

Translation and Associative Priming With Cross-Lingual Pseudohomophones: Evidence for Nonselective Phonological Activation in Bilinguals

Wouter Duyck
Ghent University

Using a lexical-decision task performed by Dutch–English bilinguals, the author showed that the recognition of visually presented first language (L1; e.g., *touw*) and second language (L2; e.g., *back*) targets is facilitated by L2 and L1 masked primes, respectively, which are pseudohomophones (*roap* and *ruch*) of the target's translation equivalent (*rope* and *rug*). Moreover, recognition of L2 targets (e.g., *church*) was also facilitated by L1 pseudohomophones (*pous*) of related words (*paus* [*pope*]). Contrastingly, no priming was observed for L1 targets (e.g., *been* [*leg*]) and L2 pseudohomophone associative primes (*knea*). Finally, the author found that an L2 target word (e.g., *corner*) is facilitated by a more frequent L2 (intra-lingual) homophone (e.g., *hook*) of its L1 translation equivalent (*hoek*). These findings strongly suggest language-independent activation of phonological representations in bilinguals and are compatible with the temporal delay assumption of the bilingual interactive activation plus model (A. Dijkstra & W. Van Heuven, 2002).

Keywords: bilingualism, masked priming, translation, associative, phonology

Ever since the quite recent development of literature on bilingual language processing, it has intrigued researchers whether languages mastered by bilinguals are processed by functionally and structurally independent systems. However, although words are represented through at least three different representational levels (i.e., in an orthographic lexicon, a phonological lexicon, and a semantic representation), research has mainly focused on orthographic–lexical autonomy (the “mental dictionary”). During the last decade, there has been a lively debate on whether lexical access¹ during visual word recognition is language specific or whether lexical representations of both languages interact early during this process. It now seems that this debate has almost been settled in favor of the latter hypothesis (for a recent review, see Dijkstra & Van Heuven, 2002). There has also been some discussion about whether both languages activate semantic representations to the same extent. Whereas the mainstream hypothesis (e.g., Kroll & Stewart, 1994) suggests that second language (L2) lexical representations only indirectly activate semantics through their first language (L1) translations, recent studies (e.g., Duyck & Brysbaert, 2002; Duyck & Brysbaert, 2004; Francis, Augustini, &

Saenz, 2003) have found convincing indications of strong L2 lexicosemantic links for at least certain types of words.

With respect to phonological representations, bilingual research is much scarcer. There have been only a few studies (e.g., Brysbaert, Van Dyck, & Van De Poel, 1999; Jared & Kroll, 2001; Van Wijnendaele & Brysbaert, 2002) that have investigated whether phonological representations from one language are activated when one reads in another language. The aim of the present study is, therefore, to investigate whether activation of phonological representations during visual word recognition is language independent (just as for orthographic–lexical representations; see above), making use of a cross-lingual masked phonological priming paradigm. Before going into more detail about the present study, I first briefly discuss earlier studies on phonological coding that have used this technique in the monolingual domain.

Phonological Coding in Monolingual Visual Word Recognition

Whereas the classical dual-route model of visual word recognition (e.g., Coltheart, 1978; Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001) attached considerable importance to a direct route from orthography to meaning (at least for skilled readers), recent accounts of visual word recognition have particularly stressed the importance of early and automatic phonological coding (e.g., Berent & Perfetti, 1995; Frost, 1998). Most of the evidence for the latter claim comes from the monolingual masked phonological priming paradigm, which also is used in this study. It was first used

This research was made possible by the Fund for Scientific Research-Flanders, of which Wouter Duyck is a postdoctoral research fellow.

I am indebted to Marc Brysbaert, who was involved with every phase of this study, and to Ton Dijkstra, for excellent feedback on many of these experiments. I would also like to thank Wouter De Baene, Susanna Flett, and Arnaud Szmalec for excellent comments on a version of this article and Els De Deken for successfully carrying out replications of several of the experiments reported in this article.

Correspondence concerning this article should be addressed to Wouter Duyck, Department of Experimental Psychology, Ghent University, Henri Dunantlaan 2, B-9000, Ghent, Belgium. E-mail: wouter.duyck@UGent.be

¹ In agreement with the literature on bilingualism (e.g., Dijkstra & Van Heuven, 2002), I use the terms *lexical* and *lexical access* mainly with reference to orthographic representations. Entries in the phonological lexicon will explicitly be labeled as *phonological representations*.

by Humphreys, Evett, and Taylor (1982), who found that tachistoscopically presented words (e.g., *made*) were more easily recognized in a perceptual identification task when preceded by a homophone prime (e.g., *maid*) than by a graphemic control word (e.g., *mark*). However, they did not succeed in replicating this finding with pseudohomophone primes. This suggests that at least some of their phonological (word) priming effect was of a lexical nature and perhaps not due to the activation of phonological representations. It was almost 10 years later that Perfetti and Bell (1991) succeeded in passing this more convincing pseudohomophone test (using slightly longer prime durations). This has been replicated by Grainger and Ferrand (1996) and extended to lexical decision (Ferrand & Grainger, 1992, 1993; Frost, Ahissar, Gotesman, & Tayeb, 2003; Grainger & Ferrand, 1996; Lukatela, Frost, & Turvey, 1998) and naming (Lukatela & Turvey, 1994b; see Kim & Davis, 2002, for similar results in a Korean naming task using word primes written in a different script).

Important for the present study, Lesch and Pollatsek (1993) extended the pseudohomophone priming effect by showing that the naming of a target word (e.g., *nut*) was facilitated not only by a real semantic associate (e.g., *beech*) prime but also by a homophone of that associate (e.g., *beach*), relative to a graphemic control word (e.g., *bench*). This was replicated by Lukatela and Turvey (1994a) with nonword primes (i.e., naming *frog* was facilitated by *tode*, a pseudohomophone of *toad*). In their view, the associative prime or its (pseudo)homophone activates the shared phonological representation. This feeds back to the corresponding semantic or lexical representation (for a discussion of lexical-associative vs. semantic priming, see the General Discussion), which in turn activates the lexical or semantic representations of related words. Among these is the target word, which is thus preactivated, leading to faster responses. This pseudohomophone associative priming effect has recently been replicated and extended to lexical decision by Drieghe and Brysbaert (2002). Also, Tan and Perfetti (1997) found that a Chinese target can be primed with a homophone of a target synonym (basically an almost maximally associated word), even though phonological coding of Chinese orthography is much less straightforward and efficient (but see Zhou & Marslen-Wilson, 1999).

To conclude, these findings from the monolingual domain strongly suggest that (a) phonological representations are activated automatically and very early (prelexically) during monolingual visual word recognition (e.g., Frost, 1998; Grainger & Ferrand, 1996; Lukatela & Turvey, 1994b; Perfetti & Bell, 1991; see Zhou & Marslen-Wilson, 1999, for a discussion of nonalphabetic languages, such as Chinese, which have less transparent grapheme-phoneme conversion rules) and (b) the activation spreading from these phonological representations is fast and strong enough to preactivate semantic or lexical (see the General Discussion) representations of associated words (e.g., Drieghe & Brysbaert, 2002; Lesch & Pollatsek, 1993; Lukatela & Turvey, 1994a). In the present study, I investigate whether these hypotheses generalize across languages by using pseudohomophone (associative) primes that do not belong to the same language as the targets.

Activation of Phonological Representations in Bilinguals

Before linking the present bilingual study to the monolingual studies mentioned above, I briefly discuss the current state of

affairs with respect to phonological coding in bilingual visual word recognition. As mentioned earlier, there are only a few studies directly assessing this issue. Among the first was that of Brysbaert et al. (1999). They reasoned that it is very likely that the prelexical, and not strategically controllable, phonological coding of visually presented words, which was observed in the monolingual domain, occurs for all grapheme-to-phoneme conversion (GPC) rules mastered by a bilingual person. Moreover, given its time course, this probably occurs before a language selection system (if any; see the discussion on language-independent lexical activation, Dijkstra & Van Heuven, 2002) gets involved. Hence, it was expected that early phonological coding through L1 GPC rules occurs during visual word recognition in L2, and vice versa.

The first part of this statement was examined in the Brysbaert et al. (1999) study itself. First, they replicated the pseudohomophone priming effect of Grainger and Ferrand (1996; see earlier) with Dutch-French bilinguals, using the same French (L2 for these participants) stimuli, which shows that the same processes underlie L1 and L2 word recognition. Second, these bilingual participants (but not French monolingual controls) also showed a similar cross-lingual phonological priming effect. It was easier to identify L2 targets (e.g., *nez* [nose]) following L1 homophonic word primes (e.g., *nee* [no]) than those following L1 graphemic control primes (e.g., *nek* [neck]). This effect was replicated more recently by Duyck, Diependaele, Drieghe, and Brysbaert (2004). Because the L1 homophonic primes were only homophones of the L2 target word according to L1 (Dutch) GPC rules, this shows that L1 GPC rules were processed even though the participants were performing a task in their L2. Brysbaert et al. also replicated their effect with nonword primes, which strongly argues against a lexical locus for this cross-lingual phonological priming effect. The above findings are compatible with those of Dijkstra, Grainger, and Van Heuven (1999), who showed that lexical decision response times (RTs) are longer for L2 words that are phonologically similar to L1 words, even though L1 phonology was not useful for this task. Further evidence for automatic phonological coding of L1 words during L2 word processing comes from a Korean-English study by Kim and Davis (2003). They found that L2 targets are primed by L1 homophone primes, even though both languages have different alphabets, both in a naming task and a lexical-decision task (although the latter effect was only significant in a one-tailed test and not acknowledged by the authors).

Some years later, evidence for the second part of the statement above (L2 activation during L1 processing) was also obtained. Reversing the language dominance of the participants, Van Wijnendaele and Brysbaert (2002) showed that recognition of L1 targets is facilitated by L2 homophonic primes. Hence, because the prime is only a pseudohomophone of the target according to Dutch (now L2) GPC rules, this strongly suggests that prelexical phonological coding during visual word recognition also occurs through L2 GPC rules, even when a task is performed in the native language (L1).

Although the two previously discussed studies (Brysbaert et al., 1999; Van Wijnendaele & Brysbaert, 2002) unambiguously point to language-independent, simultaneous activation of phonological representations (even those of the nonactive language), a study by Jared and Kroll (2001) led to more differentiating results. They found that French-English bilinguals were slower to name L2 words that have word-body enemies in L1 (e.g., the English word

bait contains the word *body ait* which is pronounced differently in French) relative to controls (e.g., the word *bump* contains the letter sequence *ump* which is illegal in French). Later, Jared and Szucs (2002) found similar results for interlingual homographs that have conflicting pronunciations in English and French (e.g., *pain*). This suggests that L1 phonological coding is automatically engaged when a task is performed in L2 (similar to Brysbaert et al., 1999). However, in contrast to Van Wijnendaele and Brysbaert (2002), Jared and Kroll did not find straightforward evidence for the opposite. English–French bilinguals were slower to name the same English words (now L1) having French (now L2) enemies relative to controls, but only after they had just named a set of French filler words (see also Jared & Szucs, 2002). Hence, activation of L2 phonological representations during L1 processing was present only if L2 GPC rules had been active just before the L1 task.

In conclusion, these few studies on language-independent activation of phonological representations suggest that visually presented words are always automatically processed through L1 GPC rules, even when they are read in L2. Evidence for the opposite statement is mixed. Whereas the results of Van Wijnendaele and Brysbaert (2002) clearly show that L2 phonological representations are accessed during L1 word recognition, the findings of Jared and Kroll (2001) suggest that the activation in these representations may only be strong enough to influence L1 processing if L2 GPC rules have recently been active. The present study further explores this issue by extending the pseudohomophone (associative) masked priming effect, discussed in the previous section, to a bilingual setting.

Activation of Lexical Representations in Bilinguals

Although the primary focus of this article is on bilingual phonological coding, the masked phonological priming paradigm adopted in this study uses a lexical-decision task with visually presented (non)word stimuli. Therefore, it is also important to discuss very briefly the current state of affairs with respect to the activation of orthographic–lexical knowledge in bilingual visual word recognition before going into detail about the present experiments. As noted in the beginning of this article, there is a growing consensus that visually presented words activate lexical representations from both languages in bilinguals. Evidence for this statement comes from studies in which L1 lexical knowledge, though irrelevant to the task at hand, influences L2 language processing. For instance, Dijkstra, Timmermans, and Schriefers (2000) showed that Dutch–English bilinguals respond slower to interlingual homographs (i.e., words that exist in both L1 and L2 but have a different meaning; e.g., *room* means *cream* in Dutch) than to words that exist only in L2 in a lexical go/no-go task (e.g., press a button only if the target is a word in L2). Moreover, Van Hell and Dijkstra (2002) recently showed that L2 (and even L3) lexical knowledge also influences L1 lexical access in an exclusive native language context. They reported faster lexical decision responses of Dutch–English–French trilinguals for L1 targets having L2 and L3 near-cognate (i.e., orthographically nearly identical) translation equivalents (e.g., *brood*, *bread*) than for control words. This shows that L2 (and even L3) lexical representations are accessed during L1 word recognition and that their activation is strong enough to influence L1 representations. Refer to Dijkstra and Van Heuven

(2002) for a comprehensive and recent review of further evidence in favor of nonselective lexical access.

