Translation Priming Between the Native Language and a Second Language

New Evidence From Dutch-French Bilinguals

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Abstract. During the last two decades, bilingual research has adopted the masked translation priming paradigm as a tool to investigate the architecture of the bilingual language system. Although there is now a consensus about the existence of forward translation priming (from native language primes (L1) to second language (L2) translation equivalent targets), the backward translation priming effect (from L2 to L1) has only been reported in studies with bilinguals living in an L2 dominant environment. In a lexical decision experiment, we obtained significant translation priming in both directions, with unbalanced Dutch-French bilinguals living in an L1 dominant environment. Also, we demonstrated that these priming effects do not interact with a low-level visual prime feature such as font size. The obtained backward translation priming effect is consistent with the model of bilingual lexicosemantic organization of Duyck and Brysbaert (2004), which assumes strong mappings between L2 word forms and underlying semantic representations.

Keywords: translation priming, bilingualism, visual word recognition

During the last two decades, two important questions have remained prevalent in the literature on bilingual word processing. One question concerns the issue whether the two languages of a bilingual are processed by two functionally independent language systems, or alternatively, whether the cross-lingual interactions exist between the two languages' representations during unilingual processing (see e.g., Dijkstra & Van Heuven, 2002; Duyck, 2005). The other question deals with the lexicosemantic organization of these two language systems. Here, the central issue has been whether the mapping of word form (lexical) representations onto underlying semantics is similar for both second (L2) and native (L1) languages. This research has originated from the most influential model of bilingual lexicosemantic organization, namely the revised hierarchical model (RHM) of Kroll and colleagues (e.g., Kroll & Stewart, 1994). The RHM assumes that L1 and L2 share a common conceptual system, but also that L2 lexical representations do not have strong form-meaning connections, unlike L1 words, but instead access semantics through their L1 translation equivalents (unless in high levels of L2 proficiency). This contrasts with the more recent models of bilingual lexicosemantic organization, such as that of Duyck and Brysbaert (2004; see also Duyck & Brysbaert, 2008). In this model, lexicosemantic organization is not necessarily qualitatively different for L2 than for L1. Instead, strength of L2 form-to-meaning mappings may vary gradually, depending on general L2 proficiency (as in the RHM), but also on word variables. Also, Duyck and Brysbaert (2004) have shown that these mappings may develop very early after L2 word acquisition.

A popular paradigm that has yielded relevant data for both of these recurring questions is the masked translation priming technique. In this paradigm, originating from the monolingual version proposed by Forster and Davis (1984), it is investigated whether the recognition of a target word (e.g., HAT) may be facilitated by the preceding tachistoscopic presentation of a translation equivalent prime (e.g., HOED, for a Dutch-English bilinguals). Typically, it is found that such priming occurs with L1 primes and L2 targets (forward translation priming), but not with L2 primes and L1 targets (backward translation priming) (e.g., Gollan, Forster, & Frost, 1997; Grainger & Frenck-Mestre, 1998; Jiang & Forster, 2001; for an excellent and complete recent overview of translation priming studies, see Altarriba & Basnight-Brown, 2007).[1] Because the forward translation priming effect involves activation spreading between lexical representations of two different languages, it has contributed to the growing consensus that representations from both languages of a bilingual are always active and interacting

[1] Because Neely (1991; see also Hutchison, Neely, & Johnson, 2001) has shown that prime-target stimulus onset asynchronies (SOAs) above 200 ms may yield strategic influences (e.g., target expectancy generation), this paper only considers masked priming studies with short prime durations (see also Altarriba & Basnight-Brown, 2007; Basnight-Brown & Altarriba, 2007).

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(see the first research question above). As the translation priming effect is generally attributed to preactivation of a shared semantic representation between prime and target (e.g., Basnight-Brown & Altarriba, 2007; Finkbeiner, Forster, Nicol, & Nakamura, 2004; Grainger & Frenck-Mestre, 1998), the asymmetry between forward and backward translation priming has been interpreted as evidence for the assumption that L2 lexical representations (primes) do not activate semantics to the same degree as L1. This finding is consistent with the RHM's asymmetric lexicosemantic organization, and has therefore contributed to the second research question above, concerning the mapping of form to meaning for L2.

