; $SD = 4.5$). All of them reported having normal or corrected-to-normal vision.

Materials

The materials consisted of 160 English words (132 nouns): 80 cognates (40 identical and 40 non-identical) and 80 non-cognates plus 160 pseudowords. For more detail see General Method.

Results

Words with an error rate greater than 40% were excluded from the analyses (this amounted to 17 words in total, i.e., 16 words from the non-cognate condition and one from the non-identical cognate condition). In order to maintain the proportion of words across conditions, the 15 cognate words with lower accuracy rates were also eliminated (eight identical cognates and seven non-identical cognates). Those 15 cognate words were chosen such that overall frequency and length of words was still comparable across conditions. Thus, of the 160 presented words, only 128 (64 cognates [32 identical and 32 non-identical] and 64 non-cognates) were considered in the analyses. Individual trials corresponding to incorrect responses (5.34%), as well as extreme reaction times -RTs- (below 250 ms or above 2,000 ms) were also not considered (0.61%). Moreover, RTs that were more than 2 standard deviations (*SD*s) above or below participants' means were also removed (5.47%). Rejection of individual trials did not lead to imbalance in the amount of items across conditions. Mean RTs and percentage of error per condition are presented in Table 3.

Linear mixed models (for RT data) and logit mixed models (for accuracy data) with random intercept for subjects and items were run using R software (Bates, Machler & Bolker, 2011). The factors cognate (cognate vs. non-cognate) and word type (identical cognates, non-identical cognates, and non-cognates) entered as fixed factors in the models. Note that, for each experiment, we first ran a model with the factor cognate, and, in the cases that a cognate facilitation effect was observed, we ran a second analysis, with word type as a factor, to see whether the effect was restricted to identical cognate words. In each model, in a first approach, we included random slopes for participants either for the cognate or word type factors (note they were both within-participants, but between-items, factors). As the results were virtually the same and the fit of the models were very similar (comparing the models fit, all the *p*'s were greater than .05), we opted to report the simpler models (with random intercepts for participants and items; see Barr, Levy, Scheepers & Tily, 2013). Only the independent variables manipulated in the study were included as predictors, as variables such as word frequency and word length were controlled for across conditions (see General Method section). Data were not averaged prior to the analyses. For the effects that reached statistical significance, the second degree of freedom of the F statistic was approximated with Satterthwaite's method (see Satterthwaite, 1941; and Khuri, Mathew & Sinha, 1998 for a review). The p-values were adjusted with Hochberg's method (see Benjamini & Hochberg, 1995, and Hochberg, 1988 for details) for all the post-hoc comparisons equal or below .05.

The models comparing cognate and non-cognate words revealed a cognate facilitation effect in both RTs and accuracy. Participants responded on average 38 ms faster to cognate words than to non-cognate words (662 and 700 ms, respectively), $F(1, 122.19) = 14.509$, $p < .001$, and made fewer errors when responding to cognates compared to non-cognates (2.6 and 8.1, respectively), $\chi^2(1) = 9.8371$, $p = .002$.

Having replicated the typical cognate facilitation effect, the following question we asked was whether the facilitation was restricted to identical cognate words. Mean reaction times and percentage of error per condition are presented in Table 3.

The analyses revealed a significant main effect of word type both in RTs ($F(2, 120.09) = 17.976$, $p < .001$) and accuracy data ($\chi^2(2) = 13.896$, $p < .001$), as expected. This effect showed that participants were faster at recognizing identical cognates over non-cognates (630 ms vs. 700 ms, respectively, $p < .001$), and also over non-identical cognate words (630 ms vs. 695 ms, respectively, $p = .059$). The difference between non-identical cognates and non-cognates was not significant (695 ms vs. 700 ms, $p = .444$).

The effect in the percentage of errors was quite similar to the effect found in the latency data. The main effect of word type

Table 3. Mean reaction times (in ms) and mean percentage of error for the Identical, Non-identical cognate conditions as well as for the cognate and non-cognate condition (standard errors are in parentheses).

	CG_Iden	CG_NI	CG	NCG
Experiment 1 (List A)	630 (6.3) 1.2 (0.5)	695 (7.7) 4.0 (0.8)	662 (5.1) 2.6 (0.5)	700 (5.2) 8.1 (0.8)
N	576	576	1152	1152
Experiment 2 (List B)	645 (9.1) 5.2 (0.9)	678 (5.3) 3.2 (0.7)	670 (4.6) 3.7 (0.6)	693 (4.7) 6.1 (0.7)
N	288	864	1152	1152
Experiment 3 (List C)	721 (21.1) 13.2 (1.4)	705 (6.2) 7.5 (1.1)	707 (6.0) 8.2 (0.8)	715 (5.7) 7.9 (0.8)
N	144	1008	1152	1152
Experiment 4 (List D)		655 (5.0) 4.5 (0.6)	655 (5.0) 4.5 (0.6)	655 (4.9) 4.5 (0.6)
N		1152	1152	1152

Note: CG_Iden, CG_NI, CG and NCG stand for identical cognate, non-identical cognate cognate and non-cognate words. N stands for the total number of trials for all the items and participants.

reached significance, as participants made fewer errors with identical cognates than with non-cognates (1.2 and 8.1, respectively, $p < .001$). However, the difference between identical and non-identical cognates was only marginally significant (1.2 vs. 4.0; $p = .052$). The difference between non-identical cognates and non-cognates failed to reach statistical significance (4.0 vs. 8.1; $p = .141$).

Experiment 2 (25-75 condition)

Participants

Eighteen EP (L1)–English (L2) unbalanced bilinguals (17 females) from the same population as the participants from the Experiment 1 took part in the experiment. Their ages ranged from 18 to 35 years ($M = 22.5$; $SD = 5.6$). They had normal or corrected-to-normal vision and received course credits for their participation as in the Experiment 1.