The Present Study

The present study was designed to find additional evidence for the claim of prelexical language-independent activation of phonological representations made by Brysbaert et al. (1999) and Van Wijnendaele and Brysbaert (2002). This was done by extension of the previously discussed monolingual pseudohomophone priming effect and pseudohomophone associative priming effect to a bilingual context.

Experiments 1 and 2 constituted a cross-lingual extension of the pseudohomophone priming effect discussed earlier (e.g., Lukatela et al., 1998; Lukatela & Turvey, 1994b; Perfetti & Bell, 1991). In these monolingual studies, it was shown that recognition of a target word (e.g., *toad*) is facilitated when it is preceded by a pseudohomophone prime (e.g., *tode*). In this study, I explore whether it is also possible to facilitate the recognition of an L2 target word (e.g., *back*) with an L1 pseudohomophone (e.g., *ruch*) of its L1 translation equivalent (e.g., *rug*), relative to a graphemic control nonword that shares the same letters with the target (e.g., *gect*). If L1 phonological representations are indeed prelexically assembled during L2 target recognition (Brysbaert et al., 1999), the L1 pseudohomophone should quickly activate its phonological representation (identical to that of the real translation equivalent), which then activates the corresponding semantic representation. Given the evidence for nonselective lexical access (e.g., Dijkstra & Van Heuven, 2002), this should trigger preactivation of the corresponding L2 target in the same way activation spreads to related intralingual lexical entries in pseudohomophone associative priming (see earlier; Lukatela & Turvey, 1994a). This was investigated in Experiment 1. If L2 GPC rules are also active during L1 processing (Van Wijnendaele & Brysbaert, 2002), the same line of reasoning should apply to L1 targets (e.g., *touw*) and L2 pseudohomophone (e.g., *roap*) primes (control prime *joll*). This was investigated in Experiment 2. Note that these two experiments are in fact very similar to those of Tan and Perfetti (1997; see earlier), who reported that L1 target recognition is facilitated by a prime that is a homophone to a synonym of the target. In these experiments, however, the synonym is a translation equivalent. According to the strong nonselective lexical access view, both are cases of different lexical labels representing the same meaning.

The second part of this study (Experiments 3 and 4) constituted a cross-lingual version of the pseudohomophone associative priming effect (see above; Drieghe & Brysbaert, 2002; Lukatela & Turvey, 1994a). In the monolingual effect, target recognition (e.g., *frog*) is facilitated by a pseudohomophone (e.g., *tode*) of a related word (e.g., *toad*). In Experiment 3, I explored whether it is possible to prime an L2 target (e.g., *church*) with an L1 pseudohomophone (e.g., *pous*) of a related L1 word (e.g., *paus* [*pope*]; graphemic control prime: *zeun*). Unlike in the first two experiments, the prime is now a pseudohomophone, not of its translation equivalent, but of a word related to it. The same line of reasoning applies: The L1 pseudohomophone *pous* (homophone of *paus*, meaning *pope*) should activate its phonological representation, which in turn activates the semantic representation of *paus*. This activation is then spread to related semantic representations (Lukatela & Turvey, 1994a), like that of *kerk*, which leads to faster responses to the L2

word (*church*) representing that meaning. Again, the same experiment was carried out with L1 targets (e.g., *been* [leg]) and L2 pseudohomophone associative primes (e.g., *knea*) in Experiment 4.

Finally, as the third part of this study, I carried out two experiments investigating whether it is possible to prime target words with intralingual homophones of their translation equivalents. In Experiment 5, I explored whether recognition of an L2 word such as *corner* is facilitated by an L2 prime such as *hook*, which is a homophone of the Dutch (L1) word *hoek* (meaning *corner*). This would offer evidence (a) for prelexical phonological coding of L2 primes and (b) for language-independent semantic activation of phonological representations (i.e., the phonological representation associated with *hook*, /huk/, activates both its L1 and L2 meaning). In Experiment 6, this was replicated in L1 (e.g., *dij* [thigh], *dag* [day]).

Experiment 1A

As pointed out in the overview of this study (see above), Experiment 1 constituted a cross-lingual extension of the pseudohomophone priming effect, investigating whether it is possible to facilitate the recognition of an L2 target word (e.g., *back*) with an L1 pseudohomophone (e.g., *ruch*) of its L1 translation equivalent (e.g., *rug*). In Experiment 1A, this was examined with noncognate (e.g., *back*, *rug*) and near-cognate (e.g., *train*, *trein*) materials. I avoided identical cognates (e.g., *film*, *film*) to keep the stimulus lists strictly unilingual. Experiment 1B was an exact replication of Experiment 1A, containing only the noncognate materials. This experiment was carried out to investigate whether the presence of even nonidentical cognate stimuli in Experiment 1A could have rendered the bilingual nature of the task more obvious.² Grosjean (1998, 2000), for example, argued that the degree to which the languages of a multilingual interact depends on the so-called language mode of the participant. If a second language has been used prior to (or during) the experiment, or if the two languages are expected to be relevant to the situation, the participant will be in a bilingual language mode. This may cause interactions between L2 and L1, which would, by default, not be present in “normal,” monolingual language processing. Because the L2 near-cognate stimuli of Experiment 1A have considerable orthographic overlap with their L1 translation equivalents, this may apply to Experiment 1A, and any pseudohomophone priming effect on the noncognate stimuli may be a consequence of that. In Experiment 1B, the participants only saw noncognate L2 target words, which were very dissimilar to their L1 counterparts. This should trigger a monolingual language mode, speaking in Grosjean’s terms.

Method

Participants. The participants were 22 Dutch–English bilinguals. Mean age was 20.80 years ($SD = 4.22$). All were students at Ghent University participating for course requirements. They had started to learn English in a scholastic setting around the age of 14–15. All participants lived in an L1-dominant environment, speaking Dutch at home, at school, with friends, and so forth. All of them were regularly exposed to their L2 (English; music, Internet, films, TV, etc.). Like almost everybody in Belgium, all participants also had knowledge of French, but this was always reported as their third language. No questions were asked regarding their knowledge of English (L2) or languages other than Dutch during their

recruitment; they were not told they were going to participate in an experiment about bilingualism. Participants were asked to rate their L2 and L1 proficiency on a 7-point Likert scale ranging from 1 (*very bad*) to 7 (*very good*) after the actual experiment. Mean self-reported general L1 and L2 proficiency was, respectively, 6.59 ($SD = 0.59$) and 3.59 ($SD = 0.67$).

Stimulus materials. The stimuli consisted of 56 L2 (English) word targets and 56 L2 nonword targets. Half of the word targets were words for which the corresponding L1 (Dutch) translation equivalents is a near cognate (e.g., *sand* [zand]). The other half of the word targets were noncognates (e.g., *bucket* [emmer]). All word targets were matched with two types of L1 (Dutch) nonword primes (see Appendix A). The first type of primes were pseudohomophone translation primes, that is, L1 (Dutch) nonwords (e.g., *ruch*) that have the same pronunciation as the L1 translation equivalent (e.g., [rug]) of the L2 target (e.g., *back*). The second type of primes were graphemic control primes, that is, L1 nonwords (e.g., *gect*) that have the same letters in common with the L2 target (e.g., *ruch*) as the L1 pseudohomophone translation prime (e.g., *back*; for the noncognate stimulus pair mentioned above, in which the prime shares a letter *c* in the third letter position). This constraint was set to ensure that any priming effect is not due to orthographic overlap of the pseudohomophone prime with the target word. These control primes always had the same number of letters as the corresponding pseudohomophone prime. In addition, I also made sure that both types of nonword primes were equally wordlike. If this were not the case, it could be argued that pseudohomophone nonword primes are intrinsically more wordlike than other random nonwords, because they contain only legal GPC rules (otherwise they would not be pronounced as real words). Therefore, it is possible that they would trigger a “word” response to a larger degree than less wordlike nonwords, causing faster responses to the following word targets. To control for likeness to a word, I matched the two types of primes with respect to two variables, that is, summated bigram frequency and neighborhood density. The first refers to the summated number of occurrences of each of the nonword’s bigrams (e.g., the nonword *gect* contains three bigrams: *ge*, *ec*, and *ct*) in the CELEX lexical database (Baayen, Piepenbrock, & Van Rijn, 1993). The latter variable refers to the number of orthographic neighbors (i.e., words that have all but one letter in common with a given nonword) within the CELEX database for that language. It is very plausible to assume that wordlike nonwords contain bigrams that are more frequent in a given language and have more neighbors than less wordlike nonwords. This matching was done by means of the WordGen program (Duyck, Desmet, Verbeke, & Brysbaert, 2004), which uses the CELEX database to generate wordlike nonwords satisfying different combinations of bigram frequency and neighborhood density constraints. The program was probed for a nonword within close range of the respective values for each of the to-be-matched pseudohomophones. The program was also set to exclude bigrams that never occur (as the onset, suffix, or any other part of the word) in L1 (Dutch). Using this procedure, I obtained two sets of pseudohomophones and pronounceable (in L1) graphemic control primes, which I matched for summated bigram frequency (cognates: respectively, $M = 24,240$ and $M = 24,599$, $F < 1$; noncognates: $M = 26,294$ and $M = 25,952$, $F < 1$), neighborhood size (cognates: $M = 5.36$ and $M = 5.04$, $F < 1$; noncognates: $M = 6.00$ and $M = 5.68$, $F < 1$), word length (identical), and orthographic overlap with the target. Care was also taken that no control prime sounded like an existing Dutch or English word and that English targets did not sound like, and were not homographs of, existing Dutch words. Finally, noncognates and cognates were matched with respect to word frequency (CELEX log frequency per million, $M = 1.70$ and $M = 1.73$, $F < 1$). The 56 L2 nonword targets were each matched to one of the L2 word targets following the procedure of nonword generation mentioned above. Hence, the nonword targets were wordlike, pro-

² I thank an anonymous reviewer for this suggestion.

nounceable (in L2) letter strings, matched with word targets with respect to length and wordlikeness.

Procedure. Participants were tested in small groups. Care was taken that they were placed sufficiently far from each other. It was not possible to see the computer screen of another participant. Similar to procedures in Drieghe and Brysbaert's (2002) study, participants received written instructions to perform a lexical-decision task. This adds further strength to any phonological effect found, as the lexical-decision task (e.g., Lukatela & Turvey, 1994a) does not explicitly require access to phonology, unlike naming (see Taft & Van Graan, 1998), which was used by Lukatela and Turvey (1994a), for example. These instructions mentioned that 10 practice trials and several experimental trials would follow. No indication was given with regard to the presence of briefly presented words (primes) during the experiment. The participants were instructed to react to the target word and press one button if the presented letter string was an existing English word or another button if this was not the case. Practice trials were followed by feedback concerning the correctness of the response, whereas no feedback was given after the experimental trials. Each participant completed 112 experimental trials (28 cognate L2 word targets, 28 noncognate L2 word targets, and 56 L2 nonword targets) in a random order. Each of the targets was only presented once. For each of the participants, 28 (14 cognate and 14 noncognate) of the word targets were presented with a pseudohomophone prime, and 28 were presented with a control prime. Each participant received a different random permutation. Across participants, all target words were presented with each prime.

Each trial started with a forward mask (consisting of six hash marks, #####) presented for 500 ms. This mask was followed by the presentation of the prime for 57 ms (similar to Drieghe & Brysbaert, 2002; Lukatela & Turvey, 1994a), a backward mask for 57 ms (similar to Lesch & Pollatsek, 1993), and the target. Stimulus presentation was synchronized with the refresh cycle of the screen (70 Hz) by use of timing routines described by Bovens and Brysbaert (1990). The prime appeared in lowercase letters, unlike the target, which was displayed in uppercase letters. The target remained on the screen until the participant gave a response (using a response box connected through the computer's gameport). Throughout the experiment, two vertical lines were displayed centered on the screen, with a gap between them of approximately 1 cm. Participants were instructed to look at the gap between these lines. Both masks and stimuli were presented so that the second character always appeared between these two lines. Earlier studies (e.g., Brysbaert, Vitu, & Schroyens, 1996) have shown that this is the optimal viewing position for short words.

All participants also completed a short questionnaire assessing their self-reported L1 and L2 reading, speaking, writing, and general proficiency level on a 7-point Likert scale ranging from 1 (*very bad*) to 7 (*very good*). In addition, the questionnaire contained some general questions regarding the participants' history of L2 acquisition (e.g., setting, age).

Results

The proportion of false responses to L2 word and nonword targets was 12.3%. This is higher than the accuracy level generally

observed in L1 lexical decision tasks (see also Experiment 2). These trials were excluded from all analyses. An analysis of variance (ANOVA) was performed with cognate status (cognate vs. noncognate) and prime type (graphemic control vs. pseudohomophone) as repeated measures factors. The dependent variable was the mean RT across trials. Mean RTs and proportion of correct trials as a function of these two independent variables are presented in Table 1.

