Translation Priming With Different Scripts: Masked Priming With Cognates and Noncognates in Hebrew–English Bilinguals

Tamar H. Gollan and Kenneth I. Forster
University of Arizona

Ram Frost
The Hebrew University

Hebrew–English cognates (translations similar in meaning and form) and noncognates (translations similar in meaning only) were examined in masked translation priming. Enhanced priming for cognates was found with L1 (dominant language) primes, but unlike previous results, it was not found with L2 (nondominant language) primes. Priming was also obtained for noncognates, whereas previous studies showed unstable effects for such stimuli. The authors interpret the results in a dual-lexicon model by suggesting that (a) both orthographic and phonological overlap are needed to establish shared lexical entries for cognates (and hence also symmetric cognate priming), and (b) script differences facilitate rapid access by providing a cue to the lexical processor that directs access to the proper lexicon, thus producing stable noncognate priming. The asymmetrical cognate effect obtained with different scripts may be attributed to an overreliance on phonology in L2 reading.

One of the aims of bilingual research is to characterize the nature of the connections between the lexical systems in the two languages. A number of techniques have been used to assess the nature of these connections, for example, cross-language priming, translation, picture naming, word naming, fragment completion, cross-language Stroop tasks, and free recall of blocked and mixed word lists (de Groot, 1992; Smith, 1991; de Groot & Nas, 1991; Kroll & Stewart, 1994; MacLeod, 1976; Scarborough, Gerard, & Cortese, 1984; Schwanenflugel & Rey, 1986; Tzelgov, Henik, & Leiser, 1990). Most of these studies have suggested that the languages of the bilingual are represented separately at the level of lexical form and yet are observably interconnected at a conceptual level (de Groot, 1993; Kroll, 1993). However, debates about the nature of bilingual lexical access continue, and the data that speak to these questions have sometimes been conflicting. For example, cross-language repetition priming techniques have in some cases failed to reveal any cross-language facilitation (e.g., Kirsner, Brown, Abrol, Chadha, & Sharma, 1980; Scarborough et al., 1984), whereas others have obtained cross-language priming but have found that it is weaker than within-language priming (Grainger & Beauvillain, 1988). A number of studies have shown that cross-language facilitation is obtained when the stimulus onset asynchrony (SOA) between prime and target is extremely short (i.e., less than 300 ms; Altarriba, 1992; Chen & Ng, 1989; Jin, 1990; Schwanenflugel & Rey, 1986) or when words across languages are related orthographically and phonologically (de Groot & Nas, 1991; Kirsner, Kirsner, & Milech, 1986; Garcia-Albea, Sanchez-Casas, Bradley, & Forster, 1985; Sanchez-Casas, Davis, & Garcia-Albea, 1992).

Several authors have cautioned that experimental techniques thought to implicate bilingual lexical organization may be influenced by variables that do not reflect automatic processing mechanisms. For example, Kirsner, Smith, Lockhart, King, and Jain (1984) showed that cross-language repetition priming could be obtained only when the bilinguals were encouraged to translate during the first presentation of words. Such facilitation might be accounted for by reactivation of an episodic memory trace of the translated version of the prime. That is, the initial exposure to the prime lays down an episodic trace that may or may not be available for conscious report. Reactivation of this episodic trace by the target stimulus could be the source of the facilitation rather than reactivation of a shared bilingual lexical representation per se (see Forster, 1985, and Forster & Davis, 1984, for a more detailed discussion of episodic contributions to results in nonmasked-priming experiments). Thus, it seems more accurate to interpret this effect as evidence for within-language priming rather than as evidence for cross-language priming.

Influence from nonautomatic or strategic processing seems particularly plausible when the bilingual nature of the task is apparent. Some evidence suggesting that cross-language facilitation can be strategic in nature is the fact that the proportion of related pairs appears to determine whether priming is obtained (Keatley, Spinks, & de Gelder, 1994). If priming is dependent on the presence of a high number of related cross-language pairs, then the effect might merely be demonstrating the bilingual's ability to strategically connect one language with the other rather than reflecting the organization of the lexical system. In fact, it has been suggested that bilinguals may have different (but overlap-
Two languages are required or in which only one language is required. Which system is activated, and when, may depend on whether the context of the experiment (or the environment) implies that more than one language is involved (Grosjean & Miller, 1994).

One way to minimize strategic factors is to use a masked priming paradigm in which the prime cannot be identified. In the masked-priming paradigm adopted by Forster and Davis (1984), a forward mask (e.g., either a dummy word or a pattern mask such as nine number signs, i.e., #######) is presented for 500 ms, followed by the prime for 50 ms, and then the target is presented for 500 ms. To distinguish the prime and the target stimulus as two physically distinct events, the primes are presented in lowercase letters and targets are presented in uppercase. Because of the combined effects of the forward-pattern mask and the backward-masking effect of the target stimulus, the prime cannot be identified, and even when directed to try to identify the prime, participants are unable to perform above chance in deciding whether it was a word or not (although they do slightly better than chance at guessing whether it differed from the target or not; Forster & Davis, 1984; Forster, Davis, Schoknecht, & Carter, 1987). It therefore seems unlikely that any episodic memory trace of the prime is formed, and it can be assumed that priming effects are more likely to reflect automatic processes rather than strategic processes.

Studies using the masked priming technique to investigate bilingual priming have consistently found that cognates show priming effects. Cognates are translation-equivalent words that also share phonological and orthographic properties across languages. In contrast, translation-equivalent words that do not overlap in form (noncognates) show no, or significantly reduced, priming (de Groot & Nas, 1991; Garcia-Albea et al., 1985; Sanchez-Casas et al., 1992). In some cases, cognate priming across languages is as strong as it is within-language; for example, rico, the Spanish word for rich, primed the English word rich as strongly as the within-language identity prime rich (Garcia-Albea et al., 1985; Sanchez-Casas et al., 1992). No such effect was obtained, however, for translation-equivalent terms that are not cognates (e.g., mujer and woman).

Cognate words overlap in form, and it is therefore possible that enhanced priming for cognates is the result of form-related priming rather than translation priming per se. If this were the case, then even monolinguals might show similar priming effects. This hypothesis, however, has been rejected (a) because it has been shown that monolinguals in fact do not benefit from the form overlap (e.g., rico–RICH; Garcia-Albea et al., 1985) and (b) also because bilinguals similarly do not benefit from one-letter-different nonword primes (e.g., rict–RICH or rict–RICO; Sanchez-Casas et al., 1992). Further, the size of the priming effect does not interact with the degree of form similarity between cognates (e.g., rico–RICH vs. torre–TOWER), again suggesting that orthographic overlap is not the sole factor that produces the cognate effect.

This study was designed to address whether the cognate effect may be purely phonological or whether it is the joint effect of overlap in both orthography and phonology that is crucial. There is some evidence to suggest that phonological effects in visual word recognition arise only when there is joint similarity in both orthography and phonology (e.g., Coltheart, Patterson, & Leahy, 1994), and this may provide an important clue to the nature of the access mechanism. One way to examine this issue is to eliminate orthographic overlap by using languages with completely different scripts. This procedure was followed in the present study, which used Hebrew–English cognates that overlap in phonological form and meaning but not in orthographic form because the Hebrew script bears no relationship at all in visual form to the roman script used in English. If Hebrew–English bilinguals also show stronger priming for cognates than for noncognates, then it can be inferred that orthography plays no role in producing the cognate effect. This result would, of course, be predicted from the view that visual word recognition is mediated exclusively by phonological representations (Luksatela, Carello, & Turvey, 1990; Luksatela & Turvey, 1990a, 1990b).

To test for a cognate–noncognate difference in a Hebrew–English experiment, it is necessary to use words that are perhaps more accurately called "loan words," because many cognates are actually borrowed from English. Hebrew is historically unique because it was revived as a spoken language early in the 20th century after having been used solely for religious purposes for hundreds of years. For this reason, the language lacked many lexical items for modern terminology. Although some modern words were created by adapting a Hebrew root morphologically, many modern words were simply borrowed from English (e.g., the Hebrew word for television is televizya). Nonetheless, these words are entirely integrated into the language and are used in both informal and formal settings (e.g., they are printed in newspapers and are spoken by newscasters on television and radio). In fact, Hebrew–English bilinguals who learn both languages at the same time may easily acquire the borrowed words in the context of Hebrew before they learn that the English translation is very similar. In contrast to the borrowed Hebrew–English cognates, Spanish–English and Dutch–English cognates share a common root for historical reasons and, as a result, are similar in both phonological and orthographic form (e.g., rico–RICH).

As can be seen in Figure 1, there is no overlap between the Hebrew and English orthographies. Although they are both alphabetic scripts, they differ in many ways: The characters are visually quite distinct, and there is no one-to-one correspondence between them. In addition, Hebrew is written from right to left, and most vowel information is actually omitted from written words. The vowel information is sometimes written under the letters in the form of diacritical marks (points and dashes), though these usually appear only in children's texts, prayer books, and poetry (Frost & Bentin, 1992).

In Experiments 1 and 2 we tested bilinguals in an L1 (the dominant language), an L2 (the nondominant language), and a cross-language condition that contained L1 primes and L2 targets. In Experiment 1 we tested Hebrew-dominant bilinguals, and in Experiment 2 we tested English-dominant
Finally, if the differences between cognates and noncognates in cross-language priming are to be attributed to the nature of the connections between words across languages, it is necessary to first establish that cognates and noncognates are comparable in a within-language priming setting. Hebrew cognates (or loan words) differ from other Hebrew words in that they are not composed of productive morphological roots. For this reason Hebrew cognates tend to be longer and often contain more consonantal vowels (which are roughly analogous to the consonant–vowel y in English).

Within-language data from the H-H list allowed comparison of Hebrew cognate targets with Hebrew noncognate targets, thus revealing any possible differences in the magnitude of priming effects. To control for any unusual characteristics that cognates written in Hebrew characters might have, we constructed half of the nonwords in each of the two sets with Hebrew targets by changing two letters of cognate words that were not used in the word-item sets. The rest of the nonwords in all three sets were constructed by changing two letters of noncognate items that were not used in the word-item sets.

