significantly different from that obtained with the control primes. Unexpectedly, the facilitation of cognate priming is not significantly different from the facilitation of control priming; and the values for cognate primes and repeated primes are significantly different. These results indicate that the cognate effect did not appear in this experiment. The false-friend condition shows no significant difference from the control condition, so the inhibitory effect displayed in Table 3.5. is not significant.

Table 3.7. shows the results obtained for the non-cognate list.

Non-cognate list

	repetition	non-cognate	false-friend	control
repetition	.	-2.21055 0.0274	-3.54513 0.0004	-3.36668 0.0008
non-cognate	2.210545 0.0274	.	-1.34183 0.1801	-1.10201 0.2708
false-friend	3.545133 0.0004	1.34183 0.1801	.	0.246332 0.8055
control	3.366679 0.0008	1.10201 0.2708	-0.24633 0.8055	.

Table 3.7. T-test values and level of significance for the non-cognate list (df=690)

No effects are obtained for both types of prime non-cognates and false friends. The mean of the reaction times obtained in these conditions does not differ significantly from that obtained with control priming. Instead, there is a significant difference between repeated primes and the rest of conditions, indicating that facilitation was found only for the repetition condition.

For the Non-word condition, the obtained means and standard deviation are shown in Table 3.8.:

Non-words	**mean**	**Sd**
false-friend	538.84	87.03
control	538.64	79.91

Table 3.8. Mean Reaction Times and Standard Deviation for non-words in Experiment 1

The difference observed between these means is not significant. This result seems to indicate that facilitation effect is a lexical effect: it does not appear when using non-lexical stimuli.

Discussion

The results obtained in this experiment were not those predicted. The cognate effect has been found across several experiments (Garcia Albea *et al.*, 1985; Alpitsis, 1990; De Groot & Nas, 1991; Sanchez-Casas, *et al.* 1992). In this experiment, the facilitation produced by the cognate primes was not significantly different from that produced by the control primes, and it is not comparable with the facilitation obtained by repeated primes.

The main conclusion after the analysis is that no form facilitation was found in this experiment. A general impression is that English primes did not affect significantly the performance of the subjects in the lexical decision task. A possible explanation for this is that performance on Dutch targets, which are more frequent words for Dutch speakers, can only be improved by the repeated primes and not by English primes. The importance of the priming direction is discussed in the subsection 3.1.4, where the discussion on the results of both experiments is elaborated.

In the next pages Experiment 2 (with Dutch primes and English targets) is introduced.

3.2.2. Experiment 2

Experiment 2 differed from Experiment 1 only in the direction of priming. In this experiment, prime words were in Dutch and target words were in English. Accordingly, the Instructions given to the subjects and the feedback were in English.

Method

Subjects

40 new subjects participated in Experiment 2, who had the same characteristics of those of Experiment 1.

Materials

The stimuli used in Experiment 2 had the same defining features as those used in Experiment 1. The target words and the cognate and non-cognate primes were the translations of words in Experiment 1, and Dutch false-friend and control words were added. An example of the lists can be seen in Table 3.9. (for the complete set of stimuli, see Appendix 5).

	primes				target
Type of translation word	**repetition**	**cognate**	**false-friend**	**control**	
cognate	form	vorm	ferm	muis	FORM
non-cognate	pig	varken	pil	rood	PIG

Table 3.9. Stimuli words (Primes and target) used for Experiment 2

The non-word list for this experiment was constructed like that for Experiment 1. Examples can be seen in Table 3.10.

non-word lists	prime	target
false-friend nonwords	pen	PENA
control non-words	rijst	CONTE

Table 3.10. Non-word stimuli used in Experiment 2

Finally, the same method for designing a different list for each subject was used.

Procedure

The procedure of Experiment 2 was identical to that of Experiment 1, except that the Instructions and the feed-back were given in English, which was the language of the targets.

