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ScienceDirect

Journal of Memory and Language 58 (2008) 916–930

Journal of Memory and Language

www.elsevier.com/locate/jml

Masked associative/semantic priming effects across languages with highly proficient bilinguals

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Received 27 June 2007; revision received 31 October 2007
Available online 6 March 2008

Abstract

One key issue for models of bilingual memory is to what degree the semantic representation from one of the languages is shared with the other language. In the present paper, we examine whether there is an early, automatic semantic priming effect across languages for noncognates with highly proficient (Basque/Spanish) bilinguals. Experiment 1 was a *between-language* masked semantic priming lexical decision experiment. Results showed a significant between-language semantic priming effect for both Basque–Spanish and Spanish–Basque pairs. Experiment 2 showed that the magnitude of the *between-language* and *within-language* masked semantic priming effects was quite similar. Experiment 3 replicated the findings of Experiment 2 with highly proficient bilinguals whose mother tongue was Spanish. Thus, highly fluent bilinguals develop early and automatic between-language links with noncognates at the semantic level, as predicted by the hierarchical revised model and the BIA+ model. We examine the implications of these results for models of bilingual memory.

Keywords: Conceptual representations; Bilingualism; Masked priming; Semantic priming

One key issue for models of bilingual memory is to what degree the semantic representation from one of the languages is shared with the other language (e.g., *chair* and *silla* for English–Spanish bilinguals). Although it is generally assumed that there is a separate word-form lexicon for the two languages and a shared semantic level, allowing cross-language semantic priming (i.e., hierarchical models; see French & Jacquet, 2004, for review), the empirical evidence is not fully conclusive. Indeed, a recent review of the literature on semantic representations in bilinguals included in the Handbook of Bilingualism (Kroll & de Groot, 2006) concluded that "the evidence may not be strong enough to confirm completely shared representations at the semantic level" (Francis, 2005, p. 260). This is not surprising when one takes into account that most research has focused on individuals who, although they are proficient in a second language (L2), have not learnt this

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doi:10.1016/j.jml.2008.01.003

L2 in a natural environment. Under those circumstances, lexical development in the second language may be quite different from lexical development in the first language (e.g., see Basnight-Brown, Chen, Hua, Kostić, & Feldman, 2007; Bosch, Costa, & Sebastian-Gallés, 2000; Brysbaert, 2003; Jiang & Forster, 2001). In the present study, we focus on early highly proficient bilinguals: individuals who have been acquiring the two languages on a daily basis since early childhood. Thus, the basic question the present paper attempts to answer is: for highly fluent bilinguals, to what degree does a word in one of the languages have *early* and *automatic* access to a shared conceptual (semantic) representation?[2]

Early and automatic effects: Masked primes vs. visible primes

Clearly, one definitive piece of evidence in favor of shared conceptual representations would be a demonstration of early, automatic associative/semantic priming across languages—in particular if the magnitude of the between-languages and within-language masked semantic priming effects is approximately similar. To examine early, automatic effects in visual word recognition, the most promising technique is the masked priming paradigm (Forster, 1998; Forster & Davis, 1984; Forster, Mohan, & Hector, 2003; see also Dehaene et al., 1998; Grainger, 2008). As Grainger (2008) recently indicated, "in the last two decades masked priming has become a key tool for studying all aspects of visual word recognition, using both behavioral measures of performance and also more direct measures of brain activity." In this technique, a forward masked, lowercase prime is presented briefly (for around 30–66 ms) and is subsequently replaced by the uppercase target. Under these conditions, participants are not only unaware of the prime's identity, but they are usually unaware of its existence. Thus, it is unlikely that any episodic memory trace is created, and hence any associative semantic priming effects are likely to reflect automatic processes rather than strategic processes.

Consistent with the view that masked associative/semantic priming experiments tap early, automatic processes, Grossi (2006) found similar behavioral or electrophysiological masked associative/semantic priming effects in a lexical decision task under high (80%) and low (20%) relatedness proportion conditions (see also Duñabeitia, Carreiras, & Perea, in press; Perea & Rosa, 2002b, for additional behavioral evidence in lexical decision, and see Pecher, Zeelenberg, & Raaijmakers, 2002, for a parallel result with a perceptual identification task). Interestingly, using the same materials with visible unmasked primes (a 500-ms prime exposure duration), Grossi (2006) found that the magnitude of the associative/semantic priming effect (both behaviorally and electrophysiologically) was modulated by the proportion of related pairs in the list (see also Perea & Rosa, 2002b).

It is important to note that the usual prime–target paradigms with visible primes (e.g., at a 200-ms prime exposure), even with a low proportion of related pairs in the list, do not preclude the presence of some post-access, strategic processes. As Shelton and Martin (1992) indicated, the results in the low-proportion paired condition "might represent a mixture of subjects—some using strategies, others not" (p. 1197). Furthermore, there is behavioral and neuroimaging evidence that suggests that the processing of masked word primes and visible word primes induce quite different processes in the human brain (e.g., see Kouider, Dehaene, Jobert, & Le Bihan, 2007).

Another option is to use a single-presentation task (e.g., *mesa* on trial $n-1$ and a semantically related word such as *silla* on trial n for English–Spanish bilinguals; see Kotz & Elston-Güttler, 2004), in which participants are less likely to notice the pairing between primes and targets. Although processing in a single-presentation paradigm may minimize participants' strategies (see Shelton & Martin, 1992), the obtained priming effects do not reflect the early stages of word processing. Unlike the masked priming paradigm, in which the prime is presented briefly and masked, the prime word in a single-presentation paradigm is fully processed (including its orthographic, phonological, and semantic properties)—and also responded to—before the target word is presented. Given that the present paper is centered on early and automatic processes, in the following sections we will focus on the findings obtained with the masked priming paradigm.