However, the failure to obtain backward translation priming has not been very consistent. First, even though Grainger and Frenck-Mestre (1998) did not obtain significant backward translation priming for lexical decision, they did report a "healthy trend" (pp. 615) (10 ms) in one of the longer (57 ms) SOA conditions. Second, in one of the five lexical decision experiments, Jiang (1999) did find a significant 13 ms L2-L1 priming effect, although his other three L2-L1 priming experiments did not yield such an effect. Third, backward translation priming has been observed in two other tasks that tap into different levels of processing than lexical decision. Grainger and Frenck-Mestre (1998) and Finkbeiner et al. (2004) have obtained L2-L1 priming in semantic categorization. Backward translation priming in semantic categorization has also been reported by Sanchez-Casas, Davis, and Garcia-Albea (1992), but only for translation equivalents that have considerable form overlap (so-called cognates, e.g., Spanish-English: RICO-RICH). Similarly, Jiang and Forster (2001) reported backward translation priming in an episodic memory recognition task (i.e., a task in which participants have to indicate whether targets were included in a previously presented word list), but again not in a lexical decision task.

Together with the earlier failures to obtain backward translation priming (e.g., Gollan et al., 1997), these findings constitute a mixed and somewhat confusing pattern of results. This has generated a renewed interest in the translation priming paradigm. Voga and Grainger (2007) for instance have recently focused on the role of cognate status in translation priming. Altarriba and Basnight-Brown (2007) on the other hand, have focused on the methodological differences between translation priming studies that may indeed be partly responsible for some of the inconsistent findings. In a detailed overview of the translation priming literature, they discussed the possible influence of methodological variables such as the proportion of related trials, nonword ratios, SOAs, language proficiency, and many others (see also Footnote 1). And, by adopting variable settings that were theoretically well-motivated to test translation priming without confounding factors, Basnight-Brown and Altarriba (2007, Experiment 2) obtained a significant 24 ms backward translation priming effect in a lexical decision task.

Surprisingly, Basnight-Brown and Altarriba (2007, Experiment 1) also observed backward, but not forward semantic priming in the same bilinguals, reversing the classical priming asymmetry. Because they tested Spanish-English bilinguals living in the USA, they argued that the participants experienced a language dominance shift, "where their L2 actually behaves as if it was their L1". Indeed, their English-Spanish participants even rated English language skills significantly higher than Spanish skills. Interestingly, this went unnoticed to Basnight-Brown and Altarriba, the only two earlier studies that yielded traces of backward translation priming in lexical decision were actually the studies that tested bilinguals that had been living for some time in an L2 dominant environment. In the Grainger and Frenck-Mestre (1998) study, which showed a "healthy" 10 ms trend, the participants were English-French bilinguals who were "living in France at the time of the experiment (the number of years spent in France ranged from 10 to 25)" (pp. 605). In the Chinese-English study of Jiang (1999), which yielded a significant 13 ms L2-L1 priming effect, the participants were "all graduate students or visiting scholars from mainland China studying at the University of Arizona [USA] at the time of testing" (pp. 62). Remarkably, it is also the case that the three studies reporting backward translation priming in tasks other than lexical decision had tested participants living in an L2 dominant environment. Similar to the L2 dominant Grainger and Frenck-Mestre (1998) study, which also included a semantic categorization task, Finkbeiner et al. (2004) tested Japanese-English bilinguals who had been living in the USA for at least 2 years. Jiang and Forster (2001, episodic recognition task) tested Chinese-English bilinguals who had been living and studying in the USA between 1 and 7 years. The only other study that used a semantic categorization task (Sanchez-Casas et al., 1992), but with (Spanish-English) bilinguals living in an L1 dominant environment did not obtain backward translation priming, except for cognates.

Based on the analysis above, it is important to note that, consistent with Basnight-Brown and Altarriba's (2007) language dominance hypothesis, backward translation priming with noncognates has only been shown in bilinguals living in an L2 dominant environment. The primary aim of this study is to further test this hypothesis with a new language pair, in a group of unbalanced Dutch-French bilinguals living in an L1 dominant environment, taking into consideration the methodological recommendations of Altarriba and Basnight-Brown (2007). To this end, we will investigate both forward and backward translation priming in the same participants. In addition, we will examine the possible influence of a low-level visual factor, namely prime size, on translation priming, because this factor has not been

[2] With the exception of the study of Voga and Grainger (2007), font size is never explicitly mentioned in the method section of translation priming studies. An E-mail inquiry addressed to the first authors of these studies revealed the use of diverging prime font sizes, ranging from 10 to 16 points, with 12 point as the most frequently used font size. We thank the authors for providing this information.

controlled in previous studies.[2] Moreover, recent studies in the monolingual domain (Tzur & Frost, 2007; see also Frost, Ahissar, Gotesman, & Tayeb, 2003) have reported quite disturbing evidence that a low-level visual feature such as prime luminance determines whether significant masked (repetition) priming is obtained or not (keeping SOA constant). Therefore, it is of interest to examine whether the font size of the prime, which is more salient, but correlated with its luminance, may interact with the translation priming effect. Therefore, both our forward and backward translation priming conditions will include smaller and larger prime font sizes, within a typical experimental range.

