Lexical access in trilinguals

Evidence from a double masked translation priming paradigm

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An original double-masked translation priming study investigates how trilingual translation trainees process their non-dominant languages (L2 and L3) and how these languages influence one another. We recruited 24 French (L1)- English (L2)- Spanish (L3) unbalanced trilinguals to perform lexical decision tasks in their L2 and L3. Target words were preceded by two primes, which were either the same word (repetition), a translation in one language, translations in two languages or unrelated words (in one or two languages). The results highlighted strong translation priming effects, with a repetition effect in both target languages. In addition, when the translation primes belonged to the other non-dominant language, reaction times (RTs) were slower in comparison to semantically unrelated primes in the same priming language. When two different languages were presented as a prime, L1 primes were more efficient when presented as first prime. These results are in line with previous experiments on masked translation priming studies in trilinguals and suggest that the multilingual lexicon is mediated by the L1.

Keywords: trilingualism, translation trainees, lexical decision, masked translation priming, repetition priming, switch cost

1. Introduction

The question of general language processing has been widely addressed in the literature focusing on bilingual language processing. A debate remains concerning the multilingual skills necessary to process several languages, often simultaneously, with a low level of interference between them (Aparicio & Lavaur 2016). The benefits of language switching in the development of general cognitive control seem to rely on the daily practice of two or more languages and, more specifically,

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on language switching, which is linked to enhanced inhibition processes (active and overcoming of inhibition; Aparicio, Heidlmayr, & Isel 2017). The ease with which bilinguals switch from one language to another is assumed to depend on age of acquisition (AoA) and the dominance relations between languages (Adorni et al. 2013; Aparicio & Lavaur 2013, 2016; Bairstow et al. 2014; Aparicio et al. 2017). Given the enhanced linguistic and cognitive skills developed by bilinguals using their languages in their professional activities (e.g., professional translators and simultaneous interpreters; Ibañez et al. 2010, Aparicio et al. 2017), it seems relevant to shed some light on these "extreme" situations of bilingualism.

For individuals who regularly use more than one language, there seem to be specific language control demands mainly due to the simultaneous activation of the multiple languages (Green 1998; Dijkstra & van Heuven 2002; Dijkstra 2005; Abutalebi & Green 2007) and bidirectional cross-language influences (Costa, Albareda, & Santesteban 2008; Blumenfeld & Marian 2013). The question of how multilingual individuals who regularly use different languages access their lexical representations and control cross-linguistic interference has been well addressed in the recent literature. It is largely admitted in the literature that in bilingual memory concepts are represented within a common unified semantic store (Potter et al., 1984). Over the past decade, the number of studies investigating the different forms of language switching has grown significantly (Aparicio 2011).

Language switching is a very common phenomenon, during which individuals have to access the semantic forms of words from the languages stored inside the mental lexicon (Moreno et al. 2002). Interestingly, the mutual influence of languages is not always balanced in consecutive bilinguals (Kroll et al. 2010), leading to asymmetrical costs associated with language switching. These costs, logically can be even greater in trilinguals (Aparicio & Lavaur 2013, 2016). Nevertheless, the semantic links between the native L1 and the non-native L2/L3, as well as the way they interact with one another and with the semantic representations they map onto, are still controversial (see French & Jacquet 2004, for a review). To increase our understanding of multilingual lexical processes, some researchers have focused on extreme situations of language switching, namely simultaneous interpreting and professional translating.

Here, we examine this issue using trilingual translation trainees. We measured their performance on lexical decision tasks in their two non-dominant languages (L2 and L3) using a double masked priming paradigm. Following Aparicio & Lavaur (2013, 2016), we assumed that L1 language dominance would play an important role in L2/L3 lexical decisions, and that introducing two primes before identifying the target would provide more information about the organization of the multilingual lexicon and on the mechanims involved in multilingual language processing and in language switching.

1.1 Language switching in translators and simultaneous interpreters

Multilinguals could be considered some sort of experts in terms of resolving competition between linguistic units due to the extensive use of their multiple acquired languages in daily life. This consideration has led some researchers to study "extreme situations" of language switching and cognitive control, focusing on simultaneous interpreting and translating (Proverbio et al. 2004; Christoffels & de Groot 2005; Christoffels et al. 2006; Yudes et al. 2011; Köpke & Signorelli 2012; Elmer et al. 2014; Hervais-Adelman et al. 2015; Aparicio et al. 2017). This research focuses on the unusual switching requirements of interpreting and translating tasks. To succeed, a high level of control and coordination is required that enables switching from one language to another and keeps the interference between the activated languages at a low level (Christoffels & de Groot 2005).

Yudes et al. (2011) and Aparicio et al. (2017) link language switching with enhanced cognitive control abilities—mainly inhibition processes—in simultaneous interpreters and translators, but do not specifically address cross-language interference. Ibañez et al. (2010) compared the reading times of proficient bilinguals and translators while reading and understanding sentences, including cognates or specific words, randomly presented in their L1 (Spanish) and in their L2 (English). They found that the group of experienced translators coactivated both languages during reading, and processed cognate words faster as compared to control words. Interestingly, their results also revealed that bilinguals processed cognates and control words at the same speed, indicating that they were only activating the languages in which sentences appeared in each trial. Ibañez et al. (2010) explained the faster processing exhibited by translators in terms of language coactivation, while bilinguals were thought to switch between two monolingual modes. The bilingual group also displayed an asymmetrical switch cost—an indicator of inhibitory processes in language selection –, suggesting a greater ability to monitor and control interference in the translator group.

To address these issues, the masked priming paradigm (Forster & Davis 1984) seems an appropriate experimental paradigm. In masked priming conditions, processing of the prime is constrained by the brief exposure to the prime combined with the masking. Nevertheless, its influence can still be measured using a target recognition time measure (review in Kinoshita & Lupker 2003).

1.2 Masked priming paradigm studies in multilinguals

Semantic priming effects were first proved with lexical decision tasks in monolinguals (Meyer & Schaneveldt 1971). The effect relies on the assumption that, when a word is presented, automatic access to its meaning results in the activation of the

concept itself, and also of any other concepts semantically related to it. A bilingual semantic priming effect has been widely demonstrated in studies where prime and target, presented in two different languages, are semantically related. The target is processed faster in the case of a semantic relationship than when target and prime are not related; this is the so-called *priming facilitation effect* (Jiang & Forster 2001; Wang 2013; Finkbeiner et al. 2004; Phillips et al. 2004; Perea et al. 2008; Wang & Forster 2010, 2014; Dimitropoulou et al. 2011a; Aparicio & Lavaur 2016).

Studies using masked translation priming paradigms with lexical decision tasks in highly proficient bilinguals have reported masked translation priming asymmetry—with non-cognate translation equivalents. This asymmetry was noted after multiple studies demonstrated consistent priming effects with L1 primes and L2 targets, but with elusive effects with L2 primes and L1 targets (review in Duñabeitia et al. 2010). These results obtain only for the lexical decision task (for cross-task differences, see Grainger & Frenck-Mestre 1998; Jiang & Forster 2001; Finkbeiner et al. 2004; Wang & Forster 2010).

According to Aparicio & Lavaur (2016), the pattern of masked translation priming effects in bilinguals and trilinguals seems modulated by their proficiency levels in their L2 and/or L3. The trilinguals who took part in the lexical decision experiments showing asymmetric translation priming effects had a reasonable level of proficiency, but they were not simultaneous or balanced trilinguals, since they had acquired their L2 during childhood and their L3 as adolescents. Interestingly, Basnight-Brown & Altarriba (2007) found masked translation priming effects of similar amplitude in both directions (L1-L2 and L2-L1) with a group of highly proficient Spanish-English bilinguals, and Duñabeitia et al. (2010) found similar effects.