Masked associative/semantic priming effects

A number of *within-language* studies have shown that masked word primes activate semantic/associative information, as demonstrated by the presence of associative/semantic priming effects using this technique (i.e., responses to *NURSE* are faster—around 10–18 ms across studies—when preceded by the

[2] As Francis (2005) recently indicated, a number of authors use the terms "semantic" representation and "conceptual" representation interchangeably. We will preferably use the term "semantic" representation—we analyze concepts that also happen to be semantic representations of words.

related prime *doctor* than when preceded by the unrelated prime *butter*; see Bodner & Masson, 2003; Bourassa & Besner, 1998; de Groot & Nas, 1991; Duñabeitia et al., in press; Duyck, 2005; Gonnerman & Plaut, 2000; Grossi, 2006; Perea & Lupker, 2003; Perea & Rosa, 2002a, 2002b; Perea & Gotor, 1997; Sereno, 1991). This associative/semantic priming effect has also been found in normal silent reading when the prime word is presented very briefly (and masked) in the fovea and the participants' eye movements are monitored (e.g., see Sereno & Rayner, 1992). Furthermore, there is recent evidence of masked associative/semantic priming effects when ERPs and the BOLD signal are measured with the standard masked priming procedure (e.g., Grossi, 2006, for ERP evidence; see Devlin, Jamison, Matthews, & Gonnerman, 2004; Gold & Rastle, 2007, for fMRI evidence). It may be important to note here that using brief forward masked word primes does not necessarily imply the absence of a subsequent processing of the word prime (see Fischler & Goodman, 1978; Perea & Gotor, 1997): semantic encoding areas may be activated rapidly once the visual input is presented, and thereby it is not surprising that semantic information from associatively/semantically related word primes facilitate the lexical access of the target word. Indeed, as shown by Naccache et al. (2005) by using intracranial recordings, access to the meaning of brief/masked words "can unfold in the absence of consciousness" (p. 7717).

But is it possible to obtain a *between-language* associative/semantic priming effect under these conditions? de Groot and Nas (1991) examined this question in fluent Dutch–English bilinguals with the masked priming technique at a 60-ms stimulus-onset asynchrony (SOA) in a lexical decision task. De Groot and Nas found a significant masked associative/semantic priming effect (around 19–24 ms) for cognate Dutch–English pairs (e.g., *zilver-GOLD*). (Cognates are translation equivalent words that also share phonological and orthographic properties; e.g., *rich* and *rico*; see Cristofanini, Kirsner, & Milech, 1986.) For noncognate Dutch–English pairs (e.g., *jongen-GIRL*; *jongen* is the Dutch for *boy*), de Groot and Nas found a nonsignificant priming effect (13 ms, $p = .11$) in Experiment 3. A replication of this experiment yielded a virtually null effect (4 ms in Experiment 4a and −3 ms in Experiment 4b). As Grainger and Frenck-Mestre (1998) pointed out, it may be the case that the between-language associative/semantic priming effect for cognates in the de Groot and Nas experiments could just be the result of within-language associative/semantic priming, due to the orthographic (or phonological) similarity between cognate translations. Needless to say, this interpretation casts some doubts on whether associatively/semantic priming effects can be obtained early in word processing.[3]

It is important to mention that, even though the Dutch bilinguals in the de Groot and Nas (1991) experiments were "reasonably good at comprehending English" (p. 97), they did not master English at a native-like level. For these bilinguals, the dissimilarity in spelling and sound in the noncognates might prevent L2 learners from automatically mapping these L2 words onto the conceptual representation of their respective translations in L1, as acknowledged by van Hell and de Groot (1998). In other words, lexical development in L2 may be quite different from lexical development in L1.

One immediate problem with assessing the presence of early/automatic semantic priming effects across languages is that there is some disagreement on whether these effects actually exist—in particular, in the context of masked translation priming effects (e.g., *silla-CHAIR*). Note that if masked translation priming does not exist, it would be highly surprising to obtain masked semantic priming across languages. As recently reviewed by Sánchez-Casas and García-Albea (2005), the empirical evidence concerning masked translation priming effects is not conclusive. There are published reports of a significant masked translation priming effect (e.g., de Groot & Nas, 1991; Gollan, Forster, & Frost, 1997; Williams, 1994), reports with mixed evidence (e.g., Finkbeiner, Forster, Nicol, & Nakumura, 2004; Grainger &

[3] Using a masked prime paradigm with a 50-ms SOA and relatively low proficiency participants, Williams (1994, Experiment 2) obtained robust masked cross-language priming effects for French–English, German–English and Italian–English bilinguals (in a *combined* analysis for the three groups) when these pairs shared many semantic features ("near translations"; e.g., *FENCE–haie*; *haie* is the French for *hedge*). Although this finding is certainly consistent with the idea of early/automatic semantic activation across languages, there were a number of problems in Williams (1994) Experiment 2. Firstly, it is surprising that low proficiency individuals (below the university level, and whose level in English was not reported) are able to show a 34-ms masked priming effect across languages. Note that this priming effect is much greater than the usual within-language masked associative/semantic priming effects (around 10–18 ms; e.g., see Perea & Gotor, 1997). Secondly, Williams (1994) used a laptop with a gas-plasma display to present the stimuli (instead of a conventional CRT display unit in which the refresh rate is well controlled); thus, as pointed out by Perea and Rosa (2002a), it is likely that some trace of the prime remained on the screen for more than the specified 50 ms. Thirdly, primes were presented in uppercase and the targets in lowercase, which may have induced a specific processing of the primes—keep in mind that the idea in masked priming is that the target is a backward mask for the prime. Thus, although suggestive, we believe that the results of Williams (1994) must be taken with some caution.

Frenck-Mestre, 1998, found the effect in semantic categorization but not in lexical decision) and reports with a null effect (e.g., Sánchez-Casas, Davis, & García-Albea, 1992). The reasons for these discrepancies are not entirely clear, although they may be related to the degree of proficiency of the participants in the second language. For instance, in the studies that resulted in a null effect of masked translation priming in lexical decision, the bilinguals were not as proficient in the two languages as the bilinguals in the present series of experiments. In the Sánchez-Casas et al. (1992) study, participants rated their knowledge of English as "good" and 18 out of 21 participants learnt English as a second language after puberty. In the Grainger and Frenck-Mestre (1998) study, participants were native English speakers who had been living in France for a period longer than 10 years and were able to read/write/speak French fluently. Finally, in the Finkbeiner et al. (2004) study, participants were native Japanese speakers who had received a minimum of 6 years of English instruction, and had been living in the United States for at least 2 years. Nonetheless, we acknowledge that it is likely that masked translation priming effects may be (to some degree) task- and script-dependent (e.g., see Finkbeiner et al., 2004; Gollan et al., 1997, for extensive discussion).

Clearly, the previous argument would not apply to the present research, since we focus on highly proficient bilinguals who have been learning (and using) the two languages on a daily basis since childhood. Participants in the present series of experiments were bilinguals from a region of Spain—the Basque Country—in which there are two official languages: Basque and Spanish. In this region, a large percentage of speakers are highly fluent (since childhood) in these two languages. The Basque language is an ancient pre-Indo-European language, with no demonstrable genetic relationship with other living languages, which is spoken at the western end of the Pyrenees, close to the Spanish–French border. Thus, Basque and Spanish have quite different origins, and the two languages only share a small percentage of cognate words (in most cases, loan words from Spanish; e.g., *libro* and *liburu*; the Spanish/Basque for *book*).