Experiment

Method

Participants

Twenty-four university students participated for course requirements. They were all Dutch-French unbalanced bilinguals, living in an L1 dominant environment (i.e., Flanders, the Dutch speaking part of Belgium), speaking Dutch at home, at school, with friends, etc. In this setting, the participants were not frequently exposed to French (television, radio, etc.). Instead, they were more often exposed to English through popular media (television, music, internet, etc.) and textbooks for example. Mean proportion of time processing French in this population was estimated at 4.4% (SD = 3.7).[3] All the participants started to learn French in a scholastic setting around age 11 (formal French courses are mandatory in Belgian primary school at that age). Those who were exposed earlier to French were excluded from the experiment. The participants were asked to rate their L1 and L2 proficiency with respect to several skills (reading, writing and speaking) on a 7-point Likert scale ranging from "very bad" to "very good". Mean values are reported in Table 1. Self-reported L1 and L2 proficiency differed significantly for all skills (all ps < .001).

Table 1. Language history and self-assessed ratings of L1 and L2 proficiency on a 7-point Likert scale ranging from 0 (very bad) to 7 (very good). Standard deviations are indicated in parentheses

Skill	L1 (Dutch)	L2 (French)
Writing	5.4 (0.9)	3.8 (1.4)
Speaking	5.3 (1.2)	3.9 (1.4)
Reading	5.7 (1.1)	4.2 (1.2)

Stimuli and Procedure

The critical stimuli were 44 L2 (French) target words and their L1 (Dutch) translation equivalents (see Appendix), with a word length between three and seven (M_{L1} = 4.86 and M_{L2} = 4.52). This ensures that any difference between forward and backward translation priming could not be confounded with the specific concepts tested. Mean log frequency per million words for L1 and L2 was respectively, 1.86 and 1.81, calculated using the WordGen stimulus generation program (Duyck, Desmet, Verbeke, & Brysbaert, 2004) on the basis of the Dutch CELEX corpus (Baayen, Piepenbrock, & Van Rijn, 1993) and the French Lexique corpus (New, Pallier, Brysbaert, & Ferrand, 2004). The L1 targets served as translation primes for L2 lexical decision targets and vice versa. For each prime, a control prime in the same language was generated using WordGen, matched item by item, on a number of lexical characteristics: Word length (L1 primes: Respectively M = 4.52 and M = 4.50; L2 primes: M = 4.86 and M = 4.89), log frequency per million words (L1: M = 1.81 and M = 1.77; L2: M = 1.86 and M = 1.75), number of orthographic neighbors (L1: M = 8.4 and M = 9.5; L2: M = 4.5 and M = 3.9),[4] and summed bigram frequency (L1: M = 33,170 and M = 34,544; L2: M = 10,567 and M = 11,601). Paired samples t tests showed that translation and control primes were similar with respect to all these variables (all ps > .15). Translation primes and controls were also matched with respect to the orthographic overlap with the targets. For instance, because the L2 target *canard* (duck) shared two letters (*n* and *d*) with its L1 translation equivalent prime *eend*, so did the L1 control prime *mond*. Cognates (i.e., words that are identical across languages with respect to meaning and orthography, e.g., Dutch-English: *Film*) and interlingual homographs (i.e., words that share orthography but not meaning, e.g., *room* which means [cream] in Dutch) were excluded. Using WordGen, we also generated 44 phonologically legal nonwords for each language and 22 filler words of the same frequency and length range as the critical targets.

All the participants completed four experimental sessions. This ensured that any difference in priming effects between languages could not be confounded by characteristics inherent to the specific bilinguals tested (e.g., proficiency). Importantly, to minimize strategically induced L2 activation, all the participants first performed two sessions with L1 targets (L2 primes), and then two sessions with L2 targets (L1 primes). For each language, one session used primes in the small (10 point) font size and another session used primes in a larger (22 point) font size. Within languages, order of font size sessions was counterbalanced across the participants. There was a minimum of two full days between all sessions.

