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Lexical Representation of Cognates and Noncognates in Compound Bilinguals

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In four experiments the representation of words in a Dutch–English bilingual lexicon was examined. Within- and between-language repetition-priming and associative (semantic)-priming effects were compared. In Experiments 1 and 2 only cognate words were presented, whereas in Experiments 3 and 4 also noncognates served as stimuli. In Experiment 1 the primes were presented unmasked; in Experiments 2 and 4 they were masked by means of a forward/backward masking technique; in Experiment 3 they occurred under both masked and unmasked presentation conditions. Within- and between-language repetition-priming and associative-priming effects were obtained, both under masked and unmasked presentation conditions, but in the masking condition the between-language associative priming effect for noncognates disappeared. The results suggest separate but connected lexical representations for Dutch–English translation equivalents, both for cognates and noncognates, shared conceptual representations for Dutch–English cognate translations, and separate conceptual representations for noncognate translations.

One of the main questions that directs bilingual research is whether the bilingual's knowledge of the two languages is stored in two language-specific memory systems or whether it is somehow integrated in a single language-independent store. Since Meyer and Ruddy's (1974) seminal study, this question has primarily been focused on the bilingual's lexical knowledge. The research presented here reflects that tradition.

A commonly adopted approach in this field of research is to compare between-language effects with the corresponding within-language effects. For example, one of the questions that has been posed (e.g., Scarborough, Gerard, & Cortese, 1984) is whether there is a between-language parallel to the within-language "repetition-priming effect" (e.g., Scarborough, Cortese, & Scarborough, 1977), that is, the phenomenon that a word is responded to faster in, for instance, a lexical decision task, when it is encountered a second time during an experimental session. A second question has been (Kirsner, Smith, Lockhart, King, & Jain, 1984; Meyer & Ruddy,

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1974) whether there is a between-language parallel to the within-language "semantic-priming" effect (e.g., Fischler, 1977; Meyer & Schvaneveldt, 1971), that is, the phenomenon that in a number of experimental tasks a word is processed faster when it is preceded by a word to which it is semantically related. The occurrence of such effects across languages, or—for that matter—their absence, is regarded as indicative of the lexical representational structure of the bilingual. More specifically, a between-language semantic-priming effect, that is, a priming effect of a word presented in the one language on a semantically related word presented in the second language, suggests that the two languages under consideration are integrated at the conceptual level of representation. A between-language repetition effect, that is, a priming effect of a word presented in the one language on its translation equivalent in the second language, could either indicate that the two languages are directly connected at the lexical level of representation, or that they are indirectly connected via a common representation at the conceptual level (see, for instance, Chen & Ng, 1989, and Kirsner et al., 1984, for a discussion of the various possibilities).

Between-language priming studies have typically shown that two semantically related words appearing in different languages do prime one another (Chen & Ng, 1989; Guttentag, Haith, Goodman, & Hauch, 1984; Jin & Fischler, 1987; Kerkman, 1984; Kirsner, 1986; Kirsner et al., 1984; Meyer & Ruddy, 1974; Schwanenflugel & Rey, 1986). However, between-language studies on repetition priming have not yielded consistent results. Some investigators (Kirsner, Brown, Abrol, Chadha, & Sharma, 1980; Kirsner et al., 1984; Scarborough et al., 1984) did not obtain a between-language repetition effect, whereas others did (Chen & Ng, 1989; Cristoffanini, Kirsner, & Milech, 1986; Jin & Fischler, 1987; Kerkman, 1984). These repetition-priming studies varied on a number of variables, including the duration of the interval between the subsequent occurrences of a word and the type of stimulus materials presented to the subjects. A major purpose of this study is to show that these two variables play a critical role in the occurrence of the repetition effect.

Two *monolingual* studies help to clarify why the repetition effect between languages has behaved so elusively. What's more, they strongly suggest that the most common technique to study repetition effects is not suitable to investigate the lexical memory, neither that of the monolingual nor that of the bilingual. One of these studies was performed by Oliphant (1983) and the second by Forster and Davis (1984).

Oliphant (1983) compared repetition effects in two conditions. In one condition both occurrences of repeated test words required an overt lexical decision response, and there was an interval of several minutes between the two occurrences. This is how repetition priming has mostly been investigated, not only in within-language studies of which Oliphant's is one, but also in between-language studies. In his second condition the first occurrence of a repeated test word was as part of a running sentence in the instructions, to be read aloud by the subjects. Its second occurrence was as one of the subsequent letter strings to be categorized as word or nonword. Only in the first condition did the usual repetition effect occur. Oliphant concluded that in a lexical-decision experiment a repetition effect only occurs when the subjects are aware of the fact that some of the words are presented a second time. This awareness is precluded when a word's first occurrence is as part of the instructions preceding the actual lexical-decision stimuli. At this point it is important to realize that in both of Oliphant's conditions upon its second occurrence is the lexical representation of a test word accessed for a second time. If the earlier lexical access procedure would underlie the increase in processing speed upon the second presentation of this same word, the effect should also have occurred in Oliphant's second condition. The fact that it did not thus suggests that there must be a different cause for the effect in his first condition.

Using a different repetition technique, Forster and Davis (1984) obtained data indicating that Oliphant's conclusion with respect to the role of awareness in the effect has to be qualified. They presented words immediately after their first occurrence, without intervening stimuli, and blocked the awareness of the first presentation by masking it. Using this procedure they obtained a reliable repetition effect, so that apparently awareness of the repetition is not critical for the effect to occur.

The combined data of these two monolingual studies suggest that two types of repetition effects must be distinguished, one episodically based and one lexically based (see also Jacoby, 1983). The former may be due to the subjects' accessing the episodic trace of a word's prior occurrence when it is presented a second time. The second may reflect facilitated access to the word's abstract lexical representation when, immediately before, this same representation was already accessed. Forster and Davis (1984) argue that the episodically-based repetition effect disappears as a result of manipulations that block the subjects' awareness of a prior presentation of a word, as in Oliphant's second condition, whereas the lexically-based repetition effect is less responsive to awareness blocking, or not at all. But why is it then that no repetition effect whatsoever occurred in Oliphant's awareness blocking condition? One might have expected the lexically-based effect still to have come about. Forster and Davis suggest that this is because the processes that give rise to the lexically-based effect are very transient, and the effect can thus only be obtained when the delay between the first and second occurrence of a test word is very short, some hundreds of milliseconds only. In Oliphant's study (an instance of the "classical" repetition paradigm) the inter-stimulus interval between the different occurrences of repeated words exceeded this critical interval by minutes.

In summary, Oliphant (1983) may not have obtained a repetition effect in his awareness-blocking condition, first, because the subjects' non-awareness of the repetition prevented the occurrence of an episodic repetition effect and, second, because the second presentation of the test words followed the first too late for a lexical repetition effect to materialize. Like Oliphant, Forster and Davis (1984) did not allow the subjects to become aware of the earlier presentation of the test words and thus prevented the occurrence of an episodic repetition effect. The repetition effect they nevertheless obtained is thus likely to be a lexically-based effect. It could show up because, unlike in Oliphant's study, the critical duration between a test word's first and second occurrences was not exceeded. The presently relevant conclusion is that the classical repetition-priming technique does not seem an appropriate tool to investigate the—monolingual or multilingual—mental lexicon. If Forster and Davis' analysis is correct, the repetition effects that were observed in (only) some of the between-language studies that made use of the classical technique are not informative on lexical structure either, but based on the earlier word-presentation episode. The elusory nature of the effect may be due to the role of awareness in the episodic effect: Awareness of the between-language repetition may sometimes have been present (e.g., when the translations had a similar appearance), and it may have been absent at other times (e.g., in case of completely different appearances of the translations). In the former case the effect came about, in the latter it did not. This issue will be discussed in more detail later.

In the present study we used the above insights derived from monolingual investigations in tackling anew the question as to whether or not repetition priming occurs across languages, in our case Dutch and

English, both Germanic languages. Because our focus here is on the bilingual's *mental lexicon,* we concentrated on the presumed lexically-based effect. Therefore, in Experiment 2 we used Forster and Davis' (1984) repetition technique; that is, we masked the test word on its first occurrence (the "prime"). In addition to thus blocking an episodic contribution to the repetition effect, there is yet a further reason for masking the prime: From the monolingual *semantic*-priming literature it is well known that—given the appropriate conditions—a number of different processes can cause the effect when lexical decision is used as the experimental task (as is done here; see Neely, Keefe, & Ross, 1989, and Neely, 1990, for recent discussions). The one that is of particular interest to the question of lexical structure is automatic spreading activation in the memory system (e.g., Collins & Loftus, 1975). Whenever a semantic-priming effect is obtained under circumstances that disable all these processes except automatic spreading activation, conclusions with respect to lexical organization may be drawn. One of the other processes is post-lexical meaning integration: After both words in a pair of semantically-related words have been recognized, but before the response has been emitted, the subject tries to integrate the meanings of prime and target. A positive outcome of this process (in case of a related pair) biases the subject towards the correct word response, thus speeding it up (see, e.g., de Groot, Thomassen, & Hudson, 1982; Forster, 1981; Seidenberg, Waters, Sanders, & Langer, 1984; Neely, 1989). A further process causing semantic priming is that, again given the appropriate circumstances, subjects try to direct their attention to the memory area containing the representation of the test word prior to its occurrence. If attention is indeed directed to the appropriate location (that of representations of words semantically related to the prime) and the interval between prime onset and target onset is long enough for the shift of attention to take place in time (before the test word is actually presented), this speeds up responding (e.g., Neely, 1976, 1977). Masking the prime presumably has the effect of disabling both meaning integration and this latter attentional priming process (de Groot, 1983), thus isolating the priming effect of spreading activation. Note that both of these processes may also affect the processing of test words preceded by semantically related, clearly visible, primes in between-language conditions: Attention may also be directed to *translations* of words semantically related to the prime, and meaning integration may operate (indeed one would expect it to) independent of the language of the words that carry the meanings.

When the primes are clearly visible, both of these processes may—mutatis mutandis—also contribute to the *repetition*-priming effect, both within and between languages. Again, after both prime and target have been identified the subject may try to relate them. If he manages to do so in time, before the response has been executed, this will cause a bias towards the appropriate (word) response, thus speeding it up. It is feasible that such facilitatory relation will be discovered both when the same word is presented twice in the same language or when a pair of translation words is presented. Note that the above process of meaning integration is replaced here by a more general post-lexical integration process, namely one that looks for *any* obvious relation between two pairwise presented words (e.g., semantic, identity, translation, rhyme, orthographic similarity). When the primes are not masked, the above attentional priming process may also contribute to the repetition effect, both within and between languages: Apart from being directed to words semantically related to the prime, attention may be directed to the prime itself and to its translation (the common label for the latter process is "translation"). Again it could be argued that these two processes are disabled when the primes are masked. The repetition effects under masked-prime circumstances would thus solely be attributable to spreading activation in memory and thus reflect aspects of its structure more clearly than with unmasked presentation of the primes (as in studies by Chen & Ng, 1989, and Jin & Fischler, 1987).

To be able to compare directly the repetition effects observed under prime-masking circumstances with semantic-priming effects, pairs of semantically-related words were also presented in the present masking experiment (Experiment 2). Pairs consisting of two unrelated words served as controls from which the repetition- and semantic-priming effects were to be assessed. Primes and targets were both presented in either English or Dutch, resulting in two between (English–Dutch; Dutch–English) and two within-language (Dutch–Dutch; English–English) presentation conditions.

For comparison with the data obtained with masked presentation of the prime, we also ran an experiment (Experiment 1) in which the primes were not masked. Again the test words followed their primes immediately, without intervening stimuli (Chen & Ng, 1989, Experiment 1; Jin & Fischler, 1987). As may be clear from the above discussion, the repetition effects obtained under these presentation conditions may be composed of both a lexical and an episodic component, and both the repetition effects and the semantic-priming effects may contain a component caused by the above post-lexical integration process. In other words, larger repetition- and semantic-priming effects were expected to occur in Experiment 1 than in Experiment 2. The attentional priming process discussed above was not expected to contribute to the priming effects, since the interval between the onsets of prime and test was presumably too short for it to be effective (Neely, 1977).