Experiment 1: Priming From L1 to L2 in Hebrew-Dominant Bilinguals

Method

Participants. Forty Hebrew-dominant Hebrew–English bilingual undergraduates at The Hebrew University in Jerusalem received course credit or were paid for their participation in the study. Participants reported having been exposed to both languages either at home or at school (or both) from an early age. They completed a language-history questionnaire in which they specified their dominant language. Self-reported language dominance was corroborated with dominance in reaction times and error rates from the within-language lexical-decision data in Hebrew and in English (i.e., those who were considered Hebrew-dominant had faster reaction times and lower error rates on lexical decision in Hebrew, whereas the data showed the opposite pattern for the English-dominants in Experiment 2). ¹

Materials and design. Three lists of items were used. Each list contained 64 words and 64 nonwords. One of the lists was a cross-language list consisting of Hebrew primes followed by English targets (H-E). The other two lists were within-language lists, one containing Hebrew primes followed by Hebrew targets (H-H) and the other containing English primes followed by English targets (E-E). Within each list, all primes were in the same language, and all targets were in the same language. To mimic the switch from lowercase primes to uppercase targets normally used with masked priming in English, we used a cursive font for the Hebrew primes and a print font for the Hebrew targets in the H-H list. Figure 2 shows the cursive characters compared with the printed characters. It can be seen that the majority of the letters are quite different in visual form across script. Because each participant was tested on all three lists, the list order was rotated in a Latin

¹There were only three cases throughout the experiments reported in this article in which self-reported dominance did not accurately predict the relative performance in lexical decision for L1 and L2. In these cases priority was given to the objective measure.
square design that controlled for position effects such that each list was presented in every position (first, second, and third) an equal number of times.

The word lists consisted of cognates and noncognate translation equivalents that were comparable as far as possible in length (although Hebrew words tend to be shorter because the vowels are omitted) and in frequency (i.e., the frequencies of the English translations of Hebrew targets were roughly matched according to the norms provided by Kučera and Francis, 1967). Each set of 64 target words consisted of 32 cognates and 32 noncognate translations. The average frequency count of the targets in the E-E list was 15.4 (SD = 28.8) for cognates and 18.5 (SD = 28.9) for noncognates; the estimated frequency in the H-H list was 23.0 (SD = 40.6) for cognates and 18.9 (SD = 33.4) for noncognates; and in the H-E list it was 19.5 (SD = 28.9) for cognates and 16.6 (SD = 24.4) for noncognates. For each of the lists two experimental versions were created so that a target preceded by a repetition (or translation) prime in one version was preceded by a frequency matched unrelated control prime in the other. Thus, each prime and each target was seen only once by each bilingual.

Table 1 shows an example of the stimuli used in each of the three lists. Each of the three blocked word lists consisted of four conditions with 16 items in each condition. The first condition, cognate repetition, had cognate targets preceded by identity primes (repetition primes for H-H and E-E, and translation primes for H-E); the second condition, cognate control, had the cognate targets preceded by unrelated primes; the third condition, noncognate repetition, had noncognate targets preceded by identity primes (again, repetition primes for H-H and E-E, and translation primes for H-E); and the fourth condition, noncognate control, had noncognate words preceded by unrelated control primes.

The nonwords for each list were constructed by changing two letters of words matched in length to the targets in that list. In the within-language lists, half of the nonword targets were preceded by the same nonword (to test if nonwords show identity priming), and the other half of the nonword targets were preceded by an unrelated control word. Thus, the lexicality of the target was not predictable on the basis of the lexicality of the prime. In the cross-language lists all of the primes were words (for both word and nonword targets). The nonwords were preceded by the translation of the word that had been used to create the nonword. Thus, form priming was tested in H-H and E-E but not in the cross-language lists. For example, the Hebrew word for obsession is obsession. From obsession the nonword ogsetya was created and presented in Hebrew characters in the list E-H. This nonword was preceded by obsession written in roman characters. This was the case both for cognate-based nonwords (e.g., the prime obsession presented in roman characters followed by the nonword-target ogsetya presented in Hebrew characters) and for noncognate-based nonwords (e.g., the prime anthem presented in roman characters followed by the nonword-target timmol also presented in Hebrew characters).

Procedure and apparatus. Items were presented on a computer-controlled video display by using the DMASTR software, developed by K. I. Forster and J. C. Forster at the University of Arizona, which synchronizes the timing of the display with the position of the video raster. (Information about DMASTR software can be accessed at the following World Wide Web site: http://u.arizona.edu/~kforsteT/dmastr). Items were centered on the screen. Each item was preceded by a forward-masking stimulus that was presented.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Control prime</th>
<th>Repetition/translation prime</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>E-E</td>
<td>rodent</td>
<td>bunker</td>
<td>BUNKER</td>
</tr>
<tr>
<td>H-H</td>
<td>בירקית (biruyim)</td>
<td>piprami (piramida)</td>
<td>הירקית (piramida)</td>
</tr>
<tr>
<td>H-E</td>
<td>ג'יר (giriz)</td>
<td>&quot;feelter&quot;</td>
<td>FILTER</td>
</tr>
<tr>
<td>E-E</td>
<td>planet</td>
<td>desert</td>
<td>DESERT</td>
</tr>
<tr>
<td>H-H</td>
<td>כדור (kaftor)</td>
<td>&quot;eshkolit&quot;</td>
<td>תטוס (eshkolit)</td>
</tr>
<tr>
<td>H-E</td>
<td>פאפה (sigatil)</td>
<td>&quot;grapefruit&quot;</td>
<td>CASTLE</td>
</tr>
</tbody>
</table>

Note. The actual experimental stimuli were presented in Hebrew characters. Pronunciations are enclosed in parentheses. English translations appear in quotation marks. E = English; H = Hebrew.
for 500 ms (#########). The instructions indicated that this stimulus was a cue signaling that a word was about to appear. Immediately following the forward mask, primes appeared for 50 ms, and then the target appeared for 500 ms. At the completion of each trial, feedback was provided about speed and accuracy.

The bilinguals were tested one at a time in a dimly lit testing room and were instructed to press one response key with the right hand when they saw a word and to press another response key with the left hand when they saw a nonword. Sixteen practice items were presented at the beginning of each experiment so we could observe performance and encourage quick but accurate responses. A brief rest was provided after each of the three lists. After the experiment, each bilingual was questioned about any awareness of the prime.

A demonstration of the masked-priming conditions used in this experiment can be downloaded from the following web site: http://u.arizona.edu/~kforster/priming/gff.htm.

Results

Means and standard deviations of response times (RTs) for correct responses were calculated for each subject and for each item in each of the experimental conditions. All RTs more than two standard deviations above or below the mean for each participant were replaced with the appropriate cutoff value. Bilinguals who made more than 20% errors (averaged over conditions) were replaced. Separate analyses of variance (ANOVs) were calculated, one by using subject means ($F_1$) and the other by using item means ($F_2$). The analyses included three variables: group (participant groups in the subject analysis, item groups in the item analysis), cognate status (cognate translations vs. noncognate translations), and priming (related vs. unrelated). The first variable was introduced by the counterbalancing procedure, and it simply extracted any variance that was due to this procedure. This was a nonrepeated variable in both analyses (see Pollatsek & Well, 1995, for a discussion of the advantages of this commonly used procedure). The second variable was a repeated measures variable in the subject analysis but not in the item analysis, and the third variable was repeated in both analyses. The .05 level of significance was adopted throughout.

Awareness of primes. During the exit interview, participants were asked specifically if they ever noticed words in two languages being presented in rapid succession. All participants in Experiment 1 and in the experiments that follow (making a total of 140 participants) were surprised to learn of the presence of the cross-language primes and, in fact, had not noticed any primes in any of the lists. One participant reported noticing "something funny" and was replaced. Thus, although participants knew they were recruited for the experiment because of their knowledge of Hebrew and English, they did not know that one of the lists was activating both language systems simultaneously.

Within-language repetition priming. The upper section of Table 2 shows the results for the H-H and E-E lists. It can be seen that substantial repetition priming effects for word targets were obtained in both L1 and L2 but that the effects for nonword targets were negligible. These results confirm that masked priming can be obtained in Hebrew and, critically, that these bilinguals were sufficiently competent in English to be able to process and benefit from a 50-ms prime in their less dominant language (L2). The absence of priming for nonword targets confirms findings from earlier studies (e.g., Forster et al., 1987) and demonstrates that the priming is lexical in nature.

In the H-H (LI-L1) list, the 31-ms repetition priming averaged over cognates and noncognates for word targets was significant, $F_1(1,38) = 44.64, MSE = 856$; $F_2(1, 60) = 56.33, MSE = 483$, but there were no significant differences between control and repetition trials in the error analysis, $F_1(1,38) = 2.27, MSE = 42; F_2(1, 60) = 2.00, MSE = 39$. In the E-E (LI-L1) list, a 44-ms priming effect averaged over cognates and noncognates for word targets was observed, $F_1(1,38) = 88, MSE = 887; F_2(1, 60) = 53, MSE = 1,408$, and there was also a significant effect in the error analysis, $F_1(1,38) = 6.26, MSE = 44; F_2(1, 60) = 6.10, MSE = 37$. There were no significant within-language differences in the magnitude of priming effects between cognate and noncognates in L1 (H-H), $F_1(1, 38) < 1; F_2(1, 60) = 1.05, MSE = 484$; nor in L2 (E-E), both $F_1, F_2 < 1$, demonstrating that cognates have no special properties with respect to within-language priming. However, in the subject analysis, RTs to cognate targets were 11 ms slower than noncognates in L1 (H-H), $F_1(1,38) = 7.18, MSE = 691$; $F_2(1, 60) = 1.21, MSE = 3,461$. The errors analysis (H-H, L1) showed the opposite pattern with more errors to noncognate targets, suggesting a speed-accuracy trade-off, but again this difference was significant in the subjects analysis only, $F_1(1,38) = 6.8, MSE = 63; F_2(1, 60) = 2.60, MSE = 135$. In L2 (E-E), RTs to cognates were 36 ms slower, and this analysis was significant by both subjects and items, $F_1(1,38) = 66.90, MSE = 758; F_2(1, 60) = 7.62, MSE = 5,918$. The error pattern (E-E, L2) was in the same direction as the RT difference; there were more errors for cognate targets, but this time the difference was only significant by

<table>
<thead>
<tr>
<th>Target</th>
<th>Cognate</th>
<th>Noncognate</th>
<th>Nonword</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M$</td>
<td>$%$ error</td>
<td>$M$</td>
</tr>
<tr>
<td>LI-L1 (H-H)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Repetition</td>
<td>590</td>
<td>4.2</td>
<td>582</td>
</tr>
<tr>
<td>Control</td>
<td>624</td>
<td>5.9</td>
<td>610</td>
</tr>
<tr>
<td>Priming</td>
<td>34</td>
<td>1.6</td>
<td>28</td>
</tr>
<tr>
<td>LI-L2 (E-E)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Repetition</td>
<td>650</td>
<td>10.2</td>
<td>615</td>
</tr>
<tr>
<td>Control</td>
<td>695</td>
<td>13.0</td>
<td>659</td>
</tr>
<tr>
<td>Priming</td>
<td>45</td>
<td>2.8</td>
<td>44</td>
</tr>
</tbody>
</table>

Note. LI = dominant language; L2 = nondominant language; H = Hebrew; E = English.

aNonword targets not primed; see text.
subjects and not by items, $F_1(1, 38) = 8.21$, $MSE = 52$; $F_2(1, 60) = 1.77$, $MSE = 194$. Unexpectedly, when collapsed over cognates and noncognates, repetition priming was 13 ms weaker in Hebrew than it was in English, and this difference proved to be significant, $F_1(1, 38) = 4.76$, $MSE = 412$; $F_2(1, 124) = 6.36$, $MSE = 923$.

