Research Article

Masked Translation Priming Effects With Highly Proficient Simultaneous Bilinguals

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Abstract. One essential issue for models of bilingual memory organization is to what degree the representation from one of the languages is shared with the other language. In this study, we examine whether there is a symmetrical translation priming effect with highly proficient, simultaneous bilinguals. We conducted a masked priming lexical decision experiment with cognate and noncognate translation equivalents. Results showed a significant masked translation priming effect for both cognates and noncognates, with a greater priming effect for cognates. Furthermore, the magnitude of the translation priming was similar in the two directions. Thus, highly fluent bilinguals *do* develop symmetrical between-language links, as predicted by the Revised Hierarchical model and the BIA+ model. We examine the implications of these results for models of bilingual memory.

Keywords: masked priming, bilingualism, translation priming

In bilinguals, to what degree is the conceptual representation of one language shared with the other language (e.g., *table* and *mesa* for English-Spanish bilinguals)? Most models assume that there is a shared semantic (conceptual) level and a word-form lexicon for each language, allowing cross-language priming at the semantic level (i.e., hierarchical models; see French & Jacquet, 2004, for review). However, a recent review of the literature on semantic representations in bilinguals concluded that "the evidence may not be strong enough to confirm completely shared representations at the semantic level" (Francis, 2005, p. 260).

One important piece of evidence in favor of shared conceptual representations would be a demonstration of early, automatic priming effects at the semantic level across the two languages (i.e., when the recognition time of the Spanish word *MESA* is faster when it is preceded by its translation *TABLE* than when it is preceded by an unrelated word like *HOUSE*). To examine early, automatic effects in visual word recognition, one of the most promising techniques is the masked priming paradigm (Forster & Davis, 1984; Forster, Mohan, & Hector, 2003; see also Grainger, 2008). In this paradigm, a forward masked, lowercase prime is presented briefly (for around 30–60 ms) and is subsequently replaced by the uppercase target. Under these conditions, participants are not only unaware of the prime's identity, but they are usually unaware of its existence.

A number of studies have explored the early influence of cross-language translation equivalents under automatic conditions (see Altarriba & Basnight-Brown, 2007, for a recent review). One critical distinction here is whether the translation equivalents are cognates or not. Noncognates are translation equivalents with different spellings and sound patterns in the two languages (e.g., the Spanish word *mesa* and its English translation *table*), whereas cognates are translation equivalents with the same origin and usually a similar spelling or sound pattern (e.g., the Spanish word *rico* and its English translation *rich*). Given that cognate translations are similarly spelt words, they may provide form priming independently of their meaning (e.g., *hosre* facilitates the processing of *horse*; e.g., see Perea & Lupker, 2003). For that reason, the critical evidence will be obtained with noncognate translations. For the sake of parsimony, we will only examine the results from masked priming studies in which the task was lexical decision (i.e., the most popular word recognition task).

When using noncognate translations, a priming asymmetry has been consistently reported in a variety of languages (see Table 1 for a review of the literature). It should be noted that: (1) most studies tested unbalanced bilinguals (i.e., participants with clear language dominance in their L1) and (2) in all cases, participants were nonsimultaneous bilinguals (i.e., participants acquired their L2 after their L1, not simultaneously). In the L1-to-L2 priming direction (i.e., primes in the dominant language and targets in the nondominant language; *forward* priming, hereafter), the magnitude of the masked translation priming effect is generally greater than in the L2-to-L1 direction (where small/null priming effects have been reported; *backward* priming, hereafter). Across

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Table 1. Magnitude of forward and backward translation priming effects using the lexical decision task with noncognate translations

