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Which Words Are Activated During Bilingual Word Production?

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Whether words are or are not activated within the lexicon of the nonused language is an important question for accounts of bilingual word production. Prior studies have not led to conclusive results, either because alternative accounts could be proposed for their findings or because activation could have been artificially induced by the experimental paradigms. Moreover, previous data only involved target translations, and nothing is known about the activation of nontarget words in the nonused language. The picture–picture interference paradigm was used here, since it allowed the activation of nontarget words to be determined without showing stimuli that could artificially activate the nonused language. Proficient Spanish–Catalan speakers were presented with pairs of partially overlapping colored pictures and were instructed to name the green picture and ignore the red picture. In Experiment 1, distractor pictures with cognate names interfered more than distractor pictures with noncognate names. In Experiment 2, facilitation was observed when the names of the distractor pictures in the nonused language were phonologically related to the names of the target pictures. Overall, these results indicate that nontarget words are activated in the nonused language, at least in the case of proficient bilingual speakers. These results help researchers to constrain theories of bilingual lexical access.

Keywords: bilingualism, speech production, lexical access, cognates

Research in the past 3 decades has made it exceedingly clear that word production is far from an orderly process in which only the word that a speaker wants to say at a specific point in time becomes activated (Cutting & Ferreira, 1999; Dell, 1986; Jescheniak & Schriefers, 1998; Levelt, 1989; Morsella & Miozzo, 2002; Peterson & Savoy, 1998; Starreveld & La Heij, 1996). Rather, word production appears to occur in a more chaotic environment where a number of words are activated simultaneously and could potentially interfere with the selection of the desired word. Some of the extraneous words are activated because they are close in meaning to the target word, others because they sound alike, while still others gain activation because the speakers became distracted or are planning words that are meant to be uttered at a later point. Despite numerous and substantial differences, current proposals share the idea that speakers succeed in producing the target word because this is the one that reaches the highest activation level among the cohort of activated words (Caramazza, 1997; Dell, 1990; Garrett, 1980; Levelt, Roelofs, & Meyer, 1999; Roelofs, 1992). But word production can be even more complicated in the case of bilingual speakers, as words in both of their lexicons can be activated when they speak in just one of their languages. Nevertheless, proficient bilinguals speak with ease, apparently unhindered by the complications potentially arising from having two lexicons (Costa, 2005; Michael & Gollan, 2005). How do they accomplish such a feat? A central issue in answering this question is to determine whether words in both lexicons are activated and interact during word production or whether there are mechanisms that allow the words of only one language to be considered at a time.

The extent of activation within both lexicons has been the focus of a few recent studies on word production in proficient bilinguals (Colomé, 2001; Costa, Caramazza, & Sebastián-Gallés, 2000; Gollan & Acenas, 2004; Hermans, Bongaerts, de Bot, & Schreuder, 1998; Kroll, Dijkstra, Janssen, & Schriefers, 2000; Rodriguez-Fornells et al., 2005). The results of these studies, obtained using a variety of experimental paradigms, were interpreted as showing that words in both lexicons were activated; that is, experimental results indicate that if, for example, a proficient Catalan–Spanish speaker is talking in Spanish, not only Spanish words but also Catalan words appear to be activated. As Costa, La Heij, and Navarrete (2006) pointed out in their review, the methodologies adopted by researchers aimed at demonstrating concurrent activation of both lexicons might not be the most suitable to provide an unequivocal answer to this question (see also Kroll, Bobb, Misra, & Guo, 2008)—a detailed description of these methodologies is presented below. Thus, it seems desirable to adopt alternative paradigms to investigate the fate of activation in bilingual lexicons and garner convergent evidence on this issue, an approach we pursued in the present study by using the picture–picture interference paradigm. Moreover, prior studies have focused on target translations. Consider again the example of the proficient Catalan–

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Spanish speaker. Previous studies have explored whether the Catalan translation *cadira* (*chair* in English) is activated when this hypothetical speaker wants to say *silla* in Spanish (*chair* in English). But as demonstrated by a host of data from the monolingual literature (e.g., Meyer & Damian, 2007; Morsella & Miozzo, 2002; Navarrete & Costa, 2005), target words are unlikely to be the only words activated in word production. Other words in addition to the target word *silla* are most likely going to be activated within the Spanish lexicon. Are nontarget words also activated in the nonused lexicon, the Catalan lexicon in our example? The current lack of evidence bearing on this issue constitutes an unfortunate omission: Experiments restricted to target translations do not provide a complete picture of which words are activated in the nontarget language. Since target translations are supposed to reach the highest activation levels, they may also be the only words for which activation can be detected if activation within the nontarget lexicon is modest. Alternatively, evidence that nontarget words are also activated in the nonused lexicon would demonstrate that activation in that lexicon could be more substantial than otherwise thought. The picture–picture interference paradigm we adopted in our experiments offers an opportunity to determine whether this is so.

One should bear in mind that activation and interference are distinct notions. This distinction is particularly important when one considers the implications of the activation of nontarget words, especially in the context of bilingual word production. Evidence that nontarget words are activated does not necessarily imply that such words would interfere with the selection of the target words; this would occur only if selection mechanisms were sensitive to the activation levels of word competitors (for a discussion of these issues, see Mahon, Costa, Peterson, Vargas, & Caramazza, 2007; Miozzo & Caramazza, 2003; Schriefers, Meyer, & Levelt, 1990). Similar considerations hold for words activated within the bilinguals' nontarget language: They interfere to the extent to which words of both languages compete for word production. However, this may not be the case if selection mechanisms operate in an encapsulated fashion so that only words in the target language compete for selection (Costa, Miozzo, & Caramazza, 1999). The implications of our data for issues related to interference in word selection are discussed in the final part of the article.

The remainder of the introduction is organized into two sections. The first section includes a review of prior studies that examined whether target translations were activated when proficient bilinguals were engaged in naming tasks. Here we review the various methodologies used in those studies. In the second section, we describe how the methodologies employed differ form the picture–picture interference paradigm we used in the present study.

Are Target Translations Activated?

There are a number of results showing that the semantic, syntactic, and phonological features of words are encoded in distinct levels of representation and that during word production activation flows through these levels, starting from semantics and culminating with phonology (for a review, see Nickels, 2001; Rapp & Goldrick, 2000). This path of activation has led researchers to focus their investigation of bilingual lexical access on word phonology. Because word phonology can be activated only after prior levels of word representations have been accessed, evidence that the phonology of the target translations is activated amounts to the demonstration of a fairly deep form of lexical access including all the stages up to phonological retrieval. The experimental paradigms previously used to investigate the phonological activation of target translations were of three kinds: phoneme monitoring, picture–word interference, and picture naming. Each of the studies reviewed here refrains from explicitly presenting words in the nonused language, because in such circumstances it would probably be impossible to prevent the activation of that language. The exclusion of late, nonproficient bilinguals was another common denominator of these studies. Evidence that the native language (L1) was activated when these bilinguals spoke their second language (L2) could have reflected the weakness of L2 processing. The same explanation may apply to evidence that L2 was not activated when L1 was used. These considerations led to testing proficient bilinguals, preferably early bilinguals demonstrating comparable dominance between languages.