Results

Again, a previous analysis of the data was performed before the statistical analysis. The subjects with less than 75% correct answers were removed from the sample (three subjects). Reaction times more than two standard deviations above or below the mean of the correct word answers were trimmed to the appropriate cut-off value to moderate the influence of outliers. For three targets ('carrot', 'knife' and 'thief') the number of valid observations was below 30 and were removed. The target 'apple' had to be removed as well because of an error during the programming of the experiment. This procedure yielded 544 valid observations for the Word condition on which the statistical analysis was performed. The same procedure was followed for the Non Word condition (except for item analysis), and yielded 643 valid observations.

The mean results for each category of prime in both conditions cognate and non-cognate are shown in table 3.11.

cognate list	R.T.	Sd	non-cognate list	R.T.	Sd
repetition	504.81	94.08	repetition	539.05	106.59
cognate	541.79	105.24	non-cognate	561.75	107.38
false-friend	570.04	106.18	false-friend	582.66	107.19
control	576.71	101.05	control	556.05	100.94

Table 3.11. Mean Reaction Times and Standard Deviation per condition in Experiment 2

The following Figure 3.2. shows a graphic representation of these results.

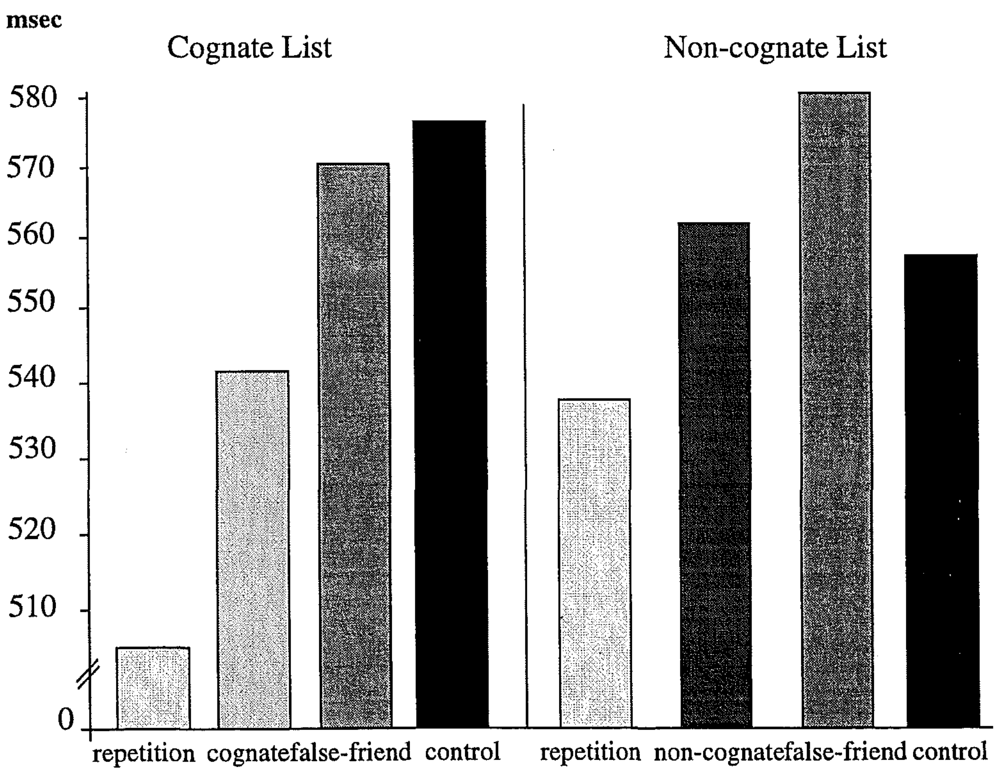

Figure 3.3. Graphic representation of results for words in Experiment 2 (rt)

The facilitation produced in each prime condition is shown in Table 3.12.

Cognate list	Facilitation	Non-cognate list	Facilitation
repetition	-71.90	**repetition**	-17.00
cognate	-34.92	**non-cognate**	+5.70
false-friend	-6.67	**false-friend**	+26.71

Table 3.12. Facilitation observed per condition (condition rt - control rt)

And the results of the T-test for means comparisons are summarized in the following tables 3.13 and 3.14.