Authors	Languages	Prime	Blank	Postmask	Direction	Effect
de Groot and Nas (1991)						
Exp. 3	Dutch-English	40	20	No	L1-L2	35*
Exp. 4	Dutch-English	40	20	No	L1-L2	40*
Gollan, Forster, and Frost (1997)						
Exp. 1	Hebrew-English	50	No	No	L1-L2	36*
Exp. 2	English-Hebrew	50	No	No	L1-L2	52*
Exp. 3	Hebrew-English	50	No	No	L2-L1	9
Exp. 44	English-Hebrew	50	No	No	L2-L1	−4
Williams (1994)						
Exp. 2B	German-English	40	10	No	L1-L2	21*
Exp. 2B	Italian-English	40	10	No	L1-L2	45*
Exp. 2B	French-English	40	10	No	L1-L2	45*
Grainger and Frenck-Mestre (1998)						
	English-French	14	No	13	L2-L1	−3
	English-French	29	No	13	L2-L1	2
	English-French	43	No	13	L2-L1	10
Jiang (1999)						
Exp. 1	Chinese-English	50	No	No	L1-L2	45*
Exp. 1	Chinese-English	50	No	No	L2-L1	13*
Exp. 2	Chinese-English	50	No	No	L1-L2	68*
Exp. 2	Chinese-English	50	No	No	L2-L1	3
Exp. 3	Chinese-English	50	50	No	L2-L1	4
Exp. 4	Chinese-English	50	50	150	L2-L1	7
Exp. 5	Chinese-English	50	50	No	L2-L1	−2
Jiang and Forster (2001)						
Exp. 1	Chinese-English	50	50	150	L2-L1	8
Exp. 2	Chinese-English	50	50	150	L2-L1	6
Exp. 3	Chinese-English	50	No	No	L2-L1	4
Exp. 3	Chinese-English	50	50	150	L2-L1	9
Exp. 4	Chinese-English	50	No	No	L1-L2	41*
Kim and Davis (2003)						
Exp. 1	Korean-English	50	No	No	L1-L2	40*
Finkbeiner, Forster, Nicol, and Nakumura (2004)						
Exp. 2	Japanese-English	50	No	150	L2-L1	−4
Voga and Grainger (2007)						
Exp. 2	Greek-French	50	No	No	L1-L2	23*
Exp. 3	Greek-French	50	No	No	L1-L2	22*
Basnight-Brown and Altarriba (2007)						
Exp. 2	Spanish-English	100	No	No	L1-L2	33*
Exp. 2	Spanish-English	100	No	No	L2-L1	24*
Duyck and Warlop (2009)						
	Dutch-French	56	No	56	L1-L2	48*
	Dutch-French	56	No	56	L2-L1	26*
Dimitropoulou, Dunabeitia, and Carreiras (manuscript submitted for publication)						
	Greek-Spanish	50	No	No	L1-L2	24*
	Greek-Spanish	50	No	No	L2-L1	−3

Note. * refers to a significant effect.

experiments, the average effect for forward masked translation priming was 39 ms, while the average effect for backward masked translation priming was only 6 ms. This pattern of data can be accommodated by the most influential models of bilingual memory. For instance, the Revised Hierarchical model (e.g., see Kroll & Stewart, 1994; Kroll & Tokowicz, 2005) assumes that, for unbalanced bilinguals, access to the conceptual system is achieved via their first language (L1). Only when the learners achieve a high degree of proficiency is there direct conceptual processing from L2. In this model, the early dependence on L1 to mediate access to meaning for L2 words creates an asymmetry of interlingual connections. Thus, L1-to-L2 links are posited to be stronger than L2-to-L1 links, and this readily explains why forward translation priming is greater than backward translation priming. The asymmetry in masked translation priming can also be accommodated by the Bilingual Interactive Activation model (BIA/BIA+; Dijkstra & van Heuven, 2002; van Heuven, Dijkstra, & Grainger, 1998). This model assumes a spread of activation through related nodes with feedback connections. The critical factor that determines the accessibility of a given word is the frequency and recency of use of that word. The idea underlying this assumption is that the more often (or recently) a word is encountered, the faster its recognition will be. Therefore, masked translation priming asymmetry is explained in terms of the lower accessibility of the L2 masked prime words, which are less frequently used and have resting levels which are higher than those of L1 words. Finally, it should be noted that other models of bilingual memory can also predict this asymmetry (e.g., the Sense model of Finkbeiner et al., 2004).

Interestingly, two recent studies with noncognate translations using very different populations have reported evidence against this asymmetry. Basnight-Brown and Altarriba (2007) reported similar forward and backward masked translation priming with a group of highly fluent Spanish-English bilinguals (forward priming effect: 33 ms and backward priming effect: 24 ms). In addition, using a group of low-proficient Dutch-French bilinguals, Duyck and Warlop (2009) found an effect of masked translation priming which did not vary significantly for L1-L2 and L2-L1: forward and backward translation priming effects were 48 and 26 ms, respectively. We now examine in further detail these two recent studies.

The results from Basnight-Brown and Altarriba are consistent with a basic assumption of the Revised Hierarchical model: For highly fluent bilinguals, L1-to-L2 and L2-to-L1 links should be approximately equally strong, and hence, the magnitude of the effects should be similar in forward and backward translation priming. This symmetrical pattern can also be captured by the BIA+ model: Highly proficient bilinguals have a more frequent use of the two languages, and this leads to lower resting levels of the L2 words. Importantly for the purposes of this study, Basnight-Brown and Altarriba used a prime exposure duration of 100 ms to provide their participants with a "slightly longer amount of time to process words in their less dominant language" (p. 960). The problem here is that, under these conditions, primes can be partially visible. Even though it has been previously demonstrated that prime exposure durations shorter than 150 ms do not generally lead to the development of strategic effects based on expectancy generation (see Hutchinson, Neely, & Johnson, 2001; Neely, 1991; Perea & Rosa, 2002a), it should be noted that the vast majority of the preceding evidence has been obtained with prime durations shorter than 60 ms (namely, with perceptually "invisible" primes; see Tables 1 and 2). Thus, it remains to be demonstrated whether there is symmetry in masked translation priming using nonvisible masked primes with a shorter and more conventional prime duration (note that partially visible and invisible primes yield to the activation of different cerebral mechanisms; see Kouider, Dehaene, Jobert, & Le Bihan, 2007).