In Experiments 1 and 2 only Dutch–English "cognates" were used as stimulus words, that is, words of which the Dutch form and its English translation are perceptually similar, both in sound and in spelling. To see whether the results obtained in those experiments would generalize to noncognates, in Experiments 3 and 4 repetition priming and semantic priming were investigated both for cognates and for noncognates. In all three experiments subjects were all Dutch–English "compound" (Ervin & Osgood, 1954) bilinguals. They were university students, all with Dutch as their native language, whose training required them to read in both English and Dutch (see also Nas, 1983). The task performed by the subjects was always lexical decision; that is, subjects categorized letter strings as words or nonwords.

EXPERIMENT 1

Method

Collecting Baseline RTs

If an effect of a prior stimulus (prime) on processing a second (target/test) is to be assessed, one has to make sure that no confounding occurs of the priming variable with any other variable. In order to preclude such confounding here, prior to the actual priming experiments a pilot study was run in which unprimed (henceforth: "baseline") lexical-decision RTs were collected to a large set of words and nonwords. The materials of Experiments 1 and 2 were selected on the basis of the results of this pilot study such that three sets of words emerged that were equivalent with respect to the baseline RTs and error scores of the words they contained. The words in each single set were to serve as targets in one (and only one) of the different priming conditions in Experiments 1 and 2. If these different conditions would subsequently show differences in RT and/or error scores, these would indeed be attributable to the priming manipulation per se and not to the fact that the targets across the priming conditions were drawn from different populations of words.

Baseline RTs were collected for Dutch words, all nouns, and for their English translations. All of these translations were cognates or "identical cognates" (Kirsner, 1986) of the equivalent Dutch term. One group of subjects provided the baseline data for the Dutch words; a second group for the English translations. Pseudowords (letter strings that conform to the orthography and phonology of the experimental language, but that carry no meaning) served as the nonword stimuli. They were Dutch-like in the Dutch list and English-like in the English list and were derived from the words on their respective lists by changing, adding, or deleting one or two letters. Subjects were drawn from the same population as those participating in Experiments 1 and 2 below. Also, the apparatus used to collect baseline RTs was the same as that used in Experiments 1 and 2.

Following data collection, mean RTs of correct responses and error scores were calculated for all stimuli. RTs and error scores for the *English* words served as the starting point for collecting the test materials of Experiments 1 and 2: Twenty-eight triads of English words were selected such that the mean baseline RT and the number of errors of the words within a triad were as similar as possible. Each member of a triad was to serve as a target in one of the three priming conditions in the subsequent priming experiments. The overall mean baseline RTs for the three sets thus composed were 559 ms, 561 ms, and 560 ms. The corresponding standard deviations were 39, 40, and 40. The mean error scores for the words within these sets were, in the same order, 1.8%, 2.4%, and 2.4%.

Materials

The test materials of Experiment 1 consisted of four lists of 168 prime-target stimuli each, List EE (English–English), List DD (Dutch–Dutch), List ED, and List DE. Of the 168 stimuli within a list, 84 had a word as target and the remaining 84 had a pseudoword as target. The 84 word targets in List *EE* were the words composing the three sets of 28 English words selected from the baseline experiment above. Each of the words in one of these sets was paired with another English word to which it was a relatively strong associate (as assessed from several corpora of *Dutch* norms of "discrete" word association. In discrete word association the subjects respond with a single response word to every stimulus word) and that was to serve as its prime. The words within these association pairs always were semantically related to one another. The mean associative strength of these 28 targets to their primes was 52.4% (SD = 18.5). That is, on average, 52.4% of the subjects in the word-association studies gave the present targets as response words to the corresponding stimulus words, presently the primes. These prime–target pairs together constituted the *associated* priming condition (i.e., the semantic-priming condition referred to in the introduction; Henceforth we use the term "associative priming" rather than the more common "semantic priming" to stress the fact that our pairs of semantically related words were selected from association norms). All 28 words in the second of the three sets selected from the baseline experiment were assigned both the roles of primes and of targets in the *repeated* priming condition. Finally, the 28 words in the third baseline set were to serve as targets in the *unrelated* priming condition. Each of them was paired with a prime word that was neither associatively related to the paired target, nor its repetition, nor related to it in any other obvious way. Because the mean baseline RTs of the target words were the same for the three priming conditions (559 ms, 561 ms, and 560 ms for the targets in the repeated, associated, and unrelated conditions, respectively), any effect of the priming variable to be obtained in the EE (and DE: see below) language condition is indeed likely to be due to the priming manipulation, unconfounded by other variables which are known to affect lexical decision. The remaining 84 stimuli in List EE consisted of a word prime (always a noun again) and an English-like pseudoword as the target. These pseudowords were the letter strings that in the baseline experiment had been derived from the 84 words that occur as *word*-targets in the present List EE. Pseudowords were chosen as nonword stimuli because a number of studies (e.g., Shulman & Davison, 1977) have shown that their presence among the experimental materials, unlike that of random letter strings, enforces the relatively deep level of stimulus processing that is required for the associative-priming effect to come about.

The word-target stimuli of List *DD* consisted of the Dutch translations of primes and targets in the word-target stimuli in List EE. Ideally, the overall mean baseline RTs of the targets in the three priming conditions should again be the same. Unfortunately, this was not the case: The mean baseline RT of the targets in the associated condition was 17 ms shorter ($p < .05$) than those of targets in the repeated and unrelated conditions (521 ms, *SD:* 19; 538 ms, *SD:* 29; 538 ms, *SD:* 25, respectively). The corresponding error scores were 1.6%, 1.6%, 3.4%, respectively. The primes in the *pseudoword*-target materials of List DD were the translations of those in the pseudoword materials of List EE. The targets in these materials were the pseudowords that in the baseline experiment had been derived from the words presently occurring as word targets in this List DD.

The materials of Lists *ED* and *DE* were derived from those of Lists DD and EE: The primes of List EE served as primes in List ED, and the targets of List DD served as targets in List ED. Conversely, the primes of List DD served as primes in List DE, and the targets of List EE served as targets in List DE. Table 1 illustrates how the sets of materials in the different language conditions relate to one another. In addition to the above test stimuli, all four lists included 56 practice stimuli, 28 with a word as target and 28 with a pseudoword as target. The composition of the practice materials of each list reflected that of the test materials of the same list. Appendix A

TABLE 1
SAMPLE OF THE STIMULUS MATERIALS USED IN EXPERIMENTS 1 AND 2

	Language condition			
	EE		DD	
Prime–target pair	Prime	Target	Prime	Target
Repeated words	GROUND	ground	GROND	grond
Associated words	CALF	cow	KALF	koe
Unrelated words	BRIDE	task	BRUID	taak
Word–pseudoword	ARTIST	grousp	ARTIEST	grons
Word–pseudoword	ADDRESS	fow	ADRES	poe
Word–pseudoword	SHELL	tosk	SCHELP	toek
	DE		ED	
Repeated words	GROND	ground	GROUND	grond
Associated words	KALF	cow	CALF	koe
Unrelated words	BRUID	task	BRIDE	taak
Word–pseudoword	ARTIEST	grousp	ARTIST	grons
Word–pseudoword	ADRES	fow	ADDRESS	poe
Word–pseudoword	SCHELP	tosk	SHELL	toek

shows all test materials presented in Experiments 1 and 2.

Subjects and Apparatus

Seventy-two subjects took part, with 18 subjects assigned to each of the four language conditions (EE, DD, ED, and DE). All subjects were students of the University of Nijmegen, being paid for participating. They all had Dutch as their native language and were reasonably good at comprehending English. Upon entering the laboratory they were asked to rate on a 7-point scale their comprehension ability in English (1 = bottom of the scale). Their overall mean comprehension-ability ratings were 5.0, 5.1, 5.0, and 4.9 for the subjects in the EE, DD, ED, and DE conditions, respectively. Comprehension ability did not differ significantly between groups ($p > .10$). All comprehension ratings varied between 4 and 6.

The subjects were tested in a group experiment room that allowed up to three simultaneous individual independent sessions, under control of a PDP 11/34 computer system. Stimuli were presented (white on grey) on individual TV monitors under program control. Individual stimulus presentation and RT recording were performed by a program called LEXSYS (Hudson & Bouwhuisen, 1985).

Procedure

One to three subjects at a time were tested in a normally lit room. Subjects were separated from one another by screens. They sat in front of a monitor at a comfortable reading distance. In the instructions, presented to them on the screen, they were told that pairs of letter strings would appear on the screen one after the other, that the first letter string of each pair (the prime) would always be a word, but that the second (the target) could either be a word or a nonword. They were asked to determine both as quickly and as accurately as possible, whether the second letter string of each pair was or was not a word. In case of a word they were to push, with their right forefinger, the right-hand one of two push-buttons located in front of them. In case of a nonword, they were to push the left-hand one of the two push-buttons with their left forefinger. Subjects who received the EE and DE materials were instructed in English. Those receiving the DD and ED materials were instructed in Dutch. All subjects tested simultaneously were presented the same list of materials. The next group that arrived at the laboratory was tested on a different list, the third group on yet a different list and the fourth on the last list. After one completed round, the next group was again tested on the list presented to the first group, and so on, until all data had been collected.

Prior to every prime–target pair, a fixation stimulus (an asterisk) appeared on the screen for one second, slightly to the left of where the prime was to appear. Then there was a blank inter-stimulus interval (ISI) of 20 ms. Subsequently, the prime was presented in the middle of the screen for 200 ms and in upper case. Following prime offset there was a blank ISI of 40 ms before the target appeared. The prime onset/target onset asynchrony (SOA) thus was 240 ms. This SOA presumably is too short for the subject to exploit the attentional priming process (see introduction), for instance, to translate the prime prior to the occurrence of the target (cf. Potter et al., 1984); in other words, it is too short to predict the target in the between-language repetition condition. The target then appeared, in lower case, one line below the place where the prime had been. It remained on the screen until the subject pushed either response key. Another 20 ms later one of the words CORRECT, WRONG, or SLOW was shown on the screen (in upper case) in the language of the targets, four lines below the position of the earlier target. The word SLOW (instead of CORRECT or WRONG) was shown when the response was correct, but exceeded a 1200 ms deadline. This feedback remained on the screen for 2 s. One second after its offset the fixation stimulus reappeared. The order in which the stimuli were presented was random, and it was different for all subjects. Practice and test materials were presented in blocks of 28 stimuli each, all practice materials preceding the test materials. After each block the mean RT and the number of errors for that block were shown on the screen. After a rest of minimally 10 s the subject initiated the presentation of a new block by pressing either response button. Whenever the number of errors for a given subject within a block exceeded 20%, a notice immediately appeared on the screen requesting him or her to try to make fewer errors.

Results

For each subject three mean RTs were calculated, one for each of the three priming conditions with words as targets. In calculating these means incorrect responses were excluded, as well as responses (less than 0.5% in all) that took less than 100 ms or more than 1400 ms. A 4 (language condition: EE, DD, DE, and ED) by 3 (prime type: repeated, associated, and unrelated) by 18 (subjects) ANOVA was performed on these means, treating language condition as a between-subjects variable and prime type as a within-subjects variable. Also, the corresponding 4 (language condition) by 3 (prime type) by 28 (items) ANOVA was performed on the item means, treating both variables as between-items variables. Table 2 shows the mean RTs, standard deviations, and error rates for all 12 language by prime type conditions.