Materials

The materials consisted of 160 English words (140 nouns): 80 cognates (20 identical and 60 non-identical) and 80 non-cognates. In addition, 160 pseudowords were presented. For more details see the General Method section.

Results

Words with an error rate greater than 40% were not considered in the analyses (22 words – 16 from the non-cognate condition and six from the non-identical cognate condition). In order to maintain the proportion of words across conditions, 10 more cognate words were eliminated. Those 10 cognate words were chosen such that overall frequency and length of words was still comparable across conditions. Thus, of the 160 presented words, only 128 (64 cognates [16 identical cognates; 48 non-identical cognates] and 64 non-cognates) were considered in the analyses. Individual trials corresponding to incorrect responses (4.90%), as well as extreme values (below 250 ms or above 2,000 ms) were also not considered (0.26%). Moreover, RT that were more than 2 SDs above or below the mean for each participant in all conditions were removed (4.77%). Rejection of individual trials did not lead to imbalance in the number of items across conditions.

The analyses done in this second experiment were the same as those in the previous one. The lmm for comparison between cognate and non-cognate words in latency data revealed a significant cognate effect CFE of 23 ms (670 and 693 ms, for cognates and non-cognates respectively; $F(1, 121.56) = 4.2183$; $p = .042$). In terms of accuracy, however, the difference between the errors committed for cognate and non-cognate conditions did not reach statistical significance, $\chi^2(1) = 2.1626$; $p = .141$.

The lmm conducted with the factor word type (identical, non-identical, and non-cognate) showed, in the latency data, a significant main effect of word type, $F(2, 120.27) = 4.5426$, $p = .013$. This effect showed facilitation for identical cognates over non-cognates (645 ms vs. 693 ms, respectively, $p = .001$), and that the difference between non-identical cognates over non-cognates failed to reach statistical significance ($p = .273$). The difference between identical and non-identical cognates was marginally significant (644 ms vs. 678 ms, $p = .062$). The results in the percentage of errors fail to show significant effects, $\chi^2(2) = 3.1167$; $p = .211$. Mean RTs and percentage of errors per condition are presented in the Table 3.

Experiment 3 (12-88 condition)

Participants

Eighteen European Portuguese (L1)–English (L2) unbalanced bilinguals (16 females) from the same population as participants from Experiments 1 and 2 took part in the experiment. Their ages ranged from 18 to 25 years ($M = 20.7$; $SD = 1.7$). They had normal or corrected-to-normal vision and received course credits for their participation.

Materials

The materials consisted of 160 English words (137 nouns): 80 cognates (10 identical and 70 non-identical) and 80 non-cognates. It also had 160 pseudowords. For more details see the General Method section.

Results

Words with an error rate greater than 40% were not considered in the analyses (25 words – 16 from the non-cognate condition, nine from the non-identical cognate condition). In order to maintain the original proportion across conditions, seven more words

were eliminated (2 identical cognates and five non-identical cognates). Those seven words were chosen such that overall frequency and length of words was still comparable across conditions. Thus, 128 (64 cognates [eight identical + 56 non-identical] and 64 non-cognates) out of 160 words were considered in the analyses. Individual trials corresponding to incorrect responses (8.07%), as well as extreme values (below 250 ms or above 2,000 ms) were also not considered (0.65%). Moreover, RTs that were more than 2 SDs above or below the mean for each participant in all conditions were removed (5.12%). Rejection of individual trials did not lead to an imbalance in the number of items across conditions.

The results of the lmm in the latency data failed to show the typical cognate facilitation effect: $F(1, 119.27) = 1.4101$, $p = .237$, as no differences were observed between cognate and non-cognate words (707 and 715 ms, respectively). The same was observed in accuracy data, as no significant differences between cognates and non-cognates were observed (8.3 and 7.9, respectively; $\chi^2(1) = 0.2431$, $p = .622$).

The lmm with the factor word type (identical, non-identical cognates and non-cognates) was not conducted because the effect of cognate was not significant. See the mean RTs and percentage of errors per condition in Table 3.

Experiment 4 (0-100 condition)

Participants

Eighteen EP (L1)–English (L2) unbalanced bilinguals (16 females) with ages ranging from 17 to 32 years ($M = 23.6$; $SD = 4.2$) took part in the experiment. They were recruited from the same population as Experiments 1, 2, and 3. They had normal or corrected-to-normal vision and received course credits for their participation.

Materials

The materials consisted of 160 English words (135 nouns): 80 non-identical cognates and 80 non-cognates. It also had 160 pseudowords.

Results

Words with an error rate greater than 40% were not considered in the analyses (25 words – 16 from the non-cognate condition and nine from the cognate condition). In order to maintain the original proportion across conditions, seven more cognate words were eliminated. Those seven cognate words were chosen such that overall frequency and length of words was still comparable across conditions. Thus, of the 160 presented words, only 128 (64 non-identical cognates and 64 non-cognates) were considered in the results. Individual trials corresponding to incorrect responses (4.51%), as well as extreme values (below 250 ms or above 2,000 ms; 0.39%) were also not considered. Moreover, reaction times that were more than 2 SDs above or below the mean for each participant in all conditions were removed (4.99%). Rejection of individual trials did not lead to imbalance in the number of items across conditions. Reaction times and percentage of error per condition are presented in Table 3.

The results failed to show the typical CFE, as no differences were observed between cognate and non-cognate words both in latency data (655 and 655 ms, respectively), $F(1, 120.18) =$

0.0418, $p = .838$, and accuracy data (4.5 and 4.5, respectively), $\chi^2(1) = 0.0171$, $p = .896$). These results are consistent with the results observed by Comesaña et al. (2012, 2015) using the same procedure and stimulus lists composition (i.e., without identical cognates).

In order to rule out general differences across Experiments 1 to 4 to drive any of the observed patterns so far, we re-analyzed the data considering the experimental list as a factor. For that purpose, we ran lmm with the factors word type (cognate, non-cognate) and experimental list (50-50, 25-75, 12-88, 0-100) as fixed factors in the models.