More importantly, Basnight-Brown and Altarriba tested high-proficient, but unbalanced, Spanish-English bilinguals that had experienced a language dominance shift, becoming more fluent/proficient in their L2 than in their L1. In their own words, "it can be concluded that the English-Spanish (L2-L1) priming direction actually behaves as the L1-L2 direction, because English was the dominant language at the time of the experiment" (p. 958). Thus, it is important to examine to what extent forward and backward masked translation priming effects can be found in a group of completely balanced and simultaneous bilinguals.

Interestingly, the findings reported by Duyck and Warlop (2009) do pose some problems for the Revised Hierarchical model and BIA+ models (i.e., the participants were low proficiency, unbalanced bilinguals living in an L1 environment). Nonetheless, the lack of a significant interaction between the translation priming effects and the language direction in the Duyck and Warlop experiment was probably due to lack of statistical power – note that the magnitude of the forward priming effect was nearly twice the

Table 2. Magnitude of forward and backward translation priming effects using the lexical decision task with cognate

Authors	Languages	Prime	Blank	Postmask	Direction	Effect
de Groot and Nas (1991)						
Exp. 2	Dutch-English	40	20	No	L1-L2	58*
Exp. 3	Dutch-English	40	20	No	L2-L1	39*
Exp. 3	Dutch-English	40	20	No	L1-L2	48*
Exp. 4	Dutch-English	40	20	No	L1-L2	64*
Gollan et al. (1997)						
Exp. 1	Hebrew-English	50	No	No	L1-L2	53*
Exp. 2	English-Hebrew	50	No	No	L1-L2	142*
Exp. 3	Hebrew-English	50	No	No	L2-L1	9
Exp. 4	English-Hebrew	50	No	No	L2-L1	4
Kim and Davis (2003)						
Exp. 1	Korean-English	50	No	No	L1-L2	34*
Voga and Grainger (2007)						
Exp. 2	Greek-French	50	No	No	L1-L2	50*
Exp. 3	Greek-French	50	No	No	L1-L2	48*

Note. * refers to a significant effect.

magnitude of the backward priming effect. Furthermore, it may also have been influenced by the stimulus-onset asynchrony they used (112 ms; a 56-ms prime and a 56-ms post-mask). In fairness to Duyck and Warlop, the key point of their experiment was the presence of a significant backward masked translation priming effect for low-proficiency bilinguals. This finding was taken to suggest that there may be direct conceptual access to L2 words even at early stages of L2 acquisition (see Altarriba & Mathis, 1997; Comesaña, Perea, Piñeiro, & Fraga, in press; see also Duyck & Brysbaert, 2004, 2008, for further evidence).

All the above-mentioned results refer solely to cross-language manipulations that used noncognate translations. When cognate translation equivalents are used with unbalanced and nonsimultaneous bilinguals, the picture is slightly more complicated – in part because the number of studies using cognates is relatively small (see Table 2). Clearly, there is strong forward translation priming for cognates, whereas the evidence for backward translation priming is weaker: The average priming effect for forward and backward translation priming across studies is 62 versus 17 ms, respectively. To our knowledge, no previous studies have examined this issue with completely balanced simultaneous bilinguals. Again, the Revised Hierarchical model and BIA+ models would predict a similar translation priming effect in the two directions for balanced simultaneous bilinguals. This study intends to fill this gap too.

In addition, there is one final aspect of the cognate/noncognate distinction that is of particular interest. As shown in Tables 1 and 2, a reduced number of studies have compared the magnitude of masked translation priming for cognates and noncognates. Some of the studies have reported a greater translation priming effect for cognate pairs than for noncognate pairs (e.g., de Groot & Nas, 1991; Dimitropoulou, Duñabeitia, & Carreiras, 2009; Gollan, Forster, & Frost, 1997; Voga & Grainger, 2007), but there are some exceptions showing undistinguishable priming effects (e.g., Kim & Davis, 2003). Hence, it is not totally clear whether words that share semantic and orthographic or phonological representations (i.e., cognates) will coactivate each other under masked priming conditions to a larger extent than words that only share semantic representations (namely noncognates).