The effect of cognate status was not significant, $F_1(1, 21) = 3.20$, $MSE = 4,657$, $p < .09$; $F_2(1, 54) = 1.11$, $MSE = 15,702$, $p < .30$. Responses to cognate targets (686 ms) were slightly slower than to noncognate targets (660 ms). Most important, the main effect of prime type was significant, both in the analysis by participants and by items; respectively, $F_1(1, 21) = 10.61$, $MSE = 2,666$, $p < .01$; $F_2(1, 54) = 5.40$, $MSE = 9,026$, $p < .03$. Responses to targets following a pseudohomophone translation prime (655 ms) were significantly faster than those following a graphemic control prime (691 ms). This priming effect did not interact with cognate status ($F_s < 1$), although Table 1 shows a slightly larger priming effect for cognate targets. Planned comparisons showed that the priming effect was significant both in the cognate and noncognate conditions, respectively, $F_1(1, 21) = 5.62$, $MSE = 3,296$, $p < .01$, and $F_2(1, 54) = 2.96$, $MSE = 9,026$, $p < .05$; $F_1(1, 21) = 3.74$, $MSE = 2,770$, $p < .05$, and $F_2(1, 54) = 2.45$, $MSE = 9,026$, $p < .06$ (because I had well-founded expectations concerning the priming effect at the onset of this study, p values are reported for one-tailed tests).

There were no effects of cognate status and prime type on the proportion of correct trials ($F_s < 1$), as Table 1 already suggests.

Experiment 1B

Method

Participants. The participants were 23 Dutch-English bilinguals. Mean age was 19.40 years ($SD = 2.21$). All were students at Ghent University participating for course requirements. None of them had participated in Experiment 1A. They belonged to the same population as, and had an L2 history similar to that of, the participants in Experiment 1A. Mean self-reported, general L1 and L2 proficiency was, respectively, 6.70 ($SD = 0.63$) and 3.74 ($SD = 1.21$).

Stimulus materials. The critical stimuli consisted of the 28 noncognate L2 target words of Experiment 1A (see Appendix A) with their corresponding L1 pseudohomophone translation primes and L1 control primes. The nonword targets were also the 28 corresponding L2 nonwords from Experiment 1A.

Procedure. The procedure was identical to that of Experiment 1A. Again, the presence of L1 primes in the experiment was not mentioned.

Table 1

Experiment 1A (L1 Pseudohomophone Translation Primes–L2 Targets) Mean RTs (in Milliseconds) and Accuracy (% Errors) as a Function of Cognate Status and Prime Type

Prime	Noncognates			Cognates		
	Example	RT	% errors	Example	RT	% errors
Orthographic control	<i>gect</i> –BACK	675	14.8	<i>ogt</i> –EIGHT	706	16.4
Pseudohomophone translation	<i>ruch</i> [rug]–BACK	644	13.6	<i>agt</i> [acht]–EIGHT	665	14.9
Net priming effect		31	1.2		41	1.5

Note. L1 homophone translation equivalents are displayed between brackets; these words were not presented during the experiment.

Results

The proportion of false responses to L2 word and nonword targets was 9.5%. These trials were excluded from all analyses. A repeated measures ANOVA was performed with prime type (graphemic control vs. pseudohomophone) as the independent variable. The dependent variable was the mean RT across trials. Mean RTs and proportion of correct trials as a function of these two independent variables are presented in Table 2.

Just as in Experiment 1A, the main effect of prime type was significant, in the analyses both by participants and by items; respectively, $F_1(1, 22) = 15.08$, $MSE = 3,819$, $p < .001$, and $F_2(1, 27) = 7.06$, $MSE = 10,871$, $p < .01$. Responses to targets following a pseudohomophone translation prime (736 ms) were significantly faster than those following a graphemic control prime (807 ms).

A similar analysis was also run with accuracy as the dependent variable. This showed that prime type also had an effect on the proportion of correct trials, as Table 2 already suggests. Participants made more errors on targets following a control prime than on targets following a pseudohomophone translation prime. However, this effect was only significant in the analysis by participants, $F_1(1, 22) = 4.97$, $MSE = 0.00323$, $p < .05$, $F_2 < 1$.

Discussion of Experiments 1A and 1B

In line with expectations, Experiment 1A showed a significant forward (L1–L2) pseudohomophone translation priming effect: L2 target words were faster recognized if they were preceded by an L1 pseudohomophone of their L1 translation equivalents. In line with Brysbaert et al. (1999), this priming effect shows that the pseudohomophone primes were phonologically coded through L1 GPC rules, even though the task involved only L2 target words. Moreover, these phonological representations were activated strongly enough to preactivate the underlying semantic representations and corresponding L2 translation equivalents. The priming effect did not interact with the degree of form overlap (cognate status) between the translation equivalents. Also, I did not find a main effect of cognate status. This is probably due to the fact that I used nonidentical cognates (only partial form similarity, e.g., *day* [*dag*]), to keep the stimulus list strictly monolingual. For further theoretical implications of these findings, refer to the General Discussion.

Table 2
Experiment 1B (L1 Pseudohomophone Translation Primes–L2 Targets, Only Noncognate Stimuli) Mean RTs (in Milliseconds) and Accuracy (% Errors) as a Function of Cognate Status and Prime Type

Prime	Example	RT	% errors
Orthographic control	<i>gect</i> , <i>BACK</i>	807	13.4
Pseudohomophone translation	<i>ruch</i> [<i>rug</i>]– <i>BACK</i>	736	9.6
Net priming effect		71	3.8

Note. L1 homophone translation equivalents are displayed between brackets; these words were not presented during the experiment.

Finally, it is important to note that the pseudohomophone priming effect was also present in Experiment 1B, which only contained noncognate stimuli. Therefore, it cannot be attributed to the presence of L1-like words (50% near cognates) in the materials of Experiment 1A. This strongly suggests that the cross-lingual pseudohomophone priming effect is not a consequence of a different bilingual language mode (Grosjean, 1998, 2000) induced by the (incomplete) orthographic overlap between the near-cognate translation equivalents of Experiment 1A. This is not a very surprising finding if one considers the lenient cognate definition adopted in Experiment 1A: No identical cognates (e.g., *film*) were used; the cognate stimuli had some resemblance with their L1 translation equivalents but were, in fact, exclusive L2 words.

To conclude this section, I would like to discuss an account of the phonological priming effect in terms of orthographic overlap. The pseudohomophone translation primes were matched with the graphemic control primes with respect to the number of letters shared with the target (e.g., because the prime *ruch* shares a *c* in the third letter position with *back*, so does the control prime *gect*). Because in any alphabetic language, phonological overlap is almost always partially correlated with orthographic overlap, the pseudohomophone prime (in most cases) also has some letters in common with the translation equivalent from which it is a pseudohomophone (in this case *rug*). I believe this is not problematic for a phonological account of the priming effect for a number of reasons. First, the real translation equivalent was not actually shown during the experiment (unlike the target for which orthographic overlap was controlled). Therefore, any effect of the *ru* that appears in *ruch* and *rug* would be an indirect effect, in that *ruch* preactivates a little bit any word starting with an *r*, any word containing a *u*, any word starting with *ru*, and so forth. Among those hundreds of words is also *rug*, which could forward some of the little activation it receives to its translation equivalent *back*. I believe such an indirect effect, mediated by the limited activation in *rug* is likely to be outweighed by the much stronger phonological manipulation. Second, Perea and Lupker (2003) actually tested whether such indirect activation occurs with nonword primes. Using the same masked priming paradigm, they found that the nonword prime *judpe* did not prime the associated target *court* (three nonsignificant effects: 6 ms, 0 ms, and 4 ms), whereas the associated prime *judge* (14 ms, 15 ms, and 19 ms, all significant), and its transposed internal letter nonword prime *jugde* did (effects of 12 ms, 10 ms, and 15 ms, all significant). If an indirect orthographic priming mechanism such as the one described above would be active, one would expect *judpe* to activate *judge* (among other words) to a certain extent (probably much more than *ruch* would preactivate *rug*, given the larger number of common letters), causing a priming effect. Moreover, if such a process does not elicit such an orthographic effect between monolingual stimulus pairs, it is unlikely to do so across languages. Third, in a similar Spanish study, Carreiras and Perea (2002) found that monosyllabic nonword primes (as most of the primes in this study are) did not prime monosyllabic targets sharing the first two letters (e.g., *blan*, *bloc*), even though this should be a much more direct and stronger effect than any indirect orthographic priming in this study. Fourth, Lukatela, Savic, Urosevic, and Turvey (1997) found that the target *robot* (/robot/) was significantly more primed by the mixed-alphabet (Roma-Cyrillic), but phonologically unique, nonword ROÁOT (/robot/) than by the phonologically ambiguous

nonword prime POBOT (/robot/ or /rovot/ or /pobot/ or /povot/) or even by the phonologically ambiguous, but orthographically identical, word prime ROBOT (/robot/ or /rovot/). Later, Lukatela, Carello, Savic, Urošević, and Turvey (1999) reported similar findings for the same primes in associative priming (target *automat*). Again, this is not compatible with an indirect orthographic priming mechanism such as described above. Therefore, I believe that the priming effects observed in Experiments 1A and 1B can be attributed with confidence to the phonological overlap between the pseudohomophone and the associated translation equivalent.

Experiment 2A

The design of Experiment 2 was identical to that of Experiment 1. However, the language of the prime and target was switched. In this experiment, it was investigated whether it is possible to facilitate the recognition of an L1 target word (e.g., *touw*) with an L2 pseudohomophone (e.g., *roap*) of its L2 translation equivalent (*rope*). Such an effect would offer strong evidence for L2 phonological coding during L1 visual word recognition. Again, this was examined with noncognate and near-cognate materials (Experiment 2A). Similar to Experiment 1, a replication of this experiment was also carried out, removing all near cognates from the stimulus list (Experiment 2B). This was done as an investigation of whether the presence of L2-like words (near cognates) in the stimulus materials interacts with any cross-lingual pseudohomophone priming effect observed in Experiment 2A.

Method

Participants. The participants were 22 Dutch–English bilinguals. Mean age was 21.00 years ($SD = 4.01$). None of them had participated in Experiments 1A or 1B. They belonged to the same population as, and had an L2 history similar to that of, the participants in Experiment 1. They were not told they were participating in an experiment about bilingualism. Mean self-reported general L1 and L2 proficiency on a 7-point scale was, respectively, 6.64 ($SD = 0.25$) and 3.68 ($SD = 0.57$).

Stimulus materials. The stimulus list was similar to Experiment 1, but the languages were switched. The stimuli consisted of 56 L1 (Dutch) word targets and 56 L1 nonword targets. Half of the word targets were words for which the corresponding L2 (English) translation equivalent is a near cognate (e.g., *melk* [milk]). The other half of the word targets were noncognates (e.g., *sleutel* [key]). All word targets were matched with two types of L2 (English) nonword primes (see Appendix B). The first type of primes were pseudohomophone translation primes, that is, L2 nonwords (e.g., *trea*) that have the same pronunciation as the L2 translation equivalent (e.g., *tree*) of the L1 target (e.g., *boom*). All these pseudohomophones were drawn from the ARC nonword database, a large set of pseudohomophone letter strings composed following strict criteria described by Rastle, Harrington, and Coltheart (2002). The second type of primes were L2 nonword graphemic control primes, matched with the pseudohomophones following the criteria and procedure used in Experiment 1. The resulting two sets of pseudohomophones and pronounceable (in L2) control primes were matched for summated bigram frequency³ (cognates: $M = 5,920$ and $M = 5,852$, respectively, $F < 1$; noncognates: $M = 4,614$ and $M = 4,603$, respectively, $F < 1$), neighborhood size (cognates: $M = 4.32$ and $M = 4.46$, respectively, $F < 1$; noncognates: $M = 5.50$ and $M = 5.54$, respectively, $F < 1$), word length (identical) and orthographic overlap with the target. Care was also taken that no control prime sounded like an existing Dutch or English word. Also, Dutch (L1) targets did not sound like, and were not, homographs of existing English words. Finally, noncognates and cognates were matched with respect to word frequency (CELEX log

frequency per million, $M = 1.62$ and $M = 1.59$, $F < 1$). The 56 L1 nonword targets satisfied the criteria mentioned above for the corresponding stimuli in Experiment 1.

Procedure. The procedure was identical to that of Experiment 1. Again, the presence of L2 primes in the experiment was not mentioned.

Results

The proportion of false responses was 4.4%. Again, these trials were excluded from all analyses. Also, all responses to the stimulus word *auto* were removed from the analyses because this is also an existing word in American English and therefore does not meet the stimulus criteria outlined above. An ANOVA was performed with cognate status (near cognate vs. noncognate) and prime type (graphemic control vs. pseudohomophone) as repeated measures factors. The dependent variable was the mean RT across trials. Mean RTs and proportion of correct trials as a function of these two variables are presented in Table 3.

Responses to cognate targets (583 ms) were slightly slower than to noncognate targets (577 ms). This difference was not significant, $F_1(1, 21) = 1.11$, $MSE = 813$, $p > .30$; $F_2 < 1$. Most important, the main effect of prime type was significant, just as in Experiments 1A and 1B (L2 targets), $F_1(1, 21) = 9.01$, $MSE = 1,010$, $p < .01$; $F_2(1, 53) = 4.17$, $MSE = 2,559$, $p < .05$. Responses to L1 targets following an L2 pseudohomophone translation prime (570 ms) were significantly faster than those following a graphemic control prime (590 ms). This priming effect did not interact with cognate status ($F_s < 1$). Indeed, Table 3 shows that the priming effect was 21 ms and 20 ms for cognates and noncognates, respectively. Similar to Experiment 1A, there were no effects of cognate status or prime type on accuracy ($F_s < 1$).