The results failed to show a main effect of experimental list in both RTs and accuracy data (all $ps > .270$), as expected. Similarly expected was the significance of the main word type effect in the RTs, $F(1, 190.1) = 9.8234$, $p = .002$. However, this effect was not significant in the accuracy data, $\chi^2(1) = 2.3468$, $p = .126$. Surprisingly, the results also failed to show an interaction between word type and experimental list both in RTs ($F(3, 7827.8) = 0.9654$, $p = .408$) and accuracy ($\chi^2(3) = 6.2406$, $p = .101$).

Discussion

In the present study, we investigated the effect of stimulus list composition on the CFE. By varying the ratio of identical and non-identical cognates across four experimental lists, we were able to analyze the impact of stimulus list composition on the direction and magnitude of the cognate effect. Overall, the results show that cognate facilitation decreases and eventually disappears with the decreasing number of identical cognates in the experimental lists. In Experiments 1 and 2, both comprising a substantial amount of identical cognates, we observed a significant CFE, as previous studies did, supporting a bilingual non-selective lexical access (e.g., Caramazza & Brones, 1979; Comesaña et al., 2012, 2015; Cristoffanini et al., 1986; de Groot & Nas, 1991; Dijkstra et al., 1999, 2000b; Guasch et al., 2017; Lemhöfer & Dijkstra, 2004; Lemhöfer et al., 2008; Midgley et al., 2011; van Hell & Dijkstra, 2002). In both experiments, significant facilitatory effects were restricted to identical cognates. Importantly, identical cognates were processed significantly faster than non-identical cognates in both experiments even when the latter only differed in one or two letters.

This finding of facilitatory effects being restricted to identical cognates replicates what was found in Comesaña et al.'s study (2015), and is in accordance with other lexical decision studies (Dijkstra et al., 2010; Vanlangendonck et al., 2020) that similarly reported a sudden drop in reaction times for identical cognates relative to non-identical cognates which varied in just one letter (see Figure 1).

Hence, our findings further support the assumption that identical and non-identical cognates are processed differently. This is consistent with the tenets of BIA+ and Multilink models, which suggest that the different cognate types rely on distinct lexical representations. Specifically, while identical cognates have a shared orthographic representation, non-identical cognates have two distinct orthographic representations, which compete for selection. As a result, a non-identical cognate's lexical activation is inhibited by stronger lateral inhibition. Notably, in Experiment 2, the magnitude of the CFE on reaction times was already reduced to almost half in comparison to the one observed in Experiment 1 (from 38 to 23 ms). This finding reinforces the idea of a dynamically modulated non-target language activation within the lexicon as a consequence of variations in the stimulus
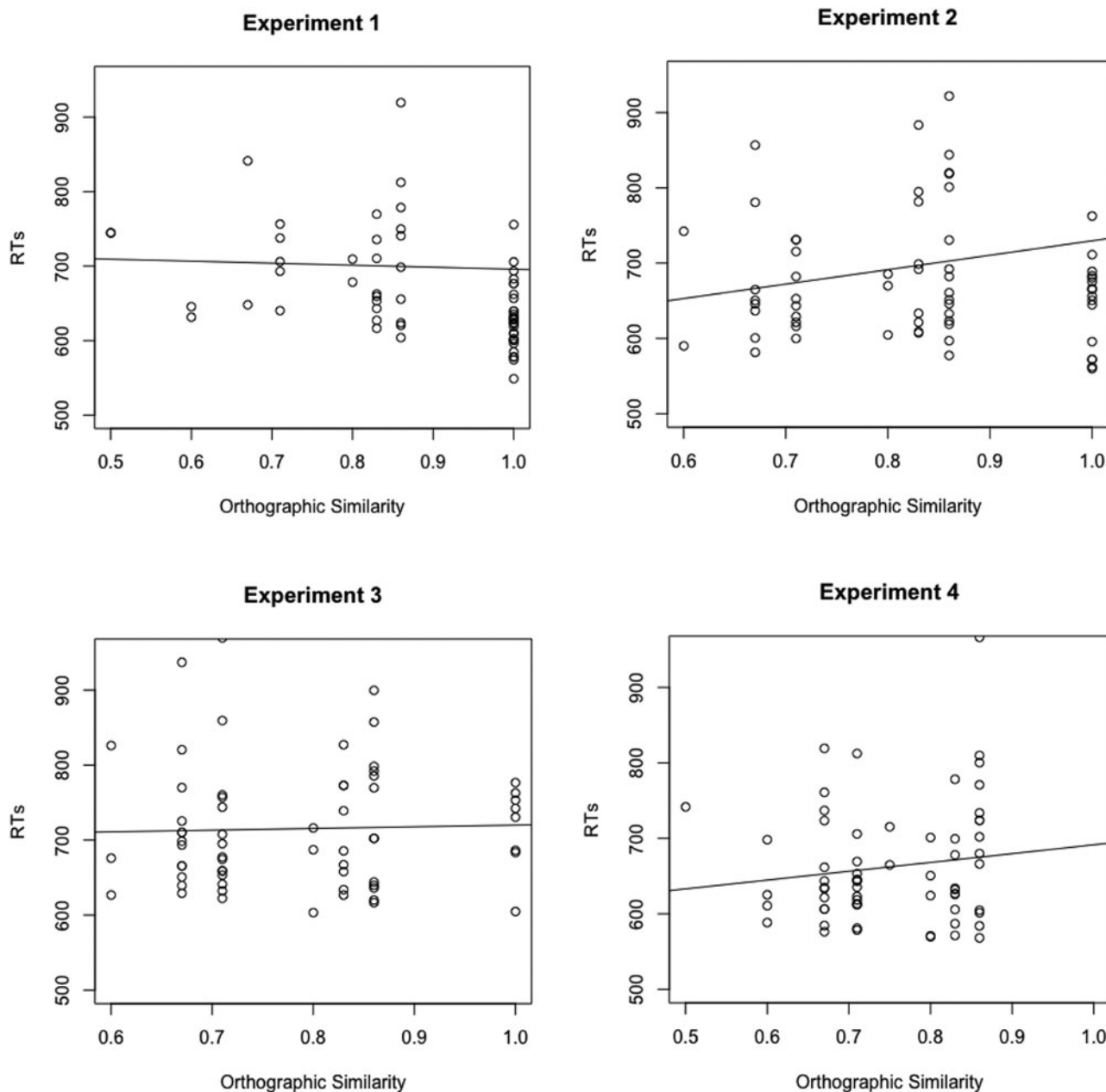
Figure 1. The average reaction times per item against degree of orthographic similarity per experiment