For nonword targets, there was no difference at all in RTs for the H-H list as a function of prime type, and for the E-E list, the effect was $-2$ ms ($F_1$, $F_2 < 1$). The error analysis showed that there was no significant effect in the H-H list ($F_1$, $F_2 < 1$), and in the E-E list, a trend toward an inhibitory effect was obtained, $F_1(1, 38) = 3.27$, $MSE = 33$, $p = .08$; $F_2(1, 62) = 3.70$, $MSE = 48$, $p = .06$.

**Translation priming.** The bottom of Table 2 shows the results in the cross-language list in which the prime was in Hebrew (L1) and the target was in English (L2). Significant facilitation effects were obtained across the two languages, and there is some indication of a special effect for cognates, because the translation priming effect for cognates (53 ms) was larger than priming for noncognates (36 ms). The overall priming effect (45 ms) was significant, $F_1(1, 38) = 49.44$, $MSE = 1,591$; $F_2(1, 52) = 76.71$, $MSE = 852$, with a significant effect in the error analysis as well, $F_1(1, 38) = 9.51$, $MSE = 84$; $F_2(1, 52) = 12.57$, $MSE = 51$. The interaction between cognate status and priming was in the expected direction, but although it was significant in the items analysis, $F_2(1, 60) = 5.90$, $MSE = 852$, it only approached significance in the subjects analysis, $F_1(1, 38) = 2.96$, $MSE = 1,076$, $p = .09$. Unlike the pattern seen with English targets in within-language priming, the RTs to cognate targets (collapsed over related and unrelated conditions) were 33 ms faster in this analysis, $F_1(1, 28) = 19.15$, $MSE = 1,656$, but this time the difference was significant only in the subjects analysis, $F_2(1, 60) = 2.51$, $MSE = 13,154$. Similarly, the analysis by errors showed fewer errors to cognate items, and the difference was significant by subjects, $F_1(1, 28) = 9.21$, $MSE = 78$, but not by items, $F_2(1, 60) = 1.98$, $MSE = 387$. In addition, the effect of translation priming for noncognates alone (36 ms) was significant both for RTs, $F_1(1, 38) = 17.05$, $MSE = 1,472$; $F_2(1, 30) = 18.27$, $MSE = 934$, and for the error analysis, $F_1(1, 38) = 8.00$, $MSE = 79$; $F_2(1, 30) = 8.36$, $MSE = 61$. No data are reported for nonword targets across language because obviously there are no translation-equivalent Hebrew–English nonwords.

**Discussion**

**Within-language repetition priming.** The purpose of the within-language priming conditions was to confirm that masked priming effects could be obtained in both L1 and L2. Significant repetition priming was obtained in the H-H list, indicating that the masked priming technique is effective in Hebrew. Further, priming for cognates written in Hebrew characters did not differ from priming effects for noncognates written in Hebrew characters, demonstrating that these stimuli have no special status with respect to reaction times or priming within Hebrew (H-H). The same pattern was shown for English; cognates and noncognates showed the same amount of priming within-language. Because significant priming was obtained in the E-E list, these results establish that the Hebrew-dominant bilinguals were able to process rapidly presented English primes. It is interesting that there was some indication that cognate targets were more difficult to process in English (L2), with RTs for cognates (collapsed over related and unrelated conditions) being 36 ms slower than RTs for noncognates, possibly suggesting that for these bilinguals cognate terms, which are actually borrowed from English, are really considered as Hebrew (L1) words. However, further discussion of this possibility is postponed until the results from later experiments are presented. There were no priming effects observed for nonword targets. Finally, repetition priming was weaker in Hebrew than in English, perhaps either because of language dominance or because of a unique characteristic of priming in Hebrew.

**Translation priming.** Stronger priming for cognates than for noncognates was obtained, but the effect was significant in the items analysis only. This pattern of results is unusual in language research, in which treatment-by-items variance is usually larger than treatment-by-subjects variance, and hence it is usually the item analysis that fails to reach significance. The implication is that more priming was observed for cognates than for noncognates but only for a limited subset of the bilinguals. It may be that in the absence of orthographic overlap, a robust enhanced priming effect for cognates will only be obtained with certain types of bilinguals.

Part of the reason for the absence of any clear difference between priming for cognates and noncognates is the fact that strong translation priming (36 ms) was obtained for noncognates. Previous studies have shown either no priming or weak priming in this condition (de Groot & Nas, 1991; Garcia-Albea et al., 1985; Sanchez-Casas et al., 1992). This finding is of considerable interest and may be linked to the fact that different scripts were used in the two languages.

It should be noted that the existence of any cross-language priming effects with Hebrew and English is especially impressive because Hebrew is read right to left and English is read left to right. The “set” would be the direction of reading appropriate for the target (within a list, all targets were either Hebrew or English), but evidently the processing direction can be reversed for the prime despite the fact that the participant is unaware of its existence. This implies that the direction of reading must be controlled purely by the nature of the script itself. Otherwise, in an H-E list, where the targets are read left to right, precious time would be wasted in attempting to process the masked Hebrew prime stimulus from left to right, and this would reduce the possibility of priming.

Finally, the results of the exit interview confirmed that the use of different scripts did not make the prime more accessible to awareness than in previous applications of this technique. Of course, this is not to say that a more careful assessment by using a forced-choice testing procedure might not reveal slightly better-than-chance detection performance (e.g., was the prime in Hebrew or English?). However, it is not clear whether this would necessarily establish linguistic awareness as opposed to visual awareness, because it might be possible to base a Hebrew–English judgment on very
fragmentary perceptual information, without any awareness at all of the linguistic properties of the prime.

In the next experiment, a group of English-dominant Hebrew–English bilinguals was tested in the same conditions (i.e., L1-L1, L2-L2, and L1-L2) to confirm that the same pattern of results would be obtained regardless of the target language.

**Experiment 2: Priming From L1 to L2 in English-Dominant Bilinguals**

In this experiment, a group of English-dominant bilinguals was tested on the same three lists used in Experiment 1, except that the primes and the targets from the cross-language list were reversed to maintain the L1-L2 prime-to-target relationship.

**Method**

**Participants.** A group of 30 English-dominant Hebrew–English bilinguals was recruited, all of whom were native English speakers, and all of whom had been exposed to both languages either at home or at school (or both) from an early age. These bilinguals either volunteered or were paid for their participation in the study. Some were American undergraduates studying for 1 year at The Hebrew University in Jerusalem; some had moved to live in Israel permanently within the past few years; and some were American teachers of Hebrew who had lived in the United States for most of their lives. Each bilingual completed a language-dominance questionnaire, and once again (as in Experiment 1) their self-reported dominance was corroborated with dominance in RTs and error rates from within-language lexical decision in both Hebrew and English.

**Materials and design.** The materials were the same as in Experiment 1, except that the cross-language list H-E was switched with a new list E-H. To create the list E-H we simply reversed the primes from H-E such that the primes that were presented in H-E became the targets for E-H and vice-versa. Thus, because these bilinguals were English dominant, the primes in the cross-language list were in L1 (E) and the targets were in L2 (H).

**Procedure.** This was identical to the procedure used in Experiment 1.

**Results**

Two items had to be eliminated from the analysis of the list with Hebrew targets because of spelling ambiguity (some cognates may be spelled in more than one way, and these stimuli generated close to 50% errors). To maintain equal numbers of items in each condition, we eliminated an additional two items from each condition (items with high error rates were chosen on the assumption that these items may not have been familiar to this group). The H-H list was left with 14 items in each condition (however, the elimination of these items did not significantly change the results in terms of effect size or pattern). Bilinguals with more than 25% errors (averaged over conditions) were replaced.

**Within-language repetition priming.** The upper section of Table 3 shows the results in the within-language lists (E-E, H-H). Significant priming for word targets (47 ms) was obtained in L1 (E-E), \( F(1, 28) = 54.79, MSE = 1.164; \)

<table>
<thead>
<tr>
<th>Condition</th>
<th>Cognate</th>
<th>Noncognate</th>
<th>Nonword</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>L1-L1 (E-E)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Repetition</td>
<td>634</td>
<td>5.6</td>
<td>590</td>
</tr>
<tr>
<td>Control</td>
<td>675</td>
<td>8.2</td>
<td>642</td>
</tr>
<tr>
<td>Priming</td>
<td>41</td>
<td>2.9</td>
<td>52</td>
</tr>
<tr>
<td><strong>L2-L2 (H-H)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Repetition</td>
<td>996</td>
<td>18.3</td>
<td>976</td>
</tr>
<tr>
<td>Control</td>
<td>1,028</td>
<td>16.4</td>
<td>1,018</td>
</tr>
<tr>
<td>Priming</td>
<td>32</td>
<td>-1.9</td>
<td>42</td>
</tr>
<tr>
<td><strong>L1-L2 (E-H)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Translation</td>
<td>863</td>
<td>11.9</td>
<td>927</td>
</tr>
<tr>
<td>Control</td>
<td>1,005</td>
<td>24.5</td>
<td>979</td>
</tr>
<tr>
<td>Priming</td>
<td>142</td>
<td>12.6</td>
<td>52</td>
</tr>
</tbody>
</table>

*Note. L1 = dominant language; L2 = nondominant language; H = Hebrew; E = English.