What we should note here is that, in previous work, we tested the presence of masked translation priming for noncognates in highly fluent Basque–Spanish bilinguals (Perea, Duñabeitia, & Carreiras, 2006). As expected, we obtained a significant masked translation priming (around 18 ms). Furthermore, there were no trends of an asymmetry between the magnitude of the masked translation priming effects across languages (16 ms for Basque–Spanish pairs and 20 ms for Spanish–Basque pairs), which is consistent with the view that the participants were well-balanced bilinguals (see Jiang & Forster, 2001, for a discussion of this issue). (Note that with less balanced bilinguals, masked translation priming is stronger when the prime is in L1 and the target in L2.) Needless to say, the presence of a masked semantic priming effect across languages would be a stronger demonstration of early semantic activation than a masked translation priming effect—one could argue that the locus of masked translation priming is at the lexical level (e.g., via lexical association, or co-occurrence, between the two translations—*chair* and *silla*).

Implications for the models of bilingual memory

What are the predictions from the models of bilingual memory? The most influential model in bilingual memory, the revised hierarchical model (e.g., see Kroll & Stewart, 1994; Kroll & Sunderman, 2003; Kroll & Tokowicz, 2001, 2005) assumes that, in the initial stages of L2 learning, learners have access to the semantic system via their first language (L1). Only when the learners have a high degree of proficiency is there direct semantic processing from L2. In this model, the early dependence on L1 to mediate access to meaning for L2 words creates an asymmetry in the form of interlanguage connections. Thus, at the semantic level, the model assumes strong connections for L1 words, but relatively weaker connections for L2 words. But the relevant point here is that the links from the two languages to the semantic level would be equivalent for L1 and L2 in highly fluent bilinguals, and hence the model allows automatic semantic priming across and within languages.

Another highly influential model in the literature on bilingual memory is the Bilingual Interactive Activation (BIA) model (Dijkstra & van Heuven, 1998; van Heuven, Dijkstra, & Grainger, 1998). In its original version, the BIA model was concerned with the recognition of orthographic representations in a bilingual's memory. For instance, the BIA model was able to simulate the effects of masked orthographic priming within- and between-languages found in the experiment of Bijeljac-Babic, Biardeau, and Grainger (1997). More important for the present purposes, an extension of this model has been proposed that deals with semantics: the BIA+ model (Dijkstra & van Heuven, 2002). In the BIA+ model, the process of bilingual word recognition can be affected by linguistic context. The idea is that when sublexical/lexical orthographic representations become active, they start to activate semantic representations. Hence, semantic representations of both languages are activated during word reading. As Kerkhofs, Dijkstra, Chwilla, and de Bruijn (2006) state, "a target word might be recognized more quickly when it is preceded by a semantically related prime because the prime could pre-activate the target's meaning representation and induce faster target recognition" (p. 171). Although the semantic layer has not been implemented in the BIA+ model yet, what is clear is that the model predicts the existence of automatic semantic priming across languages.

Recent empirical evidence has shown associative/semantic priming effects across languages with visible primes in a prime–target pairing paradigm (e.g., at a 400 ms SOA; Kerkhofs et al., 2006; Silverberg & Samuel, 2004) and with a single-presentation procedure (e.g., Kotz & Elston-Güttler, 2004; see also Alvarez, Holcomb, & Grainger, 2003). Although the above-cited studies clearly suggest the presence of shared semantic representations in bilingual memory (see Francis, 2005, for a comprehensive review of this issue), the obtained priming effects may have been affected by some post-access integration factors (e.g., via L2–L1 translation) that may occur with visible primes (see Section of Masked Priming vs. Visible Primes). Furthermore, these experiments do not prove that the obtained effect occurs early in the time course of word processing. Indeed, an experiment with masked primes is a much more stringent test of early and automatic processes. The best example is given by de Groot and Nas (1991). As indicated earlier, they failed to find a significant masked associative/semantic priming with noncognates; however, using the same materials and a longer prime duration exposure, they found a significant associative/semantic priming effect with noncognates. de Groot and Nas (1991) concluded, mainly on the basis of the masked priming experiments that there were *shared* conceptual representations for cognate translations (e.g., as in *rich-RICO*) but *separate* conceptual representations for noncognate translations (as in *table-MESA*). de Groot (1992) later qualified her position arguing that noncognates would share fewer nodes, in a distributed network, at the conceptual level than do cognates. The problem with this interpretation is that, as indicated above, there is no *a priori* reason why noncognate words (e.g., *dog* and *perro*) should have less conceptual overlap than cognate words (*cat* and *gato*) (e.g., see Costa, Santesteban, & Caño, 2005). Indeed, when discussing the lack of a masked associative/semantic priming effect for noncognates, de Groot and Nas (1991) speculated "why is it that orthographic (and acoustic) similarity between translations enhances their chance in a single conceptual representation?" (p. 119).

In sum, if (noncognate) prime words in the nontarget language do produce associative/semantic priming effects at a very short stimulus-onset asynchrony (SOA), this would provide strong empirical support for the view that words in the nontarget language are activating shared semantic representations—and not just the potential ortho-phonological shared representations between cognate pairs. In the present experiments, we chose a (word/nonword) lexical decision task rather than a semantic verification task (e.g., "is it an animal?"), the reason being that the latter has an *intrinsic* semantic component independent of lexical access (see Duñabeitia et al., in press). Therefore, the present lexical decision experiments would constitute a stronger test of interlingual links at a conceptual level than a semantic verification task.

Note that both the hierarchical revised model and in particular the computational BIA+ model predict the existence of early and automatic semantic priming effects across languages for highly proficient bilinguals (both from Basque to Spanish and from Spanish to Basque) on the basis of a common semantic level. This was the issue under scrutiny tested in Experiment 1. Furthermore, the magnitude of the masked semantic priming effect should be approximately the same across and within languages—and this should be so for early and (relatively) late highly fluent bilinguals. This was tested in Experiments 2 and 3, respectively. Finally, it is important to keep in mind that computational models of bilingual (and/or monolingual) memory need experiment data as to specify what is there to be simulated. Given that these models tend to focus exclusively on automatic (rather than strategic) processes (e.g., Cree, McRae, & McNorgan, 1999; McRae & Boisvert, 1998; Plaut, 1995; Thomas & van Heuven, 2005), masked priming experiments are ideally suited to test these models.