The main effect of language condition was significant ($F_1(3,68) = 5.71$, $p < .01$, and $F_2(3,324) = 49.42$, $p < .001$; F_1 refers to the subject analysis and F_2 to the item analysis). Responses were faster in the language conditions with Dutch targets (DD: 515 ms; ED: 521 ms) than in the language conditions with English targets (EE: 552 ms; DE: 584 ms). Planned comparisons showed this effect to be significant (F_1: $p < .05$; F_2: $p < .001$). The main effect of prime type was also significant ($F_1(2,136) = 278.76$, $p < .001$, and $F_2(2,324) = 161.98$, $p < .001$). Planned comparisons indicated that repeated targets were responded to faster than associated targets (F_1 and F_2: $p < .001$), that in turn were responded to faster than unrelated targets (F_1 and F_2: $p < .001$). Overall, the repetition-priming effect

TABLE 2
MEAN RESPONSE TIMES (MILLISECONDS), STANDARD DEVIATIONS, AND ERROR RATES (PERCENTAGES) FOR ALL LANGUAGE BY PRIME TYPE CONDITIONS IN EXPERIMENT 1 (UNMASKED PRIMES)

	Language condition					
	EE			DD		
Prime type	RT	SD	ER	RT	SD	ER
Repeated	486	104	1.4	467	103	1.0
Associated	559	121	1.2	504	99	0.8
Unrelated	610	127	3.6	574	127	4.6
Repetition priming	124			107		
Associative priming	51			70		
	DE			ED		
	RT	SD	ER	RT	SD	ER
Repeated	540	137	2.8	492	102	1.4
Associated	581	120	2.2	510	105	0.4
Unrelated	630	120	7.1	562	109	4.0
Repetition priming	90			70		
Associative priming	49			52		

was 98 ms, whereas the associative-priming effect was 55 ms. Finally, the interaction between the two variables was also statistically reliable ($F_1(6,136) = 5.68, p < .001$, and $F_2(6,324) = 3.34, p < .01$). Planned comparisons showed the associative-priming effects in the within- and between-language conditions to be the same statistically (F_1 and F_2: $p > .05$), whereas the repetition-priming effects were larger in the within-language conditions than in the between-language conditions (F_1 and F_2: $p < .001$). The error data of Experiment 1 were inspected to see whether a speed/accuracy trade-off might have occurred. Since it appeared that this had not been the case, the error data were not subjected to further analyses.

As pointed out before, the above effects were to be compared with those to be obtained in a prime-masking condition that was to prevent the subjects' awareness of the prime. These data were collected in the following experiment. As masking technique we chose the one developed by Forster and Davis (1984), although hardware restrictions necessitated a number of minor modifications (see below).

Experiment 2

Method

Materials

The stimulus materials were those of Experiment 1.

Subjects and Apparatus

Seventy-two subjects, all students at the University of Nijmegen, participated, receiving payment for their participation. Eighteen subjects were assigned to each of the four language conditions. All subjects had Dutch as their native language and were reasonably good at comprehending English. Upon entering the laboratory they were asked to rate their comprehension ability in English on a 7-point scale (1 = bottom of the scale). The overall mean comprehension-ability ratings of the subjects were 4.7, 5.0, 4.6, and 4.7 for the subjects in the EE, DD, DE, and ED conditions, respectively. Comprehension ability did not differ significantly between groups ($p > .10$). All but one of the comprehension-ability ratings varied between 4 and 6. One subject in Group ED rated her comprehension ability a 3. The apparatus was the same as that used in Experiment 1 and in the baseline experiment.

Procedure

The subjects were (falsely) told that pairs of stimuli were going to be presented, the first of which would always be a series of "hashes," and the second would be a word or a nonword. No mention was made of the occurrence of yet another stimulus clasped in between the hashes and target. A single trial consisted of the following events: First, the fixation stimulus (asterisk) appeared on the screen for one second, slightly to the left of where the subsequent stimuli were to appear. There then was a blank ISI of 20 ms. Subsequently, a string of 11 hashes (the forward mask) appeared in the middle of the screen for 480 ms and was followed by a blank ISI of 20 ms. Then the prime was presented in upper case during 40 ms, immediately followed by a blank ISI of 20 ms, that, in its turn, was followed by the target. The prime onset/target onset asynchrony was thus 60 ms. The target, presented in lower case, remained on the screen for 500 ms. Forward mask, prime, and target were all presented at the same position. Immediately after the subject's response, the CORRECT/WRONG/SLOW feedback (see Experiment 1) appeared, four lines below the position of the earlier stimuli. Following the experiment the subjects were told that on each trial a stimulus had been presented briefly in between the hashes-stimulus and the word or nonword. They were asked whether they had noticed this, and if so, whether they had been able to identify one or more of these stimuli and about how many. In all other respects the procedure was the same as that of Experiment 1.

The major differences between the present procedure and that of Forster and Davis (1984) is, first, that the latter always presented the prime for 60 ms, second, that they presented the forward mask for 500 ms, and, third, that in their experiments there was no delay (here 20 ms) between the presentation of forward mask and prime, nor between the presentation of prime and target. However, it is important to note that their study and the present one do not differ with respect to the SOAs between forward mask and prime (500 ms in both studies) and between prime and target (60 ms in both studies). Posner and Snyder (1975) have shown that the response pattern obtained with a given prime–target SOA is the same when this SOA is made up of a relatively long prime duration and a short prime–target ISI as when the SOA is made up of a shorter prime duration and a relatively long prime–target ISI. It thus appears that prime–target SOA per se, and not the way prime duration and prime–target ISI make up this SOA, determines the response pattern. A final procedural difference between the masking manipulation by Forster and Davis (1984) and the present one is that they presented primes in lower case and targets in upper case rather than the reverse.

Results

The same language condition by prime type analyses as reported for Experiment 1, one by subjects and one by items, were performed. Mean RTs, standard deviations and error rates for the various conditions are shown in Table 3.

Again the main effect of language condition was significant ($F_1(3,68) = 4.59$, $p < .01$; $F_2(3,324) = 36.83$, $p < .001$). Although the order of the four means was the same as in Experiment 1, planned comparisons showed that only the difference between the fastest RT (DD-condition: 506 ms) and the slowest (DE-condition: 565 ms) reached significance (F_1: $p < .05$; F_2: $p < .001$).

The main effect of prime type was again significant ($F_1(2,136) = 258.47$, $p < .001$; $F_2(2,324) = 84.19$, $p < .001$). Planned comparisons showed that repeated words were responded to faster than associated words (F_1: $p < .001$; F_2: $p < .01$), that, in their

TABLE 3

MEAN RESPONSE TIMES (MILLISECONDS), STANDARD DEVIATIONS, AND ERROR RATES (PERCENTAGES) FOR ALL LANGUAGE BY PRIME TYPE CONDITIONS IN EXPERIMENT 2 (MASKED PRIMES)

	Language condition					
	EE			DD		
Prime type	RT	SD	ER	RT	SD	ER
Repeated	503	104	3.0	471	85	2.4
Associated	551	96	5.6	498	83	2.4
Unrelated	580	106	5.2	549	102	4.8
Repetition priming	77			78		
Associative priming	29			51		
	DE			ED		
	RT	SD	ER	RT	SD	ER
Repeated	533	103	3.0	529	101	2.2
Associated	571	110	4.6	521	91	1.2
Unrelated	591	106	4.2	568	98	5.4
Repetition priming	58			39		
Associative priming	20			47		

turn, were responded to faster than words in the unrelated condition (F_1 and F_2: $p < .001$). Overall, the repetition effect was 63 ms, whereas the associative-priming effect was 37 ms. Finally, the interaction between the two variables was also again statistically reliable ($F_1(6,136) = 11.87, p < 0.001$; $F_2(6,324) = 3.92, p < .01$). A planned comparison showed the following results. As in Experiment 1, both within-language repetition effects (EE and DD) were larger than the corresponding between-language effects (DE and ED, F_1 and F_2: $p < .001$). However, this time there was also a difference among the associative-priming effects. The effects in the two conditions with Dutch targets (DD and ED) were larger than those in the conditions with English targets (EE and DE; F_1 and F_2: $p < .001$). That these effects are larger in the DD and ED conditions may be due to the fact (see above) that the mean baseline RT of the Dutch targets in the associated condition was shorter (521 ms) than those of the Dutch targets in the repeated and unrelated conditions (538 ms in both cases). As before, the error data indicate that the subjects have not traded off speed with accuracy. Therefore, they were not subjected to further analysis.

The above analyses show that both within- and between-language priming effects can be obtained under prime-masking conditions. It is interesting to see whether subjects who reported never to have identified the prime (see Procedure section) and those who reported to have identified at least one of the primes, contributed equally to these priming effects. Of the 72 subjects, 20 had been able to identify at least one prime (henceforth: the supra-threshold subjects) and 52 said not to have identified any of the primes (henceforth: the sub-threshold subjects).[1] On the word-target data of the 20 supra-threshold subjects and of 20 sub-threshold subjects (randomly selected from the total group of sub-threshold subjects), a 2 (threshold: supra vs. sub) by 3 (prime type) by 20 (subjects) ANOVA was performed, treating threshold as a between-subjects variable and prime type as a within-subjects variable. Only the main effect of prime type was statistically reliable $F_1(2,76) = 176.33, p < .001$). The fact that threshold and prime type did not interact ($F_1(2,76) < 1$) indicates that sub- and supra-threshold subjects contributed equally to the priming effects.

From Tables 2 and 3 it appears that the priming effects were generally larger with unmasked prime presentation (Experiment 1) than with masked prime presentation (Experiment 2). In order to test this observation statistically, the combined data of Experiments 1 and 2 were subjected to two further analyses, one by subjects and one by items. In addition to the variables language condition and prime type, the variable masking (unmasked vs. masked) was included in these analyses. This variable was treated as a between-subjects variable but a within-items variable. Not surprisingly, as in the analyses of the separate experiments on both analyses the main effects of language condition and prime type, as well as their interaction, were statistically reliable. Since these effects have already been dealt with, they will not be discussed any further. Instead, we concentrate on the new variable, masking.

[1] Out of the 20 "supra-threshold" subjects, eight reported to have identified one prime only; five reported to have identified about two to five; and seven claimed to have identified more than five (up to a quarter of the primes). Interestingly, the supra-threshold subjects were not evenly distributed across the language conditions: Nine of them were tested in condition DD; six in condition EE; four in condition DE; and one in condition ED. Of the seven subjects who had identified more than five primes, six were tested in condition DD. It is clear from these data, that the masking manipulation was less effective when the primes were presented in the subjects' first language than when presented in their second language and that it was less effective when prime and target were presented in the same language than when presented in different languages.

The mean overall RTs to word targets following unmasked and masked primes were 543 ms and 539 ms, respectively. This main effect was not significant on the analysis by subjects ($F_1(1,136) < 1$), but it was marginally significant on the analysis by items ($F_2(1,324) = 3.16$, $.05 < p < .10$). The primary purpose of the present analyses was to see whether the priming effects were statistically larger when the primes are not masked than when they are masked. The variables masking and prime type indeed interact ($F_1(2,272) = 23.84$, $p < .001$; $F_2(2,324) = 25.71$, $p < .001$). Planned comparisons showed that both the repetition effect (F_1: $p < .05$; F_2: $p < .01$) and the associative-priming effect (F_1 and F_2: $p < .001$) were larger (by 35 ms and 18 ms, respectively) when the primes were not masked.

The results of Experiments 1 and 2 can be summarized as follows. First, priming effects were larger when the primes were not masked than when they were masked. Second, the repetition effects were larger than the associative-priming effects. Third, the repetition effects were larger within than between languages. Fourth, the associative-priming effects were equally large within and between languages. This latter finding appears to hold in general, even though the data of the conditions with and without prime masking are at variance on one point: With unmasked primes the associative priming effect was equally large statistically in all four within- and between-language conditions, whereas with masked primes it was larger in the language conditions with targets in the stronger language (DD and ED) than in those with targets in the weaker language (EE and DE).

The discussion of these results will be postponed until later. For now we concentrate on the outcome that is most relevant in view of the main question posed in the introduction, that is, whether or not repetition priming occurs between languages. As is clear from Tables 2 and 3, quite large repetition effects were obtained in the between-language conditions. Translation (presented earlier as a form of attentional priming) cannot underlie the between-language repetition effect in the masking condition, because it may be assumed that conscious prime identification is required for translation (as it is for other types of attentional priming). The short SOA duration (60 ms) in this condition also rules out an interpretation of this effect in terms of translation. Furthermore, it is unlikely that post-lexical meaning integration is responsible for the effect (see introduction). It thus seems that the effect has to be attributed to spreading activation in the lexical representational structure of the bilingual, thus revealing aspects of this structure. In the unmasked condition prime–target SOA (240 ms) was presumably also far too short for translation to be the source of the between-language repetition effect, but there post-lexical meaning integration may have confounded the repetition effect due to spreading activation.