The phoneme-monitoring task requires participants to decide whether the names of the pictures contain specific phonemes. In the task variant devised by Colomé (2001), a picture and a phoneme were presented to Catalan–Spanish proficient bilinguals who decided whether the phoneme was the onset of the Catalan picture name. To illustrate, for the picture *table* (*taula* in Catalan), a "yes" response was expected for /t/ and a "no" response was expected for /d/. Of particular interest in this regard are those trials in which the incorrect phoneme was the onset of the Spanish picture name—in our example, /m/, for *mesa*, the Spanish word for *table*. Correct rejections were slower if the probed phoneme was the onset of the Spanish picture name (/m/) than if it was an unrelated phoneme (/d/). Colomé's results were interpreted as showing parallel activation of bilingual lexicons during word production. As pointed out by Costa et al. (2006), this conclusion rests on the assumption that the activation of target translations is not artificially induced by the phoneme presentation introduced in the task. But, similar to the effects of phoneme cueing observed in other circumstances (e.g., tip-of-the-tongue states), the phonemes presented with the pictures could have prompted the activation of target translations, which would otherwise have remained dormant.[1]

Similar considerations apply to the results obtained by Hermans et al. (1998), who used the picture–word interference paradigm. The proficient Dutch–English bilinguals participating in their Experiment 1 were instructed to name pictures in English. The pictures appeared along with spoken English words that were to be ignored but, nevertheless, ended up interfering with picture naming. Of relevance here is the condition in which the English word distractors were phonologically similar to the Dutch picture names. An example is the English distractor *bench*, which was paired with the picture *mountain* and was phonologically similar to *berg*, the Dutch name for *mountain*. The picture *mountain* also appeared

[1] Rodriguez-Fornells et al. (2005) found converging evidence in another variant of the phoneme monitoring task in which German-Spanish bilinguals decided whether picture names began with vowels or consonants. Decision latencies were longer when pictures had German and Spanish names that led to conflicting responses. Because Rodriguez-Fornells et al. did not present phoneme cues to prompt the responses, their results are not subject to the criticisms raised about Colomé's (2001) results. However, the bilingual participants in Rodriguez-Fornells et al.'s (2005) experiment responded to the same pictures in both of their languages. It is not altogether surprising that evidence of coactivation was obtained in these conditions.

with the unrelated English word *present*, which functioned as a baseline. Compared to baseline, picture naming latencies were significantly slower when the English word distractors sounded like the Dutch picture names. This finding can be interpreted as showing activation of translation equivalents in the nontarget language. It is possible, however, that the target translation *berg* was not primarily activated by the picture of a *mountain*; rather, its activation could have been induced experimentally by the auditory presentation of the phonologically related distractor. It is indeed possible that the English distractors activated a cohort of phonologically similar words, not only in English but also in Dutch. Thus, *berg* was one of the Dutch words activated by the English distractor *bench*. However, since it is the correct name for the picture *mountain*, *berg* would provide stiff competition. This would explain why *bench* interfered more than other distractors.

In essence, it would be better to avoid tasks involving the presentation of words or phonemes that could artificially activate the nontarget lexicon. Picture naming is a task that fits those criteria. Costa et al. (2000) compared the naming latencies of pictures with cognate versus noncognate names in Spanish and Catalan. Cognates are word translations that sound alike across languages; examples are the English word *music* and its counterparts in Spanish (*música*), German (*musik*), or Finnish (*musiikki*). When Costa et al. (2000) asked proficient Spanish–Catalan bilinguals to name pictures in Spanish, faster responses were observed for pictures with cognate names. However, this discrepancy in naming latencies could also be due to differences in the pictures used to elicit cognate versus noncognate names. This possibility was tested by Costa et al. (2000) in a follow-up experiment conducted with monolingual Spanish speakers. The naming latencies of monolingual speakers were indistinguishable between the two picture sets, a finding that rules out improper material selection as a plausible explanation of the data. Insofar as the difference between cognates and noncognates was purely phonological in Costa et al.'s (2000) experiment, the hypothesis that cognates affect phonological processing can explain the results. The relative advantage provided by cognates would reflect the convergence of activation on the shared phonemes from two sources, the Spanish target word and its Catalan translation. Naming can take place faster because the translations activate the target phonemes, rather than dissipating activation on other phonemes. Of course, accepting this account implies accepting that lexical representations are activated in the nonselected language.

Later studies replicated and further extended the finding of phonological activation within the nonselected language that Costa et al. (2000) demonstrated using cognates. Kroll et al. (2000) reproduced the cognate facilitation effect in the picture-naming task with Dutch–English and English–French bilinguals. Gollan and Acenas (2004) reported another form of facilitation associated with cognates: These words were less likely to engender tip-of-the-tongues during the naming of uncommon items. The results of Gollan and Acenas's study show that having a similar word activating part of the phonology decreases the probability that cognates might be subject to a complete block of word retrieval.

If picture naming is a task immune from the drawbacks of the phoneme monitoring and the picture–word interference paradigm, the use of cognates introduces other potential problems. Researchers have proposed that cognates differ from word translations that do not sound alike in having conceptual representations sharing more features (de Groot & Nas, 1991; Van Hell & de Groot, 1998) or for sharing their stem or part of it (Kirsner, Lalor, & Hird, 1993; Sánchez-Casas & García-Albea, 2005). As a consequence of these unique characteristics, the same semantic or lexical (morphological) representations are accessed when bilinguals produce cognates in each of their languages. Due to such multilingual access, cognates would have representations that are retrieved more frequently than noncognate words. Thus, similar to what has been observed with other frequency effects in naming (Jescheniak & Levelt, 1994; Oldfield & Wingfield, 1965), this multilingual access could have facilitated the production of cognate words. In essence, researchers do not have to posit a parallel activation of phonological forms in the two lexicons to account for a cognate naming advantage. It suffices to assume that cognates have shared representations at the semantic or lexical level.

A further explanation of the naming advantage observed with cognates stems from the specificity of cognate acquisition (Costa et al., 2006). It may be easier to learn a new word once there is already a lexical entry for its phonologically similar cognate (e.g., de Groot & Keijzer, 2000; Lotto & de Groot, 1998), a benefit that would cause cognates to be acquired, on average, at an earlier age than noncognates. Consistent with various results suggesting a faster and more accurate naming for early acquired words (e.g., Barry, Morrison, & Ellis, 1997; Carroll & White, 1973), the advantage observed with cognates could stem from their more precocious acquisition.

Although theoretically plausible, accounts appealing to the distinctiveness of cognates are for the most part speculative, lacking strong empirical support. For example, Kroll et al. (2008) reported that the facilitation effects observed when cognates were named in L2 disappeared under conditions that inhibited L1, whereas cognate facilitation in L1 depended on whether bilingual participants used one or both of their languages in the naming experiment. Such variability of the cognate effects seems to be inconsistent with explanations that attribute cognate facilitation to the way in which semantic and lexical information is acquired or accessed. Rather, such explanations would anticipate more stable effects. Moreover, Malt, Sloman, Gennari, Shi, and Wang (1999) reported that English, Spanish, and Chinese speakers provided comparable similarity ratings to common objects (containers such as *cans* or *boxes*), even though these objects took different, noncognate names in each of these languages. By showing comparable conceptual representations across the three groups of speakers, these findings further imply that variations in object names may have little consequences on object conceptual organization, thus challenging the idea that cognate words could affect the representation of meaning. Finally, the claim of uniqueness for cognate representation has been questioned on the basis of a variety of arguments reviewed by Costa, Santesteban, and Caño (2005). Nevertheless, even if accounts appealing to the distinctiveness of cognates may not be sufficiently compelling to override explanations based on the parallel activation of word phonology, it would seem advisable to employ other types of words than cognates to demonstrate the coactivation of bilingual lexicons. This is the approach we adopted in one of our experiments.