The experiments

In this paper, we intend to contribute to a resolution of the empirical issues concerning the role of semantic information across languages during the early stages of word recognition. In Experiment 1, we examined *between-language* associative/semantic priming effects using noncognate pairs for both Basque/Spanish and Spanish/Basque prime–target pairs. (We do not use the terms L1 and L2 to refer to Basque and Spanish because the participants have been exposed to the two languages on a daily basis from birth; thus, no asymmetries are predicted in terms of L1–L2 vs. L2–L1 priming effects; see Jiang & Forster, 2001.) The significant associative/semantic priming effect found in Experiment 1—which was the same magnitude for Basque–Spanish and Spanish–Basque pairs—led us to a second question: Are there any differences between the masked associative/semantic priming effects across and within languages? If one obtains similar associative/semantic priming effects within a language and between languages, it would strongly support the view of a semantic (language-independent) locus of the priming effects. Experiment 2 was designed to answer this question. The answer was positive: Masked associative/semantic priming effects were approximately of the same magnitude. Finally, it is of theoretical importance to determine whether the way in which the L2 is acquired determines the degree of sharing across languages. To examine this use, Experiment 3 used the same design as in Experiment 2 with a group of late, highly proficient Spanish–Basque bilinguals.

Experiment 1

Method

Participants

Forty students from the University of the Basque Country in Vitoria received 5 € for participating in the experiment. All of them had either normal or corrected-to-normal vision and were native speakers of Basque. All of them had had Basque as the teaching language at all academic levels, including the university level. (Note that all speakers in the Basque Autonomous Community have a perfect knowledge of Spanish as well; indeed, the most popular newspapers are written mostly in Spanish.) All the 40 participants completed a questionnaire to assess their usage of Basque (adapted from Weber-Fox & Neville, 1996). This questionnaire included questions regarding the frequency of usage of each of the two official languages in the Basque Country: Basque and Spanish. On a 1-to-7 Likert scale, the participants rated the regularity in which they used each of the languages during the childhood, youth and nowadays, in three different contexts (academic, family and other contexts). None of the ratings in the usage frequency of Basque resulted lower than 5.55 points in the 1 (less use) to 7 (more use) scale. The questionnaire also included a section of self-evaluation of the proficiency in the language in reading, writing, understanding and speaking (on a 1-to-4 scale). The mean lowest score was 3.75 for the Basque sections. Another section in the questionnaire asked about the language in which they felt more comfortable speaking (Basque, Spanish or both): 27 participants selected only Basque, whereas 13 chose both of them. None of the participants selected the 'only Spanish' option. Half of the participants were presented with target words in Spanish (average age: 19.6 years) and, the other half, target words in Basque (average age: 21.8 years).

Materials

Forty associatively and semantically related pairs (e.g., *mesa-silla*; the Spanish for *table-chair*) were selected from the Spanish free-association norms (Fernández, Díez, Alonso, & Beato, 2004), with the first member of the pair used as a prime and the second as target. For the selected pairs, the mean associative strength (i.e., the first associative response to the prime) in these norms was 41.5%. The concreteness index for the prime words and target words was 5.8 and 5.5, respectively (on a 1–7 scale; Sebastián-Gallés, Martí, Carreiras, & Cuetos, 2000). Neither of the components of the pair were cognates of Spanish words when translated into Basque (i.e., the translations did not have the same origin or any similarities in form). For instance, the Basque translation of the Spanish pair *mesa-SILLA* is *mahai-AULKI*. The targets were presented in uppercase and were preceded by primes in lowercase that were (1) a word associated to the target in the other language (related word condition), e.g., *mesa-AULKI* or *mahai-SILLA*, or (2) an unrelated word in the other language (unrelated word condition), e.g., *luna-AULKI* or *zauri-SILLA*. The characteristics of the words used in the experiment are presented in Table 1, and the related pairs are presented in Appendix 1. For half of the participants, targets were Basque words preceded by a Spanish prime, and for the other half, targets were Spanish words preceded by a Basque prime. For the Spanish and Basque groups, word primes were rotated through the related and unrelated conditions so that each target word was primed by each of the two types of primes across the experiment. Thus, two sets of materials were constructed in the Spanish group (and two sets in the Basque group) in order for each target word to appear once in each set, but each time in a different priming condition.

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

Procedure

Participants were tested individually in a quiet room. Presentation of the stimuli and recording of response times were controlled by PC compatible computers. The experiment was run using DMDX (Forster & Forster, 2003). Reaction times were measured from target onset until the participant's response. On each trial, a forward mask consisting of a row of hash marks (#'s) was presented for 500 ms in the center of the screen.[4] Next, the prime was presented in lowercase in 12-pt. Courier, and stayed on the screen for 47 ms (4 cycles; each cycle corresponding to 11.8 ms on the CRT monitor). The prime was followed immediately by the presentation of the target stimulus in uppercase. Both prime and target were presented at the same screen location as the forward mask. The target remained on the screen until the participants responded. Participants were

[4] In the pattern mask, the number of #'s was the maximum between the number of letter of the prime and the number of letters of the target (e.g., for the pair *mesa-AULKI*, the pattern mask was composed of five hash marks). Care was taken that the length of prime and target was approximately the same.

Table 1
Number of letter and mean frequency (per million) of the prime and target words in Experiment 1

	Spanish		Basque	
	Primes	Target	Prime	Target
Number of letters	5.3	5.6	5.1	5.6
Word frequency	82	153	116	170

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

instructed to press one of two buttons on the keyboard to indicate whether the uppercase letter string was a legitimate word or not and were instructed to make this decision as quickly and as accurately as possible. They were not informed of the presence of the lowercase items. Each participant received a different order of trials. Each participant received a total of 20 practice trials (with the same manipulation as in the experimental trials) prior to the 80 experimental trials. The instructions (and the interactions with the participants) were given in Spanish when the participants had to perform the lexical decision task in Spanish, and they were given in Basque when the participants had to perform the lexical decision task in Basque. None of the participants reported having seen the lowercase words when asked after the experiment. The whole session lasted approximately 9 minutes.