list composition. Importantly, despite the smaller CFE, the overall pattern of responses when considering the speed and accuracy of participants is similar to the one observed in the first experiment (see Tables 2 and 3). Furthermore, the facilitative effects of cognate words completely disappeared when there were no (Experiment 4) or only very few (Experiment 3) identical cognates in the lists. Thus, our data add to previous literature reporting null-findings or even inhibitory effects for cognate words during L2 word recognition (e.g., Comesaña et al., 2012, 2015; Schwartz, Kroll & Diaz, 2007; Vanlangendonck et al., 2020). Note that, although we do not replicate the complete reversal of the cognate effect as reported by Comesaña et al. (2015), this is likely due to the difference in phonological overlap between the studies. Whereas Comesaña et al. presented cognate words across highly similar languages (Catalan–Spanish), we presented

English–Portuguese cognates that by nature share fewer phonological features. Therefore, compared to Comesaña et al's study, our non-identical cognates were likely less affected by lateral inhibition due to phonological overlap. In fact, Comesaña et al. show that their observed inhibitory effect on non-identical cognates was significantly weaker for those with lower phonological overlap.

The fact that we only observed a CFE when a substantial number of identical cognates (50% in Experiment 1 and 25% in Experiment 2) were presented supports the idea that the facilitation effect is mainly driven by identical cognates. Although there are some studies similarly reducing the proportion of identical cognates in the list that had found facilitatory effects for cognate words, they have not controlled for the effect of phonological overlap (e.g., Costa, Caramazza & Sebastian-Galles, 2000; Yudes,

Macizo & Bajo, 2010). In previous studies in which this variable was manipulated and/or controlled for, the cognate effect was absent (e.g., Schwartz et al., 2007) or one of inhibition (Comesaña et al., 2012, 2015), which can at least partially explain the contradictory results observed in the literature.

The BIA+ and Multilink models provide a mechanism of response competition as the cause of variations in the size and direction of the cognate effect as a function of stimulus list composition. However, response competition cannot account for the present results since language-specific response requirements were held constant across all experiments. According to the authors of the models, no effects of local language context such as effects of stimulus list composition during word identification are expected (with the exception of linguistic sentence context), since word recognition processes are thought to be strongly driven by input modulations. Any effect is, hence, explained via control processes of a separate task/decision system that would arise outside of the lexicon (at the response level), specifically through inhibition of competing language task schemas. This explanation can account for findings observed during tasks for which items from the target and the non-target language were bound to different responses ("yes" for words from the target language and "no" for words from the non-target language). In the present research, as there was only a unique response associated to all real words ("yes" response), no competition should occur on the response level. One may think, however, that even in the absence of response competition, the presence of identical cognates in the lists may have reduced task difficulty and would lead participants to adjust their decision criteria. In that case, the overall reaction times and error rates should decrease as the number of identical cognates in the lists increases. The data in the present research do not support this explanation since response times and accuracy to cognates and non-cognate words as a whole were similar across experiments (bear in mind that we kept all properties of the lists the same and replaced identical words by non-identical words as well as selected control words to keep all the conditions matched on frequency, word length, etc). Indeed, the percentage of common words across lists was high (from 56% to 88%), which minimizes the effect of possible confounding effects of words exchange (see all items per experiment in the Appendix). Our findings fit better with the tenets of the earlier BIA model and its role for language nodes as language filters depending on non-linguistic factors. According to this model, top-down inhibition mechanisms enable the context to affect the word identification system by inhibiting irrelevant language representations through the so-called language nodes. The model is also further corroborated by recent studies arguing for a less categorical view of bilingual language control in which the degree of activation of two languages may dynamically vary as a function of experimental factors (Hoversten & Traxler, 2020). Further evidence for such a view comes from studies in which global language context (i.e., the environment before starting the experiment) was manipulated (Elston-Güttler et al., 2005; Elston-Güttler & Gunter, 2009; Hoversten & Traxler, 2016, 2020). For instance, Hoversten and Traxler (2020) carried out two eye-tracking experiments with Spanish–English bilinguals in an attempt to examine the relative influence of top-down language control and bottom-up input during the reading of L2 and L1 semantically low-constraint sentences. Half of the sentences were presented in the L2 and the other half in the L1 in two separated blocks. Global language context was created by greeting participants in each block's target language, as well as testing proficiency in that language prior to each

block. Stimuli contained either a small proportion of pseudo-words or single word code switches into the alternate language. Importantly, code switches were either presented as a para-foveal preview (covertly) or overtly (the monolingual language context being either strengthened or disrupted, respectively). Only when code switches were presented overtly, did they disrupt reading. This disruptive force was initially less strong as compared to pseudowords. However, it further decreased with more exposure to language switches. In the words of the authors, it seemed as participants zoomed out of the target language with increasing exposure to language switches. Conversely, when code switches were presented covertly (creating a monolingual context), code-switched words were treated like pseudowords throughout the experiment indicating that participants remained zoomed in to the target language. Hence, the authors conclude that participants were less committed to the target language when there was a more bilingual language context. The results of this and other studies (e.g., Comesaña et al., 2012, 2015; Elston-Güttler & Gunter, 2009; Hoversten & Traxler, 2016; Wu & Thierry, 2010), together with the present results, provide evidence for the flexible adjustment of the degree of accessibility of each language during reading as a function of linguistic and non-linguistic factors.