Cognate List

	repetition	cognate	false-friend	control
repetition	.	-1.85165 0.0647	-3.69707 0.0002	-4.40178 0.0001
cognate	1.851649 0.0647	.	-1.8442 0.0657	-2.56547 0.0106
false-friend	3.697072 0.0002	1.844203 0.0657	.	-0.66518 0.5062
control	4.401776 0.0001	2.565474 0.0106	0.665182 0.5062	.

Table 3.13. T-test values and level of significance for the cognate list (df = 500)

Differences of both repetition primes and the cognate primes from the control primes are significant, and there is no difference between cognate primes and repetition primes. These results confirm that in this experiment the cognate effect was found. False-friends show a facilitation effect that is comparable with that of cognates, but it does not differ from the control primes. Thus, there is a small facilitation effect produced by the false friend primes.

The results of the t-test performed on the data of the non-cognate list are shown in table 3.14.

Non-cognate list

	repetition	non-cognate	false-friend	control
repetition	.	-1.39614 0.1633	-2.77729 0.0057	-2.22254 0.0267
non-cognate	1.396143 0.1633	.	-1.4261 0.1545	-0.84301 0.3996
false-friend	2.777285 0.0057	1.426096 0.1545	.	0.596799 0.5509
control	2.222535 0.0267	0.084301 0.3996	-0.5968 0.5509	.

Table 3.14. T-test values and the level of significance for the non-cognate list (df = 500)

The results of the T-test for the list of non-cognates were expected except for the non-significant difference between the repetition and the non-cognate condition[1]. Concernng therest of the data, there is a facilitatory effect of repeated primes compared to control primes, and both non-cognate and false-friend primes do not differ from control primes.

1. This result squares with the fact that a smaller facilitation effect was found in the noncognate list compared to the cognate list in both experiments 1 and 2. A comparison of the frequencies of the targets used showed that actually the targets used in the non-cognate list were less frequent than the targets used in the cognate list. This comparison can be seen in Appendix 6.Target frequencies. The average length was in both experiments longer for the targets in the non-cognate list.

The mean reaction times obtained for the list of non-words are shown in Table 3.15.

Non-words	mean	Sd
false-friend	591.52	96.10
control	598.85	110.00

Table 3.15. Mean Reaction Times and Standard Deviation for non-words in Experiment 2

As in the former experiment, the comparison for the means obtained for the non-words did not show any significant difference between the two conditions.

Discussion

As the sample used for this experiment was extracted from the same subject population as the previous experiment, it seems that the actual direction of priming (Dutch-English) implied more difficulties for the subjects, since the number of valid observations was smaller than that of Experiment 1.

This time, in the cognate list, the cognate effect was obtained and also a small facilitatory effect of false friend primes. Thus, the results obtained for the cognate list agree with those reported in the literature (Garcia Albea *et al.*, 1985; Alpitsis, 1990; De Groot & Nas, 1991; Sanchez-Casas, *et al.* 1992);

moreover, the fact that no significant differences were found between the facilitation of false-friend primes and that of cognate primes agrees with the results of Soler (1995).

In the next subsection, a general discussion of both experiments is presented.

3.2.3. General discussion

The results obtained in the two experiments reported in this section partially disagree with those reported in the literature. While in the English-Dutch experiment (Experiment 1) no cognate effect was found, in the Dutch-English experiment (Experiment 2) the cognate effect was found. A factor that seems to be very important is the direction of the priming.

The priming direction has been reported in the literature as an important factor in associative (semantic) priming by Keatley et al. (1994) and Dufour and Kroll (1995), among others. The results of their experiments suggest that L1 (Dutch in the present experiment) primes L2 (English in the present experiment) more than L2 primes L1. These differences were also found in Keatley and De Gelder (1992, exp. 4) in a speeded lexical decision task using translation equivalents.

The effect of the priming direction found in our experiments is consistent with the cited experiments, but the tasks used tapped different levels of representation. The experiments mentioned in the paragraph above implied the conceptual level, whereas our experiments implied the lexical level. Keatley et al. (1994) and Dufour & Kroll (1995) explained the differences on the priming obtained by claiming different organization in the conceptual level for words of the first and the second language.