Comparison of Experiments 1A and 2A

To compare the strength of the priming effect for L1 and L2 primes (respectively, L2 and L1 targets), I also analyzed the data from Experiment 1A and 2A as one design. Again, an ANOVA was performed with cognate status and prime type as repeated measures factors. In addition, language of the prime/target (L1–L2 vs. L2–L1) was included as a between-subjects variable. The dependent variable was the mean RT across trials. As expected, responses were significantly slower to L2 targets (673 ms) than to L1 targets (580 ms), $F_1(1, 42) = 9.65$, $MSE = 39,050$, $p < .01$; $F_2(1, 107) = 52.06$, $MSE = 10,178$, $p < .001$. More important, the significant pseudohomophone translation priming effect did not interact significantly with prime/target language, $F_1(1, 42) = 1.44$, $MSE = 1,838$, $p > .23$; $F_2(1, 107) = 1.15$, $MSE = 5,823$, $p > .28$, although inspection of Tables 1 and 3 shows that it tended to be larger for L1 primes (36 ms) than for L2 primes (20 ms).

³ Note that these measures of summated bigram frequency (and to a lesser extent of neighborhood size) cannot directly be compared with the respective measures for the L1 nonwords of Experiment 1. The latter are much higher because the Dutch CELEX contains many more records than the English CELEX, leading to a higher overall number of bigram occurrences. For a more detailed discussion of this topic, refer to Duyck et al. (2004).

Table 3
Experiment 2A (L2 Pseudohomophone Translation Primes–L1 Targets) Mean RTs (in Milliseconds) and Accuracy (% Errors) as a Function of Cognate Status and Prime Type

Prime	Noncognates			Cognates		
	Example	RT	% Errors	Example	RT	% Errors
Orthographic control	<i>joll</i> – <i>TOUW</i>	587	4.2	<i>preef</i> – <i>DIEF</i>	594	4.3
Pseudohomophone translation	<i>roap</i> [<i>rope</i>]– <i>TOUW</i>	567	3.6	<i>theef</i> [<i>thief</i>]– <i>DIEF</i>	573	3.8
Net priming effect		20	0.6		21	0.5

Note. L2 homophone translation equivalents are displayed between brackets; these words were not presented during the experiment.

Experiment 2B

Method

Participants. The participants were 24 Dutch–English bilinguals. Mean age was 20.20 years ($SD = 3.53$). All were students at Ghent University participating for course requirements. None of them had participated in one of the previous experiments. They belonged to the same population as, and had an L2 history similar to that of, the participants in the previous experiments. The participants were not told they were participating in an experiment about bilingualism. Mean self-reported general L1 and L2 proficiency on a 7-point scale was, respectively, 6.79 ($SD = 0.51$) and 3.75 ($SD = 0.85$).

Stimulus materials. The critical stimuli consisted of the 28 noncognate L1 target words of Experiment 2A (see Appendix B), with their corresponding L2 pseudohomophone translation primes and L2 control primes. The nonword targets were also the 28 corresponding L1 nonwords from Experiment 2A.

Procedure. The procedure was identical to that of Experiment 2A. Again, the presence of L2 primes in the experiment was not mentioned.

Results

The proportion of false responses to L2 word and nonword targets was 3.6%. These trials were excluded from all analyses. Again, all responses to the stimulus word *auto* were removed from the analyses because this is also an existing word in American English and, therefore, does not meet the stimulus criteria outlined above. A repeated measures ANOVA was performed with prime type (graphemic control vs. pseudohomophone) as the independent variable. The dependent variable was the mean RT across trials. Mean RTs and proportion of correct trials as a function of these two independent variables are presented in Table 4.

Just as in Experiment 2A, the main effect of prime type was significant, both in the analysis by participants and by items; respectively, $F_1(1, 22) = 6.54$, $MSE = 1,227$, $p < .02$; $F_2(1, 26) = 6.55$, $MSE = 1,620$, $p < .02$. Responses to targets following a pseudohomophone translation prime (603 ms) were significantly faster than those following a graphemic control prime (629 ms). Similar to Experiment 2A, there was no effect of prime type on accuracy ($F_s < 1$).

Comparison of Experiments 1B and 2B

To compare the strength of the priming effects for L1 and L2 primes (respectively, L2 and L1 targets) in the two experiments without cognate stimuli, I also analyzed the data from Experiment 1B and 2B as one design. Again, an ANOVA was performed with

prime type as the repeated measures factor. In addition, language of the prime/target (L1–L2 vs. L2–L1) was included as a between-subjects variable. The dependent variable was the mean RT across trials. As expected, responses were significantly slower to L2 targets (772 ms) than to L1 targets (616 ms), $F_1(1, 44) = 29.63$, $MSE = 18,811$, $p < .001$; $F_2(1, 53) = 106.36$, $MSE = 7,843$, $p < .001$. Also, the significant pseudohomophone translation priming effect interacted significantly with prime/target language, $F_1(1, 44) = 4.48$, $MSE = 2,523$, $p < .05$, although this effect only tended toward significance in the analysis by items, $F_2(1, 53) = 2.30$, $MSE = 6,333$, $p < .14$. So, the priming effect of L1 primes on L2 targets (71 ms) was larger than the (still significant) priming effect of L2 primes on L1 targets (26 ms).

Discussion of Experiments 2A and 2B

In line with expectations, Experiment 2A showed a significant backward (L2–L1) pseudohomophone translation priming effect: L1 target words were faster recognized if they were preceded by an L2 pseudohomophone of their L2 translation equivalents. In line with Van Wijnendaele and Brysbaert (2002), this shows that the L2 pseudohomophone primes were phonologically coded through L2 GPC rules, even though the task involved only L1 target words. Moreover, these phonological representations were activated strongly enough to preactivate the underlying semantic representations and corresponding L1 translation equivalents. Similar to Experiment 1A, the pseudohomophone priming effect of Experiment 2A did not interact with the degree of form overlap (cognate status) between the translation equivalents. Also, the main effect of cognate status was not significant, which is again probably due to

Table 4
Experiment 2B (L2 Pseudohomophone Translation Primes–L1 Targets, Only Noncognate Stimuli) Mean RTs (in Milliseconds) and Accuracy (% Errors) as a Function of Cognate Status and Prime Type

Prime	Example	RT	% errors
Orthographic control	<i>joll</i> <i>TOUW</i>	629	1.9
Pseudohomophone translation	<i>roap</i> [<i>rope</i>]– <i>TOUW</i>	603	1.9
Net priming effect		26	0.0

Note. L2 homophone translation equivalents are displayed between brackets; these words were not presented during the experiment.

the fact that I used nonidentical cognates to keep the stimulus list strictly monolingual.

A significant priming effect was also obtained in Experiment 2B, which contained only noncognate stimuli. This shows that the cross-lingual priming effect of Experiment 2A may not be attributed to the presence of near-cognate stimuli (L2-like target words) in the materials, which could have triggered a bilingual language mode (see earlier, Grosjean, 1998, 2000).

It is interesting that a comparison of Experiments 2B and 1B (without near-cognate stimuli) showed that the forward (L1 primes–L2 targets) pseudohomophone translation priming effect (71 ms) was significantly stronger than the (still significant) backward (L2 primes–L1 targets) effect (26 ms), although this interaction effect was significant only in the analysis by participants. A similar comparison of the experiments with near-cognate stimuli (Experiments 1A and 2A) showed statistically equally strong priming effects, although there is a similar tendency in the raw data (forward: 36 ms; backward: 20 ms). For further theoretical implications of these findings, refer to the General Discussion.

Experiment 3

In the previous experiments, I examined pseudohomophone translation priming from L1 to L2 (Experiment 1) and vice versa (Experiment 2). The next two experiments constitute a cross-lingual version of the pseudohomophone associative priming effect (see above; Lukatela & Turvey, 1994a). In the present experiment, I investigated whether it is possible to prime an L2 target (e.g., *church*) with an L1 pseudohomophone (e.g., *pous*) of a related L1 word (e.g., *paus* [*pope*]).

Method

Participants. The participants were 20 Dutch–English bilinguals. Mean age was 20.09 years ($SD = 3.65$). None of them had participated in one of the previous experiments. They belonged to the same population as, and had an L2 history similar to that of, the participants in Experiments 1 and 2. Mean self-reported general L1 and L2 proficiency on a 7-point scale was, respectively, 6.75 ($SD = 0.44$) and 3.70 ($SD = 0.47$).

Stimulus materials. The stimulus list was similar to Experiment 1, except that the pseudohomophone primes were not homophones to the translation equivalent of the target but to a related word of the target (e.g., *pous*, [*paus*, *pope*], *church*). Also, because it was hard to find stimuli satisfying the different constraints outlined below, cognate status was not included as a stimulus variable. The stimuli consisted of 34 L2 (English) word targets and 34 L2 nonword targets. All word targets were matched with two types of L1 (Dutch) nonword primes (see Appendix C). The first

type of primes were pseudohomophone associative primes, that is, L1 nonwords that have the same pronunciation (e.g., *pous*) as the L1 translation equivalent (e.g., *paus*) of a word (e.g., *pope*) that is related to the L2 target (e.g., *church*). As mentioned above, cognate status was not manipulated: target words could be near-cognates (e.g., *cat* [*kat*]) or not (e.g., *church* [*kerk*]), but were never existing words in L1. All associated word pairs were drawn from the free association norms database from Nelson, McEvoy, and Schreiber (2004), which lists the (directional) strength of the associations between more than 4,000 words, measured as the chance that somebody produces a certain word as the first response to a given word (and vice versa) when asked to give the first word that comes to mind. I selected those associated word pairs from the database from which the associative strength was as strong as possible, provided it was still possible to find a cross-lingual Dutch pseudohomophone of one of the words. Mean associative strength between the selected associates was .353 (with a maximum of .819 for the *day–night* pair). Similar, to the previous experiments, the second type of primes was L1 nonword graphemic control primes, matched with the pseudohomophone associative primes following the criteria and procedure described in the *Method* section of Experiment 1A. The resulting set of pseudohomophone and pronounceable (in L1) control primes was matched for summated bigram frequency (respectively, $M = 22,389$ and $M = 21,520$, $F < 1$), neighborhood size ($M = 5.36$ and $M = 4.53$, $F < 1$), word length (identical), and orthographic overlap with the target. Care was also taken that no control prime sounded like an existing Dutch or English word. Also, English (L2) targets did not sound like, and were not homographs of, existing Dutch words. Mean CELEX log frequency per million of the target words was 1.87 ($SD = 0.54$). Mean word target length was 4.7 letters.

Procedure. The procedure was identical to that of Experiment 1, except for the number of trials. All participants completed 34 word and 34 nonword trials; again, half of the word targets was preceded by a pseudohomophone associative prime, whereas the other half was preceded by a control prime. Also, the presence of L1 primes in the experiment was not mentioned.

Results

The proportion of false responses to L2 word and nonword targets was 10.2%. These trials were discarded from all analyses. A repeated measures ANOVA was performed with prime type (graphemic control vs. pseudohomophone) as the only independent variable. The dependent variable was the mean RT across trials. Mean RTs and accuracy as a function of prime type are presented in the left part of Table 5

As expected, and similar to Experiments 1A and 1B, the effect of prime type was significant in both the analysis by participants and the analysis by items, respectively, $F_1(1, 19) = 4.72$, $MSE = 2,328$, $p < .05$; $F_2(1, 33) = 4.24$, $MSE = 4,121$, $p < .05$.

Table 5

Experiments 3 (L1 Pseudohomophone Associative Primes–L2 Targets) and 4 (L2 Pseudohomophone Associative Primes–L1 Targets) Mean RTs (in Milliseconds) and Accuracy (% Errors) as a Function of Target Language and Prime Type

Prime	Experiment 3				Experiment 4		
	Example	RT	% errors	Example	RT	% errors	
Orthographic control	<i>zeun–CHURCH</i>	692	5.5	<i>sned–BEEN</i>	596	2.8	
Pseudohomophone associative	<i>pous [paus]–CHURCH</i>	659	9.6	<i>knea [knee]–BEEN</i>	576	3.1	
Net priming effect		33	–4.1		20	–0.3	

Note. Homophone associatively related words are displayed between brackets; these words were not presented during the experiment.

Responses to L2 targets following a pseudohomophone of a semantically related L1 word (659 ms) were significantly faster than responses to L2 targets following a graphemic control prime (692 ms). As for accuracy, there tended to be more errors in the pseudohomophone condition than in the control condition, in contrast with my expectations and with the pattern observed in the RTs. However, this trend was not significant, $F_1(1, 19) = 3.59$, $MSE = 46.2$, $p > .07$; $F_2(1, 33) = 3.74$, $MSE = 47.6$, $p > .06$.

Similar to the analyses in which the pseudohomophone translation effect was compared for Experiments 1A and 1B (L2 targets) and Experiment 2A and 2B (L1 targets), I also compared the magnitude of the prime type effect for pseudohomophone translation primes (Experiment 1A) and pseudohomophone associative primes. The effect was somewhat (3 ms) larger for translation primes, but this difference was not significant ($F_s < 1$). A similar comparison between Experiment 3 and Experiment 1B (without cognate stimuli) showed larger pseudohomophone translation priming (71 ms; see Table 2) than pseudohomophone associative priming (33 ms; see Table 5), but again, this difference was not significant, $F_1(1, 41) = 2.41$, $MSE = 3,128$, $p > .12$, and $F_2(1, 60) = 1.89$, $MSE = 7,158$, $p > .17$.