Yet, an alternative interpretation of the between-language repetition effect, also of that obtained in the prime-masking condition, has to be considered. Recall that only cognates were presented as stimulus materials. It is possible that despite the use of a different type of print for primes and targets (upper case and lower case, respectively), peripheral visual processing of the targets in the between-language repetition condition is facilitated due to their orthographic similarity to the primes, and that this is reflected in the between-language repetition effect. This interpretation is less plausible for the condition with masked primes than for that with unmasked primes, but not altogether implausible either, given the fact that the masking manipulation was not successful on all trials for all subjects. The following experiment served to clarify this issue. In this experiment both cognates and noncognates were presented as stimulus materials. The experimental design and procedure were basically the same as those of Experiments 1 and 2, save that now only data from one within- (EE) and one between-language condition (DE) were collected and that prime presentation (masked vs. unmasked) was manipulated within this one experiment. If the between-language repetition effects obtained in Experiments 1 and 2 were not (or at least not altogether) caused by facilitated encoding of the targets due to their orthographic similarity to the primes, the effect should also materialize for noncognates, for which an interpretation in terms of facilitated encoding does not hold.

Experiment 3

Method

Collecting Baseline RTs

Prior to the actual experiment, again, a pilot experiment was run (see Method section of Experiment 1) in which unprimed (baseline) lexical-decision RTs were collected to a large set of words, again all nouns, and pseudowords. The materials of Experiment 3 were derived from this study. This time baseline RTs for only English words were collected, and the stimulus materials contained both cognates and noncognates. Pseudowords were again derived from the words by changing, adding or deleting one or two letters. All subjects, 18 in all, were presented with the complete set of materials. They were drawn from the same population as those who were to participate in the actual priming Experiment 3. All were first year psychology students at the University of Amsterdam.

Following data collection, mean RTs of correct responses and error scores were calculated for all stimuli. Subsequently, 15 sextets of words were selected such that the mean baseline RTs and the number of errors of the six words within a sextet were as similar as possible. A further selection constraint was that within each sextet three words had to be cognates and three noncognates. Each member of a sextet was to serve as a target in one of the six prime type (associated, repeated, and unrelated) by word type (cognates vs. noncognates) conditions in the actual priming experiment. The overall mean baseline RTs for the six sets thus composed were 548 ms (*SD:* 60), 550 ms (*SD:* 57), 550 ms (*SD:* 52), 549 ms (*SD:* 47), 547 ms (*SD:* 44), and 549 ms (*SD:* 39). The mean error scores for the words within these sets were, in the same order, 4.1%, 1.1%, 2.2%, 4.4%, 2.2%, and 2.2%.

Materials

The test materials of Experiment 3 consisted of two lists of 180 prime–target stimuli each, List EE and List DE. Of the 180 stimuli within a list, 90 had a word as target and the remaining 90 had a pseudoword as target. All 180 targets were the same for both lists. The 90 word targets were the words composing the six sets selected from the above baseline experiment. In deriving List EE, each of the words in two of these sets, one set of cognates and one of noncognates, was paired with another English word to which it was a relatively strong associate (as assessed from several corpora of *Dutch* association norms). These paired words were to serve as primes. The mean associative strengths of the 15 cognate and the 15 noncognate targets to their primes were 50.5% (*SD:* 19.9) and 51.5% (*SD:* 23.6), respectively. These two sets of prime–target pairs constituted the associated prime type condition. The words in two of the remaining sets selected from the baseline experiment, one consisting of cognates and one of noncognates again, were assigned the role of both prime and target in the repeated prime type condition. Finally, the words in the last two baseline sets, one consisting of cognates and one of noncognates, were to serve as targets in the unrelated prime type condition. Each of them was paired with a prime word that was not related to the target in any obvious way. All 45 cognate targets were paired with cognate primes, and all 45 noncognate targets were paired with noncognate primes. The remaining 90 stimuli in List EE consisted of a word prime, again always a noun, and an English-like pseudoword as target. Half of the primes in these stimuli were cognates and half were noncognates. The pseudowords were the letter strings that in the baseline experiment had been derived from the 90 words presently occurring as word targets in List EE. List DE was derived from List EE by replacing all primes in the latter list by their Dutch translations.

In addition to the test materials, both lists included 40 practice stimuli. The practice stimuli within a list were of the same types as the test stimuli within the list, and all of them occurred in about the same proportion as the test materials. Appendix B shows all test materials of Experiment 3.

Collecting Similarity Ratings

To assess the degree of cognate relationship between the translations in this and the earlier experiments (and to see whether our assignment of words to the categories of cognates and noncognates had been appropriate), a rating study was performed. In this study all pairs of Dutch–English cognate (e.g., hel–hell) and noncognate (e.g., konijn–rabbit) translations used in Experiments 1, 2, and 3 were presented to 60 subjects, all first year psychology students at the University of Amsterdam. They were asked to rate on a 7-point scale how similar they thought the Dutch–English translations within each pair to be. A 7 was to be marked in case of very high similarity; a 1 in case of very low similarity. The subjects were told that any single rating should reflect a combined assessment of both spelling and sound similarity of the Dutch–English word pair under consideration. In order to equate the number of cognate and noncognate translations among the materials (recall that in Experiments 1 and 2 only cognate materials were used), a number of noncognate translations were added as fillers to the stimulus set. The complete set consisted of 280 pairs of a Dutch word and its translation in English. These pairs were presented to the subjects in booklets, 10 pairs a page, all pairs underneath one another, and the pages reshuffled in every new booklet. Cognate and noncognate translation pairs were printed in a mixed order, with the constraint that never more than four cognate or noncognate pairs were allowed to occur in succession. The subjects were randomly assigned to three groups of 20 each. Group 1 got the Dutch words to the left of their English translations (blad–leaf; natuur–nature); Group 2 got the English words in left position (leaf–blad; nature–natuur); in Group 3 the left–right presentation order of the Dutch and English words was reserved for every subsequent translation pair (blad–leaf; nature–natuur). It took the subjects from 12 to 25 min to mark all 280 translation pairs.

For each of the three subject groups separately a mean similarity rating for each of the 280 translation pairs across the 20 subjects was then calculated. Subsequently, the resulting three sets of 280 mean ratings were correlated. Extremely high correlations between the groups emerged (Group 1 and Group 2: r = .995; Group 1 and Group 3: r = .994; Group 2 and Group 3: r = .994). One excepted, all translation pairs assigned a cognate status in Experiments 1, 2, and 3 received higher similarity ratings than any of the translation pairs assigned a noncognate status. The exception was the cognate pair thumb/duim, of which the words were presented as prime in the EE and DE conditions, respectively. This pair received a lower rating (3.06) than the noncognate pair with the highest rating (smoke/rook; 3.37). The reason this latter pair is rated this high presumably is that they rhyme. Appendices A and B show the mean similarity ratings for all test stimuli of Experiments 1, 2, and 3. These means are based on the ratings of the total group of 60 subjects.

Subjects and Apparatus

In all, 68 subjects took part in the actual priming part of Experiment 3. Seventeen of them were assigned randomly to each of the four language condition (EE and DE) by prime masking (unmasked vs. masked) conditions. All subjects were drawn again from the population of first-year psychology students of the University of Amsterdam. None of them had participated in the baseline and similarity-rating studies described above. They received course credit for participation. All subjects had Dutch as their native language and were reasonably good at comprehending English. Upon entering the laboratory they were asked to rate on a 7-point scale their comprehension ability in English (1 = bottom of the scale). The overall mean comprehension-ability ratings were 4.9 for the subjects in the unmasked/Dutch prime group, 4.8 in both the unmasked/English prime and masked/Dutch prime groups, and 4.4 in the masked/English prime group. Comprehension ability did not differ significantly between groups ($p > .10$). All ratings varied between 3 and 6.

The experiment was run on a Schneider PC 1640, an IBM-clone. Stimuli were presented in black against a white background on the computer screen. A PASCAL program controlled the stimulus presentation and RT- and error recording.

Procedure

The experimental procedure was identical to that of Experiments 1 (the present unmasked-prime condition) and 2 (the present masked-prime condition), except that (1) the subjects were now tested individually; (2) all subjects were instructed in English, the language of the targets; (3) they notified their responses by pushing two keys on the computer keyboard (the "del"-key for word responses and the F9-key for nonword responses; all other keys were disabled); (4) not only in the unmasked-prime condition but also in the masked-prime condition, targets remained on the screen until the subject had responded. The data of all conditions were collected in parallel. That is, the first subject who entered the laboratory was tested in the EE condition with unmasked primes; the next in condition DE with unmasked primes; the third in condition EE with masked primes; and the fourth in condition DE with masked primes. These rounds were repeated until 17 subjects per condition had been tested. Following the experiment the subjects in the masked-prime condition were told about the masked primes and were asked whether they had noticed their presence and if so, whether they had been able to identify one or more of them. Out of the 34 subjects in this condition, only six reported to have identified some of them. The other subjects claimed even not to have noticed their presence.

Results

For each subject six mean RTs were calculated on the word-target data, one for each of the six prime type (associated, repeated, and unrelated) by word type (cognates vs. noncognates) conditions. In calculating these means, incorrect responses were excluded, as well as responses (less than 0.5% overall) that took less than 100 ms or more than 1400 ms. To parallel the analyses of Experiments 1 and 2, the data analyses for the unmasked and masked presentation conditions will first be reported separately. Subsequently, the additional information provided by the analyses on the combined data will be reported.

A 2 (language condition: EE vs. DE) by 2 (word type: cognates vs. noncognates) by 3 (prime type: associated, repeated, and unrelated) by 17 (subjects) ANOVA was performed on the above six means of each subject in the unmasked condition, treating word type and prime type as within-subjects variables and language condition as a between-subjects variable. Also the corresponding 2 (language condition) by 2 (word type) by 3 (prime type) by 15 (items) ANOVA was performed on the item means, treating language condition as a within-items variable, and word type and prime type as between-items variables. Table 4 shows the mean RTs, standard devia-

TABLE 4
MEAN RESPONSE TIMES (MILLISECONDS), STANDARD DEVIATIONS, AND ERROR RATES (PERCENTAGES) FOR ALL UNMASKED-PRIME CONDITIONS IN EXPERIMENT 3

	Language condition EE					
	Cognates			Noncognates		
Prime type	RT	SD	ER	RT	SD	ER
Repeated	459	82	1.2	484	106	3.1
Associated	549	104	3.1	555	118	5.5
Unrelated	594	114	7.8	620	135	10.2
Repetition priming	135			136		
Associative priming	45			65		
	Language condition DE					
	Cognates			Noncognates		
	RT	SD	ER	RT	SD	ER
Repeated	532	134	2.0	515	82	3.1
Associated	541	93	3.5	577	124	5.1
Unrelated	600	108	9.0	628	113	11.8
Repetition priming	68			113		
Associative priming	59			51		

tions, and error rates for all 12 language condition by word type by prime type conditions.

The main effect of language condition was only significant on the item analysis ($F_1(1,32) = 1.86, p > .10; F_2(1,84) = 21.56, p < .001$): Responding in condition EE was 23 ms faster than in condition DE (543 ms and 566 ms, respectively). The main effect of word type was significant on the subject analysis ($F_1(1,32) = 21.04, p < .001$), but not on the item analysis ($F_2(1,84) = 2.64, p > .10$): Responding to cognates was 17 ms faster than to noncognates (546 ms and 563 ms, respectively). The main effect of prime type was statistically reliable on both analyses ($F_1(2,64) = 210.86, p < .001; F_2(2,84) = 36.68, p < .001$): Overall response times in the repeated, associated, and unrelated conditions were 497 ms, 556 ms, and 610 ms, respectively. A Newman–Keuls test indicated that all differences between these means were statistically reliable (F_1 and F_2: $p < .01$).

Of the interactions, that between language condition and prime type was significant on both analyses ($F_1(2,64) = 11.03, p < .001; F_2(2,84) = 10.74, p < .001$): As in Experiment 1, the repetition effect was larger within than between languages (136 ms vs. 91 ms), whereas the associative-priming effect did not differ between these two conditions (55 ms in both cases). The means for the repeated, associated, and unrelated conditions were 471 ms, 552 ms, and 607 ms in condition EE, and 523 ms, 559 ms, and 614 ms, respectively, in condition DE. Finally, the three-way interaction between language condition, word type, and prime type was significant on both analyses ($F_1(2,64) = 5.75, p < .01; F_2(2,84) = 4.71, p < .05$): In the between-language condition, the repetition effect on cognates was considerably *smaller* (68 ms) than on noncognates (113 ms). None of the remaining interactions were significant. Overall, 5.5% errors were made in the unmasked-prime condition. The error data indicated that the subjects did not trade off accuracy and speed. Therefore, they were not analysed any further.