Further evidence comes from studies using electrophysiological techniques such as event-related brain potentials (ERPs) and magnetoencephalography (e.g., Chauncey, Grainger & Holcomb, 2008; Comesaña, Ferré, Demestre, Valente, Gonçalves & van Heuven, 2021, in preparation; Pellika, Helenius, Mäkelä & Lehtonen, 2015; Yudes et al., 2010). For example, Comesaña et al. (2021, in preparation) replicated the findings by Comesaña et al. (2015) with Catalan–Spanish bilinguals and extended them to ERP data. Two lexical decision experiments in Spanish were conducted. In the first one, there was a similar proportion of identical to non-identical cognates; whereas in the second experiment only non-identical cognates were presented. The degree of O and P overlap in cognate words was manipulated. Four groups of cognates were created as a function of their form overlap: O + P+, O + P-, O-P+, and O-P-. In accordance with Comesaña et al. (2015), they found a differential processing for cognate words depending on their degree of form overlap as well as the stimulus list composition. Indeed, while the typical cognate facilitation effect appeared in several temporal windows in Experiment 1 (120-150 ms, 300-500 ms, and 500-800 ms), in Experiment 2 it was restricted to a single temporal window (200-250 ms) and even reversed in the last temporal window (500-800 ms). Importantly, differences in cognate processing across experiments appeared in early temporal windows (120-150 ms), revealing that the effect of phonology was restricted to cognates from Experiment 2 (P- larger negativities than P+). These differences remained during later time windows (300-500 and 500-800 ms) and showed up in the behavioral data as well. In the study of Yudes et al. (2010), greater effects of cognate words were observed in tasks in which words from both languages were required (e.g., translation tasks) in comparison to other purely monolingual tasks such as association decision in which participants had to decide whether or not pairs of words from a given language were related in meaning. Although, in this case, task requirements were explicitly manipulated and any difference in the results' pattern could be attributed to differences in task schemas, it serves us to infer that both processes (those occurring at the level of response and those occurring within the lexicon) influence the degree of cross-language activation.

In order to implement dynamic top-down inhibition on the lexicon depending on language activation, the original feedback connections between language nodes and lexical level would need to be re-instantiated as originally suggested by the BIA model. Previously the authors of the BIA+/Multilink model have argued that the influence of language membership is relatively small, and hence will only be available after word identification (Dijkstra et al., 2002). However, this ignored a potentially cumulative effect of language membership. For example, upon activation of a non-target language item, the corresponding language node would be activated and in turn lead to inhibition of lexical items from the other language(s). This inhibition slowly degrades as only target language items are presented subsequently. However, with many language-ambiguous items, inhibition through language nodes would be constantly reinforced before degrading back to baseline and hence multiple language-ambiguous items will have a cumulative effect leading to an overall increase in non-target language facilitation. A cumulative effect of language membership would also explain the temporal effects by Hoversten and Traxler (2020) mentioned earlier. Importantly, the inhibition through language nodes will not be all or nothing but will dynamically modulate the activation strength of the lexical items and do so in interaction with other lexical factors. This is why studies that varied additional lexical factors such as frequency, but did not specifically manipulate or model the potential cumulative effect of repeated non-target language item activation (e.g., Dijkstra et al., 2000b), do not suffice as evidence against the effect of language membership.

To conclude, the current study provides evidence for top-down influences on cognate processing which cannot be explained by increases in response conflict or adjustments in decision criteria. Thus, current leading computational models of bilingual visual word recognition such as BIA+ and Multilink should be amended to account for these results.

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Appendix (Stimuli used in each experiment. In blue the common words across experiments)

Experiment 1

Type	Target_EN	Target_PT	Type	Target_EN	Target_PT
O+P+	agenda	agenda	O-P+	asthma	asma
O+P+	albino	albino	O-P+	bishop	bispo
O+P+	animal	animal	O-P+	climate	clima
O+P+	aroma	aroma	O-P+	dilemma	dilema
O+P+	atlas	atlas	O-P+	ellipse	elipse
O+P+	aurora	aurora	O-P+	event	evento
O+P+	banana	banana	O-P+	exact	exacto
O+P+	casino	casino	O-P+	fraud	fraude
O+P+	cinema	cinema	O-P+	gorilla	gorila
O+P+	cobra	cobra	O-P+	intense	intenso
O+P+	drama	drama	O-P+	member	membro
O+P+	elite	elite	O-P+	mosaic	mosaico
O+P+	final	final	O-P+	photo	foto
O+P+	hotel	hotel	O-P+	prism	prisma
O+P+	ideal	ideal	O-P+	routine	rotina
O+P+	lateral	lateral	O-P+	salami	salame
O+P+	opera	opera	O-P+	seven	sete
O+P+	perfume	perfume	O-P+	temple	templo
O+P+	regime	regime	O-P+	tense	tenso
O+P+	zero	zero	O-P+	tomato	tomate
O+P-	actor	actor	O-P-	agent	agente
O+P-	brutal	brutal	O-P-	apathy	apatia
O+P-	casual	casual	O-P-	author	autor
O+P-	caviar	caviar	O-P-	cobalt	cobalto
O+P-	civil	civil	O-P-	creator	criador
O+P-	digital	digital	O-P-	curious	curioso
O+P-	editor	editor	O-P-	facet	faceta
O+P-	factor	factor	O-P-	grenade	granada
O+P-	genial	genial	O-P-	impulse	impulso
O+P-	glacial	glacial	O-P-	luxury	luxo
O+P-	judo	judo	O-P-	matrix	matriz
O+P-	liberal	liberal	O-P-	monarch	monarca
O+P-	menu	menu	O-P-	museum	museu
O+P-	mineral	mineral	O-P-	poem	poema
O+P-	piano	piano	O-P-	prophet	profeta
O+P-	regular	regular	O-P-	secret	secreto
O+P-	sensual	sensual	O-P-	symptom	sintoma
O+P-	vagina	vagina	O-P-	talent	talento
O+P-	virtual	virtual	O-P-	trunk	tronco
O+P-	volume	volume	O-P-	vampire	vampiro