F(1, 28) = 57.32, MSE = 1.359, and there were also fewer errors in the related condition, \( F_{1}(1, 38) = 4.11, MSE = 50; \) \( F_{2}(1, 60) = 6.61, MSE = 33. \) Significant priming was also obtained for the L2 (H-H) list (37 ms), \( F_{1}(1, 28) = 6.06, MSE = 6.770; F_{2}(1, 52) = 7.70, MSE = 6.990; \) with no significant differences in the error analysis, \( F_{1}(1, 28) = 1.70, MSE = 42; F_{2} < 1. \) There was no significant difference between the amount of priming obtained for cognates and noncognates in L1 (E-E), \( F_{1}(1, 28) = 2.03, MSE = 395; F_{2} < 1, \) nor in L2 (H-H), \( F_{1} < 1; F_{2}(1, 52) = 2.44, MSE = 6,990. \) It is also noteworthy that in this experiment the within-language priming effects for cognates were actually numerically smaller than the effects for noncognates in both L1 and L2. As for the Hebrew-dominant bilinguals in Experiment 1, collapsed over related and unrelated conditions, the RTs to cognates in English were slower for these English-dominant bilinguals as well (this time by 38 ms), \( F_{1}(1, 60) = 9.63, MSE = 6,374. \) The errors to English targets showed a similar pattern; there were significantly more errors to cognate targets in the subjects analysis, \( F_{1}(1, 28) = 9.12, MSE = 30, \) with a trend in the same direction in the item errors, \( F_{2}(1, 60) = 2.86, \)

2 These same two items were eliminated from Experiment 3. In Experiments 1 and 4 this problem was corrected. For purposes of presentation, the experiments in this article are presented in an order (1, 2, 3, 4) that differs from the order that was actually carried out in this research project (i.e., 3, 2, 1, 4).
MSE = 102. The pattern in Hebrew was similar to that observed for the Hebrew-dominant participants in Experiment 1: RTs to cognates in Hebrew were 15 ms slower, but this time no difference was significant (both F₁ and F₂ < 1). There were, however, significantly more errors in the subjects analysis, F₁(1, 28) = 6.89, MSE = 125, but not in the items analysis, F₂(1, 52) = 1.52, MSE = 652.

For nonword targets, the 9-ms priming effect in the L1 list was not significant, F₁(1, 28) = 2.73, MSE = 404; F₂(1, 62) = 1.51, MSE = 1,357, but there was a significant inhibitory effect in the errors, F₁(1, 28) = 7.73, MSE = 22; F₂(1, 62) = 8.02, MSE = 44. In the L2 list, an inhibitory effect was again observed, but this time it was the RTs that showed the effect (—51 ms), F₁(1, 28) = 11.41, MSE = 3,423; F₂(1, 62) = 8.66, MSE = 17,116. For the errors, no significant effect was obtained, (F₁, F₂ < 1). As in Experiment 1, the overall amount of priming in Hebrew, which was now L2 rather than L1, was smaller than in English, but this time the difference was not significant (both Fs < 1).

Translation priming. The bottom of Table 3 shows the results in the cross-language list, in which the prime was in English (L1) and the target was in Hebrew (L2). As can be seen, the priming effects were very substantial and were larger for cognates than for noncognates. Overall, the priming effect of 97 ms was significant, F₁(1, 28) = 29.43, MSE = 9,580; F₂(1, 52) = 29.90, MSE = 8,053, and there was also a significant effect in the errors analysis, F₁(1, 28) = 14.48, MSE = 153; F₂(1, 52) = 20.84, MSE = 99. The effect of priming for cognates alone was significant, F₁(1, 28) = 33.94, MSE = 8,962; F₂(1, 26) = 31.26, MSE = 9,187, and the effect of priming for noncognates alone was significant in the subjects analysis and marginally significant by items, F₁(1, 28) = 5.95, MSE = 6,686; F₂(1, 26) = 3.61, MSE = 6,919, p = .07. Of most importance, there was a significant difference between the amount of priming obtained for cognate items (142 ms) and noncognates (52 ms), F₁(1, 28) = 10.21, MSE = 6,068; F₂(1, 52) = 8.86, MSE = 8,053. This interaction effect was also apparent in the errors analysis, although it was significant only in the items analysis, F₁(1, 28) = 3.86, MSE = 127, p = .06; F₂(1, 52) = 4.67, MSE = 99.

Of note is the fact that facilitation effects for L2 cognate targets were greater when the primes were the L1 translations than when same-language repetition primes were presented. This implies that L2 cognates are best accessed through their L1 translations. This pattern was not obtained in Experiment 1 and therefore must be interpreted with great caution. It may be that L2 cognates are best accessed through L1 only in earlier stages of proficiency.

Discussion

The English-dominant bilinguals show the same pattern as that of the Hebrew-dominant bilinguals in Experiment 1. There are clear priming effects in the within-language conditions and clear translation priming effects for both cognates and noncognates in the cross-language condition. However, unlike the Hebrew-dominant bilinguals, the present group shows a much stronger (and significantly greater) translation priming effect for cognates (142 ms) than for noncognates (52 ms). Although this result confirms previous findings of stronger priming for cognates (de Groot & Nas, 1991; Garcia-Albea et al., 1985; Sanchez-Casas et al., 1992), it nevertheless differs from the expected pattern in both the magnitude of the priming effects and the difference between them. In fact, in the present Experiment 2, translation priming for cognates was stronger than within-language repetition priming.

It might be suggested that these unusual results are due to the fact that the overall RTs in this experiment were considerably longer (as can be seen by comparing Tables 2 and 3), and this allowed unusually large priming to emerge. To determine whether this was the case, we carried out a post hoc analysis. If only the slowest participants are responsible for this effect, then we might expect "normal" priming for the fastest bilinguals (typically, the maximum masked priming effect is approximately 50–60 ms; e.g., see Forster & Davis, 1984; Forster et al., 1987; Grainger, Cole, & Segui, 1991). Accordingly, the priming effects for the 14 fastest bilinguals were computed (mean RT was 868 ms vs. 1,019 ms for the remaining). The data for this group showed a pattern of priming effects very similar to that of the group as a whole, with a significant translation priming effect of 150 ms for cognates and 54 ms for noncognates. This time the effect for noncognates was significant in both, F₁(1, 12) = 8.76, MSE = 2,380, and F₂(1, 26) = 5.99, MSE = 5,556. Thus, we have grounds for rejecting the hypothesis that the exceptionally large priming effects were due to slower overall performance.

The emergence of an exaggerated enhanced priming effect for cognates in this experiment and the direction of the effects obtained in Experiment 1 indicate that superior priming for cognates can still be obtained when the two languages have different scripts. However, recall that only some of the bilinguals in Experiment 1 showed a stronger effect for cognates as indicated by the fact that the interaction effect generalized across items but not subjects. The reason for this difference between the two experiments may have to do with proficiency in L2. The participants in Experiment 1 were more balanced bilinguals than the participants in Experiment 2, as shown by the larger discrepancy between overall RTs and error rates in L1 and L2 (see Table 4). It is possible that the increase in translation priming from L1 to L2 depends to some degree on there

### Table 4

<table>
<thead>
<tr>
<th>Target</th>
<th>Hebrew dominant</th>
<th>English dominant</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>% error</td>
</tr>
<tr>
<td>L1</td>
<td>602</td>
<td>6.7</td>
</tr>
<tr>
<td>L2</td>
<td>655</td>
<td>9.9</td>
</tr>
<tr>
<td>Difference</td>
<td>53</td>
<td>3.2</td>
</tr>
</tbody>
</table>

Note. L1 = dominant language; L2 = nondominant language.
being a marked difference in strength between L1 and L2 representations, or cognate status may only matter when L2 representations are less developed. More specifically, the phonological overlap between prime and target may be critical only with an L2 target. If so, then it should be the case that the bilinguals in Experiment 1 who showed the largest difference in translation priming between cognates and noncognates would be those who were least proficient in L2.

To test this hypothesis, we carried out a post hoc analysis on the cross-language list from Experiment 1 by selecting bilinguals with high error rates in L2 on the assumption that those who make more errors are less-balanced bilinguals. Error rates in lexical decision are a better indicator of proficiency than RTs because RTs reflect additional cognitive processes that are not necessarily related to bilingualism (e.g., speed of decision making). Thirteen of the bilinguals in the initial analysis were included in the post hoc analysis, and 9 who were previously rejected (for having error rates that were considered to be too high) were also included in the reanalysis. This produced a group of bilinguals that had an error rate greater than or equal to 20% (the range was 20% to 37%). Table 5 shows the individual means for this comparison. Also shown in Table 5 is an analysis that included bilinguals with RTs more comparable to those seen in the post hoc analysis reported above (at the beginning of the Discussion section).

In the analysis of bilinguals with high error rates, the difference between translation priming effects for cognates and noncognates increased from 17 ms to 52 ms, and the interaction effect was now significant both by subjects, $F_1(1, 20) = 17.21$, $MSE = 858$, and by items, $F_2(1, 60) = 12.06$, $MSE = 1,499$. Note that the largest difference in RTs was observed for the cognate items that were preceded by translation primes. This is consistent with the hypothesis that cognate status has a larger impact on priming for less balanced bilinguals. Because the effect for errors seems to go in the opposite direction in this reanalysis, this effect should be interpreted with some caution. However, the effect for errors was not significant, $F_1(1, 20) = 1.66$, $MSE = 61$; $F_2(1, 60) = 1.57$, $MSE = 92$. It is interesting that bilinguals with longer RTs (range of mean RT was 723 to 952 ms and range of mean error rate was 7% to 19%) who showed significant cross-language priming overall, $F_1(1, 10) = 37.52$, $MSE = 1,120; F_2(1, 60) = 16.64, MSE = 8,376$, did not show the same pattern (i.e., more priming for cognates). In fact, they showed a nonsignificant trend in the opposite direction (both $Fs < 1$). These post hoc analyses reinforce the conclusion that stronger priming effects for cognates are found for less balanced bilinguals (as measured by error rates) and that longer RTs for cognates do not produce enhanced priming.