In summary, the first goal of this study is to examine whether there is bidirectional masked translation priming effects for cognates and noncognates with balanced simultaneous bilinguals, using a standard masked priming procedure (SOA = 47 ms). There are only few studies testing cognates and noncognates both in forward and backward masked translation priming (e.g., Gollan et al., 1997) and, to our knowledge, these studies have only tested unbalanced relatively high-proficient bilinguals. Hence, this study is the first experiment testing completely balanced simultaneous bilinguals in a masked translation priming experiment. An additional goal of this study is to compare the magnitude of the masked translation priming effect for cognate and noncognate translation equivalents. All the participants in this study were balanced and simultaneous bilinguals from the Basque country, a region in the north of Spain in which there are two official languages: Basque and Spanish. In this region, a large percentage of speakers are equally proficient (since childhood) in these two languages. The Basque language is an ancient pre-Indo-European language, with no demonstrable genetic relationship with other living languages, which is spoken at the western end of the Pyrenees, close to the Spanish-French border. The number of psycholinguistic studies in Basque has markedly increased in recent years, due to the specific orthographic, morphological, or syntactic properties of this language (e.g., Duñabeitia, Molinaro, Laka, Estévez, & Carreiras, 2009; Duñabeitia, Perea & Carreiras, 2007a, 2007b; Laka & Erriondo Korostola, 2001). Basque and Spanish have quite different origins, although these two languages also share a percentage of cognate words (in most cases, loan words from Spanish; e.g., libro and liburu; the Spanish/Basque for book).

It is important to stress that there is a clear difference between the present group of bilinguals (i.e., simultaneous bilinguals with two L1 s) and the nonsimultaneous bilinguals tested in previous research (i.e., with an L1 and an L2). In a recent study with the same population, Perea, Duñabeitia, and Carreiras (2008) highlighted the inappropriateness of the terms L1 and L2 when referring to this group of bilinguals, since they have acquired both languages from birth and use them constantly on a daily basis. Thus, conceptualizing the participants in this study as simultaneous balanced bilinguals with two L1 s is a more appropriate terminology.

We should note here that Perea et al. (2008) found a small, but significant, semantic priming effect across languages for highly fluent Basque-Spanish bilinguals (e.g., *aulki-MESA*; *aulki* is the Basque for *chair* and *mesa* is the Spanish for *table*). More important, the magnitude of the semantic priming effect was similar across (both Basque-to-Spanish and Spanish-to-Basque) and within languages – suggesting a common semantic (language-independent) locus of the effect. Given this symmetrical pattern of priming effects in the Perea et al. study, we would expect to find a significant effect of masked translation priming for cognates and noncognates with highly fluent Basque-Spanish bilinguals in lexical decision. Furthermore, because of the formal similarity for cognate pairs, masked translation priming effects should be greater for cognate pairs (e.g., *libro-LIBURU*) than for noncognate pairs (e.g., *nariz-SUDUR*).

Method

Participants

Thirty-two students from the University of the Basque country in Vitoria (average age: 22.5 years) received 5€ for participating in the experiment. All of them had either normal or corrected-to-normal vision and were native speakers of Basque and Spanish (i.e., the two official languages in the Basque country). All of them had had Basque as the teaching language at all academic levels, including the university level. It is crucial to note that all speakers in the Basque Autonomous Community have a perfect knowledge of Spanish as well; indeed, the most popular newspapers are written mostly in Spanish. All the participants completed a

Table 3. Frequency of usage of Basque and Spanish by the participants in a 1–7 Likert scale (1 = less frequent use and 7 = more frequent use), in academic and nonacademic contexts through childhood, adolescence, and nowadays. Participants' proficiency level in Basque and Spanish in comprehending, reading, speaking, and writing is also presented, according to their self-ratings in a 1–4 Likert scale (1 = less proficient and 4 = more proficient)

Frequency of use	Spanish	Basque
Academic contexts		
Childhood	1.84	6.81
Adolescence	1.75	6.69
Nowadays	1.75	6.09
Nonacademic contexts		
Childhood	5.56	5.91
Adolescence	5.31	5.75
Nowadays	5.84	5.44
Level of proficiency		
Comprehending	3.97	3.91
Reading	3.91	3.88
Speaking	3.81	3.78
Writing	3.78	3.88

questionnaire to assess their usage of Basque and Spanish. In this questionnaire, participants were asked about the age in which they started speaking each of the languages. They had to respond with 1 if they started speaking the language between 0 and 2 years, with 2 if they started between 2 and 4, and with 3 if they started after age 4. The mean score was 1.31 for Spanish and 1.34 for Basque ($p > .80$). This questionnaire also included questions regarding the frequency of usage of each of these two languages. On a 1–7 Likert scale (1 = less use and 7 = more use), participants rated the regularity in which they used each of the languages during childhood, youth, and nowadays in social (nonacademic) and academic contexts. As can be seen in Table 3, both Spanish and Basque were very frequently used in social contexts, and more importantly, no statistical differences were found between the frequency of usage of each of them (all *p*s > .14). As we noted before, Basque was predominantly used in academic contexts (all *p*s < .01). The questionnaire also included a section of self-evaluation of language proficiency in reading, writing, understanding, and speaking (on a 1–4 Likert scale; 1 = lower proficiency and 4 = higher proficiency). The lowest mean proficiency score was 3.78 for both languages, with no statistical differences between languages (all *p*s >.26; see Table 3).