In each session, the participants received one of the four stimulus lists (again matched on the lexical variables mentioned above), containing 22 critical word targets. In each list, half of these targets were presented with the translation primes and half with the control primes. Assignment of

[3] This estimation was obtained from E-mail responses of 15 of the 24 original participants.

[4] Note that neighborhood size and summed bigram frequency, unlike log frequency per million words for example, are not easily comparable across languages, because the French Lexique corpus and the Dutch CELEX corpus contain a different amount of lexical entries. For more details, see Duyck et al. (2004).

Table 2. Mean RTs (ms) and accuracy (% errors) as a function of Target/Prime Language (L1-L2 vs. L2-L1), Prime Size (small vs. large) and Prime Type (translation vs. control). Standard errors are indicated in parentheses

	L1 Primes-L2 Targets				L2 Primes-L1 Targets			
	Small		Large		Small		Large	
	RT	Accuracy	RT	Accuracy	RT	Accuracy	RT	Accuracy
Control	684 (21.4)	7.2 (1.82)	690 (23.0)	9.2 (2.33)	545 (13.9)	4.4 (1.38)	544 (11.9)	2.7 (1.30)
Translation	628 (19.6)	5.5 (1.56)	650 (15.4)	6.5 (2.29)	519 (14.7)	0.8 (0.59)	517 (11.9)	1.8 (1.06)
Effect	*56*	*1.7*	*40*	*2.7*	*26*	*3.6*	*27*	*0.9*

these lists was counterbalanced across sessions and participants, so that each participant saw each critical target only once, either in L1 or in L2, either with a translation prime or a control prime, either in small prime font size or in large font size. Across the participants, all targets appeared an equal number of times with translation/control primes and with small/large primes. Stimulus lists also contained 22 trials with filler target words (of the same language, word length, and frequency range as the critical targets) and 44 trials with phonologically legal nonwords in the Target Language (generated using WordGen, Duyck et al., 2004), so that each experimental session consisted of 88 trials.

Before the start of each session, the participants received written instructions to perform a visual lexical decision task in the respective Target Language. Each trial consisted of the following series of events, synchronized with the refresh cycle of the screen, following the masked priming paradigm: A forward mask (10 hash marks) for 56 ms, the prime (56 ms), the postmask (56 ms), and the target, which remained on the screen until a response was given, or until 2,000 ms had passed. All stimuli were presented centered on a 17 in. screen (640 × 480 resolution), in the *Tahoma* font, as white characters on a black background, using the ERTS (Experimental run time system) Software (V 3.28, Berisoft Corporation, 1999). Font sizes of the small primes and the large primes were 10 point and 22 point, respectively. Target font size was kept constant (16 point), to ensure that any difference between font conditions was actually a prime size effect, not confounded by processing differences (e.g., speed) between small and large targets. Masks were always 22 point in size, so that they would mask both prime sizes. After the experiment, the participants completed a hypothesis awareness questionnaire, which revealed that none of them was aware of the purpose of the experiment.

Results

Filler trials and nonword trials were not included in the analyses below. Accuracy and mean RTs on correct trials (see Table 2) were analyzed by means of repeated measures ANOVAs with Target Language (L1 vs. L2), Prime Type (translation prime vs. control) and Prime Size as the independent variables. All RTs that deviated >3SDs from the participant's mean word RT within a language were considered as outliers and were removed from this analysis (L1 targets: 2.14% of the data; L2 targets: 0.99%). Analyses were run with the participants (F_1) and the items (F_2) as random factors. Because the L2 targets *veine* (L1: *ader* [vein]) and *coq* (L1: *haan* [cock]) yielded >40% errors, they were also excluded from all analyses. We will first report analyses for L2 targets (L1 primes-forward translation priming), followed by analyses for L1 targets (L2 primes-backward translation priming) and the overall analysis.