In addition, the asymmetry demonstrated by late multilinguals in masked translation priming could be linked to the asymmetry observed during language switching for the same type of multilinguals. Indeed, in lexical decisions without masked priming, the cost associated when switching from L2 or L3 to L1 is greater than the one observed when switching from L1 to L2 or L3 (Grainger & Beauvillain 1987; Aparicio & Lavaur 2013; see Aparicio et al. 2017, for a recent study of language switching effects in simultaneous interpreters). Nevertheless, to our knowledge, very few studies have addressed masked translation priming or semantic priming with multiple primes.

In a monolingual experiment with English speakers, Balota & Paul (1996) tested the effects of multiple primes that are either semantically related (e.g., *lion-stripes*-TIGER) or unrelated (e.g., *kidney-piano*-ORGAN) to the target. They conducted six experiments to determine the combined influence of several primes related to the same target in different tasks, such as naming and lexical decision. Results showed a facilitator effect for the target word when multiple primes con-

verged towards the same meaning, conpared to the unrelated condition, independently of the task. The authors hypothesised that this facilitation effect could be due to the addition of two convergent primes.

De Bruijn, et al. (2001) also used a double priming paradigm in a study combining behavioral and electrophysiological recording during interlingual homograph recognition in Dutch-English bilinguals. Participants were asked to perform a generalized lexical decision task on a triad of items. They were to answer *yes* if the three items were actual words with a meaning in Dutch and/or English and *no* if one or more of them was not a word from those two languages. In some trials, the second item was an interlingual homograph semantically related to the third item presented (*house-angel-heaven—heaven* meaning 'sting' in Dutch). The first item was a specific English or Dutch word. Results revealed an N400 semantic priming effect, reflecting semantic integration. Reaction times and N400 were not impacted by the language of the first word, in line with the presumption of bottom-up processes monitoring visual word recognition in bilinguals.

Lastly, Lupker, & Davis (2009) developed a "sandwich priming paradigm", in order to compensate for the limitations of masked priming and reduce lexical competition effects. This paradigm briefly presents the target itself before presenting the primes. The authors tested this paradigm with success and obtained priming effects for the priming with letter transposition (e.g., *avacino*-VACATION; Guerrera & Forster 2008), as well as for primes differing from the target by three letters in different positions (e.g., *coshure*-CAPTURE), effects that are not usually highlighted with conventional masked priming.

The results in these studies with unbalanced bilinguals/trilinguals are in line with the predictions of many models of bilingual memory organization. Nevertheless, to our knowledge no research investigating potential asymmetry between L2 and L3 has been conducted using a double priming paradigm.

1.3 Connections between the two non-native languages

Several models in the literature have tried to account for language recognition in bilinguals and consider language asymmetry in consecutive bilinguals. The Revised Hierarchical Model (RHM, recent review in Kroll et al. 2010) proposes the existence of asymmetric links between translation directions. The RHM supports the hypothesis that a bilingual has two language specific lexicons, and a common conceptual store. At low levels of proficiency, the model suggests that L2—and, by extension, L3—words are only weakly connected to the shared conceptual nodes and, therefore, activate their corresponding concepts through the prior activation of their L1 translation equivalent. On the contrary, L1 words have strong direct connections to the conceptual store and weaker direct connections

to their L2 or L3 translation equivalents. Thus, the RHM predicts that translation should be slower from L1 to L2 than from L2 to L1, because of strong direct links between L2 words and their L1 translations. Consequently, when trilinguals have to switch between their L2 ans L3, processing of target words should be slower, because access to concept meaning has to be mediated via the L1. It is of interest to determine if such effects could be observed at a priming level, when words from two different languages are presented as primes.

More recently, Grainger, Midgley, & Holcomb (2010) proposed a developmental version of the Bilingual Interactive Activation model (BIA, Grainger & Dijkstra, 1992; van Heuven, Dijkstra, & Grainger, 1998). The BIA-d proposes that the level of exposure to the L2 accounts for the links between the lexical form of the word and its meaning. At first, individuals learn the L1, and match lexical forms and their meanings for this initial language. With late acquisition of the L2, in order to access meaning, learners must use the L1 as a conceptual mediator. However, the more frequent the use of the second language, the stronger the connections become between lexical forms and meaning across all languages. This allows bilinguals to access the common conceptual store from either L1 or L2 words. This model postulates that, with a high level of L2 exposure, bilinguals are more efficient in monitoring both languages, for instance, reducing interference during language switching. Based on these two models, we can assume that connections between L2 and L3 are weak, and that conceptual mediation via the L1 is required to process L2 and L3 words. The BIA and BIA-d models should help us interpret the performance of our population of asymmetrical trilingual translation trainees.

A double masked-translation priming paradigm should allow us to investigate the connections between the three languages simultaneously, with different degrees of semantic overlaps. To develop this double masked-translation priming paradigm we drew from a trilingual masked translation study developed by Aparicio & Lavaur (2016). That study demonstrated the influence of language dominance on the processing of the two non-native languages. Their participants were 24 French-English-Spanish unbalanced trilinguals deemed equivalent in their L2 and L3 proficiency. They were asked to perform two series of lexical decision tasks in their two non-native languages, using a masked priming translation paradigm. Target words in both languages were primed by either the same word (repetition), a translation (in one of the other languages) or an unrelated word (in L1, L2 or L3). The results highlighted a strong link between prime and target, with an effect of repetition for both target languages. Moreover, a translation priming effect was demonstrated only when primes belonged to the L1, with L2 and L3 target words identified faster when primed by their L1 translation, in comparison to the L2 and L3 translation. These translation priming effects seem well-established and it is of

interest to determine how brief exposure to two primes in one language, or in two different languages, influence lexical decision times in both L2 and L3. Considering the results discussed in this section, we designed an experiment using masked translation priming to focus more specifically on the complex lexical and semantic processes involved in using three languages.

2. The present study

We recruited a group of late high-proficient French (L1)-English (L2)-Spanish (L3) trilinguals to participate in two masked translation-priming lexical-decision tasks (Gollan et al., 1997; Jiang & Forster 2001; Kim & Davis 2003; Finkbeiner et al. 2004; Aparicio & Lavaur 2013). Two primes were presented during the same trial. As in Aparicio & Lavaur (2016), the group performed lexical decisions in their two late acquired languages (English L2 and Spanish L3). Target words were preceded by their non-cognate translation equivalents (in L1, L2 or L3), or by semantically related or unrelated words (in L1, L2 or L3). In order to achieve an accurate measure of the magnitude of the effects, while minimizing any variability due to individual differences, all translation directions were studied in the same experimental group.

Based on Aparicio & Lavaur (2016), several priming conditions were used in two lexical decision tasks for control purposes. These consisted of unrelated priming conditions with words in the two non-target languages (e.g., *chien*$^{\text{dog}}$-*perro*$^{\text{dog}}$-HOUSE), and a within-language unrelated condition (e.g., *dog-dog*-HOUSE). Several language combinations were employed for the interlingual unrelated priming condition (for L2 target language, L1L1/L2, L3L3/L2, L1L3/L2 and L3L1/L2; for L3 target language, L1L1/L3, L2L2/L3, L1L2/L3 and L2L1/L3). The within-language unrelated condition was included so as to compare any possible translation priming effects against a condition that has repeatedly been shown to lead to robust priming effects (Forster & Davis 1984; Misra & Holcomb 2003; Perea et al. 2008; Dimitropoulou et al. 2011a, b; Aparicio & Lavaur 2016).