A Different Task: Picture–Picture Interference

Participants in the picture–picture interference task view pairs of overlapping pictures and identify pictures and name a prespecified picture by name (e.g., the one shown in a particular color). The nontarget (distractor) pictures are to be ignored. Several experiments conducted with monolingual participants employed pairs of pictures with phonologically related names; an example in English would be *bed–bell* (Meyer & Damian, 2007; Morsella & Miozzo, 2002; Navarrete & Costa, 2005; Roelofs, 2006). Naming responses were faster with these pairs relative to those found when the pictures had phonologically unrelated names (e.g., *bed–hat*). These findings can be easily explained if it is assumed that distractor pictures have their names activated. Responses are faster with related distractor pictures because those pictures activate some of the phonological constituents of the target picture names (e.g., the picture distractor *bell* activates the phonemes /b/ and /e/ shared with the target picture *bed*). Controls were employed to rule out alternative explanations based on the physical properties of the pictures. For example, when the same picture pairs were named in a language in which their names did not overlap phonologically, comparable naming latencies were observed for the two picture sets. This result is clearly inconsistent with an explanation based on differences in visual characteristics. The overall pattern of findings indicates that even words that are not selected for production can, in some circumstances, have their phonology activated.[2]

The picture–picture interference task can be extended to bilinguals to examine the parallel question of whether nontarget words are activated in the nontarget language. In the picture–picture interference experiments reported here, we tested Spanish–Catalan proficient bilinguals using pictures with different types of names, specifically, cognates and cross-language similar names. In the critical condition of Experiment 1, the distractor pictures had Spanish–Catalan cognate names. An example is the picture *cup*, which has similar names in Spanish (*taza*) and Catalan (*tassa*). Participants of Experiment 2 named the target pictures in Catalan. In the critical condition of Experiment 2, the Catalan names of the target pictures were phonologically similar to the Spanish names of the distractor pictures. An example is the target–distractor pair *armilla–ardilla. Armilla*, the Catalan name of the target picture *vest*, is similar to *ardilla*, the Spanish name of the distractor picture *squirrel*. Distractor pictures with unrelated, noncognate names served as controls in both experiments. The same rationale as above motivated the choice of distractor pictures with cognates and cross-language similar names: If the names of the distractor pictures are activated in the nonused lexicon, naming responses should be different for cognates and cross-language similar names relative to controls. However, the effects induced by cognates and cross-language similar names should be of opposite sign, namely, interference for the former and facilitation for the latter.

The polarity of the predicted effects can be explained as follows (see Figures 1 and 2 for a schematic illustration). Let us first consider the cognate distractors. If a picture distractor (e.g., *cup*) activates both of the cognate names (*taza* and *tassa*), we expect the phonemes shared by its Spanish and Catalan names to be strongly activated. By contrast, a distractor picture like *net*, which has noncognate names in Spanish (*red*) and Catalan (*xarxa*), should activate the phonemes of these two names to a lesser degree. As a result of the greater activation of their phonemes, the cognate distractors should hinder picture naming more (see Figure 1). Let us now turn to the distractor pictures with cross-language similar names. An effect of opposite sign, facilitation, should be observed if the distractor pictures activate their names in the nonused lexicon (see Figure 2). In fact, if the distractor picture *squirrel* activates the Spanish name *ardilla*, the phonemes shared with the target Catalan name *armilla* (*vest*) would be strongly activated, thus facilitating the naming response "armilla."

The picture–picture interference paradigm allowed us to examine phonological activation in the nontarget language without presenting additional verbal stimuli. Thus, unlike the other paradigms used in prior studies, artificially induced activation is not an issue. Moreover, seeking converging evidence from two sources, cognates and cross-language similar words, we were able to reach more reliable conclusions concerning bilingual lexical access. Finally, and most importantly, our paradigm allowed us to assess whether there is parallel activation of nontarget words, an issue that has remained unexplored in prior studies despite its noteworthy implications for bilingual processing.

We, too, as in previous studies, tested proficient bilinguals. Our bilingual participants were Catalan–Spanish speakers and residents of Catalonia, a northern region of Spain in which Catalan and Spanish are both recognized as official languages and used in all sorts of daily activities by most of the local population. Television and radio programs as well as newspapers, magazines, and books are available in this part of Spain in either language. Bilingual education programs are provided from nursery school to high school (see Costa et al., 1999, for a detailed description of the Catalan–Spanish bilingual community; for psycholinguistic results documenting the linguistic skills of Catalan–Spanish bilingual speakers, see Costa & Santesteban, 2004; Pallier, Colomé, & Sebastián-Gallés, 2001; Perani et al., 1998). To ensure a high proficiency in both languages, we tested students from a Catalan university, since they are required to pass strict language entry tests in order to be enrolled in programs in which courses and exams can be offered in either Spanish or Catalan. Moreover, to ensure comparable dominance in both languages, we only tested participants who (a) claimed to use both languages on a regular basis and (b) were enrolled in a university program in which an approximately equal number of courses were taught in Catalan and Spanish. We also controlled for age of acquisition, a variable that along with language dominance has been demonstrated to affect bilingual language production (e.g., Hirsh, Morrison, Gaset, & Carnicer, 2003). Therefore, we only recruited individuals from monolingual families who acquired L2 before the age of 6 (mostly in nursery schools).

[2] Jescheniak et al. (2009) reported a failure to replicate the effect of phonological facilitation documented in several other picture–picture interference experiments. It is unclear why Jescheniak et al. obtained results that were at variance with those repeatedly observed in prior experiments. The use of different picture pairs in phonologically related and unrelated conditions introduces a confounding factor that in past studies was controlled for by replicating the experiment in languages in which picture names were not phonologically related. No such stringent control was introduced by Jescheniak et al. It is possible that the picture pairs selected by Jescheniak et al. were not perfectly matched for their visual characteristics.

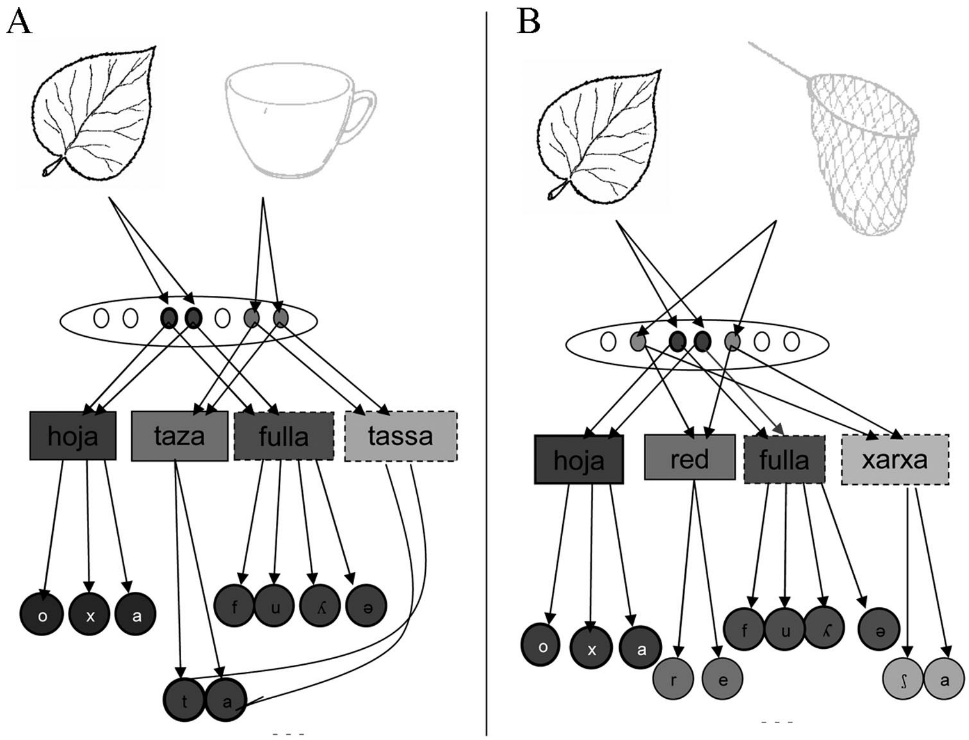

Figure 1. Schematic illustration of the phonological activation occurring in Experiment 1 during the naming of the target picture *leaf* in Spanish (*hoja*). For the sake of comprehensibility, the pictures are presented separately, though in the experimental display they overlapped. There exist three levels of representation devoted to conceptual information, lexical information, and phonological units, respectively. Words in the nontarget lexicon (Catalan) are marked with a broken line. Panel A shows the distractor picture *cup*, which has Spanish–Catalan cognate names *taza–tassa*. Panel B shows the distractor picture *net*, which has the noncognate Spanish–Catalan names *red–xarxa*. Darker representations indicate greater activation. The phonemes shared by the distractor picture with cognate names are more strongly activated since they receive activation from both of the cognate names.