Table 4. Number of letters and mean word frequency (per million) of the word pairs in the experiment

	Cognates		Noncognates	
	Spanish	Basque	Spanish	Basque
Number of letters	7.2	7.2	6.9	7.2
Word frequency	38	37	37	37

Note. The Spanish and Basque word frequency counts were taken from B-Pal (Davis & Perea, 2005) and from E-Hitz (Perea et al., 2006).

Materials

Two sets of eighty Spanish words were selected: one in which the Basque translation was a cognate of the Spanish word (e.g., *libro-liburu*; the Spanish/Basque for *book*) and the other in which the Basque translation was not a cognate of the Spanish word (e.g., *nariz-sudur*; the Spanish/Basque for *nose*). The concreteness indices for the cognate and noncognate words in Spanish were 5.2 and 5.0, respectively (on a 1–7 Likert scale; Sebastián-Gallés, Martí, Carreiras, & Cuetos, 2000). The targets were presented in uppercase and were preceded by primes in lowercase that were 1) a translation of the target in the other language (related word condition), for example, *liburu-LIBRO* or *libro-LIBURU*, or 2) an unrelated word in the other language (unrelated word condition), for example, *zarata-LIBRO* or *ruido-LIBURU*. The characteristics of the words used in the experiment are presented in Table 4. Two lists were created where targets were Basque words preceded by a Spanish prime, and two other lists were created where targets were Spanish words preceded by a Basque prime. For both Spanish and Basque conditions, word primes were rotated through the related and unrelated conditions so that each target word was primed by each of the two types of primes across the experiment. None of the unrelated prime-target word pairs were morphologically or semantically related. The mean positional letter overlap between unrelated primes and targets was below 11% in all control conditions (9.5% and 10.3%, $p > .65$, of overlapping letters in the unrelated Basque and Spanish cognate word pairs, and 6.1% and 6.2%, $p > .98$, in the unrelated Basque and Spanish noncognate word pairs). The mean positional letter overlap between related primes and targets was, unsurprisingly, different for cognate and noncognate word pairs: Basque and Spanish cognate primes had a high orthographic overlap with their corresponding targets (55.7% vs. 56.9%, respectively, $p > .35$), while Basque and Spanish noncognate-related primes had a much lower orthographic overlap, similar to that of the unrelated conditions (9.0% vs. 8.6%, $p > .41$).[1]

[1] It should be noted that Spanish and Basque unrelated and related primes in the noncognate priming conditions shared a similar orthographic overlap with the targets (all *p*s > .10). However, Spanish and Basque unrelated and related primes in the cognate priming conditions significantly differed in the percentage of overlapping letters, with related primes having more overlapping letters than unrelated primes (*p*s < .001 in both languages). Previous studies that explored masked translation priming effects for cognate word pairs also used orthographically unrelated words as control primes for the related words in the cognate priming condition (e.g., see de Groot & Nas, 1991; Gollan et al., 1997; Kim & Davis, 2003). As we indicate in the Discussion section, this is an unsurprising difference. Indeed, this difference has been proposed to be the cause of the cognate advantage in bilingual research (e.g., see Costa, Santesteban, & Caño, 2005; Voga & Grainger, 2007).

For each list, half of the related primes were cognates, and the other half were noncognates. Thus, two sets of materials were constructed in the Spanish conditions (and two sets in the Basque conditions) in order for each target word to appear once in each set, but each time in a different priming condition. Different groups of participants were used for each set of materials.

An additional set of 160 orthographically legal nonwords in Basque (e.g., *izkul and enai*) for the Basque group and of 160 orthographically legal nonwords in Spanish (e.g., *nasir and notro*) for the Spanish groups were also created for the lexical decision task. None of the Basque nonwords was a word in Spanish and none of the Spanish nonwords was a word in Basque. As occurred with the word trials, nonword targets were always preceded by a word in the nontarget language.

Table 5. Mean lexical decision times (in ms) and percentage of errors (in parentheses) for word targets in the experiment

	Type of prime		
	Related	Unrelated	Priming
Spanish targets			
Cognates	649 (1.1)	693 (2.1)	44 (1.0)
Noncognates	703 (3.8)	719 (4.0)	16 (0.2)
Basque targets			
Cognates	753 (5.9)	785 (9.6)	62 (3.8)
Noncognates	780 (3.6)	800 (3.8)	20 (0.2)

Note. Mean nonword response times and error rates were 830 ms and 4.4% for the group with Spanish targets, and 886 ms and 6.0% for the group with Basque targets.