(Continued)

(*Continued.*)

Type	Target_EN	Target_PT	Type	Target_EN	Target_PT
noncog	above	acima	noncog	madness	loucura
noncog	acorn	bolota	noncog	mirror	espelho
noncog	anthem	hino	noncog	network	rede
noncog	anvil	bigorna	noncog	nugget	pepita
noncog	armpit	axila	noncog	octopus	polvo
noncog	arrival	chegada	noncog	onion	cebola
noncog	axis	eixo	noncog	orange	laranja
noncog	barrack	caserna	noncog	potato	batata
noncog	basket	cesta	noncog	pretty	bonita
noncog	beetle	besouro	noncog	profit	lucro
noncog	bottle	garrafa	noncog	queen	rainha
noncog	bribery	suborno	noncog	rabbit	coelho
noncog	broth	caldo	noncog	razor	navalha
noncog	bucket	balde	noncog	revelry	folia
noncog	burial	enterro	noncog	rubbish	lixo
noncog	butler	mordomo	noncog	scalpel	bisturi
noncog	cabbage	repolho	noncog	scruff	nuca
noncog	carrot	cenoura	noncog	seagull	gaivota
noncog	celery	aipo	noncog	shadow	sombra
noncog	chicken	galinha	noncog	shaggy	peludo
noncog	choice	escolha	noncog	speaker	orador
noncog	church	igreja	noncog	spider	aranha
noncog	closure	fecho	noncog	spindle	fuso
noncog	cousin	primo	noncog	stirrup	estribo
noncog	delivery	parto	noncog	strong	forte
noncog	diaper	fralda	noncog	subject	assunto
noncog	donkey	burro	noncog	trough	gamela
noncog	drawer	gaveta	noncog	truth	verdade
noncog	empty	vazio	noncog	turkey	peru
noncog	enemy	inimigo	noncog	tycoon	magnata
noncog	evening	noite	noncog	ugly	feio
noncog	eyelash	pestana	noncog	unfair	injusto
noncog	frozen	gelado	noncog	village	aldeia
noncog	guilty	culpado	noncog	voter	eleitor
noncog	handout	folheto	noncog	watery	aguada
noncog	happy	feliz	noncog	wealth	riqueza
noncog	husband	marido	noncog	width	largura
noncog	ivory	marfim	noncog	window	janela
noncog	kingdom	reino	noncog	winter	inverno
noncog	kitchen	cozinha	noncog	woman	mulher

Experiment 2

Type	Target_EN	Target_PT	Type	Target_EN	Target_PT
O+P+	agenda	agenda	O-P+	mosaic	mosaico
O+P+	albino	albino	O-P+	photo	foto
O+P+	animal	animal	O-P+	prism	prisma
O+P+	aroma	aroma	O-P+	routine	rotina
O+P+	atlas	atlas	O-P+	salami	salame
O+P+	banana	banana	O-P+	success	sucesso
O+P+	cinema	cinema	O-P+	temple	templo
O+P+	cobra	cobra	O-P+	throne	trono
O+P+	drama	drama	O-P+	tomato	tomate
O+P+	regime	regime	O-P+	veranda	varanda
O+P-	brutal	brutal	O-P-	agent	agente
O+P-	casual	casual	O-P-	apathy	apatia
O+P-	caviar	caviar	O-P-	cadet	cadete
O+P-	digital	digital	O-P-	cancer	cancro
O+P-	Factor	Factor	O-P-	circus	circo
O+P-	judo	judo	O-P-	client	cliente
O+P-	mineral	mineral	O-P-	cobalt	cobalto
O+P-	regular	regular	O-P-	conduct	conduta
O+P-	tenor	tenor	O-P-	creator	criador
O+P-	vagina	vagina	O-P-	culture	cultura
O-P+	asthma	asma	O-P-	energy	energia
O-P+	astute	astuto	O-P-	famous	famoso
O-P+	bishop	bispo	O-P-	festive	festivo
O-P+	bomb	bomba	O-P-	fortune	fortuna
O-P+	climate	clima	O-P-	influx	afluxo
O-P+	concise	conciso	O-P-	matrix	matriz
O-P+	dilemma	dilema	O-P-	monarch	monarca
O-P+	duke	duque	O-P-	nudity	nudez
O-P+	ellipse	elipse	O-P-	origin	origem
O-P+	event	evento	O-P-	planet	planeta
O-P+	exact	exacto	O-P-	posture	postura
O-P+	example	exemplo	O-P-	product	produto
O-P+	flower	flor	O-P-	senator	senador
O-P+	foetus	feto	O-P-	talent	talento
O-P+	gorilla	gorila	O-P-	term	termo
O-P+	immense	imenso	O-P-	text	texto
O-P+	intense	intenso	O-P-	theatre	teatro
O-P+	leprosy	lepra	O-P-	theorem	teorema
O-P+	member	membro	O-P-	troop	tropa
O-P+	monster	monstro	O-P-	vampire	vampiro