In both of our experiments, participants responded using L1; thus, the nontarget language was always L2. For reasons explained later in the article, we tested L1 Spanish speakers in Experiment 1 and L1 Catalan speakers in Experiment 2. The participants of the two experiments, however, were equated for proficiency, age of acquisition, and language dominance so that similar generalizations could be made from both experiments. Note that by choosing L2 as the nontarget language, we put ourselves in a less favorable position for observing activation within the nontarget language. If, as it is plausible to assume, L2 words are less activated than L1 words, then it would be more difficult to demonstrate nontarget activation using L1 words than L2 words in our experiments. Focusing on activation in L2, however, may also present some advantages: If we observe activation for L2 words, the result can be generalized to L1.

Experiment 1: Cognate Words

As in prior investigations that employed the picture–picture interference paradigm (e.g., Morsella & Miozzo, 2002), we showed pairs of partially overlapping pictures varying in color (red vs. green) and used color to determine the responses (participants were instructed to name the green pictures). Target pictures always had noncognate names and were matched with two unrelated distractor pictures, one with a Catalan–Spanish cognate name and the other with a noncognate name. Differences between the bilinguals' responses to cognate and noncognate picture pairs could potentially be attributed to variations in the visual characteristics of those pairs that may render the recognition of the target and distractor pictures more difficult in one of the two conditions. The contribution of visual characteristics was tested by conducting Experiment 1 also with monolingual speakers. If the visual characteristics were critical, we expected different naming responses between cognate and noncognate distractors for bilingual and monolingual participants. However, if the cognate names were critical, such differences were to be expected only for the bilingual participants.

In Experiment 1, target picture naming could have been in either Spanish or Catalan. Ideally, however, the same language should have been tested with the bilingual speakers and the monolingual speakers taking part in the control experiment. This could be achieved only using Spanish, since it was not possible to find Catalan monolingual speakers among the student population tested in our study. Therefore, the pictures of Experiment 1 were named in Spanish, bilinguals' L1, whereas Spanish monolingual speakers participated in the control experiment.

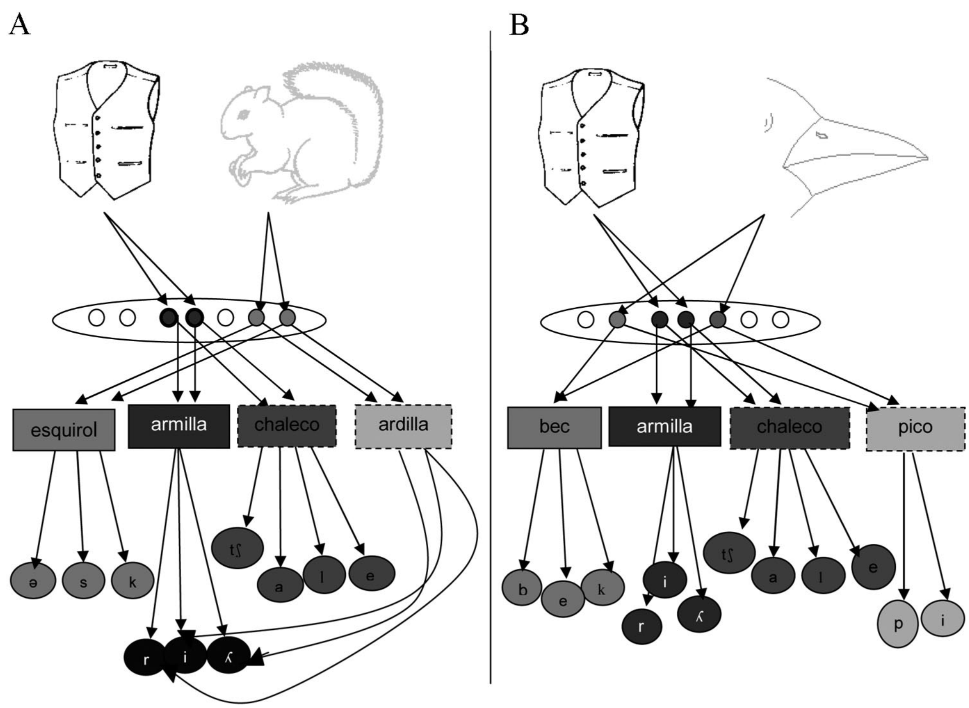

Figure 2. Schematic illustration of the phonological activation occurring in Experiment 2 during the naming of the target picture *vest* in Catalan (*armilla*). There exist three levels of representation devoted to conceptual information, lexical information, and phonological units, respectively. Words in the nontarget lexicon (Spanish) are marked with a broken line. The target picture appeared with the distractor pictures *squirrel* (Panel A) and *beak* (Panel B). *Ardilla* in Spanish (*squirrel* in English) is phonologically similar to *armilla*, the Catalan target name. Because the phonemes of the target picture receive additional activation from *ardilla*, faster naming responses are expected with the distractor picture *squirrel* than *beak*. Darker representations indicate greater activation.

Method

Participants. Two distinct groups of 27 university students were tested in Experiment 1, the first composed of Spanish–Catalan bilinguals and the second composed of Spanish monolinguals. The bilingual participants were from Catalonia, a northern region of Spain where both Catalan and Spanish are spoken. The monolingual participants were from the Canary Islands, a southern region of Spain in which Spanish is the only language. Both groups were raised in Spanish monolingual families and were closely matched for age and educational background. Only the bilingual speakers had acquired Catalan during their childhood and had reached a level of proficiency that allowed them to be fully functional in a bilingual environment. We only recruited students of Barcelona University who, as self-reported in a questionnaire, (a) were from households in which both parents were Spanish monolingual speakers, (b) had acquired Catalan before their 6th birthday, and (c) made regular use of Catalan in daily activities and social interactions. As described in the introduction, students of Catalan universities are required to pass demanding language proficiency admission tests in Catalan and Spanish. To ensure equal dominance between languages, we recruited participants from a university department (Psychology, University of Barcelona) in which Catalan and Spanish were used in similar proportions (Catalan = 53.5%; Spanish = 46.5%; data from year 2004–2005; Serveis Lingüístics, Universitat de Barcelona, 2008; note that all of the courses taken by Catalan students during their 4-year program are, with a very few exceptions, from a single department). The monolingual participants were students at the University of La Laguna (Tenerife, Spain) who claimed to have been raised in monolingual Spanish families and reported no knowledge of Catalan. All participants received course credits for their participation. Both groups were tested employing an identical procedure.

Materials. We selected a set of 18 target pictures that represented common objects and had noncognate names in Spanish and Catalan. Participants were asked to name them in Spanish (i.e., their dominant language). Each of these pictures was paired with two distractor pictures of common objects: one with a cognate Spanish–Catalan name; the other with a noncognate name. For example, the target picture *leaf* (*hoja* in Spanish; *fulla* in Catalan) was paired with the cognate picture *cup* (*taza* in Spanish; *tassa* in Catalan) and the noncognate picture *net* (*red* in Spanish; *xarxa* in Catalan; see Appendix A for the list of picture pairs shown in Experiment 1). As expected, the names of the Catalan and Spanish cognate distractors shared a greater number of phonemes in identical word position than noncognates ($M = 2.33$ vs. 0.44), $t(17) = 9.62$, $p < .001$. The two sets of distractor pictures had Spanish names matched for lemma frequencies per million ($F < 1$; mean for cognate distractors = 22.2;

mean for noncognate distractors = 23.3; norms from LEXESP corpus (Sebastián-Gallés, Marti, Cuetos, & Carreiras, 1996). Care was taken to pair pictures with unrelated meanings and phonologically different names. It was critical that the distractor pictures were identified with the Spanish and Catalan names we selected. Spanish names were controlled during the pretesting (see below). As for the Catalan names, they were controlled by asking 10 Spanish–Catalan bilinguals from the same pool as the participants in Experiment 1 to name the distractor pictures in Catalan. They used the expected names 97.7% (SD = 5.40) of the time. Each target picture was also paired with a semantically (categorically) related picture having a noncognate name. Previous researchers using the picture–picture interference task also examined the effect of semantically (categorically) related pairs (e.g., *leaf–branch*; Damian & Bowers, 2003; Navarrete & Costa, 2005). These studies have demonstrated that semantic relatedness did not affect picture naming in this task. Semantically related picture pairs were treated as fillers in our Experiment 1.