Procedure

Participants took part in two sessions on different days. In the first session, half of the participants were presented with the Spanish targets and in the second session with the Basque targets; for the other half of the participants, the order was reversed. On each session, participants were tested individually in a quiet room. Presentation of the stimuli and recording of response times were controlled by PC compatible computers. The experiment was run using DMDX (Forster & Forster, 2003). Reaction times were measured from target onset until the participant's response. On each trial, a forward mask consisting of a row of hash marks (#'s) was presented for 500 ms in the center of the screen.[2] Next, the prime was presented in lowercase in 12-pt. Courier and stayed on the screen for 47 ms (four cycles; each cycle corresponding to 11.8 ms on the CRT monitor). The prime was followed immediately by the presentation of the target stimulus in uppercase. Both prime and target were presented at the same screen location as the forward mask. The target remained on the screen until the participants responded. Participants were instructed to press one of two buttons on the keyboard to indicate whether the uppercase letter string was a legitimate word or not and were instructed to make this decision as quickly and as accurately as possible. They were not informed of the presence of the lowercase items, and none of the participants reported having seen the lowercase words when asked after the experiment. Each participant received a different order of trials. Each participant received a total of 20 practice trials (with the same manipulation as in the experimental trials) prior to the 80 experimental trials. The instructions (and the interactions with the participants) were given in Spanish when the participants had to perform the lexical decision task in Spanish, and they were given in Basque when the participants had to perform the lexical decision task in Basque. The whole session lasted ~ 9 min.[3]

Results

Incorrect responses (4.2% of the data for word targets) and reaction times less than 250 ms or greater than 1,800 ms (< 1% of the data for word targets) were excluded from the latency analysis. The mean latencies for correct responses and error rates are presented in Table 5, and participant and item ANOVAs based on the participant and item response latencies and error percentage were conducted based on a 2 (Language of target: Spanish and Basque) × 2 (Cognate status: cognate and noncognate) × 2 (Type of prime-target relationship: related and unrelated) × 2 (List: list 1 and list 2) design. The factor list was included as a dummy variable to extract the variance due to the error associated with the lists.

The ANOVA on the response time data showed that words preceded by an equivalent word in the nontarget language were responded to 36 ms faster than words preceded by an unrelated word, $F1(1, 30) = 121.72$, $MSE = 644$, $p < .001$ and $F2(1, 156) = 97.84$, $MSE = 2{,}533$, $p < .001$. Cognate words were recognized significantly faster (31 ms

[2] In the pattern mask, the number of #s was the maximum of the number of letters of the prime and the number of letters of the target. Care was taken that the length of prime and target was approximately the same.

[3] To ensure that participants could not use any conscious information from the masked primes in the present experimental setup, we conducted an additional control experiment (i.e., a lexical decision experiment on the prime stimuli). Fifteen new Spanish speakers were presented with a forwardly masked Spanish word or nonword as a prime (e.g., the word *libro* [book] or the nonword *nasir*), which was immediately followed by a consonant string (e.g., *CXMJK*). Participants were asked to perform a lexical decision on the briefly presented stimulus that preceded the consonant string. Results showed a 50.21% error rate, which is very close to responding by chance (50%). Moreover, no differences were found in the correct response for consonant strings preceded by words and nonwords (e.g., *libro-CXMJK* vs. *nasir-CXMJK*; $p > .56$). That is, the information extracted from the primes in the present experimental setup cannot be used to predict a critical effect in visual-word processing such as lexicality (see Kouider et al., 2007, for converging evidence).