The smaller between-language repetition effect on cognates than on noncognates is reminiscent of Colombo's (1986) finding that in lexical decision form-priming effects are often inhibitory. Forster et al. (1987) argued that Colombo's inhibitory effects resulted from the fact that she did not mask the primes and showed that in the masked-priming paradigm facilitatory effects of form priming are readily obtained (see also Humphreys et al., 1987). A possible explanation of the smaller between-language repetition effect with cognates (orthographically similar between languages) than with noncognates (not orthographically similar) in the unmasked-prime condition thus is that in the case of cognates the facilitatory priming effect is partly undone by an inhibitory effect of form-similarity. Indeed, in the masking condition (see below) the between-language repetition effect on cognates is no longer smaller than on noncognates, but, if anything, it is larger.

The same language condition by word type by prime type analyses as reported for the unmasked-prime condition were performed on the masked-prime data. Mean RTs, standard deviations, and error rates for the various conditions are shown in Table 5.

Although again responding was slightly faster in the EE condition (558 ms) than in the DE condition (564 ms), this main effect of language condition was not significant now ($F_1(1,32) < 1$; $F_2(1,84) = 1.95$, $p > .10$). As with the unmasked-prime data, the main effect of word type was significant on the subject analysis $F_1(1,32) = 7.42$, $p = .01$), but not on the item analysis ($F_2(1,84) = 1.52$, $p > .10$): Responding to cognates was slightly faster than to noncognates (555 ms and 567 ms, respectively). The main effect of prime type was statistically reliable on both analyses ($F_1(2,64) = 69.59$, $p < .001$; $F_2(2,84) = 10.35$, $p < .001$): Overall response times in the repeated, associated, and unrelated conditions were 533 ms, 564 ms, and 586 ms, respectively. Newman–Keuls tests indicated that on the subject analysis all differences between these means were statistically reliable at the 1% level. However, on the item analysis only the differences between the associated and repeated conditions, and between the repeated and unrelated conditions were statistically reliable ($p < .01$ in both cases).

Of the interactions, that between-lan-

TABLE 5

MEAN RESPONSE TIMES (MILLISECONDS), STANDARD DEVIATIONS, AND ERROR RATES (PERCENTAGES) FOR ALL MASKED-PRIME CONDITIONS IN EXPERIMENT 3

	Language condition EE					
	Cognates			Noncognates		
Prime type	RT	SD	ER	RT	SD	ER
Repeated	511	93	1.6	538	112	4.3
Associated	565	121	3.9	558	91	5.1
Unrelated	585	115	5.1	593	102	3.9
Repetition priming	74			55		
Associative priming	20			35		
	Language condition DE					
	Cognates			Noncognates		
	RT	SD	ER	RT	SD	ER
Repeated	531	87	3.5	553	86	2.0
Associated	560	87	4.3	575	93	6.3
Unrelated	579	106	4.7	588	105	4.7
Repetition priming	48			35		
Associative priming	19			13		

guage condition and prime type was again significant on the subject analysis ($F_1(2,64) = 3.14$, $p = .05$), but this time it was not significant on the item analysis ($F_2(2,84) = 1.89$, $p > .10$). The means for the repeated, associated, and unrelated conditions were 525 ms, 561 ms, and 589 ms, respectively, in the EE condition, and 542 ms, 567 ms, and 584 ms, respectively, in the DE condition. Unlike in the analysis of the unmasked-prime data, the two-way interaction between word type and prime type just reached significance, but only on the subject analysis ($F_1(2,64) = 3.05$, $p = .05$; $F_2(2,84) < 1$): The associative priming effect was about equally large for cognates and noncognates (20 ms and 24 ms, respectively), but the repetition effect was larger for cognates (61 ms) than for noncognates (45 ms). None of the remaining interactions was significant. Overall, 4.1% errors were made in the masked-prime condition. The error data indicated that the subjects did not trade accuracy for speed. Therefore, they were not subjected to further analysis.

Finally, two analyses, one by subjects and one by items, were performed on the combined data of the unmasked-prime and masked-prime conditions. Only the additional information provided by these analyses will be reported. Prime-masking was treated as a between-subjects variable and a within-items variable.

The main effect of prime masking was statistically reliable on the item analysis ($F_2(1,84) = 4.40$, $p < .05$) but not on the subject analysis ($F_1(1,64) < 1$): Responding in the unmasked condition was 7 ms faster overall (554 ms) than in the masked condition (561 ms). The interaction between prime masking and prime type was significant on both the subject and item analyses ($F_1(2,128) = 35.56$, $p < .001$; $F_2(2,84) = 32.13$, $p < .001$). As was observed in the overall analyses on Experiments 1 (unmasked primes) and 2 (masked primes), both the repetition effect and the associative-priming effect were larger with unmasked presentation of the prime (113 ms and 54 ms, respectively) than with masked prime presentation (53 ms and 22 ms, respectively). The three-way interaction between prime masking, word type, and prime type was significant on both the subject and the item analysis ($F_1(2,128) = 4.95$, $p < .01$; $F_2(2,84) = 4.70$, $p = .01$). This interaction reflects the fact that masking the prime resulted in a considerable drop in the size of the repetition effect on noncognates (unmasked primes: 125 ms; masked primes: 45 ms), whereas masking the prime had a much smaller effect on the size of the repetition effect for cognates (unmasked primes: 102 ms; masked primes: 61 ms). Finally, the three-way interaction between masking, language condition, and prime type was significant on the item analysis ($F_2(2,84) = 4.03$, $p < .05$), and it was marginally significant on the subject analysis ($F_1(2,128) = 2.85$, $0.5 < p < .10$). It reflects the fact that the repetition effect is particularly large when the primes are not masked and presented in English, that is, when exactly the same words are presented as prime and target and both are clearly visible. No further interactions with the masking variable were significant.

From the above analyses it is clear that the cognate condition of Experiment 3 constitutes a good replication of the corresponding conditions in Experiments 1 and 2. Again, (1) larger priming effects were obtained in the unmasked-prime condition than in the masked-prime condition, (2) the repetition effects were larger than the associative-priming effects, and (3) the repetition effect was larger within than between languages, whereas the associative-priming effect was about equally large in these two conditions. But the data for noncognates are of more relevance here. The results for noncognates generally mirror those for the cognates, except that the associative-priming effect now appears somewhat smaller between than within languages, especially in the masking condition. In fact, analyses on only the RTs of the associatively-related and unrelated noncognate stimuli in the between-language masking condition indicated that the 13-ms associative priming effect in this condition was not statistically reliable ($F_1(1,16) = 2.78$, $p = .11$; $F_2(1,28) = .49$, $p = .49$). However, the same analyses but now on the within-language data showed that the corresponding (35 ms) within-language associative-priming effect *was* significant, at least on the subject analysis ($F_1(1,16) = 23.92$, $p < .001$; $F_2(1,28) = 2.70$, $p = .11$). This finding will be elaborated in Experiment 4 below. For now, we concentrate on the between-language repetition effects for noncognates. The data clearly show such effects. They cannot be attributed to target encoding being facilitated by the primes, because, unlike cognate translations, noncognate translations are not orthographically similar. We will argue later that this finding suggests that in bilingual memory the lexical representations of translation equivalents, also those of noncognates, are connected.

Two final analyses also suggest that a cognate relation between translations is not a prerequisite for the repetition effect to occur between languages. The first was a *t* test performed on the repetition effects in the between-language condition with masked primes. It showed that the effect obtained with cognates (48 ms) and the one obtained with noncognates (36 ms) did not differ significantly from one another ($F(1,16) = 1.16$, $p = .30$; recall that in the *unmasked*-prime condition the between-language repetition effect was, in fact, *larger* for noncognates than for cognates). In the second analysis the repetition effects on the 30 words in the repetition condition (15 cognates and 15 noncognates) were correlated with the similarity ratings for these words and their translations (see Materials section).[2] This was done for each of the four language condition (DE vs. EE) by prime masking (masked vs. unmasked) conditions. The correlation coefficients associated with the DE/unmasked condition was significant, but negative ($r = -.39$, $p < .05$). This finding corroborates the above observation that in this condition a larger repetition effect was obtained for noncognates than for cognates. None of the other correlations were statistically reliable ($r = -.03$, $p > .10$, $r = .20$, $p > .10$, and $r = .19$, $p > .10$ for the EE/unmasked, EE/masked, and DE/masked conditions, respectively).

Experiment 4

Post-hoc analyses on the data of Experiment 3 raised some doubt about whether indeed, as suggested by the overall analyses of the data, the between-language associative-priming effect is as large for noncognates as it is for cognates in the masking condition. In fact, these analyses suggested the absence of a between-language associative-priming effect for noncognates in this condition. One purpose of Experiment 4 was to replicate this result. A second was to test the suggestion of Sandra (1990) that priming effects obtained when a masked prime is presented in upper case and a target in lower case disappear when case assignment to prime and target is reversed.

Method

Materials, Subjects, Apparatus, and Procedure

The test materials and apparatus were the same as those used in Experiment 3.

[2] To calculate these repetition effects, the baseline RTs of the 15 cognates that had served as targets in the repeated cognate condition were ordered from shortest to longest. The same was done with the baseline RTs of the 15 cognates that had served as targets in the unrelated cognate condition. The repeated cognate word with the shortest baseline RT was paired with the unrelated cognate word with the shortest baseline RT, and the RTs for these words as obtained in the actual priming experiment were subtracted to obtain the repetition effect on the repeated word. The repeated cognate word with the next to shortest baseline RT was paired with the unrelated cognate word with the next to shortest baseline RT, and so on, and subsequently, following the above procedure, the repetition effects for all repeated cognate words were obtained. This procedure was repeated for the noncognate words.

The experimental procedure was identical to that of Experiment 3, except that (1) the prime was always masked; (2) as in Experiments 1 through 3, primes were presented in upper case and targets in lower case in one condition, but case assignment to primes and targets was reversed in a second condition.

In all, 76 subjects took part in Experiment 4. Nineteen were assigned randomly to each of the four language condition (EE and DE) by case assignment (primes in upper case, targets in lower case vs. primes in lower case, targets in upper case) conditions. All subjects were again drawn from the population of first year psychology students of the University of Amsterdam. None of them had participated in Experiment 3 and they received course credit for participation. All subjects had Dutch as their native language, but were reasonably good in English comprehension. The mean comprehension-ability ratings (see Experiments 1 to 3) were 4.8 in the group with lower case Dutch primes; 4.7 in the group with lower case English primes; 5.2 in the group with upper case Dutch primes; and 4.7 in the group with upper case English primes. Comprehension ability did not differ significantly between groups ($p > .10$). The ratings varied between 3 and 6.

As in the masking condition of Experiment 3, following the experiment the subjects were told about the masked primes and were asked whether they had noticed their presence and, if so, whether they had been able to identify one or more of them. Out of the 76 subjects, 11 reported to have identified some of them. The others had not even noticed their presence.

Results

For each subject six mean RTs were calculated on the word-target data, one for each of the six prime type (associated, repeated, and unrelated) by word type (cognates vs. noncognates) conditions. In calculating these means, incorrect responses were excluded, as well as responses (less than 0.5% overall) that took less than 100 ms or more than 1400 ms.

A 2 (case assignment) by 2 (language condition: EE vs. DE) by 2 (word type: cognates vs. noncognates) by 3 (prime type: repeated, associated, and unrelated) by 19 (subjects) ANOVA was performed on the above six means of each subject. Word type and prime type were treated as within-subjects variables, and case assignment and language condition as between-subjects variables. Also the corresponding 2 (case assignment) by 2 (language condition) by 2 (word type) by 3 (prime type) by 15 (items) ANOVA was performed on the item means, treating case assignment and language condition as within-items variables and word type and prime type as between-items variables. Tables 6 (upper case primes, lower case targets) and 7 (lower case primes, upper case targets) show the mean RTs, standard deviations, and error rates for all experimental conditions.