Forward Translation Priming: L1 Primes-L2 Targets

Latencies. As expected, there was a main effect of Prime Type, $F_1(1, 23) = 16.41$, $p < .001$, $MSE = 3{,}389$ and $F_2(1, 41) = 18.68$, $p < .001$, $MSE = 4{,}251$. L2 targets were recognized faster after L1 translation primes ($M = 639$) than after L1 control primes ($M = 687$). The effect of Prime Size was not significant, $F_1(1, 23) = 1.00$, $p > .32$, $MSE = 4{,}896$ and $F_2(1, 41) = 2.61$, $p > .11$, $MSE = 3{,}715$, nor was its interaction with Prime Type, $F_1(1, 23) = 1.29$, $p > .26$, $MSE = 1{,}315$ and $F_2 < 1$. Numerically, the translation priming effect was even somewhat larger for small primes (56 ms) than for large primes (40 ms). Planned comparisons showed that these separate effects were both significant,[5] respectively, $F_1(1, 23) = 25.40$, $p < .001$, $MSE = 1{,}510$; $F_2(1, 41) = 17.12$, $p < .001$, $MSE = 3{,}170$ and $F_1(1, 23) = 5.94$, $p < .05$, $MSE = 3{,}194$; $F_2(1, 41) = 6.17$, $p < .05$, $MSE = 4{,}446$.

Accuracy. Although there were numerically less errors after translation primes ($M = 6.0$) than after control primes ($M = 8.2$), this difference was not significant, $F_1(1, 23) = 1.17$, $p > .29$, $MSE = 102$ and $F_2(1, 41) = 2.57$, $p > .11$, $MSE = 81$. Also, the effect of Prime Size and its interaction with Prime Type was not significant, all Fs < 1. Planned comparisons showed that there were no significant translation priming effects on error rates for both small and large primes, respectively, Fs < 1 and $F_1 < 1$, $F_2(1, 41) = 2.19$, $p > .14$, $MSE = 78$.

[5] Because the participants also had knowledge of English language, we tested whether removing all L2 *(lit and danger)* and L1 (*rook, wit, wolf, bed, warm, and week*) targets that are also existing English words changed the obtained pattern of results. This was not the case. With these stimuli removed, all translation priming effects remained significant, both for large and small primes, both in the analyses across the participants and across items. We thank an anonymous reviewer for this suggestion.

Backward Translation Priming: L2 Primes-L1 Targets

Latencies. Crucially, there was a significant backward translation priming effect, $F_1(1, 23) = 12.07$, $p < .01$, $MSE = 1{,}368$ and $F_2(1, 41) = 26.16$, $p < .001$, $MSE = 1{,}220$. L1 targets were recognized faster after L2 translation primes ($M = 518$) than after L2 control primes ($M = 544$). Also, the effect of Prime Type was not modulated by Prime Size, both *F*s < 1. Planned comparisons showed that the translation priming effect was significant both for small primes (26 ms) and for large primes (27 ms),[5] respectively, $F_1(1, 23) = 7.73$, $p < .01$, $MSE = 1{,}041$; $F_2(1, 41) = 12.03$, $p < .001$, $MSE = 1{,}703$ and $F_1(1, 23) = 5.62$, $p < .05$, $MSE = 1{,}505$; $F_2(1, 41) = 9.21$, $p < .01$, $MSE = 1{,}303$.

Accuracy. The participants made significantly less errors after translation primes ($M = 1.3$) than after control primes ($M = 3.6$), $F_1(1, 23) = 4.95$, $p < .05$, $MSE = 25$ and $F_2(1, 41) = 6.20$, $p < .05$, $MSE = 38$. The effect of Prime Size was not significant (both *F*s < 1), nor was its interaction with Prime Type, $F_1(1, 23) = 2.91$, $p > .10$, $MSE = 14$ and $F_2(1, 41) = 1.46$, $p > .23$, $MSE = 42$. Numerically, the priming effect was somewhat larger for small primes (3.6%) than for large primes (0.9%). Indeed, planned comparisons showed that the backward translation priming effect was significant for small primes, $F_1(1, 23) = 5.77$, $p < .05$, $MSE = 27$ and $F_2(1, 41) = 5.25$, $p < .05$, $MSE = 51$, but not for large primes, both *F*s < 1.

Comparison Between Priming Directions

The main effect of Target Language revealed that the responses to L2 targets ($M = 663$) were significantly slower than the responses to L1 targets ($M = 531$), $F_1(1, 23) = 121.41$, $p < .001$, $MSE = 6{,}891$ and $F_2(1, 82) = 216.95$, $p < .001$, $MSE = 6{,}832$, which is consistent with the fact that our bilinguals were not highly proficient. Across Target Languages, the effect of Prime Type remained significant, $F_1(1, 23) = 25.96$, $p < .001$, $MSE = 2{,}556$ and $F_2(1, 82) = 38.76$, $p < .001$, $MSE = 2{,}735$. The nonsignificant interaction effect of Prime Type and Target Language revealed that the 48 ms forward translation priming effect was not significantly stronger than the 26 ms backward translation priming effect, $F_1(1, 23) = 2.63, p > .11$, $MSE = 2{,}200$ and $F_2(1, 82) = 1.94$, $p > .16$, $MSE = 2{,}735$. Again, the effects of Prime Size, and its two-way and three-way interactions with Target Language and Prime Type were not significant (all *p*s > .10). Because we only obtained clear and consistent priming effects on response latencies, this analysis will not be reported for accuracy.