Dimitropoulou et al. (2011b) argued that the aim of comparing each related condition (identity, e.g., *house-house*-HOUSE; and translation, e.g., *maison-casa*-HOUSE) with its corresponding baseline was to uncover language-related and language-independent processes. Moreover, including these control conditions allowed for the creation of perfectly balanced experimental lists, with the same number of primes (related and unrelated) in the different languages and in both lexical decision tasks. According to Altarriba & Basnight-Brown (2007), this method excludes any processing advantage accruing to one of the participant languages. To the best of our knowledge, only Aparicio & Lavaur (2016) has so far

focused on masked translation priming in trilinguals, so the experimental design was adapted from it. The advantage of this design is that it allows us to examine different combinations of language switching between prime and target and, in the present study, between two primes in different languages, and the target in a third language.

Within the masked priming paradigm, language switching costs are defined as the difference between the RTs obtained when targets are preceded by primes of the non-target language and the RTs obtained when targets are preceded by primes in the target language (e.g., Chauncey et al. 2008; Duñabeitia et al. 2010; Dimitropoulou et al. 2011a, b; Aparicio & Lavaur 2016). Following the predictions of Aparicio & Lavaur (2016), and according to the models presented above, we assume that differences in processing the target word under these experimental conditions could mean that the semantic overlap between languages influences the identification of target words, especially if the two primes converge towards the same meaning. Furthermore, language switching due to presentating primes in one or two different languages from the target should slow target processing. In intralingual conditions, we expect faster answers when the prime is repeated as a target (e.g., *dog-dog-*DOG), for both L2 and L3 languages.

2.1 Variables and conditions

Concerning translation priming, we should observe differences according to the language of the prime, as well as the position of the prime in the triad. According to previous results in double priming studies, L1 primes should be more efficient in comparison with the two other languages, but the L1 position in the triad should modulate recognition of the target words. The different combination of languages used in the experiment are presented below, and synthesised in Table 1:

Repetition double priming. As presented above, the same word is presented three times, twice as a prime and once as a target (e.g., *dog-dog-*DOG*; perro-perro*/PERRO).
Double translation priming: primes in one language. E.g., two primes in a language followed by their translation as a target: *chien-chien*-DOG; *perro-perro*/DOG; *chien-chien*/PERRO; *dog-dog*/PERRO). Here, the language switching effect should be modulated by proficiency in the prime language.
Double translation priming: primes in two languages. E.g., *chien-perro*-DOG; *perro-chien*-DOG; *chien-dog*-PERRO; *dog-chien*-PERRO). The primes are presented in different languages and the target, in a third language. The three words have the same meaning. Participants have to deal with a complex language-switching task, with two switches in a row in a short interval of time. Therefore, we expect slower RTs

on the target word as compared to the repetition condition or translation priming with only a single language switch. We hypothesise that a processing slowdown associated with the language switch cost would be modulated by the position of the L1 as a prime, with faster RTs when the L1 is presented as first prime, because it coactivates more lexical units than a non-dominant language.

Double priming with related primes. Here, primes have the same meaning, but are not related to the target (e.g., *maison-casa*-DOG; *casa-maison*-DOG; *maison-house*-PERRO; *house-maison*-PERRO). Here we follow the same experimental protocol developed earlier for translation priming. First, primes are repeated in one language, introducing a language switch as well as a semantic inconsistency, slowing processing. This effect should increase with any additional language switching when translation equivalents are presented as primes in different languages. As for translation priming, these effects should be modulated depending on language proficiency in the language presented as first prime.

Double priming with unrelated primes. Here, there is no semantic link between the two primes and the target (e.g., *maison-chica*-DOG; *chica-maison*-DOG; *maison-dog*-CHICA; *dog-maison*-CHICA). Thus, we can observe language switching effects when semantic overlap is supposed to be inhibited. The same experimental conditions as those used for double translation priming and double priming by related primes were applied. Language switching effects are expected to increase when there is no semantic overlap between primes, and between primes and targets.

Based on previous evidence from relatively high proficiency bilinguals, no backward translation priming effects would be expected in our trilingual population because of a clear L1 dominance. In the same vein, L1 primes should be able to produce translation-priming effects, because they are expected to be activated rather quickly, and have strong semantic connections. However, whether or not a facilitative effect (typically reported in the forward-translation direction with bilinguals of higher levels of L2 proficiency) will be found is uncertain, because it is unknown whether the links on which the translation process relies have become functional in the case of trilinguals with late acquisition and relatively high proficiency of L2 and L3. Therefore, the results of this research should give us more information about trilingual functioning because of double masked priming, mainly by increasing our comprehension of the links binding the two non-dominant languages at an early level of processing, which is not described in the current models of bilingual functioning.

Table 1. Samples of primes-target triads for each experimental condition

	Repetition	Primes		Translation	
		Related	Unrelated	1 Language	2 Languages
prime 1	*dog*	*maison*	*maison*	*chien*	*chien*
prime 2	*dog*	*casa*	*chica*	*chien*	*perro*
target	DOG	DOG	DOG	DOG	DOG

NB: In the case of related primes there is a semantic relationship between the two primes, but not with the target. For unrelated primes, there is no semantic overlap between the two primes and the target.

Table 2. Self-rating of linguistic skills (sd) in the three languages on a 7-points Likert scale, and AoA for L2 and L3

	L1 French	L2 English	L3 Spanish
written understanding	7.0 (0.3)	5.2 (2.1)	5.1 (1.9)
oran understanding	7.0 (0.0)	5.9 (0.9)	5.1 (1.2)
speech fluency	7.0 (0.0)	6.1 (1.3)	5.4 (1.1)
age of acquisition (years)	–	9.9 (1.2)	13.4 (1.5)

2.2 Methods

2.2.1 *Participants*

Six male and 18 female trilingual translation trainees at the University of Montpellier (France) volunteered for the experiment ($n = 24$). We focused on translation trainees because they all had French as L1; English, as L2; and Spanish, as L3. On the whole, they learned their different languages at the same ages and in the same conditions (classroom), ensuring homogeneity in terms of language acquisition as well as language context. The age of the participants ranged from 22 to 27 years old (mean = 25.1, $sd = 2.8$), and they were right-handed with normal vision. Before the experiment, they were asked to complete a linguistic history questionnaire to estimate their level of knowledge in the three spoken languages (see Table 2). After the experiment, they were also asked to translate 70 French words into English and Spanish, to obtain more objective data on their language abilities. Performances on the post-test ranged from 78% to 100% of accuracy for translation in English (mean = 81%, $sd = 8$), and from 65% to 95% in Spanish (mean = 81%, $sd = 10$). A T-test showed that performance was significantly better for English translation in comparison with Spanish: $t\,(23) = 5.8$; $p < .05$.

2.2.2 *Stimuli*

Words selected as primes and targets were non-cognates with a low interlingual orthographic overlap. For each language, 540 words were selected from a trilingual database (Aparicio, Lavaur, & Laxén 2008). Word length was kept between 3 and 8 letters, with a mean occurrence of 91 per million ($sd = 25$ for French, 95 for English and 85 for Spanish). In addition, 180 pseudowords were created for each language with Wordgen Software (Duyck et al. 2004). Pseudowords were matched with target words in length and were pronounceable strings of letters in the target language. Controls ensured that a given pseudoword had few orthographical neighbors in the other known languages. See Appendices 1 and 2.