As in Experiment 1, the results of Experiment 2 demonstrate a clear translation priming effect for noncognates, a result that differs from the expected pattern based on previous investigations of cross-language masked priming that used languages with the same script (de Groot & Nas, 1991; Garcia-Albea et al., 1985; Sanchez-Casas et al., 1992). This result strongly implies that differences in script may play a role in translation priming for noncognates. The most obvious explanation is that the variation in script somehow increases the efficiency of access for the prime. The very short SOA used in the masked-priming technique clearly limits the time available for processing of the prime, and any factor that delays the recognition process should reduce the amount of priming. In a cross-language experiment, one factor that might delay recognition is uncertainty about which lexicon to access (assuming that each language has its own distinct lexicon).

In the absence of a difference in script across languages, the reader may initially attempt to access the prime in the lexicon of the target language (recall that the reader is unaware that cross-language stimuli are being presented), thereby reducing the opportunity for priming to take place. But where there is a clear difference in the script between the two languages, such an error would not occur. In an H-E list, the fact that the prime is written in Hebrew characters guarantees that the Hebrew lexicon is accessed first. However, this hypothesis would predict the same result for cognates as well as for noncognates, but this is not the case because cognate priming is found in same-script experiments (de Groot & Nas, 1991; Sanchez-Casas et al., 1992). Following the suggestion of Sanchez-Casas et al. (1992), we assume that cognates are jointly represented in both lexicons, and therefore priming for cognates is unaffected by the factor of script. Thus, in a same-script experiment, a search in either lexicon (L1 or L2) will access the lexical representation of a cognate.

The results for the nonword targets in the within-language lists are highly unusual in that significant inhibitory effects (in either errors or RTs) were obtained. The more normal pattern in a monolingual experiment is for there to be a slight but nonsignificant facilitation effect, suggesting the possibility of a weak sublexical graphemic effect. This inhibitory effect might indicate that the effect of an identity prime made the nonword targets seem more wordlike, and this delayed the decision. If the effect of an identity prime is to increase the perceived familiarity of the target, this would obviously induce a bias toward a "yes" decision, as argued by Balota.

### Table 5

<table>
<thead>
<tr>
<th>Condition</th>
<th>Cognates</th>
<th>Noncognates</th>
<th>Cognates</th>
<th>Noncognates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bilinguals with high error rates ($n=22$)</td>
<td>626</td>
<td>672</td>
<td>213</td>
<td>772</td>
</tr>
<tr>
<td>Bilinguals with longer RTs ($n=22$)</td>
<td>707</td>
<td>701</td>
<td>295</td>
<td>824</td>
</tr>
</tbody>
</table>

**Note.** Bilinguals with high error rates had greater than 20% errors. Bilinguals with longer mean RTs had RTs greater than 723 ms but less than 20% errors.
and Chumbley (1984). However, the problem with this interpretation is that such an inhibitory effect ought to be observed on a regular basis, and this is not the case (e.g., see the results of Experiment 1). To explain why the effect is present in Experiment 2, we might suggest that the bilinguals tested in this experiment were lessconfident in rejecting nonwords than would normally be the case for more proficient speakers and hence tended to place more weight on perceived familiarity as a basis for deciding what to do with a nonword. Such an effect would be more likely in L2 than in L1, as is the case here for RTs but not for errors. This explanation is compatible with the results obtained by Jacoby and Whitehouse (1989), who showed that a masked identity prime can influence old–new judgments in a recognition memory experiment when there is considerable uncertainty about the correct decision.

Finally, in Experiment 2 as well as in Experiment 1, RTs and errors to cognate targets showed a trend suggesting that cognate targets are more difficult to process in English. Because this effect was obtained with both Hebrew-dominant and English-dominant bilinguals, this result cannot be explained as a factor of language dominance. It is also a somewhat unexpected result because the cognates and noncognates were frequency matched. It would be interesting to see whether the same pattern would replicate with monolinguals as well or whether it is a unique feature of cognate processing in Hebrew–English bilinguals. The result is, however, not critical with respect to the present investigation because the magnitude of the priming effects for cognates and noncognates were the same in both E–E and H–H for all bilinguals, confirming that cognates are not unique with respect to within-language priming.

It seems reasonable to conclude at this point that for Hebrew–English bilinguals, enhanced priming for cognates is obtained only with less balanced bilinguals and that noncognates as well as cognates show strong translation priming effects. However, these conclusions hold only for the case in which the direction of priming is from L1 to L2. In the next two experiments, the direction of priming is reversed, once again with Hebrew-dominant and English-dominant bilinguals. If cognates are in fact jointly represented in both lexicons (Sanchez–Casas et al., 1992), then strong priming effects for cognates should also be obtained when primes are in L2 rather than L1. As argued by Kirsner, Lalor, and Hird (1993), cognates have overlapping lexical representations and are stored in a similar fashion to morphological relatives within a language, such as keep and kept. Hence the language of the prime should be irrelevant.

Experiment 3: Priming From L2 to L1 in Hebrew–Dominant Bilinguals

In Experiment 3, a second group of Hebrew-dominant bilinguals was tested with the cross-language list (E–H) and the same within-language lists as in the previous experiments. Thus, the primes were in L2, and the targets were in L1. Previous investigations of masked translation priming have shown a bidirectional enhanced priming effect for cognates (i.e., both from L1 to L2 and from L2 to L1; de Groot & Nas, 1991; Garcia-Albea et al., 1985; Sanchez-Casas et al., 1992). If the cognate effects observed in Experiments 1 and 2 could be explained by a similar mechanism, then a similar pattern of priming would be expected.

Method

Forty Hebrew–English bilinguals were selected in the same way as in Experiment 1. The materials and procedure were the same as in Experiment 2.

Results

Within-language repetition priming. The upper section of Table 6 shows the results when primes and targets were presented in the same language. A significant repetition–priming effect of 30 ms was obtained in the L1–L1 (H–H) list, \( F(1, 38) = 102.81, \) MSE = 347; \( F(1, 52) = 72.35, \) MSE = 403. The errors analysis for this list was also significant, \( F(1, 38) = 5.74, \) MSE = 40; \( F(1, 52) = 8.80, \) MSE = 19. A significant repetition priming effect of 57 ms was also obtained in the L2–L2 (E–E) list, \( F(1, 38) = 83.82, \) MSE = 1,573; \( F(1, 60) = 44.01, \) MSE = 2,250. The errors analysis for this list was significant only by subjects, \( F(1, 38) = 4.94, \) MSE = 57, and not by items, \( F(1, 60) = 3.57, \) MSE = 63, \( p = .06. \) As in Experiments 1 and 2, RTs to cognate targets collapsed over related and unrelated conditions were slower in English, \( F(1, 38) = 54.26, \) MSE = 2,015; \( F(1, 60) = 8.41, \) MSE = 13,798; and once again the errors analysis showed more errors for cognate targets in English, but the difference was only significant in the subjects analysis, \( F(1, 38) = 8.09, \) MSE = 53; \( F_2 < 1. \) In

Table 6

<table>
<thead>
<tr>
<th>Condition</th>
<th>Cognate</th>
<th>Noncognate</th>
<th>Nonword</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M % error</td>
<td>M % error</td>
<td>M % error</td>
</tr>
<tr>
<td>L1–L1 (H–H)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Repetition</td>
<td>555</td>
<td>542</td>
<td>646</td>
</tr>
<tr>
<td>Control</td>
<td>580</td>
<td>577</td>
<td>649</td>
</tr>
<tr>
<td>Priming</td>
<td>25</td>
<td>35</td>
<td>3</td>
</tr>
<tr>
<td>L2–L2 (E–E)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Repetition</td>
<td>706</td>
<td>656</td>
<td>838</td>
</tr>
<tr>
<td>Control</td>
<td>765</td>
<td>711</td>
<td>843</td>
</tr>
<tr>
<td>Priming</td>
<td>59</td>
<td>55</td>
<td>5</td>
</tr>
<tr>
<td>L2–L1 (E–H)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Translation</td>
<td>583</td>
<td>565</td>
<td>676</td>
</tr>
<tr>
<td>Control</td>
<td>592</td>
<td>574</td>
<td>862</td>
</tr>
<tr>
<td>Priming</td>
<td>9</td>
<td>9</td>
<td>2</td>
</tr>
</tbody>
</table>

Note. L2 = nondominant language; L1 = dominant language; H = Hebrew; E = English.

*Nonword targets not primed; see text.
Hebrew, there were no significant differences in overall responses to cognates relative to noncognates, $F_1(1, 38) = 3.39$, $MSE = 828$; $F_2 < 1$ in the RTs analysis, all $F$s < 1 in the errors analysis. However, as previously, there was no significant difference in the amount of repetition priming for cognates and noncognates either in L1 (H-H), $F_1(1, 38) = 1.42$, $MSE = 784$; $F_2(1, 38) = 2.96$, $MSE = 404$, or in L2 (E-E), both $F_1, F_2 < 1$.

An analysis comparing priming effects in Hebrew (H-H) with priming effects in English (E-E) showed that repetition priming effects in E-E were significantly greater than the effects obtained in H-H, $F_1(1, 38) = 15.42$, $MSE = 586$; $F_2(1, 108) = 14.97$, $MSE = 859$. This result was also obtained in Experiment 1 with the first group of Hebrew-dominant bilinguals tested, and a trend in the same direction was found in Experiment 2.

For the nonword targets, the only significant result was a priming effect of 2.1% in the error rates for the L1 (H-H) list, $F_1(1, 38) = 5.66$, $MSE = 15$; $F_2(1, 62) = 6.76$, $MSE = 20$. In the L1 list, the priming effect of 3 ms was not significant, $F_1 < 1$, $F_2 = 1.18$, $MSE = 924$, nor was the 5-ms effect for L2, $F_1, F_2 < 1$.