General Discussion

The obtained results were very clear. Using the masked priming paradigm with a lexical decision task, we obtained robust translation priming from L1 (e.g., EEND [duck]) primes to L2 translation equivalent targets (e.g., CANARD) and vice versa. The backward translation priming effect was significant across the participants and across the items, and was not significantly weaker than the forward translation priming effect. Both forward and backward translation priming were robust enough not to be influenced by the font size of the prime. Although earlier monolingual research (e.g., Frost et al., 2003; Tzur & Frost, 2007) has suggested that low-level visual features such as luminance may determine prime effectiveness, this current finding suggests that this methodological variable is probably not responsible for the inconsistent backward translation findings. As such, this study contributes to the interesting methodological discussion of translation priming studies' differences, initiated by Altarriba and Basnight-Brown (2007).

More importantly, to our knowledge, this is the first study ever to obtain significant backward translation priming in a group of unbalanced (Dutch-French) bilinguals living in an L1 dominant environment. The only three earlier studies that reported indications of backward translation priming in lexical decision tested bilinguals living in an L2 dominant setting. Grainger and Frenck-Mestre (1998), who reported a trend toward backward translation priming, tested English-French bilinguals living in France. Second, Jiang (1999), who reported significant backward translation priming in one of five lexical decision experiments, tested Chinese-English bilinguals studying in the USA. Finally, Basnight-Brown and Altarriba (2007), who found significant backward translation priming, tested Spanish-English bilinguals who were also living in the USA, and even rated English language skills higher than Spanish skills. Similarly, all earlier reports of priming from L2 to L1 with noncognate stimuli in a semantic categorization task tested bilinguals living in an L2 dominant environment (Finkbeiner et al., 2004; Grainger & Frenck-Mestre, 1998).

It is worth noting, however, that forward translation priming (48 ms) was numerically stronger than backward translation priming (26 ms), although this difference was not significant. We do not rule out the possibility that it might be possible to find both significant backward translation priming and significantly stronger forward translation priming in the same participants. The primary aim of this study was however, to investigate whether unbalanced bilinguals living in an L1 dominant environment may yield backward translation priming, whether it is weaker than forward translation or not. At least, this observation suggests that L2 words may not always be represented qualitatively different from L1 words, even at lower levels of L2 proficiency (see below).

At a theoretical level, these findings offer further support for the growing consensus (e.g., Dijkstra & Van Heuven, 2002; Duyck, 2005) that representations from both languages are active during unilingual word recognition (in this case, a language-specific lexical decision task). Apparently, these nontarget language representations may be strongly activated to spread activation to representations of the other language very quickly (short SOA). Second, because translation priming is generally attributed to preactivation of a shared semantic representation between prime and target (e.g., Basnight-Brown & Altarriba, 2007, Finkbeiner et al., 2004; Grainger & Frenck-Mestre, 1998), the backward translation priming effect, obtained with a short SOA, indicates that L2 word forms (primes) may quickly and strongly activate their underlying semantic representations. This is not consistent with the RHM of bilingual lexicosemantic organization, which assumes that L2 words do not have strong form-to-meaning mappings, unless in very high levels of L2 proficiency (which was not the case for this study), and should therefore not be able to yield translation priming effects. The observation that backward translation priming was not significantly smaller than forward translation priming (although it was somewhat weaker numerically) is consistent however with models of bilingual memory, such as that of Duyck and Brysbaert (2004). This model assumes that L2 word forms may be mapped strongly, and early in the acquisition process, onto their underlying semantic representations. Because lexicosemantic organization is not fundamentally asymmetric in this model, L2 word forms should yield a translation priming effect, just as L1 primes, as observed in this study.