2.2.3 *Apparatus and procedure*

Participants were comfortably seated in a soundproofed room, ca. 1.5 m from a computer monitor. Stimuli were presented at center screen using Eprime software (Psychology Software Tools Inc. 2002), in white ink on a black background. Primes were presented in lower case and targets in upper case. A trial consisted of a fixation cross presented for 500ms, followed by a pre-mask staying on the screen for 200 ms. Then, the first prime was presented for 50 ms, followed by a pre-mask presented for 200 ms. This pre-mask was replaced by the second prime, presented for 50 ms, followed by a post-mask presented for 17 ms, immediately followed by the target word. The target word stayed on the screen until the participant answered. A keyboard key was dedicated to *yes* answers, and another one to *no* answers. An interstimulus interval of 1500 ms was introduced between the answer and the next trial (example sequence in Figure 1).

In order to counterbalance the presentation of the selected words in the different conditions, six experimental lists were compiled. Word and non-word presentation was controlled to ensure that a given item was presented just once to the participant in order to avoid repetition effects. For instance, the word *dog* was presented in a repetition condition in list 1, in a translation priming condition in list 2, etc., in order to appear in every condition of presentation, as a target for L2 decisions and as a prime in L3 decisions. Each participant saw only one list, and thus was confronted only once with any given word.

2.2.4 *Results*

Data were analysed for errors and reaction times only on correct answers. Outliers below 200 ms and above 1500 ms (4% of the data) were removed from the analysis. Several repeated ANOVAs were run to compare results for each target language (L2 English and L3 Spanish) in the defined experimental conditions. We used LANGUAGE in both lexical decisions (L2 vs. L3), PRIME (repetition vs.

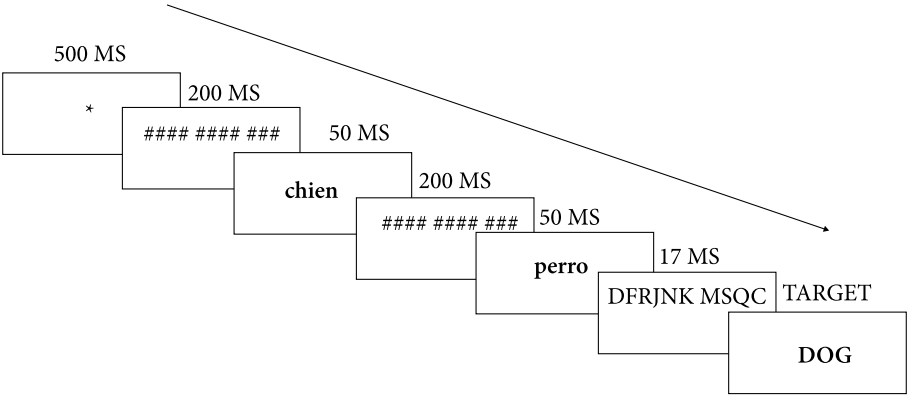

Figure 1. Example of a trial with the L2 target DOG, primed by its translation equivalents in French *(chien)* and Spanish *(perro)*

translation vs. related vs. unrelated) and SWITCH (language prime repetition vs. language prime switch) as main factors. For the switching condition, we focused on the number of prime languages, i.e., 1 or 2, to evaluate the effect on target processing. A Geisser-Greenhouse correction was applied on repeated measures with more than one degree of freedom. To make interpretation of the analysis easier, we divided the results sections in two parts—one focusing on L2 lexical decisions, the second part on L3 lexical decisions. An overview of the results from each lexical decision task is available in Table 3 for L2 lexical decisions, and in Table 4 for L3 lexical decisions.

3. Results

3.1 Overall analysis

3.1.1 *Reaction times*

Analyses revealed a main effect of target LANGUAGE independently of priming condition, with L2 words recognized faster than L3 words $F(1,23) = 7.746$, $p < .01$, MSE = 5030, $\eta 2\ p = 69\%$. In addition we found a main effect of PRIME (independently of language) $F(2,46) = 19{,}8$, $p < .001$, MSE = 1264, $\eta 2\ p = 98\%$, revealing that prime/target repetition was processed faster (542 ms) than the translation priming (594 ms), related priming (621 ms) or unrelated priming (596 ms) conditions, indicating the strength of the semantic link between prime and target. A representation of these results is reported in Figure 2.

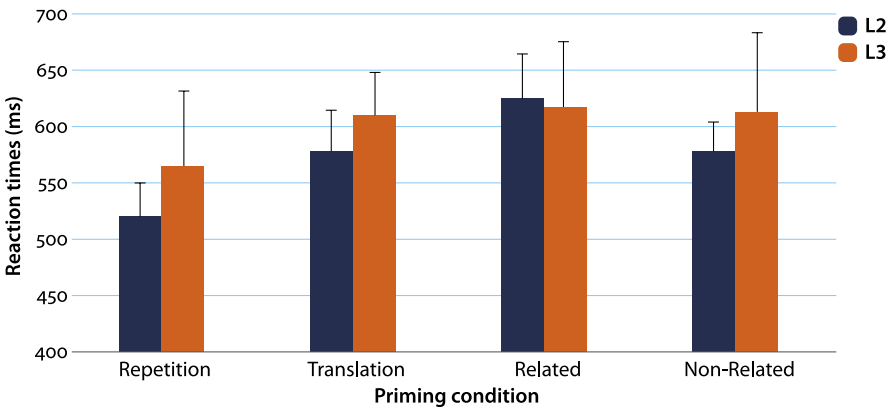

Figure 2. Reaction times and Standard Deviations (error bars) in L2 and L3 lexical decisions for the different priming condition

The analysis also revealed a main effect of SWITCH factor F (1.23) = 14.7, p < .01, MSE = 1233, η2 p = 95%, revealing slower RTs when primes belonged to two different languages (synthesis in Figure 3).

The analysis revealed a significant interaction between LANGUAGE × PRIME factors F (2.46) = 10.8, p < .001, MSE = 1390, η2 p = 97%, with larger priming effects for the L2 language in comparison to the L3 language. Another interaction was highlighted between LANGUAGE × SWITCH F (1, 23) = 4.6, p < .05, MSE = 1225, η2 p = 54%, with larger switch costs for the L2 in comparison to the L3 targets. Finally, a triple interaction LANGUAGE × PRIME × SWITCH came out as significant F (2.46) = 4.4, p < .05, MSE = 1240, η2 p = 65%. These interactions allowed us to explore the prime effects in the L2 and L3 lexical decision tasks separately.

3.1.2 *Error rates*

The analysis failed to reveal a main effect of LANGUAGE (F < 1), with an error rate close in both languages (7.4% for L2 targets; 6.7% for L3 targets). A main effect of PRIME was found F (2.46) = 5.9, p < .01, MSE = 57, η2 p = 82%, indicating more errors for translation priming (10%) in comparison to related priming (8.6%) and unrelated priming (6.5%). No significant difference appeared for SWITCH (F < 1). Other interactions were not significant. Data corresponding to error rates are presented in Figure 3 below.