**Translation priming.** The bottom of Table 6 shows the results in the cross-language list (E-H), where the prime was in L2, and the target was in L1. Although the priming effect was small (9 ms), it was nevertheless significant when the data were collapsed over cognates and noncognates, $F_1(1, 38) = 5.43$, $MSE = 575$; $F_2(1, 52) = 4.74$, $MSE = 697$. The errors analysis was also significant, $F_1(1, 38) = 6.33$, $MSE = 31$; $F_2(1, 52) = 4.08$, $MSE = 34$. However, there was no interaction at all between cognate status and priming, with exactly the same 9-ms effect being observed for both types of items. Also, translation priming for noncognates alone was not significant, $F_1(1, 38) = 2.89$, $MSE = 568$; $F_2(1, 26) = 1.67$, $MSE = 560$, nor was translation priming for cognates, $F_1(1, 38) = 1.98$, $MSE = 752$; $F_2(1, 26) = 3.10$, $MSE = 794$.

**Discussion**

It is clear from these results that when priming is from L2 to L1, Hebrew-dominant bilinguals do not show enhanced priming for cognates because exactly the same-sized translation priming effect (9 ms) was observed for both cognates and noncognates. What is not so clear is whether any translation priming occurred at all. Although this 9-ms effect was significant when the cognate and noncognate conditions were combined, the separate analyses were weak (in each case, one of the $F$ values was less than 2). Clearly, this issue needs to be examined further.

Nevertheless, it seems clear that these Hebrew-dominant bilinguals do not show any sign of an enhanced priming effect for cognates with L2-L1 translation priming, and this is not what was found in earlier experiments (de Groot & Nas, 1991; Garcia-Albea et al., 1985; Sanchez-Casas et al., 1992). The implication is that bidirectional enhanced priming effects for cognates depend on the languages having similar orthographies. It seems, therefore, that the Hebrew–English enhanced priming effects for cognates obtained in Experiments 1 and 2 must be explained by a different mechanism than that postulated to explain the cognate effect obtained with Dutch–English and Spanish–English bilinguals. This point is taken up in the General Discussion.

Finally, once again repetition priming effects observed in Hebrew (H-H) were smaller than in English (E-E). This replicates the results obtained in Experiment 1 with the first group of Hebrew-dominant bilinguals. It seems possible that the reduced repetition priming effects in Hebrew merely reflect the fact that longer RTs in L2 (in this case English) provide greater opportunity for priming to emerge. However, recall that the English-dominant group in Experiment 2 showed a (nonsignificant) trend in the same direction (less priming for Hebrew). Moreover, a post hoc analysis comparing the fastest 9 Hebrew-dominant bilinguals with the slowest 9 (selected from this experiment and Experiment 1) also suggests that the length of RT cannot predict the magnitude of priming. The results of this analysis are reported in Table 7. The priming effect for the slow group (mean RT for each participant above 640 ms) was 35 ms, whereas for the fast group (mean RT for each participant less than 520 ms) it was 31 ms. Both effects were significant. For the slow group, $F_1(1, 14) = 18.91$, $MSE = 507$; $F_2(1, 54) = 11.70$, $MSE = 2.553$, and for the fast group, $F_1(1, 14) = 12.64$, $MSE = 14$; $F_2(1, 54) = 48.45$, $MSE = 612$. However, the difference between these effects was not significant (both $F_1, F_2 < 1$).

The fact that less repetition priming is found in Hebrew suggests that the mechanism of priming in Hebrew differs from that in English. This difference cannot be explained as a function of language dominance or attributed to differences in overall RTs. It also cannot be attributed to differential frequency of usage (i.e., for Hebrew dominant bilinguals, English words should be less frequent) because masked priming effects are generally found to be independent of frequency (Forster & Davis, 1984; Rajaram & Neely, 1992; Segui & Grainger, 1990).

One possible reason why there is less repetition priming in Hebrew than in English is suggested by the fact that the difference between the priming effects corresponds roughly in size to the difference between form-priming (nonidentical stimuli, e.g., *converse* and *converge*) and repetition priming in English (Forster et al., 1987). This suggests the possibility that the omission of vowels in written Hebrew (and the

<table>
<thead>
<tr>
<th>Condition</th>
<th>Slow RTs ($n = 8$)</th>
<th>Fast RTs ($n = 8$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Repetition</td>
<td>702</td>
<td>473</td>
</tr>
<tr>
<td>Control</td>
<td>737</td>
<td>504</td>
</tr>
<tr>
<td>Priming</td>
<td>35</td>
<td>31</td>
</tr>
</tbody>
</table>

Note. RTs = response times.
consequent ambiguity at the level of form) somehow eliminates the advantage of a prime that exactly matches the target over a prime that is one letter different from the target. In other words, there may be no exact matches in the Hebrew orthography.

The final experiment in this series completes the design with a group of English-dominant bilinguals tested on the H-E list. If the enhanced priming effect for cognates is only the orthography. target over a prime that is one letter different from the target. Consequently, ambiguity at the level of form somehow obtained with LI primes, then there should be no evidence for cognates and noncognates in overall RT was less stable, $F_{(1, 60)} = 12.99, MSE = 4388; F_{2} < 1$, and as in Experiment 1 with the Hebrew-dominant bilinguals, there were actually fewer errors for cognates, $F_{(1, 28)} = 16.77; F_{(1, 60)} = 3.35, MSE = 493$, suggesting a speed–accuracy trade-off. With respect to within-language priming effects, there were no significant differences between cognates and noncognates in L1 (E-E), both $F_{1, 28} < 1$, nor in L2 (H-H), $F_{(1, 28)} = 3.86, MSE = 1.825; F_{(1, 60)} < 1$. The means reported for this list suggest a difference between repetition priming for cognates and noncognates in condition H-H (38 ms vs. 7 ms), but this difference was not significant. Moreover, in the items analysis, the corresponding means were 25 ms for cognates and 24 ms for noncognates (such discrepancies between subject means and item means can be produced when there are some items or subjects with exceptionally high error rates).

The results for repetition priming of nonword targets showed a small but nonsignificant inhibitory effect ($-2$ ms) in L1, $F_{(1, 28)} < 1; F_{(1, 62)} = 1.70, MSE = 9$, but for L2, there was a substantial inhibitory effect ($-25$ ms), which was significant, $F_{(1, 28)} = 5.38, MSE = 1.692; F_{(1, 62)} = 6.82, MSE = 7.623$. This corresponds to a similar effect observed for English-dominant bilinguals in Experiment 2 (see Table 3). This time however, there were no significant differences in the errors analysis, $F_{(1, 28)} = 3.63, MSE = 41, p = .07; F_{(1, 62)} = 3.01, MSE = 105, p = .08$.

Translation priming. The bottom of Table 8 shows the results for the L2-L1 cross-language list (H-E). There was no evidence of any translation priming. The effect for cognates (4 ms) was exactly offset by a negative priming effect for the noncognates ($-4$ ms), leading to a zero overall effect. There was also no enhanced priming effect for cognates, $F_{(1, 28)} = 3.34, MSE = 158; F_{(1, 60)} = 2.13, MSE = 723$.

Discussion

The results of this experiment confirm that enhanced translation priming effects for Hebrew–English cognates do not occur with an L2 prime and an L1 target. Further, under these conditions, there is no priming at all for noncognates. Taking these results together with the results of Experiment 3, we must conclude that strong translation priming is only obtained with an L1 prime. However, because the L2-L2 priming effect in the present experiment was only marginally significant, it could be argued that this conclusion is not justified. If bilinguals cannot benefit from an L2 prime in a within-language situation, there is little reason to expect that

---

**Table 8**

Mean Lexical-Decision Times (in Milliseconds) and Percent Error Rates Obtained With English-Dominant Bilinguals for Within-Language and Cross-Language (L2-L1) Priming Lists in Experiment 4

<table>
<thead>
<tr>
<th>Condition</th>
<th>Cognate $M$</th>
<th>Cognate % error</th>
<th>Noncognate $M$</th>
<th>Noncognate % error</th>
<th>Nonword $M$</th>
<th>Nonword % error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Repetition</td>
<td>543</td>
<td>2.3</td>
<td>515</td>
<td>2.9</td>
<td>611</td>
<td>6.6</td>
</tr>
<tr>
<td>Control</td>
<td>588</td>
<td>9.4</td>
<td>364</td>
<td>6.7</td>
<td>609</td>
<td>5.6</td>
</tr>
<tr>
<td>Priming</td>
<td>45</td>
<td>7.1</td>
<td>49</td>
<td>3.8</td>
<td>-2</td>
<td>-1.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Condition</th>
<th>Cognate $M$</th>
<th>Cognate % error</th>
<th>Noncognate $M$</th>
<th>Noncognate % error</th>
<th>Nonword $M$</th>
<th>Nonword % error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Repetition</td>
<td>833</td>
<td>13.9</td>
<td>805</td>
<td>18.5</td>
<td>985</td>
<td>16.3</td>
</tr>
<tr>
<td>Control</td>
<td>871</td>
<td>12.0</td>
<td>812</td>
<td>22.3</td>
<td>960</td>
<td>19.5</td>
</tr>
<tr>
<td>Priming</td>
<td>38</td>
<td>-1.9</td>
<td>7</td>
<td>3.8</td>
<td>-25</td>
<td>3.2</td>
</tr>
</tbody>
</table>

**Note.** L2 = nondominant language; L1 = dominant language; H = Hebrew; E = English.

*Nonword targets not primed; see text.
they could benefit from an L2 prime in a cross-language situation. Obviously, it would be more convincing if those bilinguals who did show significant priming within-L2 also did not show any cross-language facilitation from L2 to L1. To strengthen the argument, we carried out a post hoc analysis, selecting only those bilinguals who would be likely to show normal priming effects within L2. From the bilinguals included in Experiment 4, 14 with the lowest error rates were selected for reanalysis. These bilinguals had an average of 5% errors in the H-H list, whereas the remaining 16 averaged 23% errors.