Results and discussion

Incorrect responses (3.1% of the data for word targets) and reaction times less than 250 ms or greater than 1800 ms (less than 2.5% of the data for word targets) were excluded from the latency analysis. The mean latencies for correct responses and error rates are presented in Table 2, and participant and item ANOVAs based on the participant and item response latencies and error percentage were conducted based on a 2 (Language of target: Spanish, Basque) $\times$ 2 (Type of prime–target relationship: semantically related, unrelated) $\times$ 2 (List: list 1, list 2) design. The factor Language of target was manipulated between-subjects and between-items, whereas the factor Type of prime was manipulated within-subjects and within-items. The factor List was included as a dummy variable to extract the variance due to the error associated with the lists. We also report the min F' statistic; however we do not interpret these values because min F' is overly conservative (e.g., see Forster & Dickinson, 1976). Throughout the paper, all significant effects had p values less than the .05 level. Here and in subsequent analyses, the 95% confidence interval from the analysis by participants is included in each difference score.

The ANOVA on the response time data showed that words preceded by a associatively/semantically related word in the nontarget language were responded to 13 ($\pm$8) ms faster than words preceded by an unrelated word in the nontarget language, $F1(1,36) = 6.08$, $MSE = 568.5$, $F2(1,76) = 5.81$, $MSE = 1488.1$; $\min F'(1,99) = 2.98$, $p = .087$. In addition, response times to Spanish words were 69 ($\pm$43) ms faster than response times to Basque words, $F1(1,36) = 5.20$, $MSE = 18173.5$, $F2(1,76) = 22.69$, $MSE = 5371.3$; $\min F'(1,53) = 4.23$. The other effects did not approach significance.

The ANOVA on the error data only revealed that participants made more 2.5 ($\pm$1.3) % errors on unrelated words than on associatively/semantically related words, $F1(1,36) = 4.94$, $MSE = 16.18$; $F2(1,76) = 7.35$, $MSE = 21.78$; $\min F'(1,83) = 2.95$, $p = .089$. The other effects did not approach significance.

The main finding of the present experiment is straightforward: highly proficient bilinguals show significant masked associative/semantic priming effects across languages for *noncognate* pairs in lexical decision. This effect was similar for Basque–Spanish pairs and for Spanish–Basque pairs—consistent with the view that the participants were well-balanced, highly fluent bilinguals. As we discuss in General discussion, this result has important implications for models of bilingual memory.

What we should also point out is that participants were somehow faster with Spanish words than with Basque words. Even though the participants have Basque as their native language, the presence of Spanish is ubiquitous in the Basque Country (books, newspapers, TV, etc.) and hence the participants' level of orthographic recognition in Spanish could have been slightly higher than in Basque (see also Duñabeitia et al., in press, for a similar pattern of response times with native speakers of Basque). There is another possibility: the Basque nonwords in the experiment had, on average, a higher number of orthographic neighbors than the Spanish nonwords: 8 vs. 2, respectively, and this would have made the word/nonword task more difficult for the Bas-

Table 2
Mean lexical decision times (in ms) and percentage of errors (in parentheses) for word targets in Basque–Spanish and Spanish–Basque pairs in Experiment 1

	Type of prime		
	Related	Unrelated	Priming
Target language			
Spanish	662 (2.0)	673 (2.8)	11 (0.8)
Basque	729 (2.3)	744 (5.5)	15 (3.3)

Note. Mean nonword response times and error rates were 796 ms and 1.5% for the group with Spanish targets, and 867 and 5.0% for the group with Basque targets.

que group than for the Spanish group (e.g., see Perea & Rosa, 2002c).

It may be important to note that although Basque and Spanish use a Roman script, the origins and, unsurprisingly, the orthographic patterns of Basque and Spanish are somewhat different, and this may have helped the cognitive system to activate the right lexicon.[5] For instance, the letters *C* and *V* are not used in Basque, and the frequency of letters is quite different in the two languages (e.g., the frequency of the letters *Z* and *K* in Basque is much more elevated than in Spanish). Furthermore, there are conflicting bigram combinations in Basque and in Spanish (e.g., the bigram *MB* is legal in Spanish and illegal in Basque, whereas *NB* is legal in Basque and illegal in Spanish). Even more importantly, the ending of the Basque words differs from Spanish words (e.g., compare the Basque words *aulki* and *mahai* with the Spanish words *silla* and *mesa*; *chair* and *table* in English). These differences in orthography across Basque and Spanish may have helped the reader to choose the appropriate orthographic lexicon (either the Spanish one or the Basque one), and this may have maximized the chances of finding a between-languages masked associative/semantic priming effect.

Leaving aside the intrinsic interest of replicating the *between-language* associative/semantic priming effect of Experiment 1, one key question remaining is whether the magnitude of this priming effect varies *across* and *within* languages. Bear in mind that a similar magnitude of priming effects within a language and across languages would strongly suggest the presence of a semantic (language-independent) locus of the priming effects. Experiment 2 was designed to answer this question by using a within-subject design in which Spanish words could be preceded by word primes in Basque (the related pair *mahai-SILLA* or the unrelated pair *zauri-SILLA*) or in Spanish (the related pair *mesa-SILLA* or the unrelated pair *luna-SILLA*).

Experiment 2

Method

Participants

Thirty-two students from the University of the Basque Country in Vitoria received 5 € for participating in the experiment. All of them had either normal or corrected-to-normal vision and were native speakers of Basque. All of them had had Basque as the teaching language at all academic levels, including the university level. None of them had participated in Experiment 1. The same questionnaire as in Experiment 1 was completed by the 32 participants. Similar to the previous results, the lowest rating in the usage frequency of Basque was 5.43. In the proficiency section, the lowest mean value was 3.78. When asked to choose the language in which they felt more comfortable, 22 participants chose Basque, and 10 chose both languages. The average age was 22.5 years.

Materials

We used the forty associatively/semantically related pairs from Experiment 1. In this experiment, the word targets were always Spanish words. (Given that the association norms were collected in Spanish, we chose Spanish as the target language for this experiment.) The targets were presented in uppercase and preceded by primes in lowercase that were: (1) a word associated to the target in Spanish or in Basque (related word condition), e.g., *mesa-SILLA* or *mahai-SILLA*, or (2) an unrelated word in Spanish or in Basque (unrelated word condition), e.g., *luna-SILLA* or *zauri-SILLA*. Word primes were rotated through the related and unrelated conditions so that each target word was primed by each of the four types of primes across the experiment: related condition with a word prime in Basque; related condition with a word prime in Spanish; unrelated condition with a word prime in Basque; unrelated condition with a word prime in Spanish. Thus, four sets of prime–target pairs were constructed in order for each target word to appear once in each set, but each time in a different priming condition. Different groups of participants were used for each set of materials.

An additional set of forty orthographically legal nonwords in Spanish were also created for the lexical decision task. As occurred with word trials, nonword targets were preceded by a word in Basque in half of the trials and by a word in Spanish in the other half.