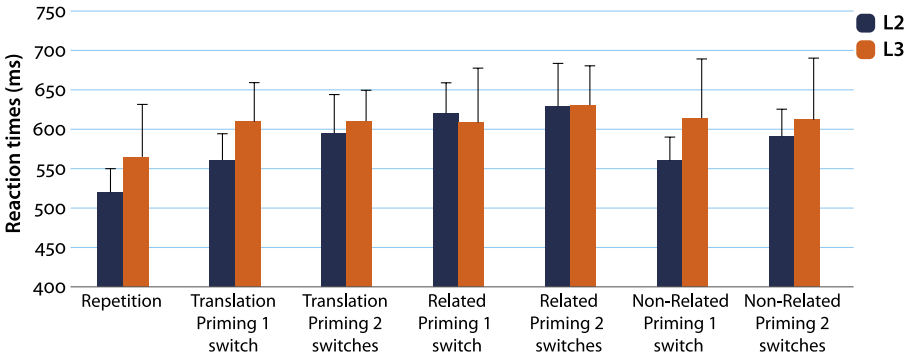

Figure 3. Reaction Times (SD) according to the priming conditions and the number of languages preceding the target. NB: 1 switch indicates that both primes are in the same language (but different from the target), 2 switches that the two primes belong to different languages, and the target to the third one

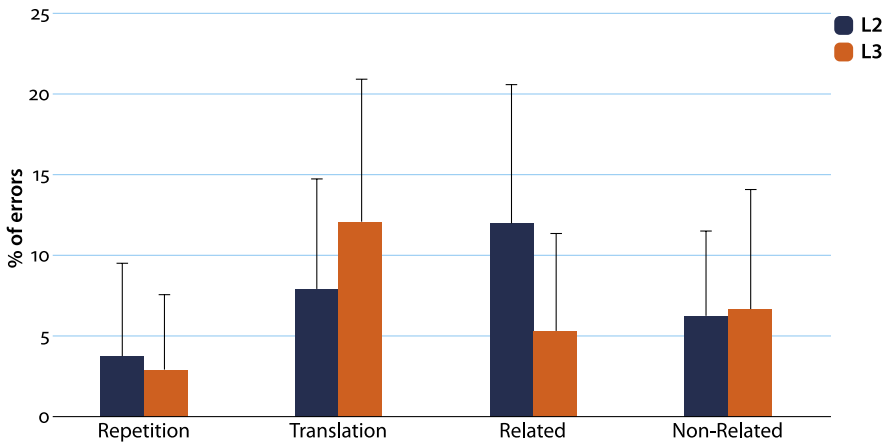

Figure 4. Percentage of error rates (sd) for both lexical decisions, according to priming condition

3.2 English lexical decision (L2 targets)

3.2.1 *Reaction times*

ANOVAs revealed a main effect of PRIME $F(2.46) = 48.1$, $p < .001$, MSE = 801.4, $\eta 2$ $p = 100\%$, with translation priming eliciting faster answers (578 ms) in comparison to related priming (625 ms), but similar to unrelated primes (578 ms). In addition, a main effect of SWITCH was highlighted $F(1.23) = 16.7$, MSE = 1312.8, $\eta 2$ $p = 97\%$, revealing that targets preceded by primes in one language were processed faster (580 ms) compared to targets preceded by primes in two different languages

(605 ms). Interaction between PRIME and SWITCH only demonstrated a tendency F (2.46) = 2.7, $p < .09$, MSE = 987.6, η2 p = 45%. Table 3 offers an overview of the RTs for L2 lexical decision.

Paired comparisons revealed that the control condition of repetition priming elicited faster answers (520 ms) than translation priming (578 ms) F (1.23) = 66.5, $p < .001$, MSE = 611, η2 p = 100%, related priming (625 ms), F (1.23) = 151.7, $p < .001$, MSE = 866.4, η2 p = 100%, and unrelated priming (578 ms), F (1.23) = 64.5, $p < .001$, MSE = 629, η2 p = 100%. Moreover, translation primes elicited significantly faster answers than related primes F (1.23) = 79.8, $p < .001$, MSE = 324.4, η2 p = 100%. No differences were observed between translation priming and unrelated priming ($F < 1$), but related primes elicited faster answers than unrelated primes F (1.23) = 51.7, $p < .001$, MSE = 501.6, η2 p = 100%.

As for language switching, paired comparison revealed that L2 targets are processed faster F (1.23) = 11.9, $p < .01$, MSE = 567, η2 p = 100%, when preceded by an L1 prime (L1L1/L2, 574 ms), in comparison to the L2 prime (L3L3/L2, 598 ms). Interestingly, we obtained a significant difference when the L1 prime was presented in first position (L1L3/L2, 595 ms), compared to its presentation in second position (L3L1/L2, 615 ms), F (1.23) = 6.01, $p < .05$, MSE = 740, η2 p = 65%, suggesting that the L1 presented at an early processing stage facilitates L2 target recognition.

3.2.2 *Error rates*

The analysis revealed a main effect of PRIME F (2.46) = 7.2, $p < .01$, MSE = 62.6, η2 p = 100%, suggesting that translation priming elicits fewer errors (8%) than related priming (12%) and unrelated priming (6%). No significant difference was found for SWITCH ($F < 1$), but interaction SWITCH × PRIME was F (2.46) = 7.5, $p < .01$, MSE = 63, η2 p = 85%. Paired comparisons showed that the SWITCH effect was larger in the related priming condition F (1.23) = 6.2, $p < .05$, MSE = 80.9, η2 p = 66%, with an error rate of 15% when two primes belong to the same language, and 8% when two primes belong to two different languages. Other comparisons were not significant.

3.3 L3 Lexical decision

3.3.1 *Reaction times*

The analysis yielded no significant effects for the PRIME and SWITCH factors (Fs < 1). An overview of the RTs is presented in Table 4.

Table 3. Overview of mean RTs (sd) in the different experimental conditions in L2 lexical decision

	repetition priming	**translation priming**			
triad sequence	L2L2L2	L1L1L2	L3L3L2	L1L3L2	L3L1L2
RT	520 (30)	551 (33)	571 (44)	587 (55)	603 (69)
switch cost (ms)	–	*+31*	*+51*	*+67*	*+83*
	repetition priming	**related primes**			
triad sequence	L2L2L2	L1L1L2	L3L3L2	L1L3L2	L3L1L2
RT	556 (39)	605 (51)	635 (52)	620 (71)	638 (72)
switch cost (ms)	–	*+49*	*+79*	*+64*	*+82*
	repetition priming	**unrelated primes**			
triad sequence	L2L2L2	L1L1L2	L3L3L2	L1L3L2	L3L1L2
RT	534 (46)	568 (35)	589 (55)	579 (41)	603 (47)
switch cost (ms)	–	*+34*	*+55*	*+45*	*+69*

NB: switch cost is a differential between language repetition and language switching conditions.

Table 4. Overview of mean RTs (sd) in the different experimental conditions in L3 lexical decision

	repetition priming	**translation priming**			
triad sequence	L3L3L3	L1L1L3	L2L2L3	L1L2L3	L2L1L3
RT	565 (67)	589 (66)	630 (51)	603 (51)	618 (44)
switch cost (ms)	–	*+24*	*+65*	*+48*	*+53*
	repetition priming	**related primes**			
triad sequence	L3L3L3	L1L1L3	L2L2L3	L1L2L3	L2L1L3
RT	646 (104)	616 (61)	564 (69)	646 (55)	615 (66)
switch cost (ms)	–	*+30*	*+82*	*0*	*−31*
	repetition priming	**unrelated primes**			
triad sequence	L3L3L3	L1L1L3	L2L2L3	L1L2L3	L2L1L3
RT	591 (76)	603 (77)	626 (86)	625 (87)	599 (86)
switch cost (ms)	–	*+12*	*+35*	*+34*	*+8*

3.3.2 *Error rates*

Here, analysis revealed a main effect of PRIME F (2.46) = 13.4, $p < .001$, MSE = 60.4, $\eta 2$ $p = 98\%$, suggesting that translation priming elicited more errors (12%) than related priming (5%) and unrelated priming (6.7%). No significant

effects were found for SWITCH, and the interaction between the two factors was non-significant.