Discussion

Experiment 3 showed a significant forward pseudohomophone associative priming effect. L2 target words were faster recognized if they were preceded by an L1 pseudohomophone of a word related to their L1 translation equivalents. In line with Brysbaert et al. (1999), this strongly suggests that the L1 pseudohomophone primes were phonologically coded through L1 GPC rules, even though the task involved only L2 target words. Moreover, these phonological representations were activated strongly enough to preactivate their underlying semantic representations, which in turn activated related semantic representations and their corresponding L2 lexical entries. Also, the pseudohomophone associative priming effect found in this experiment was not significantly smaller than the pseudohomophone translation priming effect (Experiments 1A and 1B). For further theoretical implications of these findings, refer to the General Discussion.

Experiment 4

The design of Experiment 4 was identical to that of Experiment 3. However, as pointed out earlier, the language of the prime and target was reversed. In this experiment, it was investigated whether it is possible to prime an L1 target (e.g., *kat* [*cat*]) with an L2 pseudohomophone (e.g., *mowse*) of a related L2 word (*mouse*).

Method

Participants. The participants were 20 Dutch–English bilinguals. Mean age was 22.20 years ($SD = 4.86$). None of them had participated in one of the previous experiments. They belonged to the same population as, and had an L2 history similar to that of, the participants in Experiments 1, 2, and 3. The participants were not told they were participating in an experiment about bilingualism. Mean self-reported general L1 and L2 proficiency on a 7-point scale was, respectively, 6.80 ($SD = 0.41$) and 4.05 ($SD = 1.36$).

Stimulus materials. The composition of the stimulus list was identical to Experiment 3, but language of the primes and targets was

switched. There were now 36 L1 (Dutch) word targets and 36 L1 nonword targets. Again, all word targets were matched with two types of L2 (English) nonword primes (see Appendix D). The first type of primes was pseudohomophone associative primes, that is, L2 nonwords that have the same pronunciation (e.g., *mowse*) as the L2 translation equivalent (e.g., *mouse*) of a word (e.g., *muiss*) that is related to the L1 target (e.g., *kat* [*cat*]). Target words could be near-cognates (e.g., *kat* [*cat*]) or not (e.g., *kikker* [*frog*]) but were never existing words in L2. Just as in Experiment 3, all associated word pairs were drawn from the free association norms database of Nelson, McEvoy, and Schreiber (2004), on the condition that it was possible to find a cross-lingual English pseudohomophone of one of the words. Like in Experiment 2, only pseudohomophones that are in the ARC nonword database were selected (Rastle et al., 2002). Mean associative strength between the selected associates was .313 (with a maximum of .828 for the *toad*–*frog* pair), not differing from the mean association strength of Experiment 3 ($F < 1$). Similar to the previous experiments, the second type of primes were L2 nonword graphemic control primes, matched with the pseudohomophone associative primes following the criteria and procedure described in the *Method* section of Experiment 1A. The resulting set of pseudohomophone and pronounceable (in L2) control primes were matched for summated bigram frequency (respectively, $M = 5,382$ and $M = 5,495$, $F < 1$), neighborhood size ($M = 4.97$ and $M = 5.31$, $F < 1$), word length (identical), and orthographic overlap with the target. Care was also taken that no control prime sounded like an existing Dutch or English word. Also, English (L1) targets did not sound like, and were not homographs of, existing Dutch words. Mean CELEX log frequency per million of the target words was 1.68 ($SD = 0.53$). Mean word target length was 4.7 letters.

Procedure. The procedure was identical to that of Experiment 3, except for the number of trials. All participants completed 36 word and 36 nonword trials; again, half of the word targets was preceded by a pseudohomophone associative prime, whereas the other half was preceded by a control prime. Also, the presence of L2 primes in the experiment was not mentioned.

Results

The proportion of false responses was 3.9%. These trials were discarded from all analyses. A repeated measures ANOVA was performed with prime type (graphemic control vs. pseudohomophone) as the only independent variable. The dependent variable was the mean RT across trials. Mean RTs and accuracy as a function of prime type are presented in the right part of Table 5.

Similar to Experiment 3 (L1 primes–L2 targets), responses to L1 targets following a pseudohomophone of a semantically related L2 word (576 ms) were somewhat faster than responses to L1 targets following a graphemic control prime (596 ms). However, this 20-ms effect was not statistically reliable, $F_1(1, 19) = 2.69$, $MSE = 1,508$, $p > .11$; $F_2(1, 35) = 2.56$, $MSE = 2,320$, $p > .11$. As can already be seen in Table 5, there was no effect of prime type on accuracy ($F_s < 1$).

Discussion

Whereas pseudohomophone translation priming could be observed from L1 to L2 and vice versa, this was not the case for the cross-lingual pseudohomophone associative priming effect. In contrast with the strong effect of L1 associative primes–L2 targets obtained in Experiment 3, the effect observed in this Experiment (L2 primes–L1 targets) was not statistically reliable. Responses to L1 target words following L2 pseudohomophone associative

primes were not significantly faster than those following L2 control primes (although there was a 20-ms effect). This suggests that the L2 pseudohomophones were possibly phonologically coded to some degree (given the results of Van Wijnendaele & Brysbaert, 2002), but these phonological representations were not activated strongly enough to preactivate their underlying semantic representations and/or related semantic representations and their corresponding L1 lexical entries. For further theoretical implications of these findings, refer to the General Discussion.

Experiment 5

In the first two parts of this study, I have respectively studied pseudohomophone translation priming (Experiments 1A and 1B and Experiments 2A and 2B) and pseudohomophone associative priming (Experiments 3 and 4). In the present experiment, I explored whether recognition of an L2 target word such as *corner* can be facilitated by an L2 prime such as *hook*, which is a homophone of the Dutch (L1) word *hoek* (meaning *corner*). Such an effect would imply that the phonological representation accessed by the prime *hook* (/huk/), activates both its L1 and L2 meanings.

Method

Participants. The participants were 22 Dutch–English bilinguals. Mean age was 21.23 years ($SD = 4.44$). None of them had participated in one of the previous experiments. They belonged to the same population as, and had an L2 history similar to that of, the participants in Experiments 1 to 4. Mean self-reported general L1 and L2 proficiency on a 7-point scale was, respectively, 6.71 ($SD = 0.46$) and 3.71 ($SD = 0.46$).

Stimulus materials. The stimuli consisted of 23 L2 (English) word targets and 23 L2 nonword targets. All word targets were matched with two types of L2 (English) nonword primes (see left part of Appendix E). The first type of primes were intralingual homophone intermediate translation primes, that is, L2 words (e.g., *hook*) that have the same pronunciation as the L1 translation equivalent (e.g., *hoek*) of the L1 target (e.g., *corner*). The second type of primes were L2 graphemic control primes, matched with the homophones analogue to the criteria and procedure described in the *Method* section of Experiment 1A. The resulting set of homophones and control primes was matched for word frequency (respectively, $M = 1.67$ and $M = 1.57$, $F < 1$) summated bigram frequency ($M = 7,445$ and $M = 7,042$, $F < 1$), neighborhood size ($M = 12.83$ and $M = 9.91$, $p > .11$), word length (identical), and orthographic overlap with the target. Care was also taken that no words were existing words in Dutch (L1). The 23 pronounceable L2 nonword targets satisfied the criteria mentioned above for the nonword target stimuli in Experiment 1. Mean log frequency per million of the L2 target words was 1.53 ($SD = 0.65$).

Procedure. The procedure was identical to that of Experiment 1. Each participant completed 56 trials. Twelve or 11 (counterbalanced over participants) of the 23 word targets were preceded by a homophone intermediate translation prime. The other word targets were preceded by a control prime. Again, each participant received a different prime permutation. Across participants, all targets were displayed with the two types of primes. Again, the presence of L2 primes in the experiment was not mentioned. The intermediate L1 translation equivalents (or any other L1 words) were not displayed during the experiment.

Results

The proportion of false responses was 13.1%. Again, these trials were excluded from all analyses. Mean RTs and proportion of correct trials as a function of prime type are presented in the left part of Table 6.

A repeated measures ANOVA was performed with prime type (graphemic control vs. homophone of translation equivalent) as the only independent variable. The dependent variable was the mean RT across trials. It is interesting that this showed a large significant effect of prime type, $F_1(1, 21) = 4.53$, $MSE = 7,360$, $p < .05$. Responses to targets following an intralingual homophone of its translation equivalent (880 ms) were 56 ms faster than responses to control primes (936 ms). This effect however, although very large, was not significant in the item analysis ($F_2 < 1$). Finally, there was no effect of prime type on the proportion of correct responses, $F_1(1, 21) = 1.14$, $MSE = 64.5$, $p > .29$; $F_2(1, 22) = 1.76$, $MSE = 69.5$, $p > .19$.

Because the effect of prime type was very large and reliable in the analysis by participants, but by far not significant in the analysis by items, there is reason to believe that the prime type effect interacts with some item variable not accounted for in the experimental design, and was therefore present for only some of the stimuli. To further explore this hypothesis, I have repeated the analysis described above, including one additional independent variable, which I believed might have interacted with the prime type effect. Because word frequency is probably the linguistic variable with the most robust effects in the psycholinguistic literature, I decided to include the relative word frequency of the target compared with that of the primes. Whereas homophone and control primes were matched for word frequency, this was not the case for target frequency relative to prime frequency, because there are only very few stimuli that are homophones to the other's translation equivalent (in addition to the other selection criteria mentioned above). Hence, the stimulus set contained triplets ($n = 11$) for which the target had a lower frequency compared with the

Table 6
Experiments 5 (L2 Primes and Targets) and 6 (L1 Primes and Targets) Mean RTs (in Milliseconds) and Accuracy (% Errors) as a Function of Target Language and Prime Type

Prime	L2 primes and targets			L1 primes and targets		
	Example	RT	% errors	Example	RT	% errors
Orthographic control	<i>foot</i> – <i>CORNER</i>	936	9.8	<i>dek</i> – <i>DAG</i>	724	4.8
Homophone	<i>hook</i> [<i>hoek</i>]– <i>CORNER</i>	880	12.3	<i>dij</i> [<i>day</i>]– <i>DAG</i>	731	3.8
Net priming effect		56	–2.5		–7	1.0

Note. Intermediate homophone translation equivalents are displayed between brackets; these words were not presented during the experiment.

primes (e.g., *thigh*, *day/new*), whereas the opposite was true for other triplets ($n = 12$, e.g., *time*, *tideltile*). This variable had no effect on overall RTs, $F_1(1, 21) = 2.23$, $MSE = 20,437$, $p > .15$; $F_2 < 1$. However, interestingly enough, this factor interacted with the prime type effect, $F_1(1, 21) = 4.46$, $MSE = 16,376$, $p < .05$; $F_2(1, 21) = 3.77$, $MSE = 7,767$, $p < .07$. The priming effect was 113 ms when the frequency of the target was lower than that of the primes, whereas the effect was -2 ms when the opposite was true. Planned comparisons showed that this first difference was significant in both the analysis by participants and analysis by items, $F_1(1, 21) = 4.80$, $MSE = 29,338$, $p < .05$; $F_2(1, 21) = 4.40$, $MSE = 7,766.72$, $p < .05$, whereas the second was not ($F_s < 1$). Note that this interaction effect of prime type and relative prime and target frequency is not a confounded effect of target frequency (i.e., a prime type effect for low frequent but not for high frequent targets). An analysis with this factor instead of the relative frequency factor yielded no significant results.

Discussion

As mentioned earlier, the present experiment was designed to find evidence (a) for prelexical phonological coding of L2 primes during L2 processing and (b) for language-independent semantic activation of phonological representations (i.e., does the prelexically assembled phonological representation of *hook*, /huk/, activate both its L1 and L2 meaning?). The significant 113-ms priming effect for intralingual translation equivalent homophones supports both statements. Hence, it is very likely that the prime *hook* was prelexically phonologically coded. This phonological representation (/huk/) activated both its L1 (*corner*) and L2 (*hook*) meaning. The former led to preactivation of the associated L2 lexical label for that meaning, which caused the prime effect observed. An important qualification to this line of reasoning concerns the fact this strong effect was only found when the L2 prime was more frequent than the L2 target. It is unclear whether this factor mainly influenced the degree of prelexical phonological coding of the L2 prime or the strength of the phonology (/huk/) to meaning (*corner*) mapping.⁴ For further theoretical implications of these findings, refer to the General Discussion.

Experiment 6

In Experiment 5, I investigated whether the phonological representation accessed by an L2 interlingual homophone prime (e.g., *hook*) activates both its L1 and L2 meanings. The design of the present experiment is identical, but again, the language of the primes and targets was switched. In this experiment, I explored whether it is possible to prime an L1 target (e.g., *dag*) with an L1 homophone (e.g., *dij* [*thigh*]) of the target's translation equivalent ([*day*]). Finding such an effect would imply that the phonological representation accessed by an L1 prime (e.g., *dij*) activates both its L1 ([*thigh*]) and L2 ([*day*]) meaning, even in an L1 monolingual task.