In this analysis, the repetition priming effect of 28 ms within L2 (H-H) was significant both by subjects and by items, \( F_1(1, 12) = 8.52, \text{MSE} = 1,221 \); and \( F_2(1, 60) = 7.29, \text{MSE} = 4,593 \). Nevertheless, there was still no significant translation priming in the H-E list (both \( F_1, F_2 < 1 \)), the effect for cognates being 5 ms and for noncognates being −12 ms. This analysis provides a stronger test of the hypothesis that an L1 prime is important in obtaining a Hebrew–English translation priming effect, for despite normal repetition priming from L2 to L2, no translation priming was found from L2 to L1.3

**General Discussion**

This study was designed to determine if enhanced masked translation priming for cognates could be found across languages with different scripts. The central question was whether orthographic overlap is required to obtain a special effect for cognates. The results provide a straightforward answer to this question: Enhanced cognate priming can be obtained in Hebrew–English bilinguals, despite the absence of orthographic overlap. Nevertheless, a number of aspects of the present set of results differ from previous same-script investigations, and this suggests that differences in orthography have a strong influence on lexical access and representation in bilingual systems.

A consistent result that emerged throughout the study was a pronounced asymmetry in cross-language priming. Although enhanced priming was found for cognates, it was only obtained when the primes were in L1. Further, significant translation priming effects were found for noncognates but, again, only with L1 primes. When primes were in L2 and targets were in L1, translation priming effects were very weak and inconsistent. A summary of the translation priming effects obtained in all four experiments is given in Table 9.

The directional asymmetry apparent in Table 9 had not been found in earlier single-script studies in which strong cognate priming was observed for both L1 and L2 primes, and translation priming effects for noncognates were either small in size (de Groot & Nas, 1991) or were not present at all (Sanchez-Casas et al., 1992). Thus, the main question to be examined concerns the manner in which orthographic factors could have influenced the pattern of priming in the present study.

Several possibilities can be proposed. First, the script itself provides a powerful access cue that unequivocally directs the reader to a specific lexicon. This cue increases the chances of obtaining priming by guaranteeing rapid access to the lexicon that contains the representation of the prime. If we assume that the lexicons for L1 and L2 are distinct and are not accessed in parallel, then access time will obviously depend on which lexicon is accessed first. When the prime and the target are in the same script (e.g., Spanish–English or Dutch–English), there is nothing to indicate in which lexicon the prime is likely to be located; therefore the lexical processor may initially attempt to access a Spanish prime in the English lexicon (or vice versa). Under these conditions, access of translation primes would simply fail, or if a subsequent correction is made, be so slow that there would be little or no chance that the prime could influence the processing of the target. Note that all that would be needed to significantly reduce the masked priming effect would be a small delay. Hence, even a model that posits that both lexicons are always accessed, but the processes are staggered such that the search of one lexicon begins just prior to the other, would predict a reduction in priming when there is no orthographic cue. In contrast, when primes and targets are printed in two different scripts, the characters themselves provide an unequivocal cue as to which lexicon should be accessed first. This cue permits more rapid access of the relevant lexicon and increases the probability that the prime will be accessed quickly enough to influence the processing of the target. Thus, according to this view, strong translation priming should be observed for both cognates and noncognates in a two-script experiment but not in a single-script experiment.

One obvious implication of this hypothesis is that strong translation priming effects for noncognates should be observed in other languages with different scripts, and the available evidence is quite encouraging for this view. Strong translation priming effects for noncognates have been re-

<table>
<thead>
<tr>
<th>Condition and translation type</th>
<th>Language dominance</th>
<th>Hebrew</th>
<th>English</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1-L2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cognate</td>
<td>53</td>
<td>3.3</td>
<td>142</td>
</tr>
<tr>
<td>Noncognate</td>
<td>36</td>
<td>5.7</td>
<td>52</td>
</tr>
<tr>
<td>L2-L1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cognate</td>
<td>9</td>
<td>2.4</td>
<td>4</td>
</tr>
<tr>
<td>Noncognate</td>
<td>9</td>
<td>2.0</td>
<td>-4</td>
</tr>
</tbody>
</table>

Note. RT = response time; L1 = dominant language; L2 = nondominant language.

---

3 A small interaction effect emerged between cognate status and priming, \( F_1(1, 12) = 6.16, \text{MSE} = 174; F_2(1, 60) = 8.48, \text{MSE} = 573 \). However, it is difficult to interpret this effect because the direction of priming for noncognates was inhibitory, the direction of priming for cognates was facilitatory, and neither of these two main effects alone was significant. The effect was not significant in the errors analysis, \( F_1(1, 12) = 1.26, \text{MSE} = 45; F_2(1, 60) = 1.90, \text{MSE} = 68 \).
ported for Chinese–English bilinguals (Jiang, 1995) and also for Thai–English bilinguals (Davis & Schoknecht, 1996) when two distinct alphabetic scripts were used. Other evidence that the orthographic distinctiveness of L1 and L2 influences bilingual processing comes from a same-script bilingual lexical-decision task (Grainger & Beauvillain, 1987). In this task, targets from English and French were mixed in the same list and were either orthographically legal in both languages (e.g., anger and menton) or only legal in one language and not in the other (e.g., narrow and suivre). RTs were faster for mixed lists containing the latter type of words, which are not orthographically legal in both languages. This suggests that the presence of an orthographic cue produces faster responses, thereby demonstrating that carefully manipulated orthographic factors may direct lexical search even in languages that share the same script. Because de Groot and Nas (1991) and Sanchez-Casas et al. (1992) did not manipulate orthographic legality in L1 and L2, it is possible that this factor may explain why priming for noncognates has been inconsistent in these studies.

The orthographic cue hypothesis requires the assumption that there are separate lexicons for each language and that the two retrieval operations cannot be launched simultaneously (though search of the two languages may proceed in parallel once the two retrieval mechanisms have been launched). Thus, our results cannot be easily accommodated by an activation model that assumes that one unified lexicon for both languages with parallel access to the different words of both languages (Grainger, 1993). In such an activation model, the prime should activate its appropriate lexical and semantic code in both languages simultaneously. Because there is no (or weak) translation priming for noncognates in a same-script experiment, one would be forced into the unlikely conclusion that masked noncognate primes do not activate any lexical representations whereas masked cognate primes do. Hence the absence of, or reduction in, translation priming for noncognates in same-script experiments creates a problem for a single-lexicon model.

One might still support a single lexicon model and account for the lack of translation priming effects by assuming that the prime in one language activates many distracting competitors in both languages (Grainger, 1993), thereby reducing the likelihood that translation priming might occur. According to this view, the Spanish prime nube (meaning cloud) would activate all candidates of the unified lexicon that are similar in form. If English is the expected language for the target, then the English candidates would be checked first (e.g., cube, nude, nuke, cube), and thus the Spanish entry for the prime would have less chance of being accessed in time to facilitate the English target cloud (the translation of nube). For the present experiments, however, a Hebrew prime will activate only Hebrew candidates because of the orthographic cue it provides, thus increasing the opportunity for translation priming to emerge. It should be noted that this model still involves a serial processing assumption, namely that candidates in one language are checked before candidates in another. Thus, models that postulate a unified lexicon, in which access to words in one language occurs before access to words in the another, yield similar predictions to models that postulate distinct lexicons. In this case, however, it is not truly clear what properties of the “unified” lexicon make it unified in terms of psychological processes.

Although the orthographic cue hypothesis can account for the increased priming observed for noncognates when the prime and the target are in different scripts, it cannot explain why the effects should only be obtained with L1 primes. To account for this asymmetry, some properties of the masked priming paradigm must be considered. As argued above, because the prime and the target are presented in such rapid succession, it is reasonable to assume that the amount of priming should depend on how quickly the prime is processed relative to the target. According to this view, marked differences in reading proficiency of the two scripts will increase the chance that L2 primes will not be processed rapidly enough to influence the processing of L1 targets. This is because of the close temporal proximity of primes and targets in the masked priming paradigm. If the target is processed much more rapidly than the prime, the prime may reach a stage where it could affect the target only after the processing of the target has already been completed. That is, the processing of the L1 target essentially “overtakes” the processing of the L2 prime, and hence no priming is observed.

This account emphasizes the importance of relative speed in processing the different scripts and not the overall performance in processing words in L2. Note that robust priming was obtained from L2 to L2 in both English and Hebrew, suggesting that the L2 primes were indeed processed. The priming effects in this condition occurred because the L2 targets were also processed at the same slow rate as the primes, thereby giving the L2 primes sufficient time to complete the access process before processing of the L2 target was completed.

The argument for the importance of the relative speed of processing makes the assumption that when short SOAs are used, processing of the prime is still underway when processing of the target begins. One interesting prediction that follows is that priming from L2 to L1 should begin to emerge if the difference in processing speeds between L1 and L2 is reduced (and the masking procedure is not interrupted). One way to test this prediction is to compare translation priming effects for more and less balanced bilinguals who differ in their relative speed of processing L1 and L2 words. Tables 6 and 8 reveal that the Hebrew-dominant bilinguals in Experiment 3 were more balanced bilinguals than the English-dominant bilinguals in Experiment 4. This can be seen in the more discrepant performance of the English-dominants with English relative to Hebrew words. As the hypothesis would predict, significant priming was obtained for Hebrew-dominant bilinguals with L2 primes, whereas the respective effect for English-dominant bilinguals in Experiment 4 was virtually zero. It should also be noted that the results of Keatley et al. (1994), in which cross-language priming was greater from L1 to L2 even for bilinguals with very similar RTs in L1 and L2, do not contradict the predictions of the relative-speed-of-processing argument for two reasons. First, two of three experi-
ments in that study investigated cross-language priming for semantic associates rather than translation priming. Of more importance, the primes in that study were presented for much longer (200 to 250 ms) and were not masked (participants were in fact able to report the primes). Clearly, the results of nonmasked studies are influenced by different factors. For example, the relative weakness of L2 in accessing semantic memory probably played a much larger role under those priming conditions.