A main effect of case assignment occurred on the item analysis ($F_2(1,84) = 8.93, p < .01$) but not on the subject analysis ($F_1(1,72) = .37, p > .10$): With lower case targets RT was slightly shorter (560 ms) than with upper case targets (567 ms), a finding that is likely due to the larger distinctiveness of lower case letters. The main effect of language condition was significant on the item analysis ($F_2(1,84) = 4.11, p < .05$), but not on the subject analysis ($F_1(1,72) = .27, p > .10$): Responding in condition EE was 6 ms slower than in condition DE (566 ms and 560 ms, respectively). The main effect of word type was significant on the subject analysis ($F_1(1,72) = 25.41, p < .001$), but not on the item analysis ($F_2(1,84) = 1.90, p > .10$): Responding to cognates was 12 ms faster than to noncognates (557 ms and 569 ms, respectively). The main effect of prime type was statistically reliable on both analyses ($F_1(2,144) = 175.13, p < .001$; $F_2(2,84) = 12.71, p < .001$): Overall, response times in the repeated, associated, and unrelated conditions were 530 ms, 571 ms, and 589

TABLE 6
MEAN RESPONSE TIMES (MILLISECONDS), STANDARD DEVIATIONS, AND ERROR RATES (PERCENTAGES) FOR ALL UPPER CASE PRIMES/LOWER CASE TARGETS CONDITIONS IN EXPERIMENT 4

	Language condition EE					
	Cognates			Noncognates		
Prime type	RT	SD	ER	RT	SD	ER
Repeated	519	92	3.2	538	93	3.5
Associated	568	101	6.0	567	99	9.1
Unrelated	593	102	8.4	588	106	7.7
Repetition priming	74			50		
Associative priming	25			21		
	Language condition DE					
	Cognates			Noncognates		
	RT	SD	ER	RT	SD	ER
Repeated	514	76	4.2	541	80	3.2
Associated	554	93	3.9	577	111	6.0
Unrelated	578	116	3.5	581	104	7.4
Repetition priming	64			40		
Associative priming	24			4		

ms, respectively. A Newman–Keuls test indicated that on the subject analysis all differences between these means were statistically reliable. However, on the item analysis all differences except one were significant, the exception being that between the associated and unrelated conditions.

Of the interactions, that between lan-

TABLE 7
MEAN RESPONSE TIMES (MILLISECONDS), STANDARD DEVIATIONS, AND ERROR RATES (PERCENTAGES) FOR ALL LOWER CASE PRIMES/UPPER CASE TARGETS CONDITIONS IN EXPERIMENT 4

	Language condition EE					
	Cognates			Noncognates		
Prime type	RT	SD	ER	RT	SD	ER
Repeated	522	103	2.5	535	99	3.5
Associated	570	105	5.6	590	118	10.2
Unrelated	599	114	8.1	608	110	7.0
Repetition priming	77			73		
Associative priming	29			18		
	Language condition DE					
	Cognates			Noncognates		
	RT	SD	ER	RT	SD	ER
Repeated	516	80	4.2	554	110	4.2
Associated	564	114	4.6	579	120	8.4
Unrelated	591	114	6.0	576	94	7.4
Repetition priming	75			22		
Associative priming	27			−3		

guage condition and prime type was significant on the subject analysis ($F_1(2,144) = 3.96, p < .05$), and marginally significant on the item analysis ($F_2(2,84) = 2.93, .05 < p < .10$). The means for the repeated, associated, and unrelated conditions were 528 ms, 574 ms, and 597 ms, respectively, in the EE condition, and 531 ms, 568 ms, and 582 ms, respectively, in the DE condition. The interaction between word type and prime type was significant on the subject analysis ($F_1(2,144) = 9.67, p < .001$), but not on the item analysis ($F_2(2,84) = .65, p > .10$): The associative priming effect was 26 ms for cognates and 10 ms for noncognates; the repetition effect was 72 ms for cognates and 46 ms for noncognates. None of the remaining interactions was significant nor approached significance. Particularly noteworthy is that the new variable, case assignment, did not interact with any of the other variables. Contrary to Sandra's suggestion (see above), the priming effects obtained with the primes in lower case and the targets in upper case are, statistically, equally large than those obtained with case assignment reversed. Overall, 5.7% errors were made. With one exception, the faster conditions were associated with the smaller error scores. The exception is the associated/noncognate condition, in which relatively many errors were made. However, these large error scores appeared not to be evenly distributed across the items, but attributable to one word ("rifle") that was categorized as a nonword relatively often. At the same time, the mean RT of correct responses to this word was always the longest among the responses to associated stimuli, thus suggesting that no speed/accuracy trade-off has occurred.

Experiment 4 constitutes a good replication of the comparable (masking) condition of Experiment 3. Again reliable between-language repetition effects were obtained for both cognates and noncognates (note, however, that the between-language repetition effect on noncognates in the lower case primes/upper case targets condition was considerably smaller than this same effect on cognates; further analyses on the relevant subset of the data indicated that this difference was reliable on the subject analysis, $p < .01$, and marginally so on the item analysis, $p = .06$). The pattern of associative-priming effects was also similar to that obtained in Experiment 3. Most striking is that the between-language associative-priming effect on noncognates (13 ms, but not significant in Experiment 3) has now disappeared altogether (4 ms in the condition with upper case primes and lower case targets, and −3 ms in the reversed case assignment condition). These data thus strongly suggest that a between-language associative priming effect is restricted to cognates.

General Discussion

The aim of this study was to gain insight into the organization of the mental lexicon of Dutch–English compound bilinguals by comparing within- and between-language repetition- and associative priming effects. As set out before (see introduction), a major focus of this study was on a possible repetition effect across languages. Such effect was indeed obtained, both with masked and unmasked prime presentation, and both for cognates and noncognates. Especially its occurrence for noncognates and under prime-masking circumstances is relevant in view of our present interest in lexical organization. When the translations are cognates and both are clearly visible it is conceivable that the effect is caused by their orthographic similarity, facilitating peripheral processing of the target, and by the retrieval of episodic traces (see below). Also, in the unmasked-prime condition post-lexical processing (see introduction) may have contributed to the effect, both when cognates and noncognates served as stimulus materials. To the extent that the masking manipulation was not altogether efficacious (in the sense that some information on the prime's spelling may still have leaked through even though the subjects could not identify it), orthographic similarity of prime and target may also be responsible, at least in part, for the effect on cognates in the masking condition. But such interpretation will not do for the effect on noncognate translations, with totally different appearances. It thus appears that this effect on noncognates has to be attributed to automatic spreading activation within the lexical memory of the bilingual, thus suggesting across-language connections between the representations of translations. In all, these data provide clear support for an integrated bilingual lexical memory.

The above findings corroborate those of Jin and Fischler (1987), obtained with Korean–English bilinguals, and those of Chen and Ng (1989), who tested Chinese–English bilinguals. As here, in both those studies the SOA between the translations was short (150 ms and 300 ms, respectively), so that the between-language effect could materialize. But the prime was always presented unmasked there, so that the effect due to spreading activation along links in the mental lexicon may have been confounded by those of other processes (contacting episodic traces; post-lexical translation). In addition to masking the prime, a further new feature of this study was the manipulation of "cognateness" of the translations.

Although consistent with the above two investigations, the present findings conflict with those of other studies on between-language repetition, all of which are instantiations of the classical repetition paradigm. Scarborough et al. (1984, Experiment 1) first presented a block of lexical decision trials in the one language (Spanish), followed by a block in the second language (English). Half of the words in the second block were new words, whereas the remainder were translations of words in the first block. The translations were all noncognates, hence orthographically dissimilar words. Not a trace of a between-language repetition effect was observed (−4 ms). Similarly, no between-language repetition effects emerged in studies with English–Hindi bilinguals (Kirsner et al., 1980) and French–English bilinguals (Kirsner et al., 1984). Although the latter two studies differed from that of Scarborough and his colleagues in a number of ways, they were similar on two presumably critical aspects. First, again a relatively long time elapsed between the presentation of a word in the one language and its occurrence in the second language. Second, the translations were orthographically dissimilar (Kirsner et al., 1980) or presumably so (Kirsner et al., 1984. They report them to be phonemically dissimilar, but since phonemic and orthographic similarity are usually confounded, orthographic dissimilarity of the translations was presumably also the case). As was set forth earlier (see introduction), the long interval between the occurrence of the translations presumably is unfavorable for a lexically-based repetition effect to come about (Forster & Davis, 1984). Furthermore, it was noted there that an episodic priming effect likely requires the subjects' awareness of the repetition (Oliphant, 1983). It is plausible that in the case of orthographically dissimilar translations being presented between languages the subjects are not aware of the repetition, and consequently no such episodic effect would occur. In contrast, if cognates, that is, orthographically similar translations, are presented between languages the subjects may become aware of the repetition, so that an episodic repetition effect should come about. Indeed, Cristoffanini et al. (1986; Experiment 1) and Kerkman (1984), also using long intervals between the presentation of the translations, obtained reliable between-language repetition effects for cognates (Spanish–English and Dutch–English, respectively). An interesting extension of this result was recently provided by Gerard and Scarborough (1989), who used the classical (long-lag) repetition technique to investigate between-language priming on Spanish–English *identical* cognates (translations with exactly the same form and meaning across languages), noncognate translations, and homographic noncognates (words spelled exactly the same in the two languages, but with different meanings). Again, for noncognates no between-language repetition effect was obtained, but equally large effects were observed for cognates and homographic noncognates. The latter finding suggests that orthographic similarity is sufficient for the between-language repetition effect to materialize; in other words, meaning equivalence is not required. Gerard and Scarborough (1989) attribute the between-language effect for cognates and homographic noncognates to facilitated encoding processes on a word's second occurrence and interpret its absence on noncognates as support for the view that lexical knowledge is stored in separate language specific lexicons. Because between-language repetition effects for noncognates *did* show up in the present study, a different conclusion with respect to lexical organization is drawn here. It was argued that these effects could come about because, in contrast to those of the classical repetition studies, the conditions were beneficial for the lexically-based repetition effect to show up.

As for the second priming effect investigated here, associative priming, our results are in agreement with a number of other studies that have all shown that associative priming can occur between languages (Chen & Ng, 1989; Guttentag et al., 1984; Jin & Fischler, 1987; Keatley, Spinks, & De Gelder, 1990; Kerkman, 1984; Kirsner et al., 1984; Meyer & Ruddy, 1974; Schwanenflugel & Rey, 1986; Tzelgov & Henik, 1989). In fact, some of them have suggested that the between-language effects are as large as the within-language effects (Chen & Ng, 1989; Meyer & Ruddy, 1974; Schwanenflugel & Rey, 1986; Tzelgov & Henik, 1989). The cognate data of the present study corroborate this latter finding. However, the data of Experiment 3 and, more strongly, those of Experiment 4 suggest that the equality of the effect within- and between-languages is restricted to cognates: In the masked-prime condition of Experiment 3 the between-language effect for noncognates appeared smaller than the within-language effect, and it turned out not to be statistically reliable. In Experiment 4 the between-language associative-priming effects on noncognates, but not on cognates, disappeared. These results cannot be interpreted in terms of differential orthographic similarity between primes and targets in the cognate and noncognate associated word pairs, because for both of these types of word pairs the primes and their targets were orthographically dissimilar. They thus suggest that at the conceptual level of representation only the nodes for semantically related cognate words are linked up both within and between languages, whereas those for noncognates are only connected within a language. That the occurrence of a between-language associative-priming effect may depend upon particular characteristics of the associated word-pairs (presently, whether or not they are composed of cognates), was also shown by Jin and Fischler (1987), who observed a between-language associative-priming effect for concrete but not for abstract words. They interpreted this dissociation in terms of an imagery system common to both languages but only representing concrete words (cf. Paivio & Desrochers, 1980).[3]

[3] All through this article conceptual memory is assumed to be the structure where the associative-priming effects originate. As suggested by one of the reviewers of this journal, lexical memory may also be the locus of these effects: Not only may a link exist between the concept nodes for "baker" and "bread," but also there may be one between the corresponding nodes in lexical memory. Such links may have come about through past spatiotemporal contiguity of the corresponding words. Because their translation equivalents are so similar in spelling, such links at the lexical level may also exist between associatively related cognate words between languages, e.g., between "baker" and "brood." The presence of such between-language links for noncognates is less plausible. Therefore, it is plausible that the present dissociation between cognates and noncognates should be assigned to the structure of lexical memory. However, the results from a recent study (de Groot, 1990) seem to rule out this possibility. I argued there that if (within-language) associative-priming effects originate both at the lexical

In the above discussion we focused primarily on the priming effects observed in the masked-prime, between-language conditions. Several further findings have received little attention so far. One of them is that in general both the associative-priming effects and the repetition-priming effects were larger when the primes were clearly visible than when masked. The reasons presumed for this have already been set forth (see introduction): The fact that the effects are larger when the primes can be identified than when they are masked may be attributed to the possibility that in addition to automatic spreading activation in memory a post-lexical prime-target integration process causes associative and repetition priming under the former prime-presentation conditions. Furthermore, the repetition effect in the unmasked-prime condition but not in the masked-prime condition may contain an episodic component.