4. Discussion and conclusions

In this experiment, we developed an explanatory double masked priming protocol. Participants, French-English-Spanish trilingual translation trainees, were asked to perform lexical decision tasks in their L2 (English) and L3 (Spanish). Target words in both languages were preceded by two primes, belonging to one or two languages: repeated primes, translation equivalents, related primes, or unrelated words. The trials were selected in order to determine the influence of the semantic links on different combinations and directions of language switching.

4.1 Language repetition

Results highlighted language repetition effects, independently of the target language, in line with Aparicio & Lavaur (2016). We observed faster access to the meaning of target words previously presented as primes because of their preactivation in the lexical system. This facilitation comes from the repetition of the word itself, as well as from the absence of language switching. When primes and target are not semantically related, this repetition effect tends to decrease, independently of the target language. The pattern is accentuated when the prime is repeated but not related to the target; e.g., *chien-chien-* **HOUSE** [*chien* ='dog']. This situation creates an inconsistency between prime and target: presentation of a word as first prime and its repetition as a second prime strongly activates lexical and semantic representations, making the target word more difficult to process, even in an intralingual condition; this result is congruent with de Bruijn et al. (2001). By contrast, when the two primes are semantically different from the target and from one another, primes are not reinforced, and there is less interference with the processing of the target, which is processed faster. Furthermore, recognising its also requires less inhibition as compared with the previous condition.

4.2 Translation priming

Considering that translation equivalents are strongly linked in the multilingual memory (Dijkstra 2005), here primes and targets have a strong semantic overlap. Nevertheless, our analyses revealed modulations in the process of target recognition influenced, on the one hand, by prime language and, on the other hand, by the number of languages (one or two) presented as primes. For both target lan-

guages we observed shorter lexical decision times when the L1 was presented as a prime, in line with Aparicio & Lavaur (2016)—see also de Bruijn et al. (2001) and Wang & Forster (2010, 2014). These results indicate that the dominant language strongly impacts word recognition in other acquired languages, which is also congruent with Finkbeiner et al. (2004), Duñabeitia et al. (2010) and Aparicio & Lavaur (2013, 2016).

In addition, when primes were presented in two languages, processing times generally slowed down, with major speed decreases when the first prime was in L2 or L3. This suggests that, if the first prime belongs to the dominant language, nodes linking the three languages would be activated with more strength than when the first prime is in a non-dominant language. In addition, when the dominant language is presented as a second prime, perhaps a less efficient activation of the semantic network has already begun via the L2 or L3, which could explain the slower RTs, according to the BIA and BIA-d models.

4.3 Related and unrelated primes

Our results here are in line with the literature on masked translation priming (Wang 2010, 2014; Aparicio & Lavaur 2016) and clearly indicate preactivation of the mental lexicon via the primes. As a matter of fact, in monolingual or bilingual presentation, when primes are related to one another but not with the target, we observed a clear slowing down in processing, becoming greater when the two primes are not related. According to the BIA model (van Heuven et al. 1998), the presentation of the first prime activates the mental representations of lexical candidates from all languages known (notably translation equivalents). This activation will be strengthened by the presentation of the second prime with a similar meaning. Therefore, when participants process a target word semantically different from the primes, they are confronted by a semantic disjunction, perhaps leading to slower RTs. By contrast, when primes/target triads differ semantically, a presentation of the second prime does not reinforce the first one, requiring less inhibition of the second prime to access the meaning of the target word.

4.4 Language switching

Introduction of repetition as a baseline and interlingual priming allowed us to examine several language switching aspects. The strength of this study derives from using three languages for two primes and one target in the same task trial. On the whole, target words were processed faster when they were preceded by a word from the same language, in contrast with the situation where primes are in a different language. The most interesting results in this study concerned transla-

tion priming effects. For L2 lexical decision tasks, processing slowdown was more pronounced when two primes were presented in L3 (L3L3/L2) than when presented in the dominant language (L1L1/L2), reflecting a larger switch cost when the prime is in a non-dominant language (see Aparicio & Lavaur 2016, for similar findings in a masked priming paradigm). In addition, we noticed significantly greater switch costs when translation primes from two languages are involved in a triad, for instance when the first prime is in L3 and the second in L1 (e.g., *perro-chien*-DOG). L3 has a reduced "negative" influence on L3 processing when presented as a second prime, suggesting that the first prime initiates the processing, and the second prime plays a less important role in target recognition.

In L3 decision tasks, we observed different patterns associated with language switching, with related primes eliciting the smallest switch cost. However, as in the L2 lexical decision tasks, larger switch costs are observed when the non-dominant language (L2) is presented as a prime, with a larger switch cost in the L2L2/L3 condition, where the L2 translation is repeated and the L1 receives less activation. Language switching also seemed more difficult to process for our population when the non-dominant language was presented as first prime (L2L1/L3). Please note that this interpretation is only qualitative, because ANOVAs performed on L3 targets yielded no significant results.

According to computational models of bilingual memory, i.e., BIA (Grainger & Dijkstra 1992; van Heuven et al. 1998) and BIA-d (Grainger et al. 2010), costs associated with language switching arise from bottom-up activation processes from a language node, driven by the presentation of a word in the salient language, leading to inhibition of lexical representations from the other languages. In lists involving several languages, the activation of the language node will be determined by the language of the preceding word (here, the prime). When prime and target belong to different languages, the activation of the language node of the prime is not compatible with the target, and therefore the processing of the target is slowed down. In our experiment, this is verified when the two primes belong to different languages, which could account for the major slowdown observed in translation priming, when both primes are presented in different languages.

Moreover, according to Green's (1998) inhibitory control model, the observed switch cost is the result of the influence of executive control systems involved when participants monitor their decisions and their answers in an artificial task. Thus, task schemas for translation must actively suppress the language most recently activated—for instance, by reading words in an L2 source text—so as to allow the selection of lexical items in the L2 output language. This suppression is much more important when the number of languages increases, which could account for the larger switch costs observed when primes belong to different languages.

Our study highlights early language switching effects during visual word recognition in a specific population of trilingual translation trainees. The results are in line with previous evidence from masked translation priming studies and could be integrated with computational models of bilingualism, such as the BIA (van Heuven et al. 2008), the BIA-d (Grainger et al. 2010), and the inhibitory control model (Green 1998). Our study contributes to the field of trilingualism, where the literature is still quite sparse, and we argue that studies of trilingualism can play an important and necessary role in increasing our comprehension of the multilingual mind.