Method

Participants. The participants were 24 Dutch–English bilinguals. Mean age was 23.23 years ($SD = 6.44$). None of them had participated in one of the previous experiments. They belonged to the same population as, and had an L2 history similar to that of, the participants in Experiments

1–5. The participants were not told they were participating in an experiment about bilingualism. Mean self-reported general L1 and L2 proficiency on a 7-point scale was, respectively, 6.63 ($SD = 0.58$) and 3.63 ($SD = 0.82$).

Stimulus materials. The composition of the stimulus list was identical to that of Experiment 5, but language was switched. The stimuli consisted of 23 L1 (Dutch) word targets and 23 L1 nonword targets. All word targets were matched with two types of L1 nonword primes (see right part of Appendix E). The first type of primes were intralingual homophone intermediate translation primes, that is, L1 words (e.g., *bijl* [*axe*]) that have the same pronunciation as the L2 translation equivalent (e.g., *bail*) of the L1 target (e.g., *borg*). The second type of primes were L1 graphemic control primes, matched with the homophones analogue to the criteria and procedure described in the *Method* section of Experiment 1A. The resulting set of homophones and control primes were matched for word frequency (respectively, $M = 1.23$ and $M = 1.26$, $F < 1$) summated bigram frequency ($M = 21,900$ and $M = 21,288$, $F < 1$), neighborhood size ($M = 12.35$ and $M = 10.70$, $F < 1$), word length (identical), and orthographic overlap with the target. Care was also taken that no words were also existing words in English (L2). The 23 pronounceable L1 nonword targets satisfied the criteria mentioned above for the nonword target stimuli in Experiment 1. Mean log frequency per million of the L1 target words was 1.40 ($SD = 0.87$).

Procedure. The procedure was identical to that of Experiment 1. Each participant completed 56 trials. Twelve or 11 (counterbalanced over subjects) of the 23 word targets were preceded by a homophone intermediate translation prime. The other word targets were preceded by a control prime. Again, each participant received a different prime permutation. Across participants, all targets were displayed with the two types of primes. Again, the presence of (L2) primes in the experiment was not mentioned. The intermediate L1 translation equivalents (or any other L1 words) were not displayed during the experiment.

Results

The proportion of false responses was 7.1%. Again, these trials were excluded from all analyses. Mean RTs and proportion of correct trials as a function of prime type are presented in the right part of Table 6. A repeated measures ANOVA was performed with prime type (graphemic control vs. homophone of translation equivalent) as the only independent variable. The dependent variable was the mean RT across trials. In contrast with the previous experiment (L2 targets), the effect of prime type was far from significant ($F_s < 1$). Responses to L1 targets following an intra-

⁴ It could be argued that the strength of the mapping between /huk/ and the meaning *corner* is (at least partially) correlated with the frequency with which /huk/ occurs in a language to indicate the meaning *corner* (i.e. the mapping will be stronger for high frequent than for low frequent phonological representations). As /huk/ is used in Dutch to indicate the meaning *corner*, this would coincide with the Dutch spoken word frequency of /huk/. Because spoken word frequencies are not available for Dutch, written word frequencies of the corresponding words (*hoek* in this case) probably are good approximate measures (for the English CELEX, I calculated the correlation between available spoken and written word frequencies; this was .87, $p < .001$). Now, an analysis similar to the relative prime/target frequency analysis, including these frequencies instead, indicated that this variable did not influence the prime type effect at all and is, therefore, probably not responsible for the Prime Type \times Relative Frequency interaction. This suggests that this interaction effect observed is probably due to weaker activation of phonological representations in low frequent L2 primes. Of course, this line of reasoning is by no means a definite explanation for the issue at hand.

lingual homophone of its translation equivalent were even slightly slower than responses to control primes (respectively, 731 ms and 724 ms). Just as in the previous experiments, there was also no effect of prime type on the proportion of correct responses ($F_s < 1$).

In accordance with Experiment 5, I also ran the same analysis including the relative frequency of the target compared with the primes. In contrast with the previous experiment, this factor had no effect ($F_s < 1$ for all main and interaction effects). The prime type effect was -4 ms for targets with higher word frequency than their primes and -8 ms for targets with lower frequency.

Discussion

In contrast with Experiment 5, no effects were found of intralingual translation equivalent homophones on the processing of L1 targets. Given the large body of evidence supporting the claim of prelexical phonological coding of L1 words (see the introduction), it is unlikely that the absence of this effect is due to the fact that the L1 primes might not have activated their phonological representations. Instead, it is more probable that this was caused by the fact that the mapping from an ambiguous phonological code (e.g., /dei/) on its L2 meaning [*day*] is weaker than the mapping from phonology on L1 meaning [*thigh*]. For further theoretical implications of these findings, refer to the General Discussion.

General Discussion

During the last decade, a strong phonological model of monolingual word recognition has gained importance (e.g., Frost, 1998). In this model, it is assumed that words are coded phonologically before lexical access takes place. Recently, Brysbaert et al. (1999) showed that these processes generalize across languages in multilinguals. They found that L2 words are recognized faster if they are preceded by a masked L1 pseudohomophone prime. Van Wijnendaele and Brysbaert (2002) later replicated this effect with L1 targets and L2 primes. These findings offer strong evidence that L1 GPC rules are processed during L2 processing and vice versa (but see Jared & Kroll, 2001). The goal of this article was to further investigate phonological coding in bilinguals by extending the monolingual pseudohomophone priming effect (e.g., Perfetti & Bell, 1991) and the pseudohomophone associative priming effect (e.g., Lesch & Pollatsek, 1993) to a bilingual setting.

Experiments 1 and 2 yielded the strongest evidence for my claim. First (in Experiment 1A), I showed that the recognition of L2 words (e.g., *back*) is significantly facilitated by an L1 masked prime that is a pseudohomophone of its translation equivalent (e.g., *ruch* [*rug*]). This effect emerged irrespective of the presence of cognate stimuli in the materials (see Experiment 1B). Second (in Experiment 2A), I showed that the same applies for L1 targets (e.g., *touw*) and L2 pseudohomophone translation primes (e.g., *roap* [*rope*]; control prime *joll*). Again, this effect was also observed if the stimulus list did not contain cognates (see Experiment 2B). Because the primes in these experiments were only homophone to the translation equivalent according to GPC rules of the nontarget language, this strongly suggests that L1 GPC rules are active during L2 word recognition, and vice versa. This is in line with the respective studies of Brysbaert et al. (1999) and Van Wijnendaele and Brysbaert (2002). There was an indication of

asymmetry, however: A comparison between Experiments 1B and 2B showed that the priming effect from L1 to L2 was significantly stronger than the (still significant) priming effect from L2 to L1. Overall, these pseudohomophone translation effects are compatible with findings of Tan and Perfetti (1997; but see Zhou & Marslen-Wilson, 1999), who demonstrated that a Chinese target word can be primed with a homophone of a target synonym. If one starts from a strong nonselective view on lexical access in bilinguals (see earlier, Dijkstra & Van Heuven, 2002), there is not much difference between an intralingual synonym and a cross-language translation equivalent, in that they are both different lexical labels representing the same meaning.

These findings suggest that L2 phonology can influence L1 processing. Earlier, Jared and Kroll (2001) found that this was only the case if the participants read L2 words prior to the experiment. A possible explanation for this difference may lie in the fact that Jared & Kroll used a naming task, whereas this study used a lexical-decision task. Having to produce the stimulus word may slightly affect the degree of nonselective language processing relative to a task in which decisions can be made based on lexical activation alone. On the other hand, the fact that these effects were obtained with a lexical-decision task, which does not explicitly require phonology (and should therefore be less susceptible to phonological manipulations than a naming task), adds further support for the automaticity of these processes. Another possibility may be the similarity between the languages of the bilinguals. Dutch and English (this study) are two Germanic languages and have many more similarities (orthographic and phonological overlap, etc.) than English and French (Jared & Kroll, 2001), which is a Romance language. Also, there may be a difference in L2 proficiency of the participants of the two studies. However, this is hard to evaluate without a standardized test, and the bilinguals tested by Jared and Kroll were still quite fluent.

In Experiment 3, I replicated the above effect with L2 targets (e.g., *church*) and L1 pseudohomophone associative primes (e.g., *pous* [*paus-pope*]). This shows that the overlap between the concepts that the pseudohomophone and the target represent need not be complete (as is the case for translation equivalents) for the pseudohomophone priming effect to arise. Apparently, the activation in the L1 phonological representations is quite large, certainly large enough to spread to related concepts. This pseudohomophone associative priming effect was not significant with L1 targets (e.g., *been* [*leg*]) and L2 primes (e.g., *knea*). Possibly, the L2 pseudohomophones were phonologically coded (given the results of Van Wijnendaele & Brysbaert, 2002, and the current study, Experiment 2) to a certain extent, but these phonological representations were not activated strongly enough to preactivate their underlying semantic representations and/or related semantic representations and their corresponding L1 lexical entries. Alternatively, the results of Jared and Kroll (2001), who found that L2 phonology only influences L1 naming when L2 GPC rules have recently been active, suggest that the weakness of the effect here may be due to the low resting activation in the L2 phonological processing system.

Finally, in the last two experiments, I tried to find indications of cross-lingual phonological influences in a monolingual stimulus context. In Experiment 5, I found that the recognition of L2 words (e.g., *corner*) is facilitated by L2 homophones (e.g., *hook*) of their L1 translation equivalents (e.g., *hoek*). First, this shows that words

are also prelexically phonologically coded when reading in L2 (see also Brysbaert et al., 1999, Experiment 1). Second, this shows that ambiguous L2 phonological representations (interlingual homophones, e.g., /huk/) quickly activate all underlying semantic representations, even if they correspond to two different languages and are not related (e.g., [hook]–[corner]). In this case for instance, the phonological representation /huk/ activated its L1 meaning [corner], even though the experiment contained only L2 stimuli. However, it is important to note that the prime was only able to influence target recognition if it was more frequent than the target. In Experiment 6, I observed no significant effects: L1 targets (e.g., *dag*) were not processed faster if they were preceded by intralingual homophones (e.g., *dij*) of their L2 translations (*day*). Given the large body of evidence for prelexical phonological coding in L1 word recognition (see the introduction), the absence of an effect here is probably due to the fact that the mapping from an ambiguous phonological code (e.g., /dei/) on its L2 meaning ([*day*]) is much weaker than the mapping from phonology on L1 ([*thigh*]).

As noted in the beginning of this article, research on language-selective functioning of the bilingual language processing system has mainly focused on lexical representations (e.g., Dijkstra & Van Heuven, 2002). As a consequence, there is no model of bilingual phonological processing at present. It is clear from the present and previous research (Brysbaert et al., 1999; Jared & Kroll, 2001; Van Wijnendaele & Brysbaert, 2002) that any future model will have to be structurally language nonselective with regard to the activation of phonological representations, much in the way that the bilingual interactive activation plus (BIA+) model (Dijkstra & Van Heuven, 2002) is nonselective for lexical access. This model is an extension of the interactive activation model for monolingual word recognition (e.g., McClelland & Rumelhart, 1981), containing language, word, letter, and feature nodes. In the model, all L2 and L1 words are represented in a unitary word-level system. Lexical access during word recognition is initially nonselective, as word activation is affected by competing items from both languages. Because the model (unlike the earlier BIA model; e.g., Dijkstra et al., 1999) does not contain any top-down connections, effects of language context and stimulus list composition (e.g., Dijkstra et al., 2000) are dealt with at the task schema level, which only receives input from the (fundamentally language nonselective) word identification system.

More important for the present study, the sketch of the recent BIA+ model also contains semantic and phonological representations, although these have not yet been implemented and are essentially still black boxes. It will be very interesting to see whether this model will be able to cope with the results of this and previously mentioned studies, if the phonological subsystem is also conceived as being fundamentally nonselective and highly interactive with semantic and lexical representations. At present, probably the most important assumption that Dijkstra and Van Heuven (2002) have made with respect to this subsystem is the temporal delay assumption. This states that L2 phonological (and semantic) representations are delayed in activation relative to L1 codes. The present study provides some indirect evidence for this hypothesis. For instance, in the experiments without cognate stimuli (Experiments 1B and 2B), the cross-lingual pseudohomophone translation priming effect was stronger from L1 to L2 than from L2 to L1. Accordingly, cross-lingual pseudohomophone associative priming was found with L1 primes (Experiment 3) but not with L2

primes (Experiment 4). This may be because L2 primes need more time to cause the same amount of phonological (and following lexical/semantic) activation as L1 primes, because of the lower resting activation of L2 phonological/orthographic/semantic representations. Note that it may not only be the case that L1 phonological representations of the primes were activated faster. Because the targets in Experiments 1 and 3 were in the L2, responses to these targets were slower. Therefore, the L1 primes may have had more time to exert an influence on target recognition relative to L2 primes (L1 targets, eliciting faster responses). Experiments 5 and 6 can also be interpreted within the framework of the temporal delay assumption. Experiment 5 showed that ambiguous phonological representations (from interlingual homophones) always activate their L1 meaning, even during an L2 task, whereas there was no sign of those phonological representations activating their L2 meaning in an L1 task (Experiment 6). In accordance with the temporal delay assumption, this may be due to the fact that L2 semantic representations were not activated as fast and as strongly as their L1 counterparts. Of course, this is only indirect evidence, and future modeling and experimental work must further investigate the plausibility of this temporal delay assumption and its susceptibility to context effects. Indeed, the findings of Jared and Kroll (2001) suggest that the speed of L2 phonological processing and its impact on L1 processing may be very sensitive to recent use of L2 (such as naming a block of L2 filler words).