Picture outlines were colored in green for targets and in red for distractors. The composites were created by partially overlapping the distractors and targets with Paint Shop Pro software. As in prior studies, overlapping pictures were used to allow for foveal presentation of both pictures, thus increasing the likelihood of distractor interference. On each presentation, a given target was shown in the same location on the screen. Distractors were positioned in locations that did not prevent target recognition and appeared with similar probabilities in the left and right parts of the composites.

There were three blocks, each containing the entire set of target pictures and six distractors from each of the different distractor sets (cognates, noncognates, and semantically related fillers). Composites were randomized with the constraints that (a) distractors of the same kind would not appear in consecutive trials, and (b) targets would not appear in the same position within the composite for more than three trials in a row. Blocks were shown in three different orders, each presented to an equal number of participants.

Procedure and analyses. Participants were tested individually inside soundproof booths. The experimenter used Spanish exclusively to interact with the participants and deliver task instructions. Identical procedures were used to test the bilingual and monolingual participants. Each testing session had four parts. At the beginning of a session, participants received a booklet, in which the whole set of targets and distractors were presented in black and white along with their Spanish names. Participants were invited to study the booklet for about 5 min, so that they would use the expected Spanish names during the experiment. Next, the same pictures appeared on the computer screen without their Spanish names. This time, participants were asked to name the pictures as quickly as possible using the expected names. Feedback was given if participants produced names other than those expected. The experimental task was then introduced, and participants were instructed to name the green pictures as quickly and accurately as possible while ignoring the superimposed red pictures. Participants practiced the experimental task by naming six composites created specifically for the practice block. The experiment proper followed immediately. Note that none of the distractor pictures were named during the experiment.

The sequence of events within a trial and their durations were as follows: A fixation point appeared in the middle of the screen for 500 ms; next, the screen remained blank for 500 ms; finally, the picture composite was displayed for 400 ms. The recording of response latencies started with picture appearance and continued up to 2 s. A blank interval of 1 s separated consecutive trials. The EXPE program (Pallier, Dupoux, & Jeannin, 1997) controlled stimulus display and response time recording, and a voice key ensured computer–microphone interface. The experimenter manually recorded participant responses.

Four types of responses were excluded from response latency analyses: (a) names that differed from those designated by the experimenter, (b) verbal dysfluencies (stuttering, utterance repairs, production of nonverbal sounds), (c) recording failures, and (d) very fast responses (shorter than 200 ms). Responses that included incorrect names and verbal dysfluencies were entered in error analyses. Two-way analyses of variance were used to determine the effects of the variables group (Spanish–Catalan bilinguals vs. Spanish monolinguals) and distractors (cognates vs. noncognates) on naming latencies and error rates. One-way analyses of variance were used in post hoc analyses to investigate the effects of distractor type. The same analyses were also carried out with semantically related distractors and noncognate (unrelated) distractors to determine whether there was an effect of semantic relatedness. Participant means and item means were both analyzed.

Results

The results of bilingual and monolingual participants are summarized in Table 1.

Recording failures and very fast responses invalidated a similar proportion of trials in both participant groups (bilinguals: 1.4%; monolinguals: 1.7%), $F(1, 52) < 1$. Responses classified as errors (i.e., incorrect names and verbal dysfluencies) also occurred in similar proportions within the two groups (bilinguals: 2.6%; monolinguals: 2.9%). None of the results of the error analyses was significant (all $ps > .27$).

Response latencies were faster with bilingual than monolingual participants, though the difference was reliable in the by-items analysis, $F_2(1, 17) = 25.71$, $MSE = 510.48$, $p < .001$, but not in the by-participants analysis, $F_1(1, 52) = 1.47$, $MSE = 13{,}888.92$, $p = .23$. This finding attests to the proficiency of our bilingual participants, whose responses tended to be faster than those of the monolingual participants. We observed a significant effect of the variable distractor, $F_1(1, 52) = 9.71$, $MSE = 1{,}210.11$, $p < .001$, and $F_2(1, 17) = 5.77$, $MSE = 1{,}821.84$, $p = .02$, due to slower responses to cognate versus noncognate pictures (*M*s: 725 vs. 704

Table 1
Mean Picture Naming Latencies (in Milliseconds), Standard Deviations, and Error Percentages (E%) in the Picture–Picture Interference Task of Experiment 1

Participant and distractor type	RT	*SD*	E%
Bilingual participants			
Distractors with cognate names	718	75	2.5
Distractors with noncognate names	684	63	2.7
Cognate effect[a]	34		
Monolingual participants			
Distractors with cognate names	733	103	3.5
Distractors with noncognate names	725	100	2.5
Cognate effect[a]	8		

[a] Naming latency difference between pairs with distractors having cognate versus noncognate names.

ms, respectively). Crucially, the interaction between the variables group and distractor was significant, $F_1(1, 52) = 3.83$, $MSE = 1{,}210.11$, $p = .05$, and $F_2(1, 17) = 4.61$, $MSE = 1{,}043.60$, $p < .05$. Post hoc analyses clarified that the interaction arose because bilingual speakers named pictures significantly slower when paired to cognate distractors, $F_1(1, 26) = 17.70$, $MSE = 880.25$, $p < .001$, and $F_2(1, 17) = 8.38$, $MSE = 1{,}762.61$, $p = .01$, a difference that was absent with monolingual speakers (Fs < 1).

As mentioned above, previous researchers using the picture–picture interference task failed to observe an effect of semantic relatedness (Damian & Bowers, 2003; Navarrete & Costa, 2005). That is, related pairs like *leaf–branch* produced responses undistinguishable from those of unrelated pairs like *leaf–spoon*. Pairs of related pictures with noncognate names had also been tested in Experiment 1. Related and unrelated noncognate distractors did not differ in terms of error rates and latencies, a pattern of results holding for bilingual and monolingual participants alike (all Fs < 1). We thus confirmed the lack of semantic effect and have extended it to a bilingual variant of the picture–picture interference task.

The absence of a cognate effect with monolingual participants rules out an explanation based on the visual characteristics of the pictures. If visual characteristics were responsible for the findings with the bilingual participants, monolingual participants would also have shown increased response latencies with cognate distractor pictures.

We anticipated longer responses to cognate distractor pictures if these pictures activated the phonology of their names in both languages. The finding of a 34-ms cognate effect in Experiment 1 confirmed that nontarget words are activated in the nontarget language. However, as discussed in the introduction, cognate effects like the one we observed in Experiment 1 could be explained on the basis of different proposals that attribute to cognates a unique form of representation. According to these proposals, cognate words may share semantic or lexical representations, may be functionally equivalent to high-frequency words, or may be acquired at an earlier age. These are all factors that together or individually may cause cognates to access their phonology faster and more robustly and, consequently, to generate the increased interference we observed in Experiment 1.[3] Although claims that cognates are represented differently from other words remain highly controversial, it would be desirable to extend the findings of Experiment 1 by demonstrating phonological activation with types of words other than cognates. This was the objective of Experiment 2 in which we investigated pairs of Spanish and Catalan words that, though differing in meaning, were phonologically similar.

Experiment 2: Cross-Language Similar Words

Three major changes were introduced in the picture–picture interference task conducted in Experiment 2. First, Catalan was the L1 and dominant language for the participants of Experiment 2. Second, pictures were named in Catalan. Third, and most importantly, we introduced distractor pictures whose Spanish names shared part of their phonemes with the Catalan names of the target pictures. An example is the distractor picture *squirrel*; its Spanish name *ardilla* is phonologically related to the Catalan name of the target picture *armilla* (*vest* in English). No other evident phonological relations existed between the Spanish and Catalan names of the paired pictures. In our example of the target–distractor pair *vest–squirrel*, the Spanish name of the target (*chaleco*) and the Catalan name of the distractor (*esquirol*) were phonologically different. Picture pairs related through languages were compared to picture pairs whose names bore no relationship either phonological or semantic. We predicted faster naming responses with related than unrelated pairs if distractor pictures activated their names in the nontarget language (Spanish). This is because the phonemes of the target Catalan names would receive additional activation from the related Spanish names of the distractor pictures (see Figure 2).