Type	Target_EN	Target_PT	Type	Target_EN	Target_PT
noncog	above	acima	noncog	kingdom	reino
noncog	acorn	bolota	noncog	kitchen	cozinha
noncog	advice	conselho	noncog	madness	loucura
noncog	anthem	hino	noncog	mirror	espelho
noncog	anvil	bigorna	noncog	network	rede
noncog	armpit	axila	noncog	nugget	pepita
noncog	arrival	chegada	noncog	octopus	polvo
noncog	axis	eixo	noncog	onion	cebola
noncog	barrack	caserna	noncog	orange	laranja
noncog	basket	cesta	noncog	potato	batata
noncog	bottle	garrafa	noncog	pretty	bonita
noncog	branch	ramo	noncog	profit	lucro
noncog	bribery	suborno	noncog	queen	rainha
noncog	bucket	balde	noncog	rabbit	coelho
noncog	burial	enterro	noncog	razor	navalha
noncog	butler	mordomo	noncog	rubbish	lixo
noncog	buzzard	abutre	noncog	scallop	vieira
noncog	cabbage	repolho	noncog	scalpel	bisturi
noncog	celery	aipo	noncog	scruff	nuca
noncog	chicken	galinha	noncog	seagull	gaivota
noncog	choice	escolha	noncog	shadow	sombra
noncog	church	igreja	noncog	shaggy	peludo
noncog	closure	fecho	noncog	silver	prata
noncog	cousin	primo	noncog	smooth	macio
noncog	darling	querido	noncog	speaker	orador
noncog	dirty	sujo	noncog	spider	aranha
noncog	donkey	burro	noncog	spindle	fuso
noncog	drawer	gaveta	noncog	stirrup	estribo
noncog	dream	sonho	noncog	subject	assunto
noncog	empty	vazio	noncog	trough	gamela
noncog	*enemy*	inimigo	noncog	truth	verdade
noncog	evening	noite	noncog	turkey	peru
noncog	eyelash	pestana	noncog	tycoon	magnata
noncog	frozen	gelado	noncog	ugly	feio
noncog	glass	copo	noncog	unfair	injusto
noncog	guilty	culpado	noncog	village	aldeia
noncog	handout	folheto	noncog	watery	aguado
noncog	husband	marido	noncog	width	largura
noncog	ivory	marfim	noncog	window	janela
noncog	jungle	selva	noncog	winter	inverno

Experiment 3

Type	Target_EN	Target_PT	Type	Target_EN	Target_PT
O+P+	agenda	agenda	O-P+	success	sucesso
O+P+	albino	albino	O-P+	temple	templo
O+P+	banana	banana	O-P+	throne	trono
O+P+	cobra	cobra	O-P+	tomato	tomate
O+P+	regime	regime	O-P+	veranda	varanda
O+P-	brutal	brutal	O-P-	agent	agente
O+P-	caviar	caviar	O-P-	apathy	apatia
O+P-	judo	judo	O-P-	cadet	cadete
O+P-	mineral	mineral	O-P-	cancer	cancro
O+P-	virtual	virtual	O-P-	circus	circo
O-P+	asthma	asma	O-P-	cobalt	cobalto
O-P+	astute	astuto	O-P-	conduct	conduta
O-P+	bishop	bispo	O-P-	creator	criador
O-P+	bomb	bomba	O-P-	culture	cultura
O-P+	climate	clima	O-P-	curious	curioso
O-P+	concise	conciso	O-P-	energy	energia
O-P+	crisis	crise	O-P-	facet	faceta
O-P+	dilemma	dilema	O-P-	famous	famoso
O-P+	duke	duque	O-P-	festive	festivo
O-P+	ellipse	elipse	O-P-	influx	afluxo
O-P+	event	evento	O-P-	matrix	matriz
O-P+	exact	exacto	O-P-	melody	melodia
O-P+	example	exemplo	O-P-	monarch	monarca
O-P+	flower	flor	O-P-	nudity	nudez
O-P+	foetus	feto	O-P-	origin	origem
O-P+	front	frente	O-P-	person	pessoa
O-P+	gorilla	gorila	O-P-	planet	planeta
O-P+	immense	imenso	O-P-	product	produto
O-P+	intense	intenso	O-P-	roman	romano
O-P+	latrine	latrina	O-P-	senator	senador
O-P+	leprosy	lepra	O-P-	signal	sinal
O-P+	member	membro	O-P-	sincere	sincero
O-P+	monster	monstro	O-P-	talent	talento
O-P+	mosaic	mosaico	O-P-	term	termo
O-P+	photo	foto	O-P-	text	texto
O-P+	prism	prisma	O-P-	theatre	teatro
O-P+	quartz	quartzo	O-P-	theorem	teorema
O-P+	routine	rotina	O-P-	tourist	turista
O-P+	salami	salame	O-P-	troop	tropa
O-P+	seven	sete	O-P-	vampire	vampiro

Type	Target_EN	Target_PT	Type	Target_EN	Target_PT
noncog	above	acima	noncog	layer	camada
noncog	advice	conselho	noncog	madness	loucura
noncog	anthem	hino	noncog	mirror	espelho
noncog	anvil	bigorna	noncog	network	rede
noncog	armpit	axila	noncog	nugget	pepita
noncog	arrival	chegada	noncog	octopus	polvo
noncog	axis	eixo	noncog	onion	cebola
noncog	barrack	caserna	noncog	orange	laranja
noncog	basket	cesta	noncog	potato	batata
noncog	blue	azul	noncog	pretty	bonita
noncog	bottle	garrafa	noncog	profit	lucro
noncog	bribery	suborno	noncog	queen	rainha
noncog	burial	enterro	noncog	rabbit	coelho
noncog	butler	mordomo	noncog	razor	navalha
noncog	cabbage	repolho	noncog	rubbish	lixo
noncog	celery	aipo	noncog	scalpel	bisturi
noncog	chicken	galinha	noncog	scruff	nuca
noncog	choice	escolha	noncog	seagull	gaivota
noncog	church	igreja	noncog	shaggy	peludo
noncog	closure	fecho	noncog	silver	prata
noncog	cousin	primo	noncog	slipper	chinelo
noncog	darling	querido	noncog	speaker	orador
noncog	dirty	sujo	noncog	spider	aranha
noncog	donkey	burro	noncog	stirrup	estribo
noncog	drawer	gaveta	noncog	strong	forte
noncog	dream	sonho	noncog	subject	assunto
noncog	empty	vazio	noncog	trough	gamela
noncog	enemy	inimigo	noncog	truth	verdade
noncog	evening	noite	noncog	turkey	peru
noncog	eyelash	pestana	noncog	tycoon	magnata
noncog	frozen	gelado	noncog	ugly	feio
noncog	glass	copo	noncog	unfair	injusto
noncog	guilty	culpado	noncog	village	aldeia
noncog	handout	folheto	noncog	voter	eleitor
noncog	happy	feliz	noncog	watery	aguado
noncog	husband	marido	noncog	wealth	riqueza
noncog	ivory	marfim	noncog	width	largura
noncog	jungle	selva	noncog	window	janela
noncog	kingdom	reino	noncog	winter	inverno
noncog	kitchen	cozinha	noncog	woman	mulher