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Appendix 1. Target words and primes for L2 lexical decision

L2 Target	Primes					
	Repetition	L1 Translation	L3 Translation	L1 Unrelated	L2 Unrelated	L3 Unrelated
house	house	maison	casa	livre	book	libro
bacon	bacon	lard	tocino	calme	still	calmoso
duck	duck	canard	pato	grimper	climb	trepar
fear	fear	crainte	temor	avoine	oat	avena
cold	cold	rhume	catarro	souris	mouse	ratón
seed	seed	graine	semilla	chaton	kitten	gatito
puddle	puddle	flaque	charco	pouce	inch	pulgada
rabbit	rabbit	lapin	conejo	luge	sledge	trineo
thumb	thumb	pouce	pulgar	havre	haven	remanso
lamb	lamb	agneau	cordero	briquet	lighter	mechero
belly	belly	ventre	barriga	sapin	fir	abeto
knee	knee	genou	rodilla	volet	shutter	postigo
shade	shade	nuance	matiz	dinde	turkey	pava
joke	joke	blague	chiste	chemin	path	camino
bell	bell	cloche	campana	pupitre	desk	atril
cheese	cheese	fromage	queso	rame	oar	remo
apple	apple	pomme	manzana	balai	broom	escoba
fight	fight	bagarre	pelea	renard	fox	zorro
thief	thief	voleur	ladrón	chaque	each	cada
pig	pig	cochon	cerdo	creux	hollow	hueco
board	board	tableau	cartel	fourmi	ant	hormiga
ring	ring	bague	anillo	peu	little	poco
candle	candle	bougie	vela	boue	mud	fango
wide	wide	large	ancho	nuit	night	noche
heavy	heavy	lourd	pesado	facteur	postman	cartero
fish	fish	poisson	pez	craie	chalk	caliza
frozen	frozen	gel	helado	faible	weak	flojo
shaft	shaft	puits	pozo	corps	body	cuerpo
cheek	cheek	joue	mejilla	porte	door	puerta
peak	peak	sommet	cumbre	corde	lead	correa
ugly	ugly	vilain	feo	clair	light	claro
pretty	pretty	jolie	bonita	lieu	place	lugar

L2 Target	Primes					
	Repetition	L1 Translation	L3 Translation	L1 Unrelated	L2 Unrelated	L3 Unrelated
shore	shore	rivage	orilla	sabre	sword	espada
fog	fog	brume	niebla	amour	love	amor
clean	clean	propre	limpio	cinq	five	cinco
rubbish	rubbish	ordure	basura	vie	life	vida
skirt	skirt	jupe	falda	jeter	throw	tirar
oil	oil	huile	aceite	jeune	young	joven
key	key	clef	llave	tige	stem	tallo
shoe	shoe	soulier	zapato	sang	blood	sangre
wave	wave	vague	ola	jeu	game	juego
slim	slim	mince	delgado	malin	crafty	astuto
wound	wound	plaie	herida	champ	field	campo
below	below	dessous	debajo	semaine	week	semana
coat	coat	manteau	abrigo	fort	strong	fuerte
madness	madness	folie	locura	droit	right	derecho
leg	leg	jambe	pierna	foin	hay	heno
leaf	leaf	feuille	hoja	cerf	stag	ciervo
lawn	lawn	pelouse	césped	roi	king	rey
shop	shop	magasin	tienda	voyage	travel	viaje
breath	breath	haleine	aliento	noir	black	negro
flag	flag	drapeau	bandera	suivre	follow	seguir
frame	frame	cadre	entorno	mort	dead	muerto
purchase	purchase	achat	compra	marche	stair	marcha
tail	tail	queue	cola	loi	law	ley
pocket	pocket	poche	bolsillo	nain	dwarf	enano
candy	candy	bonbon	dulce	pied	foot	pie
sand	sand	sable	arena	paix	peace	paz
lawyer	lawyer	avocat	abogado	douleur	ache	dolor
corner	corner	coin	esquina	poids	burden	peso
ceiling	ceiling	plafond	techo	peau	skin	piel
clothes	clothes	habit	traje	retour	return	vuelta
well	well	source	fuente	vingt	twenty	veinte
burden	burden	fardeau	carga	tueur	killer	asesino
crazy	crazy	fou	loco	feu	fire	fuego
sick	sick	malade	enfermo	just	right	justo

L2 Target	Primes					
	Repetition	L1 Translation	L3 Translation	L1 Unrelated	L2 Unrelated	L3 Unrelated
watch	watch	montre	reloj	peine	grief	pena
nostril	nostril	narine	nariz	plaisir	delight	placer
warm	warm	chaud	cálido	cerveau	brain	cerebro
full	full	plein	lleno	canot	dinghy	bote
dress	dress	robe	vestido	esprit	mind	mente
rain	rain	pluie	lluvia	salle	room	sala
dog	dog	chien	perro	vent	wind	viento
meal	meal	repas	comida	ombre	shade	sombra
horse	horse	cheval	caballo	miroir	mirror	espejo
kitchen	kitchen	cuisine	cocina	douze	twelve	doce
back	back	dos	espalda	prix	cost	precio
dear	dear	cher	querido	justice	law	justicia
blow	blow	coup	golpe	mouche	fly	mosca
sister	sister	sœur	hermana	pierre	stone	piedra
linen	linen	linge	ropa	dur	hard	duro
neck	neck	cou	cuello	rouge	red	rojo
happy	happy	heureux	feliz	bras	arm	brazo
girl	girl	fille	chica	lune	moon	luna
call	call	appel	llamada	mieux	better	mejor
heat	heat	chaleur	calor	doigt	finger	dedo
fall	fall	tomber	caer	coupe	cup	copa
meat	meat	viande	carne	bref	short	breve
over	over	dessus	encima	reine	queen	reina
pencil	pencil	crayon	lápiz	plage	beach	playa
hair	hair	cheveux	pelo	tiroir	drawer	cajón
wish	wish	vœu	deseo	ouvert	open	abierto
help	help	aide	ayuda	sept	seven	siete
target	target	cible	meta	orgueil	pride	orgullo
chest	chest	coffre	baúl	emploi	job	empleo
bed	bed	lit	cama	pont	bridge	puente
bride	bride	mariee	novia	conseil	advise	consejo
mouth	mouth	bouche	boca	mort	death	muerta
gaze	gaze	regard	mirada	lueur	light	luz
word	word	mot	palabra	caisse	crate	caja

L2 Target	Primes					
	Repetition	L1 Translation	L3 Translation	L1 Unrelated	L2 Unrelated	L3 Unrelated
cattle	cattle	betail	ganado	enfer	hell	infierno
road	road	chemin	camino	vapeur	steam	vapor
money	money	argent	dinero	aucun	none	ninguno
lack	lack	manque	falta	herbe	grass	hierba
bird	bird	oiseau	pájaro	neveu	nephew	sobrino
street	street	rue	calle	seau	bucket	cubo
too	too	aussi	tampoco	nager	swim	nadar
evening	evening	soir	tarde	manger	eat	comer
city	city	ville	ciudad	savoir	know	saber
outside	outside	dehors	fuera	soldat	soldier	soldado
water	water	eau	agua	pauvre	poor	pobre
thing	thing	chose	cosa	conte	tale	cuento
below	below	sous	bajo	huit	eight	ocho
wife	wife	femme	mujer	jus	juice	zumo
ever	ever	jamais	nunca	odeur	smell	olor
time	time	fois	vez	court	short	corto
always	always	toujours	siempre	sauvage	wild	salvaje
since	since	depuis	desde	casque	helmet	casco
heart	heart	cœur	corazón	tableau	panel	tablero
breast	breast	sein	pecho	neuf	nine	nueve