Finally, our findings are not consistent with two alternative models of bilingual language organization that have been proposed. First, in the Sense model of Finkbeiner et al. (2004), semantic word representations are conceptualized as a number of distributed *senses*. Crucially, it is assumed that L2 words activate less senses than their L1 counterparts. Consequently, because an L1 word prime activates all senses on which the L2 translation equivalent target is mapped, the sense model predicts forward translation priming. However, because L2 primes do not preactivate all of the senses on which the L1 target is mapped, the model does not predict backward translation priming in a lexical decision task, which is inconsistent with these findings. Of course, if the Sense model would assume that L2 words may activate all senses at high levels of L2 proficiency, it could still be able to explain backward translation priming, at least for the participants living in an L2 dominant environment (see the *Introduction*). Second, in the episodic model of Jiang and Forster (2001), just as in the RHM or in the Sense Model, L2 words are also represented in a different way than L1 words. In this view, only L1 words are represented in semantic memory, whereas L2 words are only represented as a trace (with their L1 translation) in episodic memory. This was tested using a lexical decision task and an episodic memory recognition task (i.e., a task in which participants have to indicate whether targets were included in a previously presented word list or not). Interestingly, Jiang and Forster obtained only L2-L1 priming in the episodic recognition task, whereas the lexical decision task only yielded forward translation priming, which is again inconsistent with this study.

To summarize, we report both forward and backward translation priming in a lexical decision task with bilinguals living in an L1 dominant environment. This symmetrical pattern of priming effects support models of bilingual lexicosemantic organization such as that of Duyck and Brysbaert (2004), which assume strong form-to-meaning mappings for L2 words.

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References

Altarriba, J., & Basnight-Brown, D. M. (2007). Methodological considerations in performing semantic- and translation-priming experiments across languages. *Behavior Research Methods, Instruments, & Computers, 39*(1), 1–18.

Baayen, R., Piepenbrock, R., & Van Rijn, H. (1993). *The CELEX lexical database.* [CD-ROM]. Philadelphia: University of Pennsylvania: Linguistic Data Consortium.

Basnight-Brown, D. M., & Altarriba, J. (2007). Differences in semantic and translation priming across languages: The role of language direction and language dominance. *Memory & Cognition, 35*(5), 953–965.

Berisoft Corporation. (1999). *Experimental run time system. Version 3.28*.

Dijkstra, T., & Van Heuven, W. (2002). The architecture of the bilingual word recognition system: From identification to decision. *Bilingualism: Language and Cognition, 5*(3), 175–197.

Duyck, W. (2005). Translation and associative priming with cross-lingual pseudohomophones: Evidence for nonselective phonological activation in bilinguals. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 31*(6), 1340–1359.

Duyck, W., & Brysbaert, M. (2004). Forward and backward number translation requires conceptual mediation in both balanced and unbalanced bilinguals. *Journal of Experimental Psychology: Human Perception and Performance, 30*(5), 889–906.

Duyck, W., & Brysbaert, M. (2008). Semantic access in number word translation: The role of cross-lingual lexical similarity. *Experimental Psychology, 55*(2), 102–112.

Duyck, W., Desmet, T., Verbeke, L. P. C., & Brysbaert, M. (2004). Wordgen: A tool for word selection and nonword generation in Dutch, English, German, and French. *Behavior Research Methods, Instruments, & Computers, 36*(3), 488–499.

Finkbeiner, M., Forster, K., Nicol, J., & Nakamura, K. (2004). The role of polysemy in masked semantic and translation priming. *Journal of Memory and Language, 51*(1), 1–22.

Forster, K. I., & Davis, C. (1984). Repetition priming and frequency attenuation in lexical access. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 10*(4), 680–698.

Frost, R., Ahissar, M., Gotesman, R., & Tayeb, S. (2003). Are phonological effects fragile? The effect of luminance and exposure duration on from priming and phonological priming. *Journal of Memory and Language, 48*(2), 346–378.

Gollan, T. H., Forster, K. I., & Frost, R. (1997). Translation priming with different scripts: Masked priming with cognates and noncognates in Hebrew-English bilinguals. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 23*(5), 1122–1139.

Grainger, J., & Frenck-Mestre, C. (1998). Masked priming by translation equivalents in proficient bilinguals. *Language and Cognitive Processes, 13*(6), 601–623.

Hutchison, K. A., Neely, J. H., & Johnson, J. D. (2001). With great expectations, can two "wrongs" prime a "right"? *Journal of Experimental Psychology: Learning, Memory, and Cognition, 27*(6), 1451–1463.

Jiang, N. (1999). Testing processing explanations for the asymmetry in masked cross-language priming. *Bilingualism: Language and Cognition, 2*, 59–75.