Yet a further cause for the enhanced associative- and repetition-priming effects with unmasked prime presentation—not discussed before—has to be considered: Prime-target SOA was always larger in the unmasked-prime condition (240 ms) than in the masked-prime condition (60 ms). It is possible that only with the longer SOA activation has had enough time to spread fully to the representation of the target by the time the latter is presented. Consequently, the targets in this condition will be processed relatively fast and the priming effects will be large. Unlike with the masking technique adopted by Fowler et al. (1981), de Groot (1983), and Marcel (1983), with the present technique the SOA and prime masking manipulations cannot be disentangled.[4] Note, however, that also when the earlier technique is used and SOA and prime masking are not confounded, the associative-priming effect is larger with unmasked than with masked presentation of the prime (de Groot, 1983; no repetition condition was included in that study). This suggests that in the unmasked condition automatic spreading activation is indeed not the only process causing the priming effects.

One further finding that requires comment is that the repetition-priming effects were generally larger than the associative-priming effects. We attend to this shortly, when looking for a bilingual lexical structure that can account for the whole of the results obtained in this study.

Equality of associative-priming effects within and between languages strongly suggests an amodal conceptual memory (e.g., Potter et al., 1984) in which translations are represented in a single node and with links connecting the nodes that represent related concepts. Thus, within conceptual memory there would be one node representing, for

level as well as at the conceptual level, these effects should be larger in semantic-classification tasks than in lexical decision. The effects were in fact equally large in both types of tasks, suggesting a single locus. Unless we are willing to dismiss conceptual memory as the locus of the present associative-priming effects (but note that the words within all associated prime-target pairs are also semantically related, so their representations in conceptual memory are likely connected), the conclusion must be that the lexical-memory links suggested above do not exist.

[4] In fact, in an additional experiment we did try to disentangle SOA and prime masking. This experiment included two language conditions (DE and EE). The materials from the corresponding conditions in Experiments 1 and 2 (cognates only) served as stimuli. As in Experiment 2 and the masking part of Experiment 3, prime-target SOA was 60 ms, consisting of a 40-ms prime duration and a prime-target ISI of 20 ms, but now the prime was not preceded by a forward mask. Thus, except for the SOA, presentation conditions were similar to those of Experiment 1 and the unmasked part of Experiment 3. It turned out that under these new presentation conditions still very few subjects managed to identify one or more of the primes. Thus, this condition was effectively a masking condition. Not surprisingly, therefore, the priming effects that were obtained were very similar to those of Experiment 2 and the masking part of Experiment 3 (associative-priming effect: 25 ms; repetition-priming effect: 51 ms).

instance, both the English word "baker" and the Dutch word "bakker"; one node representing both the English word "bread" and the Dutch word "brood"; and there would be a link connecting these two nodes. The effect can then be attributed to spreading activation across this link. The occurrence of *smaller* but reliable associative-priming effects between than within languages is compatible with two memory structures (see also Schwanenflugel & Rey, 1986): Between-language connections exist for all associatively related words within conceptual memory, but they are weaker than the corresponding within-language connections (Scheme 1). Alternatively, between-language connections exist for some associatively-related words, and they may be as strong as the corresponding within-language connections (in fact, they will then be the *same* connections; see below), whereas for other words the concept nodes of associatively related words are not connected between languages (Scheme 2). Scheme 1 demands the existence of language specific conceptual nodes (e.g.,one concept node for "baker" and a separate one for "bakker"); Scheme 2 requires, within one and the same bilingual's memory, shared concept nodes for some pairs of translations and language specific concept nodes for others. The complete *absence* of associative priming between languages would suggest a structure with exclusively language specific concept nodes that are not connected to the concept nodes of associated words in the other language. For the cognate stimuli we obtained associative-priming effects that were equally large between as within languages, a finding thus suggesting shared concept nodes for these translations as well as the existence of a link connecting the nodes of associatively-related words. In contrast, the masking data clearly point towards the absence of between-language associative priming in the case of noncognates, suggesting that these translations are represented in separate concept nodes that lack connections to related-concept nodes in the other language.

Leaving for the moment the obtained pattern of associative priming, two explanations of between-language repetition-priming effects come to mind. Both assume a lexical level of representation in addition to the conceptual level, as is typically done in modeling memory (e.g., Collins & Loftus, 1975), also bilingual memory (Potter et al., 1984; Snodgrass, 1984). At the lexical level the nodes represent the concepts' names. It has been suggested (Collins & Loftus, 1975) that lexical nodes representing orthographically and/or acoustically similar words are connected. In foreign language education words are often taught in a paired-associate paradigm. It is therefore reasonable to assume that in addition to the links reflecting orthographic and acoustic similarity between words, the nodes for translations, cognates as well as noncognates, also get connected in the lexical network. The between-language repetition effect can then be attributed to spreading activation within this lexical network from the node for the word in the one language to that for its translation. The second interpretation of the between-language repetition effect does not assume the existence of links between the nodes of translations within lexical memory. Instead, it assumes that the—separate—lexical nodes for translations are connected via their shared conceptual node (Potter et al., 1984). The effect can then come about, in two steps, via spreading activation from the lexical node for the word in the one language, via the shared conceptual node, to the lexical node for this word in the other language.

The observed pattern of between-language associative-priming effects may be decisive in choosing between these two possible structures underlying the between-language repetition-priming effects: As already discussed, the absence (under prime-masking conditions) of a between-language associative-priming effect for noncognates suggests that noncognate translations are represented in separate nodes at the conceptual representational level. Thus, the second of the above interpretations of the between-language repetition effect cannot account for such effect on noncognate translations, since they lack the required shared conceptual representation. In other words, to be able to explain the effect for noncognates, links between the translations' lexical nodes will have to be assumed. The effect can then be attributed to spreading activation along these links. If links exist between the lexical nodes for noncognates, there is no reason not to assume them for cognate translations as well (indeed, the fact that cognate translations are orthographically similar is a further reason to assume these links for cognates; see above), and hence, spreading activation within the lexical network may also cause the between-language repetition effect for cognates.

The conclusion that lexical nodes for translations are linked in bilingual memory is at variance with Potter et al.'s (1984) conclusion that these nodes are not connected to one another. They based their conclusion on a comparison of the time it took subjects to name pictures in the second language and the time it took them to translate a first-language word to the second language. They argued that in the case of direct links between nodes at the lexical representational level (the "word-association hypothesis"), translation in L2 should be faster than picture naming in L2. This prediction was not borne out by the data (see also Chen & Leung, 1989) and the word-association model was rejected in favor of the "concept-mediation" model, according to which translation is mediated by conceptual memory. However, Kroll and Curley (1988; see also Chen & Leung, 1989, and Kroll & Borning, 1987) showed that subjects who were much less fluent in their second language than the subjects in Potter et al.'s (1984) study, *did* take longer to name a picture in L2 than to translate an L1 word to L2. As in the study by Potter et al., subjects more proficient in L2 were equally fast in picture naming and translating in L2. The data thus suggested that at least in less fluent bilinguals direct relations between the lexical nodes of translations exist. The absence of the relevant effect in the more fluent bilinguals may indicate that these connections cease to exist over time, but an equally plausible interpretation is that they are still there but bypassed in the translation task. In fact, Kroll and Borning's (1987) conclusion, that more fluent and less fluent bilinguals may be using different *strategies* when accessing their second language, is consistent with this latter interpretation. The fact, that in the present study we *did* obtain support for the existence of links between translations at the lexical representational level in subjects who were as proficient in L2 as the subjects tested by Potter et al. (1984), suggests that the lexical decision task does tap processing at other levels than the translation task. That different tasks produce different patterns of results, leading to different conclusions with respect to the organization of bilingual lexical memory, has been convincingly demonstrated by Durgunoglu and Roediger (1987).

In summary, our data are most consistent with the view that (1) the representations of both cognate and noncognate translations at the lexical level of representation are connected; (2) cognate translations share a representation at the conceptual level and these shared representations are connected to those of associatively related words at the same level; (3) noncognate translations are represented in separate concept nodes and these nodes only have connections to those of associatively related words of the same language. A representative part of such bilingual lexical memory is depicted in Fig. 1.

A finding that has not yet been discussed but that can also be accounted for by this bilingual lexical structure is that the be-

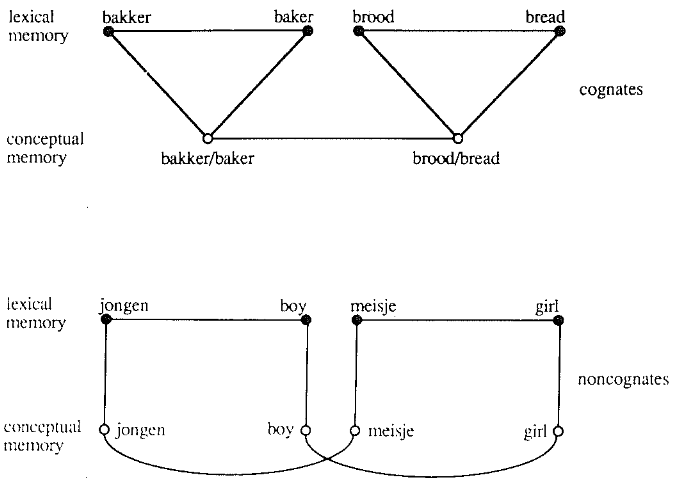

FIG. 1. Some representations and connections in bilingual memory.

tween-language repetition effects were generally larger than the corresponding associative-priming effects (the latter in fact being absent for noncognates in the prime-masking condition). In terms of the model, for the noncognates the reason is clear, there being connections between translations at the lexical representational level (along which activation can spread from a prime's node, pre-activating that of the target), but no between-language connections between associated words at the conceptual level. A plausible cause for the larger between-language repetition than associative-priming effects for cognates is the distance between the critical nodes in the network: For the associative-priming effect to come about, activation will have to traverse three links (from the lexical node of the prime to its conceptual node; from the prime's conceptual node to that of the target; from the target's conceptual node to its lexical node). The occurrence of a between-language repetition effect only requires activation to ply a single link, from the prime's lexical node to the target's lexical node. If, as is often assumed (e.g., Anderson, 1976; Collins & Loftus, 1975), activation decreases over links, the amount of pre-activation in the representation of a target associatively related to the prime (in either the same or a different language) will be less than in that of a target that is a translation of the prime, and the priming effect will consequently be smaller. Of course, the orthographic similarity between a cognate prime and its translation as opposed to the orthographic dissimilarity between a cognate prime and an associatively related cognate target presented in the other language, may also contribute to the fact that the between-language repetition effect for these words is larger than the corresponding associative-priming effect: Target encoding may be facilitated when it is orthographically similar to the prime (but note that this argument does not hold for the noncognates). In fact, this possibility of facilitated encoding is the reason why another robust finding, not yet discussed, is not all that interesting in the present context. The finding referred to is that the within-language repetition effect generally stands out as particularly large: Because exactly the same stimulus is presented as prime and target on these trials (of course, this is true both for cognates and noncognates), in this condition target encoding will benefit maximally from the presentation of the prime. This interpretation cannot be dissociated from a more interesting alternative, namely that the relatively large within-language repetition effect is due to the fact that shortly after a first access event the same lexical node is accessed for a second time, whereas in the case of between-language repetition or of the presentation of associatively-related words different nodes are accessed. In the latter case pre-activation in the relevant memory node, that came to reside there through spreading activation from another node, may be less than in the former case, where the activation is due to the fact that the relevant node was already accessed just before.