Appendix 2. Target words and primes for L3 lexical decision

L3 Target	Primes					
	Repetition	L1 Translation	L2 Translation	L1 Unrelated	L2 Unrelated	L3 Unrelated
casa	casa	maison	house	livre	book	libro
tocino	tocino	lard	bacon	calme	still	calmoso
pato	pato	canard	duck	grimper	climb	trepar
temor	temor	crainte	fear	avoine	oat	avena
catarro	catarro	rhume	cold	souris	mouse	ratona
semilla	semilla	graine	seed	chaton	kitten	gatito
charco	charco	flaque	puddle	pouce	inch	pulgada
conejo	conejo	lapin	rabbit	luge	sledge	trineo
pulgar	pulgar	pouce	thumb	havre	haven	remanso
cordero	cordero	agneau	lamb	briquet	lighter	mechero
barriga	barriga	ventre	belly	sapin	fir	abeto
rodilla	rodilla	genou	knee	volet	shutter	postigo
matiz	matiz	nuance	shade	dinde	turkey	pava
chiste	chiste	blague	joke	chemin	path	camino
campana	campana	cloche	bell	pupitre	desk	atril
queso	queso	fromage	cheese	rame	oar	remo
manzana	manzana	pomme	apple	balai	broom	escoba
pelea	pelea	bagarre	fight	renard	fox	zorro
ladrón	ladrón	voleur	thief	chaque	each	cada
cerdo	cerdo	cochon	pig	creux	hollow	hueco
cartel	cartel	tableau	board	fourmi	ant	hormiga
anillo	anillo	bague	ring	peu	little	poco
vela	vela	bougie	candle	boue	mud	fango
anchura	anchura	largeur	width	nuit	night	noche
pesado	pesado	lourd	heavy	facteur	postman	cartero
pez	pez	poisson	fish	craie	chalk	caliza
helado	helado	gel	frozen	faible	weak	flojo
pozo	pozo	puits	shaft	corps	body	cuerpo
mejilla	mejilla	joue	cheek	porte	door	puerta
cumbre	cumbre	sommet	peak	corde	lead	correa
feo	feo	vilain	ugly	clair	bright	claro
bonita	bonita	jolie	pretty	lierre	ivy	hiedra

L3 Target	**Primes**					
	Repetition	**L1 Translation**	**L2 Translation**	**L1 Unrelated**	**L2 Unrelated**	**L3 Unrelated**
orilla	orilla	rivage	shore	sabre	sword	espada
niebla	niebla	brume	fog	amour	love	amor
limpio	limpio	propre	clean	cinq	five	cinco
basura	basura	ordure	rubbish	vie	life	vida
falda	falda	jupe	skirt	jeter	throw	tirar
aceite	aceite	huile	oil	jeune	young	joven
llave	llave	clef	key	tige	stem	tallo
zapato	zapato	soulier	shoe	sang	blood	sangre
ola	ola	vague	wave	jeu	game	juego
delgado	delgado	mince	slim	malin	crafty	astuto
herida	herida	plaie	wound	champ	field	campo
debajo	debajo	dessous	below	semaine	week	semana
abrigo	abrigo	manteau	coat	fort	strong	fuerte
locura	locura	folie	madness	droit	right	derecho
pierna	pierna	jambe	leg	foin	hay	heno
hoja	hoja	feuille	leaf	cerf	stag	ciervo
césped	césped	pelouse	lawn	roi	king	rey
tienda	tienda	magasin	shop	voyage	travel	viaje
aliento	aliento	haleine	breath	noir	black	negro
bandera	bandera	drapeau	flag	suivre	follow	seguir
entorno	entorno	cadre	frame	mort	dead	muerto
compra	compra	achat	purchase	marche	stair	marcha
cola	cola	queue	tail	loi	law	ley
bolsillo	bolsillo	poche	pocket	nain	dwarf	enano
dulce	dulce	bonbon	candy	pied	foot	pie
arena	arena	sable	sand	paix	peace	paz
abogado	abogado	avocat	lawyer	douleur	ache	dolor
esquina	esquina	coin	corner	poids	burden	peso
techo	techo	plafond	ceiling	peau	skin	piel
traje	traje	habit	clothes	retour	return	vuelta
fuente	fuente	source	well	vingt	twenty	veinte
carga	carga	fardeau	burden	tueur	killer	asesino
loco	loco	fou	crazy	feu	fire	fuego
enfermo	enfermo	malade	sick	just	right	justo

L3 Target	Primes					
	Repetition	L1 Translation	L2 Translation	L1 Unrelated	L2 Unrelated	L3 Unrelated
reloj	reloj	montre	watch	peine	grief	pena
nariz	nariz	narine	nostril	plaisir	delight	placer
cálido	cálido	chaud	warm	cerveau	brain	cerebro
lleno	lleno	plein	full	canot	dinghy	bote
vestido	vestido	robe	dress	esprit	mind	mente
lluvia	lluvia	pluie	rain	salle	room	sala
perro	perro	chien	dog	vent	wind	viento
comida	comida	repas	meal	ombre	shade	sombra
caballo	caballo	cheval	horse	miroir	mirror	espejo
cocina	cocina	cuisine	kitchen	douze	twelve	doce
espalda	espalda	dos	back	prix	cost	precio
querido	querido	cher	dear	justice	law	justicia
golpe	golpe	coup	blow	mouche	fly	mosca
hermana	hermana	sœur	sister	pierre	stone	piedra
ropa	ropa	linge	linen	dur	hard	duro
cuello	cuello	cou	neck	rouge	red	rojo
feliz	feliz	heureux	happy	bras	arm	brazo
chica	chica	fille	girl	lune	moon	luna
llamada	llamada	appel	call	mieux	better	mejor
calor	calor	chaleur	heat	doigt	finger	dedo
caer	caer	tomber	fall	coupe	cup	copa
carne	carne	viande	meat	bref	brief	breve
encima	encima	dessus	over	reine	queen	reina
lápiz	lápiz	crayon	pencil	plage	beach	playa
pelo	pelo	cheveux	hair	tiroir	drawer	cajón
deseo	deseo	vœu	wish	ouvert	open	abierto
ayuda	ayuda	aide	help	sept	seven	siete
meta	meta	cible	target	orgueil	pride	orgullo
baúl	baúl	coffre	chest	emploi	work	empleo
cama	cama	lit	bed	pont	bridge	puente
novia	novia	mariee	bride	conseil	advise	consejo
boca	boca	bouche	mouth	mort	death	muerta
mirada	mirada	regard	glance	lueur	bright	luz
palabra	palabra	mot	word	caisse	crate	caja

L3 Target	Primes					
	Repetition	L1 Translation	L2 Translation	L1 Unrelated	L2 Unrelated	L3 Unrelated
ganado	ganado	betail	cattle	enfer	hell	infierno
camino	camino	chemin	road	vapeur	steam	vapor
dinero	dinero	argent	money	aucun	none	ninguno
falta	falta	manque	lack	herbe	grass	hierba
pájaro	pájaro	oiseau	bird	neveu	nephew	sobrino
calle	calle	rue	street	seau	bucket	cubo
tampoco	tampoco	aussi	too	nager	swim	nadar
tarde	tarde	soir	evening	manger	eat	comer
ciudad	ciudad	ville	town	savoir	know	saber
fuera	fuera	dehors	outside	soldat	soldier	soldado
agua	agua	eau	water	pauvre	poor	pobre
cosa	cosa	chose	thing	conte	tale	cuento
bajo	bajo	sous	below	huit	eight	ocho
mujer	mujer	femme	woman	jus	juice	zumo
nunca	nunca	jamais	ever	odeur	smell	olor
vez	vez	fois	time	court	short	corto
siempre	siempre	toujours	always	sauvage	wild	salvaje
desde	desde	depuis	since	casque	helmet	casco
corazón	corazón	cœur	heart	tableau	panel	tablero
pecho	pecho	sein	breast	neuf	nine	nueve

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