Another interesting issue will be whether BIA+ will be able to account for cross-linguistic differences between studies. For instance, evidence for L2 phonological coding during L1 processing is less convincing for bilinguals whose two languages have different alphabets (see earlier, Gollan, Forster, & Frost, 1997; Kim & Davis, 2003; Zhou & Marslen-Wilson, 1999; but see Tan & Perfetti, 1997). This is consistent with the idea that in more form-related languages (such as Dutch and English), transfer of L1 knowledge (such as GPC rules) during L2 acquisition is easier because those languages contain many letter–sound combinations that are very similar (for a more detailed discussion of this issue, see Brysbaert, Van Wijnendaele, & Duyck, 2002).

Throughout this article, I have assumed semantic involvement in both the cross-lingual pseudohomophone associative and translation effects, following the accounts of the respective monolingual effects (e.g., Frost, 1998; Lesch & Pollatsek, 1993; Lukatela & Turvey, 1994a). For instance, the forward pseudohomophone translation effect was accounted for as follows: First, the L1 nonword prime accesses its phonological code. This activates the corresponding semantic representation, which in turn preactivates the corresponding L2 lexical entry for that meaning (causing the priming effect). The same line of reasoning applies for the backward pseudohomophone translation priming effect (L2 primes/L1 targets). For pseudohomophone associative priming (e.g., Experiment 3), one additional step is required: After semantic access, activation spreads to related concepts that share semantic features. Consequently, corresponding lexical entries of those related concepts are preactivated. Although this account of the observed effects seems very plausible, it is important to point out one alternative explanation. It is possible that the prelexically assembled phonological code does not activate semantic representations but rather the lexical entry that is associated with that phonological representation. Then, activation can be spread to translation equivalents (Experiments 1 and 2) or related words through strong

lexical links, without semantic involvement (see, e.g., the strong lexical links between L2 translation equivalents and L1 words in the model of bilingual language organization of Kroll & Stewart, 1994). Although my data do not enable this hypothesis to be ruled out with absolute certainty, I am inclined to situate the locus of the priming effects within the semantic system (like Lesch & Pollatsek, 1993; Lukatela & Turvey, 1994a) for a number of reasons. First, Lukatela and Turvey (1994a) showed that pseudohomophone associative primes (e.g., *tode*) are as effective as word primes (e.g., *toad*). This should not be the case if the associative priming effect occurs through lexical representations, because activation in the lexical entry should be larger when the lexical form is actually displayed than when it is only activated through phonological code. Similarly, in the homophone associative priming study of Lesch and Pollatsek (1993, see earlier), homophones of associated words (e.g., *beach*) were equally effective primes for targets (e.g., *nut*) as the associated words (e.g., *beech*) themselves. Second, the pseudohomophone translation priming effect found in Experiments 1A and 2A did not interact with the form overlap (cognate status) between the two translation equivalents involved. If these two words preactivate each other through lexical links, one would expect a larger effect for (near) cognates. Third, the hypothesis that phonology accesses orthography before meaning is not only counterintuitive but also not compatible with the speech primacy axiom, according to which the primary association formed during language acquisition is the connection between spoken words and meaning. In this view, written language is a secondary system, appended onto the already existing system (Frost, 1998, p. 74). Fourth, Lucas (2000) showed in a meta-analysis of 26 studies that semantic priming generally has an effect independent of association, which is nevertheless able to add an “associative boost” (Lucas, 2000, p. 618) to a semantic relation. Finally, if these effects are indeed semantically mediated, this suggests that mappings from L2 lexical representations onto meaning may be stronger than previously thought (e.g., in the model of Kroll & Stewart, 1994), which is in line with more recent research on this issue (for a detailed discussion, see Duyck & Brysbaert, 2002, 2004; Francis et al., 2003).

In conclusion, the present study provided evidence against a strong language selective view on phonological coding in bilinguals, in line with previous research from Brysbaert et al. (1999), Jared and Kroll (2001), and Van Wijnendaele and Brysbaert (2002). Using a masked priming paradigm, I showed that L2 words can be primed with L1 pseudohomophones of their translation equivalents, and vice versa. Also, I extended the pseudohomophone associative priming effect (Drieghe & Brysbaert, 2002; Lukatela & Turvey, 1994a) to L2 targets and L1 pseudohomophone associative primes. Finally, I found strong indications that interlingual homophones always activate their L1 meaning, even when performing a task in L2.

References

- Baayen, R., Piepenbrock, R., & Van Rijn, H. (1993). *The CELEX lexical database* [CD-ROM]. Philadelphia: University of Pennsylvania, Linguistic Data Consortium.
- Berent, I., & Perfetti, C. A. (1995). A rose is a REEZ: The two-cycles model of phonology assembly in reading English. *Psychological Review*, *102*, 146–184.
- Bovens, N., & Brysbaert, M. (1990). IBM-PC/XT/AT and PS/2 Turbo Pascal timing with extended resolution. *Behavior Research Methods, Instruments & Computers*, *22*, 332–334.
- Brysbaert, M., Van Dyck, G., & Van De Poel, M. (1999). Visual word recognition in bilinguals: Evidence from masked phonological priming. *Journal of Experimental Psychology: Human Perception and Performance*, *25*, 137–148.
- Brysbaert, M., Van Wijnendaele, I., & Duyck, W. (2002). On the temporal delay assumption and the impact of non-linguistic context effects. *Bilingualism: Language and Cognition*, *5*, 199–201.
- Brysbaert, M., Vitu, F., & Schroyens, W. (1996). The right visual field advantage and the optimal viewing position effect: On the relation between foveal and parafoveal word recognition. *Neuropsychology*, *10*, 385–395.
- Carreiras, M., & Perea, M. (2002). Masked priming effects with syllabic neighbors in a lexical decision task. *Journal of Experimental Psychology: Human Perception and Performance*, *28*, 1228–1242.
- Coltheart, M. (1978). Lexical access in simple reading tasks. In G. Underwood (Ed.), *Strategies of information processing* (pp. 151–216). London: Academic Press.
- Coltheart, M., Rastle, K., Perry, C., Langdon, R., & Ziegler, J. (2001). DRC: A dual route cascaded model of visual word recognition and reading aloud. *Psychological Review*, *108*, 204–256.
- Dijkstra, T., & Van Heuven, W. (2002). The architecture of the bilingual word recognition system: From identification to decision. *Bilingualism: Language and Cognition*, *5*, 175–197.
- Dijkstra, T., Grainger, J., & Van Heuven, W. J. B. (1999). Recognition of cognates and interlingual homographs: The neglected role of phonology. *Journal of Memory and Language*, *41*, 496–518.
- Dijkstra, T., Timmermans, M., & Schriefers, H. (2000). On being blinded by your other language: Effects of task demands on interlingual homograph recognition. *Journal of Memory and Language*, *42*, 445–464.
- Drieghe, D., & Brysbaert, M. (2002). Strategic effects in associative priming with words, homophones, and pseudohomophones. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *28*, 951–961.
- Duyck, W., & Brysbaert, M. (2002). What number translation studies can teach us about the lexico-semantic organisation in bilinguals. *Psychologica Belgica*, *42*, 151–175.
- Duyck, W., & Brysbaert, M. (2004). Forward and backward number translation requires conceptual mediation in both balanced and unbalanced bilinguals. *Journal of Experimental Psychology: Human Perception and Performance*, *30*, 889–906.
- Duyck, W., Desmet, T., Verbeke, L. P. C., & Brysbaert, M. (2004). Wordgen: A tool for word selection and nonword generation in Dutch, English, German, and French. *Behavior Research Methods, Instruments & Computers*, *36*, 488–499.
- Duyck, W., Diependaele, K., Drieghe, D., & Brysbaert, M. (2004). The size of the cross-lingual masked phonological priming effect does not depend on second language proficiency. *Experimental Psychology*, *51*(2), 1–9.
- Ferrand, L., & Grainger, J. (1992). Phonology and orthography in visual word recognition: Evidence from masked nonword priming. *Quarterly Journal of Experimental Psychology Section A: Human Experimental Psychology*, *45*, 353–372.
- Ferrand, L., & Grainger, J. (1993). The time-course of orthographic and phonological code activation in the early phases of visual word recognition. *Bulletin of the Psychonomic Society*, *31*, 119–122.
- Francis, W. S., Augustini, B. K., & Saenz, S. P. (2003). Repetition priming in picture naming and translation depends on shared processes and their difficulty: Evidence from Spanish–English bilinguals. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *29*, 1283–1297.
- Frost, R. (1998). Toward a strong phonological theory of visual word

- recognition: True issues and false trails. *Psychological Bulletin*, *123*, 71–99.
- Frost, R., Ahissar, M., Gotesman, R., & Tayeb, S. (2003). Are phonological effects fragile? The effect of luminance and exposure duration on form priming and phonological priming. *Journal of Memory and Language*, *48*, 346–378.
- Gollan, T. H., Forster, K. I., & Frost, R. (1997). Translation priming with different scripts: Masked priming with cognates and noncognates in Hebrew–English bilinguals. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *23*, 1122–1139.
- Grainger, J., & Ferrand, L. (1996). Masked orthographic and phonological priming in visual word recognition and naming: Cross-task comparisons. *Journal of Memory and Language*, *35*, 623–647.
- Grosjean, F. (1998). Studying bilinguals: Methodological and conceptual issues. *Bilingualism: Language and Cognition*, *1*, 131–149.
- Grosjean, F. (2000). The bilingual's language modes. In J. L. Nicol (Ed.), *One mind, two languages: Bilingual language processing* (pp. 1–22). Oxford, England: Blackwell Publishing.
- Humphreys, G. W., Evett, L. J., & Taylor, D. E. (1982). Automatic phonological priming in visual word recognition. *Memory & Cognition*, *10*, 576–590.
- Jared, D., & Kroll, J. F. (2001). Do bilinguals activate phonological representations in one or both of their languages when naming words? *Journal of Memory and Language*, *44*, 2–31.
- Jared, D., & Szucs, C. (2002). Phonological activation in bilinguals: Evidence from interlingual homograph naming. *Bilingualism: Language and Cognition*, *5*, 225–239.
- Kim, J., & Davis, C. (2002). Using Korean to investigate phonological priming effects without the influence of orthography. *Language and Cognitive Processes*, *17*, 569–591.
- Kim, J., & Davis, C. (2003). Task effects in masked cross-script translation and phonological priming. *Journal of Memory and Language*, *49*, 484–499.
- Kroll, J. F., & Stewart, E. (1994). Category interference in translation and picture naming: Evidence for asymmetric connections between bilingual memory representations. *Journal of Memory and Language*, *33*, 149–174.
- Lesch, M. F., & Pollatsek, A. (1993). Automatic access of semantic information by phonological codes in visual word recognition. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *19*(2), 285–294.
- Lucas, M. (2000). Semantic priming without association: A meta-analytic review. *Psychonomic Bulletin & Review*, *7*, 618–630.
- Lukatela, G., Carello, C., Savic, M., Urošević, Z., & Turvey, M. T. (1999). When nonwords activate semantics better than words. *Cognition*, *69*, B31–B40.
- Lukatela, G., Frost, S. J., & Turvey, M. T. (1998). Phonological priming by masked nonword primes in the lexical decision task. *Journal of Memory and Language*, *39*, 666–683.
- Lukatela, G., Savic, M., Urošević, Z., & Turvey, M. T. (1997). Phonological ambiguity impairs identity priming in naming and lexical decision. *Journal of Memory and Language*, *36*, 360–381.
- Lukatela, G., & Turvey, M. T. (1994a). Visual lexical access is initially phonological: 1. Evidence from associative priming by words, homophones, and pseudohomophones. *Journal of Experimental Psychology: General*, *123*, 107–128.
- Lukatela, G., & Turvey, M. T. (1994b). Visual lexical access is initially phonological: 2. Evidence from phonological priming by homophones and pseudohomophones. *Journal of Experimental Psychology: General*, *123*, 331–353.
- McClelland, J. L., & Rumelhart, D. E. (1981). An interactive activation model of context effects in letter perception: 1. An account of basic findings. *Psychological Review*, *88*, 375–407.
- Nelson, D. L., McEvoy, C. L., & Schreiber, T. A. (2004). The University of South Florida free association, rhyme, and word fragment norms. *Behavior Research Methods, Instruments & Computers*, *36*, 402–407.
- Perea, M., & Lupker, S. J. (2003). Does judge activate court? Transposed-letter similarity effects in masked associative priming. *Memory & Cognition*, *31*, 829–841.
- Perfetti, C. A., & Bell, L. (1991). Phonemic activation during the first 40 ms of word identification: Evidence from backward-masking and priming. *Journal of Memory and Language*, *30*, 473–485.
- Rastle, K., Harrington, J., & Coltheart, M. (2002). 358,534 nonwords: The Arc Nonword Database. *Quarterly Journal of Experimental Psychology Section A: Human Experimental Psychology*, *55*, 1339–1362.
- Taft, M., & Van Graan, F. (1998). Lack of phonological mediation in a semantic categorization task. *Journal of Memory and Language*, *38*, 203–224.
- Tan, L. H., & Perfetti, C. A. (1997). Visual Chinese character recognition: Does phonological information mediate access to meaning? *Journal of Memory and Language*, *37*, 41–57.
- Van Hell, J. G., & Dijkstra, T. (2002). Foreign language knowledge can influence native language performance in exclusively native contexts. *Psychonomic Bulletin & Review*, *9*, 780–789.
- Van Wijnendaele, I., & Brysbaert, M. (2002). Visual word recognition in bilinguals: Phonological priming from the second to the first language. *Journal of Experimental Psychology: Human Perception and Performance*, *28*, 616–627.
- Zhou, X. L., & Marslen-Wilson, W. (1999). Phonology, orthography, and semantic activation in reading Chinese. *Journal of Memory and Language*, *41*, 579–606.