Experiment 4

Type	Target_EN	Target_PT	Type	Target_EN	Target_PT
O-P+	ample	amplo	O-P-	agent	agente
O-P+	asthma	asma	O-P-	apathy	apatia
O-P+	astute	astuto	O-P-	cadet	cadete
O-P+	band	banda	O-P-	cancer	cancro
O-P+	bishop	bispo	O-P-	circus	circo
O-P+	bomb	bomba	O-P-	cobalt	cobalto
O-P+	climate	clima	O-P-	conduct	conduta
O-P+	concise	conciso	O-P-	creator	criador
O-P+	crisis	crise	O-P-	culture	cultura
O-P+	dilemma	dilema	O-P-	curious	curioso
O-P+	duke	duque	O-P-	cycle	ciclo
O-P+	ellipse	elipse	O-P-	duel	duelo
O-P+	event	evento	O-P-	energy	energia
O-P+	exact	exacto	O-P-	facet	faceta
O-P+	example	exemplo	O-P-	famous	famoso
O-P+	flower	flor	O-P-	festive	festivo
O-P+	foetus	feto	O-P-	humour	humor
O-P+	fraud	fraude	O-P-	influx	afluxo
O-P+	front	frente	O-P-	matrix	matriz
O-P+	gorilla	gorila	O-P-	melody	melodia
O-P+	immense	imenso	O-P-	monarch	monarca
O-P+	intense	intenso	O-P-	nudity	nudez
O-P+	latrine	latrina	O-P-	origin	origem
O-P+	leprosy	lepra	O-P-	person	pessoa
O-P+	member	membro	O-P-	planet	planeta
O-P+	monster	monstro	O-P-	product	produto
O-P+	mosaic	mosaico	O-P-	rare	raro
O-P+	photo	foto	O-P-	roman	romano
O-P+	poet	poeta	O-P-	senator	senador
O-P+	prism	prisma	O-P-	signal	sinal
O-P+	quartz	quartzo	O-P-	sincere	sincero
O-P+	routine	rotina	O-P-	talent	talento
O-P+	salami	salame	O-P-	term	termo
O-P+	seven	sete	O-P-	text	texto
O-P+	success	sucesso	O-P-	theatre	teatro
O-P+	temple	templo	O-P-	theorem	teorema
O-P+	throne	trono	O-P-	tourist	turista
O-P+	tomato	tomate	O-P-	troop	tropa
O-P+	tube	tubo	O-P-	trunk	tronco
O-P+	veranda	varanda	O-P-	vampire	vampiro

Type	Target_EN	Target_PT	Type	Target_EN	Target_PT
noncog	above	acima	noncog	kingdom	reino
noncog	anthem	hino	noncog	kitchen	cozinha
noncog	anvil	bigorna	noncog	knife	faca
noncog	arrival	chegada	noncog	layer	camada
noncog	arrow	seta	noncog	madness	loucura
noncog	axis	eixo	noncog	mirror	espelho
noncog	basket	cesta	noncog	network	rede
noncog	beer	cerveja	noncog	nugget	pepita
noncog	blond	loiro	noncog	octopus	polvo
noncog	blue	azul	noncog	onion	cebola
noncog	bottle	garrafa	noncog	orange	laranja
noncog	branch	ramo	noncog	potato	batata
noncog	bribery	suborno	noncog	pretty	bonita
noncog	bull	touro	noncog	profit	lucro
noncog	burial	enterro	noncog	queen	rainha
noncog	butler	mordomo	noncog	raven	corvo
noncog	cabbage	repolho	noncog	rubbish	lixo
noncog	celery	aipo	noncog	scalpel	bisturi
noncog	chicken	galinha	noncog	scruff	nuca
noncog	choice	escolha	noncog	seagull	gaivota
noncog	church	igreja	noncog	shaggy	peludo
noncog	closure	fecho	noncog	silver	prata
noncog	cousin	primo	noncog	slipper	chinelo
noncog	darling	querido	noncog	smooth	macio
noncog	dirty	sujo	noncog	speaker	orador
noncog	donkey	burro	noncog	stirrup	estribo
noncog	drawer	gaveta	noncog	straw	palha
noncog	dream	sonho	noncog	strong	forte
noncog	empty	vazio	noncog	subject	assunto
noncog	*enemy*	inimigo	noncog	truth	verdade
noncog	evening	noite	noncog	tycoon	magnata
noncog	eyelash	pestana	noncog	ugly	feio
noncog	frozen	gelado	noncog	unfair	injusto
noncog	glass	copo	noncog	village	aldeia
noncog	guilty	culpado	noncog	voter	eleitor
noncog	handout	folheto	noncog	watery	aguado
noncog	happy	feliz	noncog	width	largura
noncog	husband	marido	noncog	window	janela
noncog	ivory	marfim	noncog	winter	inverno
noncog	jungle	selva	noncog	woman	mulher