In a picture–picture interference task conducted by Morsella and Miozzo (2003) with monolingual speakers, phonological facilitation (faster naming latencies for pictures paired with onset-related vs. unrelated distractors) was found only when the monosyllabic names shared more than just the initial phoneme. In consideration of these results, and to have a good chance in Experiment 2 to find a cross-linguistic phonological effect, we sought to select picture pairs with the greatest phonological overlap possible. This could be achieved more easily in Catalan than Spanish, in part because Catalan words tend to be relatively shorter, as indicated, for example, by a greater occurrence of monosyllabic (content) words in Catalan (27%; Guasti & Gavarró, 2003) than in Spanish (7%; Alcina & Blecua, 1975). These features of the Catalan language led us to have the bilingual participants of Experiment 2 name the pictures in Catalan. As we explained in the introduction, it would be more informative to have the participants of our experiments naming the pictures in L1. For this reason, the participants tested in Experiment 2 were L1 Catalan speakers who demonstrated high proficiency in Spanish and a rather balanced use of Catalan and Spanish. Note that response language changed relative to Experiment 1, where bilingual participants responded in Spanish, their L1. In all other respects, enrollment criteria were identical between Experiments 1 and 2, so that the results of these experiments can be compared directly.

As in Experiment 1, we also conducted Experiment 2 with monolingual speakers. This control experiment ensured that the differences between related and unrelated picture pairs observed with Spanish–Catalan bilinguals could not be ascribed to discrepancies in the visual characteristics of related versus unrelated picture pairs. Ideally, one would conduct this control experiment with monolingual Catalan speakers. However, because within the Catalan student population we tested monolingual Catalan speakers do not exist and Spanish monolinguals are very rarely found, we decided to have monolingual English speakers participate in the control experiment.

[3] Under the hypothesis that cognates are functionally equivalent to words of high frequency or words that are acquired at an early age, the greater interference produced by pictures with cognate names could be explained in terms of the relatively high level of activation achieved by cognate words. That is, like high frequency words and early acquired words, cognate words would also achieve high levels of activation, thus causing greater interference. This account would anticipate that effects of frequency and age of acquisition would also be observed when monolingual speakers are tested in the picture–picture interference tasks. It is presently not known whether distractor pictures with early acquired names interfere substantially. The effects of frequency, however, were investigated in this task by Leoncini, Paolieri, Lotto, Cubelli, and Job (2007). In their experiment, frequencies of picture names did not affect naming latencies. An account of the cognate effect in terms of frequency is not supported by available results.

Method

Participants. Twenty-four Catalan–Spanish speakers participated in Experiment 2. The questionnaire and the criteria for enrollment were the same as in Experiment 1.

Consistent with the goals of Experiment 2, criteria for participation included (a) having been raised in Catalan monolingual families, (b) the learning of Spanish before the age of 6, and (c) regular use of both languages in daily activities. Participants of Experiments 2 were university students from the same program as those in Experiment 1. The 24 English monolinguals were undergraduate students at the University of Cambridge (Cambridge, England) who met two criteria for inclusion in the study: (a) having been raised in an English monolingual family and (b) use of English in daily activities. All of the participants had only studied a foreign language in high school. Both groups participated in the experiment in exchange for monetary compensation or class credits. The testing procedure was identical for the two participant groups except for the language (Catalan vs. English).

Materials. Each of the 21 pictures of common objects selected as targets was paired with two distractor pictures varying as to their Spanish names. The Spanish name of one distractor (*ardilla* [*squirrel* in English]) was phonologically related to the Catalan name of the target picture (*armilla* [*vest* in English]). The Spanish name of the other distractor (*pico* [*beak* in English]) bore no phonological similarities with the target name. The mean number of phonemes shared by the Catalan target names and the Spanish distractor names in identical word positions varied between 2.38 and 0.47 for related versus unrelated pairs, $t(20) = 8.35$, $p < .001$. The distractor pictures shown in related and unrelated pairs had Spanish names comparable for lemma frequency per million (mean occurrences in LEXESP corpus [Sebastián-Gallés et al., 1996] equal to 64 and 51, respectively [$t < 1$]) and length (mean number of phonemes equal to 4.8 and 5.2, respectively, $t[20] = 1.033$, $p = .30$). None of the target and distractor pictures had cognate names in Catalan and Spanish. We also avoided presenting pairs formed by semantically related pictures. In this respect, Experiment 2 differed from Experiment 1, where semantically related pairs had been used as fillers. We reasoned that the semantic related condition could be dropped given the lack of semantic effect in Experiment 1. We also controlled the degree of phonological overlap between the English names of the picture pairs, which was similarly negligible for related and unrelated picture pairs (*M*s: 0.33 vs. 0.28, respectively; $t < 1$). The list of related and unrelated pairs along with their Spanish, Catalan, and English names are presented in Appendix B. Target pictures were also presented with an additional set of semantically and phonologically unrelated pictures that acted as fillers and were not analyzed. Thus, each target picture appeared in the experiment three times, each time with a different distractor picture.

The possibility of finding a phonological effect in Experiment 2 depended critically on whether the pictures were identified with the expected Spanish and Catalan names. Whether participants used the expected Catalan names was controlled in two ways. First, the list of target and distractor pictures along with their expected Catalan names was presented to participants at the beginning of the experiment. Second, participants practiced naming the pictures in Catalan and were reminded of the expected names whenever they produced a diverging name. The Spanish names of the distractor pictures were controlled less directly by soliciting the Spanish names of these pictures from (a) the last five participants soon after they had completed the experiment and (b) 10 Catalan–Spanish bilinguals who did not take part in any of our experiments. Name agreement was high with both groups: 97% ($SD = 11.1$) and 96.5% ($SD = 10.5$), respectively.

The same procedures outlined in Experiment 1 were followed for the testing and response analyses of Experiment 2, with two exceptions: (a) Catalan was the only language used in the bilingual version of the experiment, and (b) e-prime (Psychological Software Tools, 2002) was used for computerized task administration and response recording. The variables examined in the analyses of Experiment 2 were group (Spanish–Catalan bilinguals vs. English monolinguals) and distractors (translation related vs. unrelated).

Results

A summary of the results obtained with bilingual and monolingual participants is presented in Table 2. Two target pictures were discarded: *pea* because of an error with the selection of the Spanish translation of the distractor, and *can* because English-speaking participants used the names "can" and "tin" interchangeably in naming this picture. No responses in both variants of the experiments were discarded due to recording failures or very fast responses (shorter than 200 ms). Responses classified as errors (i.e., incorrect names and verbal disfluencies) were recorded with similar rates among the responses of bilingual and monolingual participants (3.2% and 3.6%, respectively). None of the error analyses revealed significant results (all *t*s < 1).

The interaction between the variables group (bilinguals vs. monolinguals) and distractors (related vs. unrelated) represents a critical result for the hypothesis of parallel phonological activation in bilingual lexicons. The interaction was significant in the analysis by participants, $F_1(1, 46) = 5.27$, $MSE = 1{,}057.21$, $p = .02$, and closely approached significance in the analysis by items, $F_2(1, 18) = 3.83$, $MSE = 1{,}152.33$, $p = .06$. To further explore this interaction, we analyzed the effects of distractor types for each participant group. While bilinguals' naming responses were significantly faster for related than unrelated picture pairs (means: 730 vs. 761 ms, respectively; $t_1[23] = 2.98$, $p < .01$; $t_2[19] = 2.98$, $p = .03$), no such difference appeared with monolingual responses, which indeed had identical means in the two conditions (710 ms; *t*s < 1).