Procedure

The procedure was the same as in Experiment 1.

Results and discussion

Incorrect responses (2.5% of the data for word targets) and reaction times less than 250 ms or greater than 1800 ms (less than 1% of the data for word targets) were excluded from the latency analysis. The mean latencies for correct responses and error rates are presented in Table 3, and participant and item ANOVAs based on the participant and item response latencies and percentage error were conducted based on a 2 (Language of prime: Spanish, Basque) × 2 (Type of prime–target relationship: semantically related, unrelated) × 4 (List: list 1, list 2, list 3, list 4) design. The factors Language of prime and Type of prime–target relationship were manipulated within-subjects and within-items.

[5] We thank Ken Forster for pointing out this possibility.

Table 3
Mean lexical decision times (in ms) and percentage of errors (in parentheses) for word targets for between- and within-language semantic pairs in Experiment 2

	Type of prime		
	Related	Unrelated	Priming
Prime language			
Spanish	628 (1.6)	641 (2.8)	13 (1.8)
Basque	631 (3.1)	650 (2.5)	19 (−0.6)

Note. Mean nonword response times and error rates were 751 ms and 6.3%.

The ANOVA on the response time data showed that words in Spanish preceded by an associatively/semantically related word were responded to 15 (±13) ms faster than words preceded by an unrelated word, $F1(1,28) = 4.33$, $MSE = 1747.6$, $F2(1,36) = 8.69$, $MSE = 1304.1$; $\min F'(1,53) = 2.89$, $p = .09$. The magnitude of the associative/semantic priming effect was similar for primes in Spanish and for primes in Basque (13 vs. 19 ms), as deduced from the lack of an interaction between Language of prime and prime–target relationship (both Fs < 1). The effect of Language of the prime did not approach significance (both Fs < 1).[6]

The ANOVA on the error data did not reveal any significant effects.

The main finding of the present experiment is again clear-cut: the magnitude of the associative/semantic priming effect for noncognate pairs is very similar *between* and *within* languages. Therefore, this result suggests the presence of a semantic, language-independent, locus of the priming effects.

Experiment 3

Experiments 1–2 showed clear associative/semantic priming effects across languages. As indicated earlier, participants in these experiments were early, simultaneous bilinguals. It is of theoretical importance to determine whether the way in which the L2 is acquired determines the degree of sharing across languages. Indeed, it has been previously shown that early Catalan–Spanish bilinguals in spite of their excellent degree of linguistic competence, have difficulty in perceiving some vocalic Catalan contrasts and that this failure has consequences at the lexical level (Pallier, Colomé, & Sebastián-Gallés, 2001; Sebastián-Gallés, Echeverrıa, & Bosch, 2005). For that reason, it is important to examine the presence of associative/semantic priming effects across languages with bilinguals who have not acquired L2 from birth. This is the goal of Experiment 3: it was intended to replicate the masked semantic priming effect within and across languages obtained in Experiments 1–2 in relatively late bilinguals. The Spanish–Basque bilinguals in the present experiment were all native speakers of Spanish and started to learn Basque at the age of six—at school. Their current proficiency level is comparable to the level of the bilinguals recruited in Experiments 1–2 (i.e., at a native-like level). If participants in Experiment 3 show no semantic priming across languages (or at least attenuated), this would suggest that the key factor is not the proficiency in L2 but rather the nature in which L2 is acquired. Alternatively, if the pattern of data in Experiment 3 mirrors the pattern found in Experiment 2, then the likely factor responsible for the semantic priming effect across languages is the degree of proficiency in the languages.

Method

Participants

Thirty-two undergraduate and graduate students from the University of Basque Country in Vitoria received 5 € for participating in the experiment. All of them had either normal or corrected-to-normal vision and had Spanish as their mother tongue. Nonetheless, all of them started their schooling at the age of 6 either in a Basque monolingual or in a Spanish–Basque bilingual teaching system.[7] Ten participants had a bilingual Spanish–Basque language of instruction in primary and secondary school, and 22 only had Basque as teaching language in primary and secondary school. The teaching language in college for all participants was Basque. All the participants had obtained the Basque Proficiency Certificate (EGA; *Euskara Gaitasun Agiria*), which officially certifies a perfect proficiency in Basque. All the participants filled in the same questionnaire used in Experiments 1 and 2. While the mean of responses to the questions regarding the frequency of usage of Basque in family contexts was 1.65 (a lower score indicates less use of Basque), the mean score in academic contexts was 5.44, indicating a daily use of Basque in educational contexts. When asked about their competency level in Basque (understanding, writing, reading, and speaking),

[6] The semantic priming effect was numerically similar across and between languages, so that if one performs a post hoc power analysis, the probability of detecting a significant interaction is .09. Nonetheless, this power analysis should be taken with extreme caution: Firstly, it is a post hoc analysis on the basis of the estimated means from the experiment, and secondly, it would reflect an (unlikely) interaction in which the semantic priming effect across languages would be greater than the semantic priming effect within a language.

[7] The Basque educational system offers a bilingual schooling option, in which the academic curriculum contains at least half of the subjects taught in Basque.

the mean score was 3.33 (on a 1–4 scale, where 4 indicates high performance), with 3.22 the lowest mean score. Unlike the participants in Experiments 1–2, most of the participants (22) in the present experiment indicated that they felt more comfortable when talking in Spanish, whereas 9 did not mind which language, and only 1 chose Basque. The average age was 24.8 years.

Materials and procedure

These were the same as in Experiment 2.

Results and discussion

Incorrect responses (1.1% of the data for word targets) and reaction times less than 250 ms or greater than 1800 ms (less than 1% of the data for word targets) were excluded from the latency analysis. The mean latencies for correct responses and error rates are presented in Table 4, and participant and item ANOVAs based on the participant and item response latencies and percentage error were conducted based on a 2 (Language of prime: Spanish, Basque) × 2 (Type of prime–target relationship: semantically related, unrelated) × 4 (List: list 1, list 2, list 3, list 4) design.

The ANOVA on the response time data showed that words in Spanish preceded by an associatively/semantically related word were responded to 22 (±19) ms faster than words preceded by an unrelated word, $F1(1,28) = 5.15$, $MSE = 3296.8$, $F2(1,36) = 10.96$, $MSE = 1800.2$; $\min F'(1,52) = 3.50$, $p = .066$. The magnitude of the associative/semantic priming effect was similar for primes in Spanish and for primes in Basque (28 vs. 17 ms), as deduced from the lack of an interaction between Language of prime and prime–target relationship (both $Fs < 1$).