An alternative explanation of the asymmetrical priming from L1 to L2 focuses on the relative strength of the connections between lexical representations and conceptual memory. On this account the connections between lexical representations in L2 and conceptual memory are weak and impoverished, whereas L1 representations activate conceptual memory strongly. Thus, while an L1 prime activates all the semantic representations needed to interpret an L2 word, an L2 prime activates only some of the semantic representations needed to interpret the L1 translation. Hence translation priming is asymmetrical, and in fact, this account predicts that priming from L2 to L1 should always be weaker than the reverse. This argument has been used to explain other cross-language priming experiments in which priming from L1 to L2 was greater than priming from L2 to L1 (e.g., Keatley et al., 1994). Other bilingual data have also motivated the assumption that L2 activates conceptual memory weakly relative to L1. For example, Kroll and Stewart (1990, 1994) demonstrated that translation from L1 to L2 was influenced by semantic manipulations, whereas translation from L2 to L1 was not. Kroll and Stewart argued that translation from L1 to L2 is conceptually mediated, whereas translation from L2 to L1 is mediated by strong lexical links from L2 to L1 (which presumably are established as an L2 is acquired and translations are associated with each other). The main difficulty with this explanation is that strong lexical links from L2 to L1 predict strong priming from L2 to L1, when in fact the opposite was obtained. However, if the argument for relative speed of processing is accepted, then this model is nevertheless consistent with our results because under this account the L2 to L1 links may never have a chance to affect recognition of the L1 target.

A more general difficulty with semantic accounts of asymmetrical masked translation priming is that many studies that have used the same masked priming paradigm obtained very small or nonsignificant priming effects when semantically related primes were used (e.g., Brown & Hagoort, 1993; Colwell, 1992; de Groot & Nas, 1991; Perea, Gotor, Rosa, & Algarebel, 1995; von Baggo, 1990). These results contrast sharply with the strong translation priming effects observed in the present study that are virtually equivalent to within-language repetition priming effects. Of particular relevance here is a finding reported by Frost, Forster, and Deutsch (1997). These authors investigated whether masked morphological priming effects in Hebrew could be explained on the basis of semantic overlap and found no facilitation at all (−3 ms) for semantically related pairs that did not share a root morpheme.

It should be noted that we are not claiming that semantic factors are ineffective in masked priming experiments. Rather, the claim is simply that the size of the semantic effect obtained within-language is not large enough to account for the translation effects obtained in our study. Obviously, translation-equivalent terms have far greater semantic overlap than semantically or associatively related items within a language because translation equivalents are, in effect, synonyms. Nevertheless, it seems doubtful whether this additional semantic similarity could explain why strong effects are found for translations, whereas no priming whatsoever is obtained within language for very closely related pairs (e.g., musician–orchestra; see Frost et al., 1997).

If it is considered unlikely that purely semantic factors could account for the present results, then the only obvious alternative account is one that focuses on lexical-level links alone. According to this view, priming occurs because of lexical links between translations, and the magnitude of priming for cognates relative to noncognates reflects the strength of these connections. One possible model of enhanced priming for cognates in these terms would suggest that cognates in the two languages are strongly connected, whereas connections between noncognates are significantly weaker. The advantage of describing translation priming effects for noncognates in terms of lexical connections is that this description focuses on form and does not rely on semantic overlap as the basis of priming. Thus, it can easily account for the strong translation priming effects between languages, without contradicting the weak semantic effects obtained within language. Further, a lexical-connection interpretation is compatible with the finding that only cognates produce cross-language priming for semantic associates (de Groot & Nas, 1991). If such priming occurs at the lexical level (Lupker, 1984; Shelton & Martin, 1992) rather than at the conceptual level, then translations with strong lexical connections (i.e., cognates) should produce semantic priming, whereas translations that have weaker lexical connections (i.e., noncognates) should not.

Postulating that lexical connections are the basis of priming does not, however, explain the asymmetrical nature of cognate priming. A major finding in this study is that enhanced priming for cognates was found only with L1 primes, whereas there was no difference in the magnitude of priming from L2 to L1 for cognates and noncognates (when such priming was obtained, i.e., in Experiment 3). This pattern contrasts sharply with same-script studies that reported greater priming for cognates relative to noncognates, both with L1 and L2 primes (de Groot & Nas, 1991; Sanchez-Casas et al., 1992). To explain symmetrical enhanced priming for cognates, two types of models have been proposed. One model postulates shared representations at the lexical level (Sanchez-Casas et al., 1992). According to this view, the lexicon of a Spanish–English reader, for example, would contain a joint lexical representation for both rich and rico, which can be accessed equally well by either stimulus. It is easy to explain bidirectional enhanced priming effects for cognates in this model, even in the absence of an orthographic cue. Because of their shared lexical representations, each time a cognate occurs in either language the ability to recognize it in the other language is
reinforced as well. Hence, the ability to access a cognate term in L2 is reinforced by practice in L1, and priming from L2 to L1 is as stable as priming from L1 to L2. This model interprets enhanced priming for cognates as an access advantage that takes place in early levels of processing; cognates have a special status such that access gradually becomes equally efficient in L1 and L2. Further, in this model the same-script cognate advantage should be clearest in balanced bilinguals because presumably it would take some time before the L1 cognate representation could accommodate a new, though perhaps only slightly altered, access code.

A second model of enhanced priming for cognates assumes that both cognates and noncognates are linked at the lexical level to the same extent and that the cognate advantage is explained by enhanced overlap at the conceptual level; cognates share a single conceptual representation, whereas noncognates are distinct at the conceptual level (de Groot & Nas, 1991). This model was proposed to account for the stronger priming for cognates, and another finding (from the same study) that masked cross-language priming for semantic associates is obtained for cognates but not for noncognates. The claim in this model is that bilinguals find it more difficult to acquire semantic distinctions between phonologically and orthographically similar forms because the form similarity of the cognates prevents bilinguals from distinguishing them at a semantic level. Thus, this model assumes that form and meaning are not independent and that the enhanced priming for cognates occurs at a deeper (i.e., semantic rather than lexical) level of processing.

Although these models are quite different in their assumptions about lexical structure and priming mechanisms, they both make the assumption that cognates share a single representation at some level. This proposal is supported by other bilingual studies showing that L2 cognates are accessed with greater facility than L2 noncognates (e.g., Caramazza & Brones, 1979); by studies demonstrating that cognates show translation priming when many items are presented between the prime and target, whereas noncognates do not show priming under such conditions (e.g., Cristoffanini et al., 1986); and by studies showing similar translation performance from L1 to L2 and from L2 to L1 for cognates and asymmetrical translation performance for noncognates (de Groot, Dannenburg, & van Hell, 1994; Sanchez-Casas et al., 1992; but see Kroll & Stewart, 1994, for an exception).

The results reported in the present study, however, do not correspond to these findings. First, unlike the same-script masked priming studies, we found enhanced priming for cognates only with L1 primes (i.e., an asymmetric effect). When priming was obtained from L2 to L1 (Experiment 3), there was absolutely no hint of enhanced priming for cognates. Further, although the differences between cognates and noncognates in terms of overall RTs were not always significant, the trend was always in the direction of slower access to cognates relative to noncognates. Finally, the only experiment that produced clear enhanced priming for cognates in the present study (Experiment 2), produced unusually large facilitation of 142 ms for cognates. In fact, translation priming in this experiment was larger than repetition priming within-language. If the same representation produces within-language and cross-language priming for cognate terms, then the effects should be roughly of the same magnitude, and the unusual size of the effect raises the possibility that different mechanisms are involved in translation priming for Hebrew–English cognates. All of these findings lead us to suggest that Hebrew–English cognates do not share the same lexical representation, probably because of the difference in script. Thus, we propose that the establishment of shared lexical representations requires simultaneous overlap in orthography, phonology, and meaning. This proposal assumes that Hebrew–English cognates do not have a special status relative to noncognates and predicts that priming effects for cognates and noncognates should be identical. Thus, it clarifies why enhanced priming for cognates was not obtained from L2 to L1, but it cannot explain why it was obtained from L1 to L2.

One possible explanation focuses on the shared phonological (as opposed to orthographic) properties of cognates in languages having two different scripts and is suggested by the post hoc analysis reported in Experiment 2. This analysis revealed that less balanced bilinguals (as measured by error rates rather than by RTs) showed a more pronounced enhanced priming effect for cognates (see Table 5). Similarly, the bilinguals in Experiment 2 who were less balanced than those in Experiment 1; see Table 4) showed a robust enhanced priming effect for cognates, with an unusually large main effect of priming for cognates. These results suggest that enhanced priming for cognates was characteristic of the processing of less proficient bilinguals. Thus, on this view proficient bilinguals in different-script languages would not at all display an enhanced priming effect for cognates.

The enhanced cognate effect for less proficient bilinguals could be related to a possible greater reliance of these readers on phonological assembly in processing the L2 targets (e.g., Baron & Baron, 1977). If less proficient bilinguals indeed rely more heavily on phonological computation of L2 words, an enhanced cognate effect would emerge because the phonological similarity of the prime and target would become relevant. What could be primed is the actual procedure of phonological computation for the L2 target. Because rapid access of an L1 cognate prime generates a phonological code that is similar to that of the L2 target, the recovery of the phonological structure of the L2 target would occur more rapidly for a cognate than it would for a noncognate. Note that analogous arguments have been used to interpret articulatory priming effects with masked primes in a naming task (Forster & Davis, 1991). Assuming that access of L1 targets does not rely on phonological recoding to the same extent, this proposal would also explain why the effect is not bidirectional. Thus, enhanced cognate effects in two different scripts are expected to emerge because of a feature of lexical processing in L2 that is either not present, or much less present, in L1; that is, a heavy reliance on a phonological code. This hypothesis, however, deserves further investigation.

In conclusion, the results of this investigation suggest that
orthographic properties play a critical role in cross-language masked priming. Differences in script may operate as a powerful cue that directs lexical search. This cue allows rapid access to the masked cross-language prime and hence also allows stable noncognate priming to emerge. The differences in script also have implications to the representation of cognates. Our results suggest that Hebrew–English cognates are not accessed in the same way as cognates in languages that share the same script. Enhanced cognate priming in languages having different scripts seems to be mediated by the shared phonological structure and emerges only when greater reliance on a phonological code is needed.

At a more general level, the results of this study provide evidence for the automaticity of visual word recognition. Hebrew and English are read in opposite directions; English words are read from left to right, whereas Hebrew words are read from right to left. Thus, the mere fact that priming is obtained without awareness across two such distinct orthographies is remarkable. It suggests either that direction in reading only matters in connected text, or that the direction of reading is controlled purely by the nature of the script itself, and that this direction (first letter to last letter) is automatically launched, without awareness and even in a context that involves consciously reading in the opposite direction.

References


Received December 13, 1995
Revision received June 24, 1996
Accepted January 22, 1997