It was also examined whether the use of different languages affected the speed of naming responses. Response latencies tended to be

Table 2
Mean Picture Naming Latencies (in Milliseconds), Standard Deviations, and Error Percentages (E%) in the Picture–Picture Interference Task of Experiment 2

Participant and distractor type	RT	*SD*	E%
Bilingual participants			
Distractors with cross-language related names	730	70	3.1
Distractors with unrelated names	761	79	3.3
Relatedness effect[a]	−31		
Monolingual participants			
Distractors with cross-language related names	710	84	3.7
Distractors with unrelated names	710	83	3.5
Relatedness effect[a]	0		

[a] Naming latency difference between pairs with distractors having related versus unrelated names.

faster in English than Catalan (means: 710 vs. 745 ms, respectively; $F_1[1, 46] = 2.61$, $MSE = 11{,}252.26$, $p = .13$; $F_2[1, 18] = 3.97$, $MSE = 5{,}080.34$, $p = .06$). This trend toward faster naming responses in English can be explained by the relative shortness of English picture names. The average phoneme length was 4.14 for English words and 4.80 for Catalan words, $t(20) = 1.75$, $p = .09$.

The most significant result of Experiment 2 concerned related picture pairs, which produced a sizable facilitation of 31 ms with bilinguals but had virtually no effects with monolinguals. The implications of this result are twofold. First, it establishes that the effect of the related picture pairs cannot be attributed to their visual characteristics. If the visual characteristics were critical, an analogous effect would have been observed with monolinguals. Second, the finding that the effect only occurred with bilinguals indicates instead that nontarget words are susceptible to phonological activation even in the nontarget language. The results of Experiment 2 thus converge with those obtained with the same paradigm in Experiment 1, albeit in that case with cognates.

The results of Experiment 2 have further implications for interpreting the findings of Experiment 1. One of the motivations for conducting Experiment 2 was to seek evidence of parallel lexical activation with words other than cognates. As we have mentioned earlier in the article, the phonological effects observed with cognates could have resulted from the specific characteristics of cognate representations rather than from a parallel activation of the two lexicons. We reasoned that if the phonological effect observed with cognates was due to the specificity of cognate representations, we should not observe a phonological effect with the noncognate words tested in Experiment 2. The appearance of a phonological effect in Experiment 2 supports an interpretation of the cognate effect in terms of parallel activation rather than an explanation based on the uniqueness of cognate representations. This explanation can also be extended to the results of Costa et al. (2000), who reported shorter naming latencies with pictures having cognate names.

Cross-language similar distractors were previously investigated by Costa et al. (1999) in the picture–word interference paradigm. This study was similar to ours in that it tested picture naming with the same population of Catalan–Spanish bilinguals. The only substantial variation concerned the presentation of the distractors, which Costa et al. (1999) showed as written words superimposed on the pictures. To illustrate with an example, participants had to name the picture *mussol* in Catalan (*owl* in English), and the Catalan written word *dona* (woman) was superimposed on the picture; *dona* translates as *mujer* in Spanish, a word phonologically related to *mussol*, the Catalan name of the picture target. Cross-language distractors did not facilitate the naming responses in Costa et al. (1999), unlike in our Experiment 2. This discrepancy may stem from the fact that the distractors were presented in different formats—written words versus pictures. It is possible that access to the nonused lexicon is faster and more robust with pictures than written words, which have to undergo translation prior to accessing the nonused lexicon. Another, simpler explanation relates to differences in the degrees of phonological overlap existing with the materials selected in the two studies. The number of phonemes shared by a target–distractor pair was divided by target length in order to take into account differences in target length between the two studies. The proportion of shared phonemes was significantly greater in our study (0.53 vs. 0.41, respectively), $t(37) = 2.07$, $p = .04$, a difference that may explain why we were successful in demonstrating a phonological effect that remained elusive in Costa et al. (1999).

We interpreted our results as showing that even words that are not selected for production can have their phonology activated. An alternative account was advanced by Bloem and La Heij (2003), who suspected that the phonological effect was a task artifact stemming from difficulty in discriminating between target and distractor pictures, which led to the inadvertent selection of the distractor name in a few trials. However, Navarrete and Costa (2005) failed to find supportive evidence for this when they tested Bloem and La Heij's interpretation. Navarrete and Costa asked their participants to name the colors in which the pictures appeared and to ignore the depicted objects. In some trials, the target colors had names that sounded like the depicted objects. An example in English would be the picture of a *blouse* shown in *blue*. The presentation of phonologically related objects facilitated color naming. Note that object names were not part of the response set and, therefore, should not generate the same confusions that Bloem and La Heij attributed to picture names in the task variant we used. The results of Navarrete and Costa seriously challenge an attempt to explain the results of the picture–picture interference paradigm simply in terms of confusions between target and distractor pictures.

General Discussion

Understanding how bilinguals speak effortlessly even if they have at least two alternatives for every meaning they intend to express requires determining (among other things) whether both languages are activated at once and how lexical selection takes place. The results of a few prior studies have been taken as evidence of a parallel activation of both languages in bilingual speakers. As we outlined in the introduction, these results are subject to question on methodological grounds (Costa et al., 2006; Kroll et al., 2008). The task and materials tested in our two experiments were selected because they avoided the criticisms raised concerning previous studies.

The bilingual speakers who took part in our picture–picture interference tasks named one picture (the target) and ignored the other picture (the distractor). This task allowed us to keep the experimental setting entirely monolingual avoiding the presentation of linguistic cues, which in prior studies might have artificially activated both languages. By varying the phonological properties of the distractor pictures, we were able to demonstrate that (a) activation spreads to words in the nontarget lexicon; (b) activation is not restricted to target translations but it also involves other words, which, in our experiment, included the names of other objects present in the context; and (c) activation further extends to the phonological features of the words in the nontarget language. The participants in our experiment were very proficient bilinguals who regularly used both of their languages. This population probably provides the best possible situation for observing L2 activation when L1 is being used. Whether coactivation can also be found when less proficient bilinguals use their L1 or L2 is a question awaiting further investigation.

The extent of the activation revealed by our experiments has implications for models of bilingual language production. Theories that do not allow words in the nonused language to activate their phonology are obviously incompatible with our findings. There could be different reasons why activation does not spread to the nonused lexicon. One such could be that activation is only channeled to the lexicon selected for production. Alternatively, a tight containment of activation within the selected lexicon could result from a "preemptive" inhibition of the nonused lexicon.

None of the current models of bilingual word production have incorporated the idea of a complete lack of activation of the nonused lexicon, opting instead for partial activation. This is the case with the serial model proposed by Levelt (1989; Levelt et al., 1999; see also Roelofs, 1998). A critical distinction is made in this model between two levels of word representation that are accessed sequentially in word production: The first level encodes syntactic features, whereas the second level is devoted to word phonology. Activation can spread to the first of these levels for any word. In normal circumstances, however, only the words selected for production can have their phonological features activated. Under this model, words in the nonused language are not candidates for lexical selection and therefore should not have their phonology activated, a prediction that is not consistent with our data. Our data also failed to support another model proposing partial activation of the nonused language put forward by Bloem and La Heij (2003; see also Bloem, van den Boogard, & La Heij, 2004). A key feature of this model is that target translations could have their phonology activated; the activation of other words in the nonused language, including our distractors, would not propagate to phonology. This form of restricted activation results from selection at the conceptual level causing activation to spread only to the words in multiple languages that correspond to the selected concept. Our evidence that nontarget words are activated in the nonused language would not be expected under the model of Bloem and La Heij. In short, our results suggest that the phonology of words in the nonused language is extensively activated and, hence, models that put some restrictions on such activation fail to account for our data.

Our results indicate that activation of the phonemes of words in the nonused language could affect the production of the target word. Such activation led to slower naming responses in Experiment 1 and faster naming responses in Experiment 2. The most likely reason for these results is that (a) the two languages share many of the same phoneme representations, and (b) activation converges from the two languages on the same phonemes. Having phonemes shared by the two languages further implies that phoneme selection will not be language specific; instead, it would include phonemes activated by the words of both languages. Phoneme activation of such a type could explain the interference we found in Experiment 1 with picture distractors that had cognate names. The convergence of activation from two languages strongly activated the phonemes of these picture names, thus supplying stiff competitors for phoneme selection. By contrast, the facilitation found in Experiment 2 with target–distractor pairs with similar names occurred because activation converged from two languages on the same target phonemes.