The ANOVA on the error data did not reveal any significant effects.

Again, we found that the magnitude of the associative/semantic priming effect for noncognate pairs is very similar *between* and *within* languages. This effect, obtained with (relatively) late, proficient bilinguals was parallel to the priming effect found in Experiment 2 with early proficient bilinguals.

One could argue that it would be of interest to include a group of late, highly proficient bilinguals who had learnt the Basque language after the age of 12. However, the vast majority of native Spanish speakers who learn Basque relatively late in life (age 12 or older) tend not to be highly proficient bilinguals (i.e., native-like bilinguals), and thereby, this experiment would confound age-of-acquisition and proficiency.

Table 4
Mean lexical decision times (in ms) and percentage of errors (in parentheses) for word targets for between- and within-language semantic pairs in Experiment 3 (late bilinguals)

	Type of prime		
	Related	Unrelated	Priming
Prime language			
Spanish	693 (0.9)	721 (0.6)	28 (−0.3)
Basque	710 (0.9)	727 (1.9)	17 (1.0)

Note. Mean nonword response times and error rates were 836 ms and 3.9%.

General discussion

The main findings of the present masked priming experiments are straightforward: (i) highly proficient bilinguals show early and automatic associative/semantic priming effects across languages for noncognate pairs in lexical decision (both Basque–Spanish and Spanish–Basque), (ii) the magnitude of the associative/semantic priming effects is similar across and within languages—thus suggesting a common semantic (language-independent) locus of the effect, and (iii) the same pattern of data was also obtained with late, highly proficient bilinguals (i.e., individuals who did not acquire the two languages simultaneously in early childhood). The presence of early associative/semantic priming effects across languages has clear implications for models of bilingual memory.

The presence of early and automatic associative/semantic priming across languages is consistent with recent empirical evidence that has shown semantic priming effects across languages with visible primes in a paired prime–target procedure (e.g., at a 400 ms SOA; see Silverberg & Samuel, 2004) and with a single-presentation procedure (e.g., Kotz & Elston-Güttler, 2004). Consistent with this view, in an fMRI study with proficient English–Spanish bilinguals, Illes et al. (1999) found that semantic activation for both languages in a semantic decision task ("is it a concrete word?") occurred (approximately) in the same cortical locations, which suggests that a common neural system mediates conceptual processes for the two languages. Likewise, Kerkhofs et al. (2006) found that homographs like *STEM* (*voice* in Dutch) were responded to faster in lexical decision following semantically related primes of the English word than following unrelated primes—they also found an N400 priming effect.

However, the above-cited studies employed visible primes and relatively long SOAs, and thereby these effects do not necessarily imply an early common semantic code for the two languages. Bear in mind that the obtained masked semantic priming effects not only reflect an automatic process of semantic activation across languages, but they also reflect very early processes in the process of word recognition—note that the target is presented only 50 ms after the word prime. Furthermore, there was the possibility that the effects obtained with visible primes could have been affected by some post-access integration factors (e.g., via L2–L1 translation). In either case, the evidence is converging: there is semantic priming across languages, and the present experiments add to that evidence the detail that these effects are *early* and *automatic*.

Furthermore, it is important to note that between-languages associative/semantic priming effect was *similar* in size to the within-language associative/semantic effect (Experiments 2 and 3): this finding strongly suggests that the obtained masked priming effect is language-independent. Furthermore, the presence of a shared semantic code occurs for both early and late highly proficient bilinguals—this suggests that age-of-acquisition did not play a critical role in the masked priming effect. Note however that, for late highly proficient bilinguals, there seemed to be a (nonsignificant) trend towards a greater within-language than between-language priming effect—this would be consistent with the view that early bilinguals develop stronger interlingual links at the semantic level than late bilinguals.

Consistent with connectionist models of semantic priming (e.g., Cree et al., 1999; Plaut, 1995), the obtained associative/semantic priming effects also seem to reflect semantic similarity (i.e., a semantic effect) rather than just some degree of lexical association. The Pearson coefficients between the size of the associative/semantic priming effect and the prime–target associative strength (via free-production norms) was negligible across experiments (all $ps > .40$; see also Lucas, 2000; Perea & Rosa, 2002a, for a similar pattern). This is also consistent with the presence of similar priming effects across and within languages; if the degree of prime–target association had played a key role in the effect one would have expected a greater associative/semantic priming effect within a language (e.g., on the basis of prime/target co-occurrence). We should note that Kotz and Elston-Güttler (2004) found some differences between associative + semantic and semantic-only priming effects in bilinguals. However, the associative + semantic and semantic-only pairs also differed in terms of their semantic relatedness, which makes it difficult to draw strong conclusions (see McRae & Boisvert, 1998, for a discussion of this topic; see also Perea & Gotor, 1997 & Perea & Rosa, 2002a, for empirical evidence of semantic-only priming effects with the masked priming paradigm).

What are the implications of the present findings for models of bilingual memory? In a distributed model of bilingual memory, semantic representations would be distributed across a number of nodes—as in connectionist models of semantic memory. Semantic representations of noncognates in the two languages would share a number of nodes, which should be enough to produce an associative/semantic priming effect (as shown in Experiments 1–3). Thus, the present findings give empirical support to a proficiency hierarchical model of bilingual memory in which highly proficient bilinguals have access to shared conceptual/semantic store for the two languages (e.g., Kroll & Stewart, 1994; Kroll & Tokowicz, 2001, 2005). That is, semantic overlap develops with increased proficiency. In this model, the shared semantic representations are likely to work in the same way for cognate and noncognate pairs. Of course, to make more specific predictions, the hierarchical model would have to include specific estimates of the time course with which lexical and semantic activation is included—in fairness to Kroll and colleagues, the hierarchical model was proposed to account for production data in tasks such as translation rather than as a precise account of the time course of semantic priming across languages.

The present data are also compatible with the BIA+ model (Dijkstra & van Heuven, 2002). The BIA+ model has the obvious advantage (over "verbal models") of being a computational model, and it correctly predicts the presence of early semantic priming effects (via a nonimplemented, shared semantic module). As Dijkstra and van Heuven (2002) pointed out, the BIA+ framework complements—rather than opposes—recent versions of the revised hierarchical model (e.g., Kroll & Sunderman, 2003). Interestingly, although the current version of the BIA+ model does not have a learning mechanism, it may be used to simulate bilingual word recognition performance for bilinguals at different proficiency levels (see Thomas & van Heuven, 2005, for a discussion on localist and connectionist models of bilingual memory).