(Appendixes follow)

Appendix A

Stimuli Experiment 1: Second-Language Targets With Their Respective First-Language Pseudohomophone Translation Primes and Graphemic Control Primes

Noncognates				Cognates			
Target	Translation equivalent	Pseudohomophone translation prime	Graphemic control prime	Target	Translation equivalent	Pseudohomophone translation prime	Graphemic control prime
AXE	[bijl]	beil	keis	ABBEY	[abdi]	abdei	abrem
BACK	[rug]	ruch	gect	BRIDGE	[brug]	bruch	bromo
BUCKET	[emmer]	emmur	evaus	CAT	[kat]	kad	zas
CAR	[auto]	outo	bigi	CLAY	[klei]	klij	slis
CAVE	[grot]	grod	slo	COAST	[kust]	cust	cest
CHALK	[krijt]	kreit	kirie	COUGH	[kuch]	kug	gug
CHEESE	[kaas]	caas	cors	COW	[koe]	coe	cof
CHILD	[kind]	kint	siet	CRUST	[korst]	corst	carst
CITY	[stad]	stat	tont	DAY	[dag]	dach	dar
DOG	[hond]	hont	rors	DEED	[daad]	daat	dras
FORCE	[kracht]	kragt	wraki	EIGHT	[acht]	agt	ogt
FROG	[kikker]	kiccer	ijbaar	END	[eind]	eint	fing
GLUE	[lijm]	leim	lemp	FACT	[feit]	feid	flio
IRON	[ijzer]	eizer	wiber	GOAT	[geit]	gijt	grat
KING	[koning]	coning	daning	GREY	[grijs]	greis	grels
MARROW	[merg]	merch	merim	HELMET	[helm]	hellum	hellam
POPE	[paus]	paus	polm	ISLAND	[eiland]	eilant	gilang
RABBIT	[konijn]	konein	joelig	LIST	[list]	leist	luist
RIBBON	[lint]	lind	tins	MAID	[meid]	meit	slis
ROPE	[touw]	tauw	jijl	NIGHT	[nacht]	nagt	negt
SALT	[zout]	zaut	gamt	OLIVE	[olijf]	oleif	oleid
SNAIL	[slak]	slac	slau	PLEA	[pleit]	plijt	plilo
THIGH	[di]	dei	eri	PRIZE	[prijs]	preis	prein
TOOTH	[tand]	tant	trit	SALMON	[zalm]	zallum	tallim
WASTE	[afval]	affal	agdak	SAND	[zand]	zant	jora
WIFE	[vrouw]	vrauw	alauw	SEED	[zaad]	zaat	mong
WIRE	[draad]	draat	arton	TRAIN	[trein]	trijn	trion
WOOD	[hout]	haut	spib	WAY	[weg]	wech	wino

Note. Translation equivalents were not displayed during the experiment.

Appendix B

Stimuli Experiment 2: First-Language Targets With Their Respective Second-Language Pseudohomophone Translation Primes and Graphemic Control Primes

Noncognates				Cognates			
Target	Translation equivalent	Pseudohomophone translation prime	Graphemic control prime	Target	Translation equivalent	Pseudohomophone translation prime	Graphemic control prime
AUTO ^a	[car]	karr	yald	BOT	[bone]	boan	boly
BLAD	[leaf]	leav	larp	DIEF	[thief]	theef	preef
BOOM	[tree]	trea	vini	DROOM	[dream]	dreem	draim
DATUM	[date]	dait	dalt	EIK	[oak]	oack	lask
DOOLHOF	[maze]	maiz	suke	HOL	[hole]	hoal	hoil
GEVANG	[jail]	jail	zane	HUIS	[house]	howse	slask
GOLF	[wave]	waiv	shee	KAM	[comb]	kome	kimo
GRAP	[joke]	joak	wyam	KAP	[cape]	caip	jarp
GRIEP	[flue]	floo	thac	KLEI	[clay]	cley	blep
GROT	[cave]	caiv	flyn	KNIE	[knee]	knea	kned
JAS	[coat]	kote	bily	KRAAI	[crow]	croe	trym
KADER	[frame]	fraim	cralp	KRAAN	[crane]	crain	trawn
KIST	[crate]	crait	rexit	MAAT	[mate]	mait	mant
OORLOG	[war]	woar	shor	MELK	[milk]	mylk	mulk
PAD	[toad]	tode	fide	MUIS	[mouse]	mowse	moost
REM	[brake]	braik	cruso	NAAM	[name]	naim	nalm
ROOK	[smoke]	smoak	knolk	NEUS	[nose]	noze	nibe
SCHUIM	[foam]	fome	wamp	PIEK	[peek]	peec	peem
SLANG	[snake]	snaik	snabe	RIJ	[row]	wroe	prun
SLEUTEL	[key]	kea	jed	SCHAAP	[sheep]	sheap	sharp
SPEL	[game]	gaim	coxy	STEEN	[stone]	stoan	strun
TAART	[pie]	pye	gox	STOOM	[steam]	steem	starm
THUIS	[home]	hoam	hyll	TOON	[tone]	toan	toin
TOUW	[rope]	roap	joll	TREIN	[train]	trane	trune
VORM	[shape]	shaip	klegy	VLOER	[floor]	flore	plore
VROUW	[wife]	wyfe	wazz	WIJN	[wine]	wyne	wund
WINST	[gain]	gane	hend	WOORD	[word]	wurd	wrad
ZEEP	[soap]	sope	hape	ZOOL	[sole]	soal	roil

Note. Translation equivalents were not displayed during the experiment.

^a Excluded from analyses because this is an existing word in American English.

(Appendixes continue)

Appendix C

Stimuli Experiment 3: Second-Language (L2) Targets With Their Respective First-Language (L1) Pseudohomophone Associative Primes and Graphemic Control Primes

Target	Associated translation equivalents [L2–L1]	Pseudohomophone associative prime	Graphemic control prime	Target	Associated translation equivalents [L2–L1]	Pseudohomophone associative prime	Graphemic control prime
BEACH	[sand–zand]	zant	pani	MONEY	[price–prijs]	preis	krech
BIKE	[car–auto]	outo	jarp	MOUSE	[cheese–kaas]	caas	tars
BLACK	[grey–grijs]	greis	troet	NIGHT	[day–dag]	dach	jech
BOARD	[chalk–krijt]	kreit	grisp	NINE	[eight–acht]	agt	zad
BONE	[marrow–merg]	merch	verui	OIL	[olive–olijf]	oleif	oluit
BREAD	[crust–korst]	corst	horin	PATH	[road–weg]	wech	vich
BRUSH	[tooth–tand]	tant	geem	PEPPER	[salt–zout]	zaut	tuum
BUTLER	[maid–meid]	meit	gemt	QUEEN	[king–koning]	coning	ginant
CAT	[dog–hond]	hont	bost	RIVER	[bridge–brug]	bruch	truon
CHURCH	[pope–paus]	pous	zeun	SHEEP	[goat–geit]	gijt	muid
CORD	[wire–draad]	draat	drief	SLOW	[snail–slak]	slac	slir
DAY	[night–nacht]	nagt	vaur	SNEEZE	[cough–kuch]	kug	wup
DOG	[cat–kat]	kad	vid	SPINE	[back–rug]	ruch	koro
FIRE	[wood–hout]	haut	wolm	STRONG	[power–kracht]	kragt	hregt
HOLE	[cave–grot]	grod	apon	TRACK	[train–trein]	trijn	trome
HUSBAND	[wife–vrouw]	vrauw	praug	WHITE	[rabbit–konijn]	konein	ranuis
MILK	[cow–koe]	coe	eef	WIRE	[rope–touw]	tauw	pluw

Note. Associated translation equivalents were not displayed during the experiment. They are displayed here to illustrate the relation between the pseudohomophone associative prime and the target.

Appendix D

Stimuli Experiment 4: First-Language (L1) Targets With Their Respective Second-Language (L2) Pseudohomophone Associative Primes and Graphemic Control Primes

Target	Associated translation equivalents [L1–L2]	Pseudohomophone associative prime	Graphemic control prime	Target	Associated translation equivalents [L1–L2]	Pseudohomophone associative prime	Graphemic control prime
APPEL	[taart–pie]	pye	pue	MANTEL	[kap–cape]	caip	hasy
BEEN	[knie–knee]	knea	sned	OCEAAN	[golf–wave]	waiv	laky
BERG	[piek–peak]	peec	yees	PEDAAL	[rem–brake]	braik	scair
BIER	[wijn–wine]	wyne	vupe	PLAFOND	[vloer–floor]	flore	flost
BORSTEL	[kam–comb]	kome	zove	ROTS	[steen–stone]	stoan	stomi
CEL	[gevangenis–jail]	jale	hile	SCHOEN	[zool–sole]	soal	sorm
DRAAD	[touw–rope]	roap	reaf	SLAAP	[droom–dream]	dreem	midor
FOTO	[kader–frame]	fraim	furid	SPOOR	[trein–train]	trane	grent
GEZICHT	[neus–nose]	noze	caze	STAM	[boom–tree]	trea	tona
HEET	[stoom–steam]	steem	oteer	THUIS	[huis–house]	howse	hemsy
HOED	[jas–coat]	kote	fole	VERLIES	[winst–gain]	gane	mone
HOL	[grot–cave]	caiv	sepa	VREDE	[oorlog–war]	woar	plur
HUIS	[thuis–home]	hoam	hacy	VRIEND	[maat–mate]	mait	coit
KAT	[muis–mouse]	mowse	scoze	VUUR	[rook–smoke]	smoak	ebaga
KIKKER	[pad–toad]	tode	cune	WOL	[schaap–sheep]	sheap	vunge
KOE	[melk–milk]	mylk	zurk	ZEEP	[schuim–foam]	fome	dige
KOLOM	[rij–row]	wroe	apos	ZIEK	[griep–flu]	floo	turg
LACH	[grap–joke]	joak	piam	ZIN	[woord–word]	wurd	pulm

Note. Associated translation equivalents were not displayed during the experiment. They are displayed here to illustrate the relation between the pseudohomophone associative prime and the target.

Appendix E

Stimuli Experiment 5 and 6: Second-Language (L2) and First-Language (L1) Targets With Their Intralingual Homophones of Their Respective L1 and L2 Translation Equivalents and Graphemic Control Primes

Experiment 5 L2 targets and primes				Experiment 6 L1 targets and primes			
L2 target	L1 translation equivalent	L2 homophone prime	L2 graphemic control prime	L1 target	L2 translation equivalent	L1 homophone prime	L1 graphemic control prime
ARROW	[pijl]	pale	camp	AAS	[ace]	ijs	les
AXE	[bijl]	bail	cart	BAAI	[bay]	bij	bil
BEE	[bij]	bay	bow	BAAS	[boss]	bos	bes
CHALK	[krijt]	crate	candy	BORG	[bail]	bijl	beek
CORNER	[hoek]	hook	foot	DAG	[day]	dij	dek
CORPSE	[lijk]	lake	bite	DIJ	[thigh]	taai	Klei
COURAGE	[moed]	mood	book	HAAK	[hook]	hoek	Heks
FACT	[feit]	fate	fast	HOOI	[hay]	hei	Hik
GLUE	[lijm]	lame	lobe	HUMEUR	[mood]	moed	Melk
GOLD	[goud]	goat	gone	KAMER	[room]	roem	Riem
JOURNEY	[reis]	raise	rifle	KLOP	[knock]	nok	Wok
LEAK	[lek]	lack	lark	LOF	[praise]	prijs	Maand
LINE	[lijn]	lane	lone	LUS	[loop]	loep	Lijm
MILE	[mijl]	male	mule	MEER	[lake]	lijk	Zout
PLEA	[pleit]	plate	plane	PLAAT	[plate]	pleit	Plint
PRICE	[prijs]	praise	priest	POORT	[gate]	geit	kant
ROW	[rij]	ray	rub	PROOI	[prey]	prei	prik
SCREW	[vijs]	vase	fuse	RUVAK	[lane]	lijn	tijd
SONG	[lied]	lead	pick	RUIMTE	[space]	spijs	klink
SQUARE	[plein]	plane	whale	STAAL	[steel]	stiel	stijl
THIGH	[dij]	day	new	STAART	[tail]	teil	toog
TIME	[tijd]	tide	tile	STRAAL	[ray]	rij	ruk
TRAIT	[trek]	track	trace	WEG	[way]	wei	web

Note. Intermediate translation equivalents were not displayed during the experiment. They are displayed here to illustrate the relation between the intralingual (homophone of the translation equivalent) prime and the target.

Received January 22, 2004
Revision received May 19, 2005
Accepted May 25, 2005 ■