Given this account of bilingual lexical memory, an intriguing question that may be worth pursuing in future research is *why* it is that noncognates, unlike cognates, are represented language-specifically in conceptual memory. As mentioned before, a similar dissociation has been reported concerning bilingual conceptual representation of concrete and abstract words (Jin & Fischler, 1987), but unlike with the cognate–noncognate dissociation, a plausible cause for that dissociation is readily available. As pointed out by Potter et al. (1984), translations often have somewhat different meanings, and this may be more so in the case of abstract words than of concrete words (Tayler, 1976). Of course, the more different the meanings of translations, the more reasonable it is to store them separately in conceptual memory. A more explicit explanation for the dissociation is one in terms of Paivio's dual-coding theory (e.g., Paivio, 1986) applied to bilingual memory (Paivio & Desrochers, 1980), that assumes an imagery system common to both languages, but only representing concrete words. But why is it that orthographic (and acoustic) similarity between translations enhances their chance of being stored in a single conceptual representation?[5] Whatever the reason may turn out to be, the fact that these dissociations occur indicates that there is no unitary answer to the question as to how words are stored in bilingual memory, but that the storage format varies with word type.

[5] Our cognate/noncognate distinction is not confounded with the concrete/abstract distinction (if it were, the concrete/abstract distinction could have underlied our word-type effects): The mean imageability rating (van Loon-Vervoorn, 1985; it is well-known that word imageability and word concreteness are strongly correlated) of 14 of the 15 noncognates that served as targets in the associated condition in Experiment 3 (one of the words in this condition, "paint," was not included in the corpus of imageability ratings) was 6.34 (based on a 7-point scale). The corresponding standard deviation was .73. The mean imageability rating for the 15 cognate targets in this condition was 6.49 (*SD:* .31). The small difference was due to one noncognate word ("peace") rated relatively low on imageability (3.97). With this word excluded, the mean for the noncognate associatively related targets was 6.53 (*SD:* .28). The mean imageability ratings for the *primes* in the association condition were 6.39 (*SD:* .32) and 6.06 (*SD:* .86) for noncognates and cognates, respectively.

APPENDIX A
STIMULUS MATERIALS OF EXPERIMENTS 1 AND 2

Repeated prime–target pairs

Prime		Target	
English/Dutch	SR	English/Dutch	SR
bath/bad	5.75	bath/bad	5.75
cat/kat	6.48	cat/kat	6.48
form/vorm	6.50	form/vorm	6.50
friend/vriend	5.86	friend/vriend	5.86
ground/grond	5.38	ground/grond	5.38
guitar/gitaar	5.57	guitar/gitaar	5.57
hair/haar	5.65	hair/haar	5.65
head/hoofd	4.12	head/hoofd	4.12
heat/hitte	4.41	heat/hitte	4.41
height/hoogte	4.51	height/hoogte	4.51
house/huis	5.13	house/huis	5.13
metal/metaal	5.96	metal/metaal	5.96
middle/midden	5.52	middle/midden	5.52
name/naam	5.60	name/naam	5.60
pearl/parel	5.06	pearl/parel	5.06
pirate/piraat	5.87	pirate/piraat	5.87
police/politie	5.28	police/politie	5.28
price/prijs	5.70	price/prijs	5.70
prince/prins	6.38	prince/prins	6.38
public/publiek	5.84	public/publiek	5.84
rain/regen	3.93	rain/regen	3.93
sea/zee	5.56	sea/zee	5.56
stone/steen	5.05	stone/steen	5.05
thief/dief	5.86	thief/dief	5.86
violin/viool	4.48	violin/viool	4.48
will/wil	6.64	will/wil	6.64
word/woord	6.01	word/woord	6.01
world/wereld	4.88	world/wereld	4.88

Associated prime-target pairs

Prime English/Dutch	SR	Target English/Dutch	SR
author/auteur	5.59	book/boek	6.68
baker/bakker	5.48	bread/brood	4.98
calf/kalf	6.32	cow/koe	4.52
crown/kroon	5.16	king/koning	4.23
day/dag	4.81	night/nacht	4.60
father/vader	5.54	mother/moeder	5.39
flame/vlam	5.18	fire/vuur	3.61
ink/inkt	5.86	pen/pen	7.00
insect/insekt	6.68	fly/vlieg	3.41
lamb/lam	5.64	sheep/schaap	4.91
moon/maan	4.77	sun/zon	5.16
needle/naald	4.41	thread/draad	3.77
pear/peer	6.38	apple/appel	6.11
pepper/peper	5.70	salt/zout	3.82
rhythm/ritme	5.14	music/muziek	5.66
river/rivier	5.71	water/water	6.65
sail/zeil	5.42	boat/boot	6.59
silver/zilver	6.61	gold/goud	4.61
sister/zus	3.55	brother/broer	4.23
sock/sok	6.41	shoe/schoen	4.56
son/zoon	5.41	daughter/dochter	5.23
summer/zomer	5.18	winter/winter	6.94
tea/thee	5.57	coffee/koffie	6.11
thumb/duim	3.06	finger/vinger	6.36
tiger/tijger	5.73	lion/leeuw	3.98
time/tijd	4.23	clock/klok	6.41
tobacco/tabak	5.20	pipe/pijp	5.59
tongue/tong	5.64	mouth/mond	4.42

Unrelated prime-target pairs

Prime English/Dutch	SR	Target English/Dutch	SR
bible/bijbel	5.69	fox/vos	4.77
block/blok	6.52	sauce/saus	6.04
bride/bruid	5.16	task/taak	4.98
captain/kapitein	5.71	heart/hart	6.29
cotton/katoen	4.79	earth/aarde	3.93
dance/dans	6.07	hand/hand	6.77
doctor/dokter	6.49	nature/natuur	5.43
end/einde	4.93	wheel/wiel	5.84
field/veld	4.93	season/seizoen	5.33
fist/vuist	4.33	leader/leider	5.82
flood/vloed	5.64	corn/koren	5.03
hedge/heg	4.18	action/actie	5.44
honey/honing	5.18	circle/cirkel	6.29
manner/manier	5.18	sugar/suiker	4.62
master/meester	5.38	street/straat	5.40
mile/mijl	5.96	rose/roos	6.31
mouse/muis	4.91	soap/zeep	4.88
negro/neger	4.82	pair/paar	5.36
panic/paniek	5.82	ear/oor	5.03
plan/plan	6.80	hell/hel	6.82
rice/rijst	4.99	maid/meid	5.42
rule/regel	3.80	pound/pond	5.38
shame/schaamte	4.25	lesson/les	4.72
shoulder/schouder	5.73	ball/bal	6.54
slave/slaaf	5.39	year/jaar	5.25
snow/sneeuw	4.96	figure/figuur	5.86
sweat/zweet	5.22	fruit/fruit	6.46
train/trein	5.66	foot/voet	5.95

Note. SR = similarity ratings of translation equivalents.

Appendix B
Stimulus Materials of Experiments 3 and 4

Repeated prime-target pairs, noncognates

Prime English/Dutch	SR	Target English/Dutch	SR
body/lichaam	1.18	body/lichaam	1.18
carrot/wortel	1.48	carrot/wortel	1.48
face/gezicht	1.18	face/gezicht	1.18
horse/paard	1.30	horse/paard	1.30
joke/grap	1.23	joke/grap	1.23
knife/mes	1.46	knife/mes	1.46
mirror/spiegel	1.25	mirror/spiegel	1.25
money/geld	1.20	money/geld	1.20
office/kantoor	1.29	office/kantoor	1.29
pig/varken	1.22	pig/varken	1.22
rabbit/konijn	1.34	rabbit/konijn	1.34
shop/winkel	1.23	shop/winkel	1.23
trousers/broek	1.30	trousers/broek	1.30
watch/horloge	1.13	watch/horloge	1.13
wing/vleugel	1.50	wing/vleugel	1.50

Associated prime-target pairs, noncognates

Prime English/Dutch	SR	Target English/Dutch	SR
blanket/deken	1.50	sheet/laken	1.29
boy/jongen	1.34	girl/meisje	1.29
brush/kwast	1.36	paint/verf	1.23
bullet/kogel	1.23	rifle/geweer	1.07
butcher/slager	1.49	meat/vlees	1.47
dress/jurk	1.36	skirt/rok	1.36
garden/tuin	1.29	flower/bloem	1.36
husband/man	1.34	wife/vrouw	1.75
lady/dame	1.78	gentleman/heer	1.30
leaf/blad	1.39	tree/boom	1.23
pigeon/duif	1.18	bird/vogel	1.29
tail/staart	1.68	dog/hond	1.98
uncle/oom	2.19	aunt/tante	2.32
village/dorp	1.16	town/stad	1.63
war/oorlog	1.29	peace/vrede	1.52

Unrelated prime-target pairs, noncognates

Prime English/Dutch	SR	Target English/Dutch	SR
anger/boosheid	1.21	leg/been	1.61
bike/fiets	1.43	pillow/kussen	1.29
coat/jas	1.28	ticket/kaartje	1.43
danger/gevaar	1.50	glove/handschoen	1.14
dirt/vuil	1.43	roof/dak	1.39
grape/druif	1.41	car/auto	1.39
law/wet	1.75	question/vraag	1.23
mail/post	1.16	duck/eend	1.43
rope/touw	1.59	spoon/lepel	1.30
shark/haai	1.45	fashion/mode	1.29
smoke/rook	3.37	wall/muur	1.20
stomach/maag	1.61	duke/hertog	1.27
turtle/schildpad	1.14	chair/stoel	1.57
window/raam	1.20	juice/sap	1.34
woman/vrouw	1.97	arrow/pijl	1.18

Repeated prime-target pairs, cognates

Prime English/Dutch	SR	Target English/Dutch	SR
apple/appel	6.11	apple/appel	6.11
ball/bal	6.54	ball/bal	6.54
bath/bad	5.75	bath/bad	5.75
brother/broer	4.23	brother/broer	4.23
clock/klok	6.41	clock/klok	6.41
corn/koren	5.03	corn/koren	5.03
form/vorm	6.50	form/vorm	6.50
fruit/fruit	6.46	fruit/fruit	6.46
hair/haar	5.65	hair/haar	5.65
heart/hart	6.29	heart/hart	6.29
hell/hel	6.82	hell/hel	6.82
middle/midden	5.52	middle/midden	5.52
music/muziek	5.66	music/muziek	5.66
pound/pond	5.38	pound/pond	5.38
thief/dief	5.86	thief/dief	5.86

Associated prime-target pairs, cognates

Prime English/Dutch	SR	Target English/Dutch	SR
author/auteur	5.59	book/boek	6.68
baker/bakker	5.48	bread/brood	4.98
calf/kalf	6.32	cow/koe	4.52
crown/kroon	5.16	king/koning	4.23
day/dag	4.81	night/nacht	4.60
flame/vlam	5.18	fire/vuur	3.61
insect/insekt	6.68	fly/vlieg	3.41
needle/naald	4.41	thread/draad	3.77
pepper/peper	5.70	salt/zout	3.82
river/rivier	5.71	water/water	6.65
silver/zilver	6.61	gold/goud	4.61
sock/sok	6.41	shoe/schoen	4.56
son/zoon	5.41	daughter/dochter	5.23
thumb/duim	3.06	finger/vinger	6.36
tobacco/tabak	5.20	pipe/pijp	5.59

Unrelated prime-target pairs, cognates

Prime English/Dutch	SR	Target English/Dutch	SR
foot/voet	5.95	circle/cirkel	6.29
ground/grond	5.38	maid/meid	5.42
guitar/gitaar	5.57	fox/vos	4.77
head/hoofd	4.12	violin/viool	4.48
heat/hitte	4.41	name/naam	5.60
lesson/les	4.72	friend/vriend	5.86
mother/moeder	5.39	height/hoogte	4.51
nature/natuur	5.43	ear/oor	5.03
police/politie	5.28	sauce/saus	6.04
rose/roos	6.31	pair/paar	5.36
sugar/suiker	4.62	boat/boot	6.59
task/taak	4.98	metal/metaal	5.96
will/wil	6.64	cat/kat	6.48
word/woord	6.01	year/jaar	5.25
world/wereld	4.88	coffee/koffie	6.11

Note. SR = similarity rating of translation equivalents.

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