In sum, we believe that the use of highly proficient speakers from fully bilingual regions may provide important insights into the study of bilingual memory. These data may complement the data from learners of a second language with varying levels of proficiency, and thereby help attain a better understanding of the structure of a bilingual's lexical/semantic memory. In the present study, we have shown that highly proficient bilinguals develop between-language links (with noncognate pairs) at the semantic level—via associative/semantic priming. Interestingly, masked associative/semantic priming effects were of the same magnitude across/within languages, and were also obtained for highly fluent individuals who did not acquire the second language in early childhood. More computational modeling effort is necessary to understand the intricacies of a bilingual's semantic memory.

Acknowledgments

The research reported in this article has been partially supported by Grants SEJ2004-07680-C02-02/

PSIC, SEJ2006-09238/PSIC, SEJ2005-05205/EDU, and PR2007-0201 from the Spanish Ministry of Education and Science. Jon Andoni Duñabeitia was the recipient of a post-graduate grant from the Basque Government. We thank Ken Forster and an anonymous reviewer for their helpful comments on an earlier version of the paper.

Appendix 1. Semantically related words in the experiments

The order of the prime–target pais is the following (prime in lowercase and target in UPPERCASE): prime (Basque) and target (Spanish), prime (Spanish) and target (Basque). We also provide the associative strength for each pair, and the approximate English translation in parentheses. (Word-frequency for each word is given between brackets.)

galdera (210.38)-RESPUESTA (113.75), pregunta (116.79)-ERANTZUNA (165.10), 79.2%; (question-ANSWER)
eskuin (38.1)-IZQUIERDA (92.86), derecha (116.25)-EZKER (80.07), 79.2%; (right-LEFT)
euritako (2.21)-LLUVIA (59.46), paraguas (12.5)-EURI (65.71), 74.3%; (umbrella-RAIN)
aingura (2.76)-BARCO (47.68), ancla (3.39)-ITSASONTZI (7.73), 70.1%; (anchor-SHIP)
senar (52.73)-MUJER (493.39), marido (136.79)-EMAZTE (91.39), 65.3%; (husband-WIFE)
orrazi (3.31)-PELO (100.71), peine (5)-ILE (59.36), 61.7%; (comb-HAIR)
sartu (865.26)-SALIR (170), entrar (105.71)-IRTEN (231.64), 57%; (enter-EXIT)
izotz (16.29)-FRÍO (98.75), hielo (30.89)-HOTZ (57.7), 53%; (ice-COLD)
erloju (20.43)-HORA (216.96), reloj (50.71)-ORDU (339.31), 50.7%; (watch-TIME)
behi (45)-LECHE (54.11), vaca (11.07)-ESNE (59.36), 49%; (cow-MILK)
hiztegi (84.21)-PALABRA (175.71), diccionario (9.64)-HITZA (181.39), 31.7%; (dictionary-WORD)
on (442.57)-MALO (54.29), bueno (202.86)-TXAR (55.77), 46%; (good-BAD)
usaimena (4.97)-NARIZ (52.86), olfato (11.43)-SUDUR (30.65), 44%; (smell-NOSE)
zuri (258.97)-NEGRO (130.36), blanco (116.25)-BELTZ (117.89), 42%; (white-BLACK)
erle (27.33)-MIEL (18.39), abeja (3.57)-EZTI (45.28), 41.5%; (bee-HONEY)
zauri (22.09)-SANGRE (184.46), herida (22.86)-ODOL (115.96), 40%; (wound-BLOOD)
jatetxe (13.25)-COMIDA (61.25), restaurante (25.71)-JANARI (74.54), 40%; (restaurant-FOOD)
giltza (37)-PUERTA (278.04), llave (22.86)-ATE (143.57), 40%; (key-DOOR)
iltze (9.11)-MARTILLO (5.36), clavo (5.36)-MAILU (9.94), 39.6%; (nail-HAMMER)
teilatu (9.66)-CASA (629.82), tejado (11.07)-ETXE (500.27), 39.5%; (roof-HOUSE)
hari (158.2)-AGUJA (8.93), hilo (27.68)-ORRATZ (12.98), 38.7%; (thread-NEEDLE)
ibai (81.72)-AGUA (295.36), río (101.43)-UR (398.12), 38.6%; (river-WATER)
handi (348.98)-PEQUEÑO (130.54), grande (112.68)-TXIKI (332.13), 36%; (big-SMALL)
hilabete (131.42)-AÑO (343.93), mes (103.04)-URTE (1340.13), 35.6%; (month-YEAR)
mahai (99.67)-SILLA (48.21), mesa (172.14)-AULKI (47.21), 34.1%; (table-CHAIR)
ezpainak (20.98)-BESO (29.46), labios (8.04)-MUSU (39.48), 32.6%; (lips-KISS)
ilargi (20.98)-NOCHE (405.71), luna (52.5)-GAU (243.23), 29.9%; (moon-NIGHT)
eraztun (16.84)-DEDO (50.89), anillo (14.82)-ATZAMAR (9.94), 29.7%; (ring-FINGER)
arrautza (23.47)-GALLINA (13.04), huevo (20.36)-OILO (19.33), 29%; (egg-CHICKEN)
haitz (18.77)-PIEDRA (64.46), roca (20.89)-HARRI (126.45), 28.8%; (rock-STONE)
bihotz (122.58)-AMOR (267.5), corazón (151.43)-MAITASUN (92.77), 28.6%; (heart-LOVE)
txapel (18.22)-CABEZA (352.86), sombrero (30.54)-BURU (350.91), 28.6%; (hat-HEAD)
ama (692.43)-PADRE (383.57), madre (380.54)-AITA (826.06), 20%; (mother-FATHER)
bizitza (408.33)-MUERTE (257.32), vida (850.89)-HERIOTZA (76.2), 28%; (life-DEATH)
ontzi (86.97)-MAR (154.11), barco (47.68)-ITSAS (141.63), 27.8%; (ship-SEA)
hodei (24.85)-CIELO (110.71), nube (16.79)-ZERU (87.52), 27.4%; (cloud-SKY)
maisu (56.32)-PROFESOR (78.04), maestro (41.79)-IRAKASLE (181.67), 27%; (teacher-PROFESSOR)
oihan (27.06)-ÁRBOL (35), bosque (48.75)-ZUHAITZ (89.18), 22.5%; (wood-TREE)
urre (53.84)-PLATA (47.68), oro (90)-ZILAR (12.7), 22%; (gold-SILVER)
ardi (64.88)-LANA (14.29), oveja (6.61)-ARTILE (4.97), 50.3%; (sheep-WOOL)

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