Under all current models of word production, phoneme activation can only take place after semantic and lexical representations have been activated at prior levels of processing. To the extent that our results demonstrated phoneme activation for words in the nonused language, they also imply the activation of lexical representations in that language. However, our data remain silent about the consequences of activating the lexical representations in the nonused language. It is possible that this activation affects lexical selection, such that, following their activation, the lexical representations in the nonused language somehow interfere with the selection of the target lexical representation in the target language. Alternatively, as proposed by Costa et al. (1999), only the lexical representations in the target language are considered for selection. In this scenario the activation of lexical representations in the nontarget language would have no consequences for lexical selection. Note that if this alternative were correct, selection would occur in different ways for lexical than for phoneme representations: Representations activated by the nonused language would affect selection of phonemes but not of lexical forms.

By suggesting extensive phoneme activation for the words in the nonused language, our data naturally raise the question of what mechanisms allow bilingual speakers to efficiently select the right phonemes in the right language. Current accounts of bilingualism have considered two possible solutions. A first solution proposes boosting the activation received by the target language (Finkbeiner, Gollan, & Caramazza, 2006; La Heij, 2005). The intention to speak in a given language causes the target lexicon to receive a greater amount of activation than the nontarget lexicon. Given that the activation arriving at the phonological units is proportional to that received by the lexical level, the phonemes of the words in the target language would also be activated more quickly and robustly. This faster and greater activation would secure the selection of the right phonemes. The same result can be obtained through the mechanism of reactive inhibition proposed by Green (1998) and Meuter and Allport (1999). This concept holds that there is partial suppression of the activation received by the words in the nonused lexicon and their phonemes. Such a reduction of activation makes it unlikely that words and phonemes of the nonused language would be selected for production.

The results of the picture–picture interference paradigm have demonstrated that multiple objects present in the visual scene can activate their names at the same time, and our results have further shown that names in both of the languages spoken by the bilinguals can be activated. Does this mean that speakers activate the names of all of the objects in the visual scene and that multilingual speakers do so in each of their languages? Several researchers have argued that this is not the case, proposing instead that the activation of the names of nontarget objects is subject to several limitations (Meyer & Damian, 2007; Morsella & Miozzo, 2002; Navarrete & Costa, 2005). For one thing, such activation may only occur when there is an intention to speak and therefore objects are seen in the context of tasks involving speaking. Moreover, only objects on which attention has been allocated are likely to have their lexical representations activated to a degree sufficient to be detected in experimental settings like the one adopted in the picture–picture interference paradigm. These limitations may severely constrain the extent to which visual objects can activate their names, but at the same time they would make speaking a far more manageable task.

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Appendix A

Pairs of Target–Distractor Pictures Shown in Experiment 1

Target pictures were named in Spanish. Each target picture appeared with two distractor pictures, one with cognate names in Catalan and Spanish; the other with noncognate names in those two languages. The Spanish and Catalan names of the target and distractor pictures are presented along with their English translations.

Target pictures			Distractor pictures cognate names			Distractor pictures noncognate names		
English name	Spanish name	Catalan name	English name	Spanish name	Catalan name	English name	Spanish name	Catalan name
Bottle	Botella	Ampolla	*Ball*	Pelota	Pilota	*Birdcage*	Jaula	Gàbia
Duck	Pato	Ànec	*Hammer*	Martillo	Martell	*Brush*	Cepillo	Raspall
Table	Mesa	Taula	*Ear*	Oreja	Orella	*Candle*	Vela	Espelma
Fork	Tenedor	Forquilla	*Castle*	Castillo	Castell	*Mattress*	Colchón	Matalàs
Squirrel	Ardilla	Esquirol	*Pumpkin*	Calabaza	Carabassa	*Piggy bank*	Hucha	Guardiola
Carrot	Zanahoria	Pastanaga	*Saw*	Sierra	Serra	*Crutch*	Muleta	Crossa
Clog	Zueco	Esclop	*Pencil*	Lápiz	Llapis	*Screw*	Tornillo	Cargol
Kite	Cometa	Estel	*Onion*	Cebolla	Ceba	*Glasses*	Gafas	Ulleres
Leaf	Hoja	Fulla	*Moon*	Luna	Lluna	*Net*	Red	Xarxa
Lizard	Lagartija	Sargantana	*Cup*	Taza	Tassa	*Shell*	Concha	Petxina
Grapes	Uva	Raïm	*Sheep*	Oveja	Ovella	*Tray*	Bandeja	Safata
Cheese	Queso	Formatge	*Nest*	Nido	Niu	*Beak*	Pico	Bec
Slice	Rebanada	Llesca	*Belt*	Cinturón	Cinturó	*Worm*	Gusano	Cuc
Vest	Chaleco	Armilla	*Bridge*	Puente	Pont	*Egg*	Huevo	Ou
Lettuce	Lechuga	Enciam	*Paintbrush*	Pincel	Pinzell	*Swing*	Columpio	Gronxador
Calf	Ternera	Vedella	*Ring*	Anillo	Anell	*Handkerchief*	Pañuelo	Mocador
Eye	Ojo	Ull	*Box*	Caja	Caixa	*Window*	Ventana	Finestra
Strawberry	Fresa	Maduixa	*Wig*	Peluca	Perruca	*Washing machine*	Lavadora	Rentadora

Appendix B

Pairs of Target–Distractor Pictures Presented in Experiment 2

Target pictures were named in Catalan. In one condition, the Spanish names of the distractor pictures were phonologically related to the Catalan names of the target pictures. In the other condition, target and distractor pictures had phonologically unrelated names. The Spanish and Catalan names of the target and distractor pictures are presented along with their English translations.

Target pictures			Distractor pictures phonologically related names			Distractor pictures phonologically unrelated names		
English name	Spanish name	Catalan name	English name	Spanish name	Catalan name	English name	Spanish name	Catalan name
Shell	Concha	Petxina	*Cucumber*	Pepino	Cogombre	*Window*	Ventana	Finestra
Ham	Jamón	Pernil	*Persil*	Perejil	Julivert	*Sock*	Calcetín	Mitjó
Birdcage	Jaula	Gàbia	*Glasses*	Gafas	Ulleres	*Pig*	Cerdo	Porc
Vest	Chaleco	Armilla	*Squirrel*	Ardilla	Esquirol	*Beak*	Pico	Bec
Horn	Cuerno	Banya	*Fence*	Valla	Tanca	*Mirror*	Espejo	Mirall
Can	Lata	Llauna	*Key*	Llave	Clau	*Apple*	Manzana	Poma
Strawberry	Fresa	Maduixa	*Wood*	Madera	Fusta	*Bull*	Toro	Bou
Worm	Gusano	Cuc	*Crib*	Cuna	Bressol	*Table*	Mesa	Taula
Eye	Ojo	Ull	*Footprint*	Huella	Petjada	*Bottle*	Botella	Ampolla
Pea	Guisante	Pésol	*Dog*	Perro	Gos	*Lightning*	Rayo	Llamp
Branch	Rama	Branca	*Panties*	Bragas	Calcetes	*Spot*	Mancha	Taca
Oil bottle	Aceitera	Setrill	*Mushroom*	Seta	Bolet	*Butterfly*	Mariposa	Papallona
Dove	Paloma	Colom	*Mattress*	Colchón	Matalàs	*Leaf*	Hoja	Fulla
Egg	Huevo	Ou	*Sickle*	Hoz	Falç	*Hat*	Sombrero	Barret
Brush	Cepillo	Raspall	*Frog*	Rana	Granota	*Chair*	Silla	Cadira
Match	Cerilla	Llumí	*Rain*	Lluvia	Pluja	*Glass*	Vaso	Got
Claw	Garra	Urpa	*Grapes*	Uva	Raïm	*Bed*	Cama	Llit
Owl	Búho	Mussol	*Woman*	Mujer	Dona	*Knife*	Cuchillo	Ganivet
Breast	Pecho	Pit	*Whistle*	Pito	Xiulet	*Cheese*	Queso	Formatge
Comb	Peine	Pinta	*Leg*	Pierna	Cama	*Cork*	Corcho	Suro
Tray	Bandeja	Safata	*Sheet*	Sábana	Llençol	*Faucet*	Grifo	Aixeta

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