Jiang, N., & Forster, K. I. (2001). Cross-language priming asymmetries in lexical decision and episodic recognition. *Journal of Memory and Language, 44*(1), 32–51.

Kroll, J. F., & Stewart, E. (1994). Category interference in translation and picture naming: Evidence for asymmetric connections between bilingual memory representations. *Journal of Memory and Language, 33*, 149–174.

Neely J. (1991). Semantic priming effects in visual word recognition: A selective review of current findings and theories. In D. Besner and G. W. Humphreys (Eds.), *Basic processes in reading: Visual word recognition* (pp. 264–336). Hillsdale, NJ: Erlbaum.

New, B., Pallier, C., Brysbaert, M., & Ferrand, L. (2004). Lexique 2: A new french lexical database. *Behavior Research Methods, Instruments, & Computers, 36*(3), 516–524.

Sanchez-Casas, R. M., Davis, C. W., & Garcia-Albea, J. E. (1992). Bilingual lexical processing-exploring the cognate non-cognate distinction. *European Journal of Cognitive Psychology, 4*(4), 293–310.

Tzur, B., & Frost, R. (2007). Soa does not reveal the absolute time course of cognitive processing in fast priming experiments. *Journal of Memory and Language, 56*(3), 321–335.

Voga, M., & Grainger, J. (2007). Cognate status and cross-script translation priming. *Memory & Cognition, 35*(5), 938–952.

Appendix

Used Stimuli. L1 targets and L1 control primes served as primes for L2 targets. L2 targets and L2 control primes served as primes for L1 targets. English language translation equivalents, displayed between brackets, were not presented during the experiment.

L2 targets	L1 targets	L1 control prime	L2 control prime
mouton [sheep]	*schaap*	*beitel*	*ventre*
fumée [smoke]	*rook*	*laan*	*canal*
fou [mad]	*gek*	*lid*	*sac*
glace [ice]	*ijs*	*kom*	*photo*
blanc [white]	*wit*	*der*	*donné*
boeuf [cow]	*rund*	*aula*	*appui*
bouton [button]	*knop*	*snor*	*cochon*
cerise [cherry]	*kers*	*pers*	*averse*
loup [wolf]	*wolf*	*dolk*	*lobe*
pont [bridge]	*brug*	*vaas*	*salle*
lune [moon]	*maan*	*bron*	*port*
jupe [skirt]	*rok*	*bil*	*bain*
feuille [sheet]	*blad*	*slot*	*colonne*
pied [foot]	*voet*	*fles*	*clef*
lait [milk]	*melk*	*golf*	*loup*
champ [field]	*veld*	*boog*	*croix*
canard [duck]	*eend*	*mond*	*pinard*
église [church]	*kerk*	*boom*	*épaule*

L2 targets	L1 targets	L1 control prime	L2 control prime
chou [cabbage]	*kool*	*poot*	*flot*
*veine** [vein]	*ader**	*klem*	*queue*
fromage [cheese]	*kaas*	*baan*	*battant*
*coq** [cock]	*haan**	*beek*	*blé*
lit [bed]	*bed*	*arm*	*mur*
mort [dead]	*dood*	*hoog*	*coup*
chaud [warm]	*warm*	*bang*	*étant*
mouche [fly]	*vlieg*	*akker*	*cabane*
bref [short]	*kort*	*aard*	*gris*
jour [day]	*dag*	*wel*	*bien*
automne [autumn]	*herfst*	*zelfde*	*visible*
été [summer]	*zomer*	*dalen*	*ici*
choix [choice]	*keuze*	*basis*	*maman*
sécher [dry]	*drogen*	*flink*	*metier*
danger [danger]	*gevaar*	*gebaar*	*imager*
guerre [war]	*oorlog*	*partij*	*garrot*
faim [hunger]	*honger*	*dubbel*	*cure*
rire [laugh]	*lachen*	*genoeg*	*type*
toit [roof]	*dak*	*bel*	*cuir*
joie [joy]	*vreugde*	*toename*	*face*
peur [fear]	*angst*	*beeld*	*choc*
juge [judge]	*rechter*	*beloven*	*acte*
doute [doubt]	*twijfel*	*baseren*	*saint*
nager [swim]	*zwemmen*	*pleiten*	*fouet*
semaine [week]	*week*	*deel*	*cellule*
malade [sick]	*ziek*	*boer*	*bourse*

* Removed from analyses because of high error rates.

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