faster) than noncognate words, $F1(1, 30) = 49.74$, $MSE = 700$, $p < .001$ and $F2(1, 156) = 8.36$, $MSE = 9{,}172$, $p < .01$. The effect of target language was also significant, showing that Spanish targets were recognized 88 ms more rapidly than Basque targets, $F1(1, 30) = 91.49$, $MSE = 6{,}453$, $p < .001$ and $F2(1, 156) = 169.35$, $MSE = 8{,}999$, $p < .001$. Prime-target relationship did not significantly interact with target language, showing that the priming effects did not differ for Spanish and for Basque targets, $F1(1, 30) = 2.86$, $MSE = 719$, $p > .10$ and $F2(1, 156) = 1.35$, $MSE = 2{,}533$, $p > .24$. On the contrary, the magnitude of the translation priming effect was greater for cognate pairs than for noncognate pairs, as deduced from the significant interaction between Cognate status and Prime-target relationship, $F1(1, 30) = 26.31$, $MSE = 771$, $p < .001$ and $F2(1, 156) = 24.92$, $MSE = 2{,}177$, $p < .001$. For cognates, the translation priming effect was 53 ms, $F1(1, 30) = 139.17$, $MSE = 641$, $p < .001$ and $F2(1, 156) = 94.60$, $MSE = 2{,}822$, $p < .001$, whereas for noncognates, the translation priming effect was 18 ms, $F1(1, 30) = 12.23$, $MSE = 775$, $p < .01$ and $F2(1, 156) = 18.59$, $MSE = 1{,}888$, $p < .001$. The interaction between the cognate translation priming effect and Target language approached significance in the $F2$ analysis, $F1(1, 30) = 2.83$, $MSE = 917$, $p > .10$ and $F2(1, 156) = 3.76$, $MSE = 2{,}822$, $p = .05$, showing that the magnitude of the effect was slightly higher for Basque targets (62 ms) than for Spanish targets (44 ms). In contrast, the noncognate translation priming effect did not interact with Target language, showing that both effects were very similar (16 and 20 ms, respectively), $F1(1, 30) = .34$, $MSE = 506$, $p > .55$ and $F2(1, 156) = .21$, $MSE = 1{,}888$, $p < .60$. In addition, pairwise comparisons were conducted to assess the reliability of the priming effects for cognate and noncognate pairs within and across languages. All the priming effects were significant: the 44-ms effect for Spanish targets and cognate pairs, $F1(1, 30) = 58.13$, $MSE = 528$, $p < .001$ and $F2(1, 78) = 49.65$, $MSE = 1{,}723$, $p < .001$; the 62-ms effect for Basque targets and cognate pairs, $F1(1, 30) = 59.38$, $MSE = 1{,}030$, $p < .001$ and $F2(1, 78) = 48.97$, $MSE = 3{,}921$, $p < .001$; the 16-ms effect for Spanish targets and noncognate pairs, $F1(1, 30) = 5.03$, $MSE = 703$, $p < .04$ and $F2(1, 78) = 12.63$, $MSE = 1{,}703$, $p < .001$; and the 20-ms effect for Basque targets and noncognate pairs, $F1(1, 30) = 10.58$, $MSE = 577$, $p < .01$ and $F2(1, 78) = 6.75$, $MSE = 2{,}072$, $p < .02$.

The ANOVA on the error data showed that participants made 1.3% more errors on unrelated words than on related words, $F1(1, 30) = 4.91$, $MSE = 21$, $p < .04$ and $F2(1, 156) = 8.68$, $MSE = 30$, $p < .01$. In addition, participants made 3.0% more errors on Basque words than on Spanish words $F1(1, 30) = 20.35$, $MSE = 27$, $p < .001$ and $F2(1, 156) = 9.38$, $MSE = 148$, $p < .01$. This relatedness effect was qualified by a significant interaction between Prime-target relationship and Cognate status, $F1(1, 30) = 8.52$, $MSE = 9$, $p < .01$ and $F2(1, 156) = 7.11$, $MSE = 28$, $p < .01$: The relatedness effect occurred for cognate pairs (1.6%; $F1(1, 30) = 10.79$, $MSE = 17$, $p < .01$ and $F2(1, 78) = 13.86$, $MSE = 33$, $p < .001$), but not for noncognate pairs (0.2%, both Fs < 1). As for the reaction latency data, pairwise comparisons were conducted for cognate and noncognate relationships within and across languages. Results only showed significant differences for Basque cognate pairs (a 3.8% difference), $F1(1, 30) = 13.89$, $MSE = 16$, $p < .01$ and $F2(1, 78) = 10.25$, $MSE = 55$, $p < .01$. The rest of the pairwise comparisons did not show any significant difference (all ps > .15). In sum, the present experiment has shown a significant translation priming effect for cognate and noncognate pairs with balanced simultaneous Basque-Spanish bilinguals when tested in their two L1 s. Despite the lack of interaction of the relatedness effect with target language, for cognate pairs, a healthy trend toward significance showed that the magnitude of the priming effect was somehow higher for Basque than for Spanish targets (62 vs. 44 ms). More importantly, the critical interaction with the priming language direction was not significant for noncognate pairs (i.e., forward and backward noncognate priming effects were similar in magnitude; 16 and 20 ms, respectively). In addition, the translation priming effect was substantially greater for cognate than for noncognate pairs (53 ms and 2.4% vs. 18 ms and 0.2%, respectively).

Discussion

The main findings of the present masked priming experiments are straightforward: (i) balanced and simultaneous bilinguals show early and automatic translation priming effects for noncognate and for cognate pairs, (ii) masked translation priming effects were substantially greater for cognate than for noncognate pairs, and (iii) there were no clear asymmetries between the magnitude of the translation priming effects across languages (Basque-Spanish and Spanish-Basque). Taken together, these findings have clear implications for models of bilingual memory. As reviewed in the Introduction (see Table 1), the presence of L1-to-L2 masked translation priming is frequently reported, whereas evidence of L2-to-L1 priming is relatively scarce. In the present experiment, using highly balanced bilinguals, we found a remarkably similar magnitude of masked translation priming for noncognates in the two directions: Basque-to-Spanish and Spanish-to-Basque (16 vs. 20 ms, respectively). That is, we obtained similar results to those found by Altarriba and Basnight-Brown (2007), but under shorter prime duration conditions (note that Altarriba and Basnight-Brown used a 100-ms SOA, while we used a 47-ms SOA). In addition, for cognate pairs, the priming effect was numerically higher for Spanish-Basque pairs than for Basque-Spanish pairs (62 vs. 44 ms). Although the critical interaction was not significant for cognate pairs, this pattern is consistent with the fact that response times were (nearly 100 ms) slower for Basque words than for Spanish words (which also occurred in the experiments of Perea et al., 2008), and hence there were more chances for the related prime to have an effect on the target (e.g., see Perea & Rosa, 2002b, for discussion). Furthermore, despite the fact that all the bilinguals in the experiment had Basque as the teaching language at all academic levels, the level of orthographic recognition in Spanish was probably slightly higher than in Basque (e.g., the percentage of books and newspapers in the Basque country is larger in Spanish than in Basque).

Thus, the present findings provide empirical support for the Revised Hierarchical model of bilingual memory, in which highly proficient bilinguals have access to a shared conceptual/semantic store for the two languages (Kroll & Stewart, 1994; Kroll & Tokowicz, 2005). In this model, the shared conceptual representations are likely to work in the same way for cognate and noncognate pairs. Of course, to make specific predictions, the Revised Hierarchical model would have to include estimates of the time course of lexical/semantic activation. The present data are also compatible with the BIA+ model (Dijkstra & van Heuven, 2002). As Dijkstra and van Heuven pointed out, the BIA+ framework complements – rather than opposes – recent versions of the Revised Hierarchical model. The lack of asymmetry observed in the present experiment is a consequence of the proficiency level of these bilinguals – who have native knowledge and daily usage of both languages. Note that this would imply more stable lexical representations and stronger interlingual connections, especially if one considers that the BIA+ model assumes the existence of one integrated lexicon, rather than two separate ones. Interestingly, the BIA+ model is especially suited for accounting for the "cognate" effect obtained in the present experiment (i.e., faster response times for cognate than for noncognate translation; e.g., see also de Groot & Nas, 1991). Due to the ortho-phonological feature overlap between the two cognates (e.g., the Spanish *camión* and the Basque *kamioi*, which refer to *truck*), and considering the bidirectional flow of activation among the different levels underlying the architecture of the BIA+ model, the two word forms (*camión* and *kamioi*) are coactivated to a large degree when one of them is presented. At this point, it should be mentioned that the underlying factor responsible for the cognate advantage over noncognate translations may be the amount of shared sublexical representations. As proposed by Voga and Grainger (2007), cognates may not have a privileged role in a bilingual's lexicon, and the reason for the greater priming effects for cognates as compared to the noncognates would be the additional form-priming component. Keep in mind that in this and preceding studies, cognate related prime-target word pairs share more ortho-phonological overlap with each other than the unrelated word pairs. In line with this view, we performed a correlation analysis between the net priming effect at the item-level (RTs in the unrelated conditions – RTs in the related conditions) and the difference in orthographic overlap (percentage of overlap in the related conditions – percentage of overlap in the unrelated conditions), and results showed that priming effects increased as a function of shared orthographic representations ($r = .18$, $p < .01$). In any case, this finding does not compromise the present data: the magnitude of the translation priming was similar in the two directions for both cognate and noncognate pairs. Even though a perfect symmetry of the priming effects for cognate words was not found, our results did show a perfect symmetry in the priming effects for noncognate words. The partially asymmetrical pattern of priming effects for cognates across languages could have been influenced by uncontrolled orthographic (rather than semantic) priming effects. The symmetrical pattern obtained for noncognates is not subject to this confound and therefore clearly supports the idea of symmetrical priming effects across languages for highly proficient and balanced bilinguals.

There is another model which can also capture the observed findings with simultaneous balanced bilinguals: the model proposed by Duyck and Brysbaert (2004; see also Duyck & Warlop, 2009). As stated by Duyck and Warlop, this model offers a symmetrical organization of the lexico-semantic representations of a bilingual, assuming that the newly acquired L2 words are "mapped strongly, and early in the acquisition process, onto their underlying semantic representations". Considering the fast and stable mapping of L2 word forms onto the preexisting L1-based semantic representations, the model does not predict a masked translation priming asymmetry. Our results fit well with the predictions of this model. Finally, the Sense model (Finkbeiner et al., 2004) captures the presence of masked translation priming as a function of overlapping "senses". Normally, translation equivalents have one sense in common but beyond that given sense, others might differ. Following this line of reasoning, Finkbeiner and colleagues' model readily accounts for the masked translation priming asymmetry that has been previously found. However, this model fails at predicting the lack of asymmetry that has been found in the present experiment (see also Duyck & Warlop, 2009, for similar criticism). In sum, we have shown that completely balanced simultaneous bilinguals develop symmetrical between-language links on the basis of early and automatic translation priming for both cognates and noncognates. We believe that the use of highly proficient speakers from bilingual regions with languages with very different properties, as it is the case with Basque and Spanish, may provide important insights into the study of bilingual memory.

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