The results obtained in the experiments here might suggest either that the effect of the priming direction occurs at the lexical level of processing, or that the procedure used was not good enough to avoid all conceptual effects. In fact, the masked priming differed from the procedure of Forster and Davis (1984). With the procedure used here, the length of primes and targets did not match, and the mask had a constant length of 6 characters. Although only two subjects reported having seen the primes (one on each experiment), the different length of the mask, the primes and the targets might have had an effect that obliterated the facilitation obtained. In any case, the results suggest that more research is needed on cross-language lexical effects, using tasks that ensure that the processing is at the lexical level.

On the other hand, there is no clear evidence of a facilitation effect due to Form Similarity. In Experiment 1, the lack of the cognate effect implies no form effects; accordingly, no form-similarity effects could be expected. In Experiment 2, the effect of the false-friends primes differs considerably across the cognate list and the non-cognate list: In the former, a small facilitatory effect was found; while in the latter the effect was inhibitory, although both effects are not significant in any case.

As mentioned above, the different length of primes and target might explain in part the lack of effect. For both cognates and false-friends, the orthographic and phonological overlap varies substantially when the words are different in lengths. In Experiment 1, the average orthographic overlap was equal for cognate and false-friend primes, but the phonological overlap was larger for the cognates. In Experiment 2, cognates have an average overlap (both orthographic and phonological) larger than false-friends. How these differences may affect the reaction times has not been measured.

Altogether, no effect can be attributed to the factor Form Similarity based on the results obtained in these experiments, but the characteristics of the set of stimuli used might have reduced this effect.

Two main conclusions can be drawn from the previous discussion: First, the direction of priming seems to be an intervening factor at the lexical level; secondly, there is no evidence supporting the facilitation effect of Form Similarity. Both findings need to be further explored in experiments that control strictly the length of the words, making thus possible to control the average orthographic and phonological overlap of primes and targets.

4. Representational Structure of BAR 2

The final tests performed on the results of BAR 2 aimed to check its validity as a cognitive model for bilingual lexical access, by means of examining the internal lexical representations built by the network and by comparing these representations with the results found in the experiments presented in the previous section.

The examination of the internal representations of BAR 2 was performed, as for BAR 1, with a cluster analysis of the activation patterns at the hidden units layer. The cluster analysis compares the different patterns of activation and groups them according to their similarity, thus showing how BAR 2 deals with the orthographic and phonological features of the two training sets Dutch and English. This analysis is presented in next Subsection 4.1.

The comparison of the representations of BAR 2 with the empirical data is presented in Subsection 4.2., together with a discussion on the results.

4.1. Analyses on the Internal Representations

The first step in the analysis of the internal structure of BAR 2 was to perform a cluster analysis on the internal representations built up by the network. The clustering analysis used was, as for BAR 1, the Hierarchical Cluster Method. The list of words used for the clustering was similar to that used for BAR 1. This list can be seen in Table 3.16

primes			TARGETS	
appeal	less	hart	APPEL	BALL
ball	horse	hert	BAL	BROTHER
fire	mirror	mond	BROEK	FORM
task	nature	heel	BROER	FRUIT
broad	form	hel	GELD	HAIR
brother	king	kat	GRAP	HEART
time	warm	horde	HAAR	HELL
money	shop	paard	HART	HORSE
coat	year	prooi	HART	JOKE
joke	nacht	grap	HEL	MIRROR
boat	winkel	koffie	KANTOOR	MONEY
hair	broer	spiegel	KLOK	OFFICE
hear	tafel	geld	MES	SHOP
heart	muis	mond	PAARD	
part	vorm	regen	SPIEGEL	
hell	auto	kantoor	VARKEN	
office	fiets	rivier	VORM	

block	haar	hoop	WINKEL	
law	hier			

Table 3.16. List of words (primes and targets) used for the clustering analysis of BAR 2

The following figure illustrates the results of the clustering analysis. Not all the words are represented in the figure, only those that were clustered at a maximum distance of 0.75.

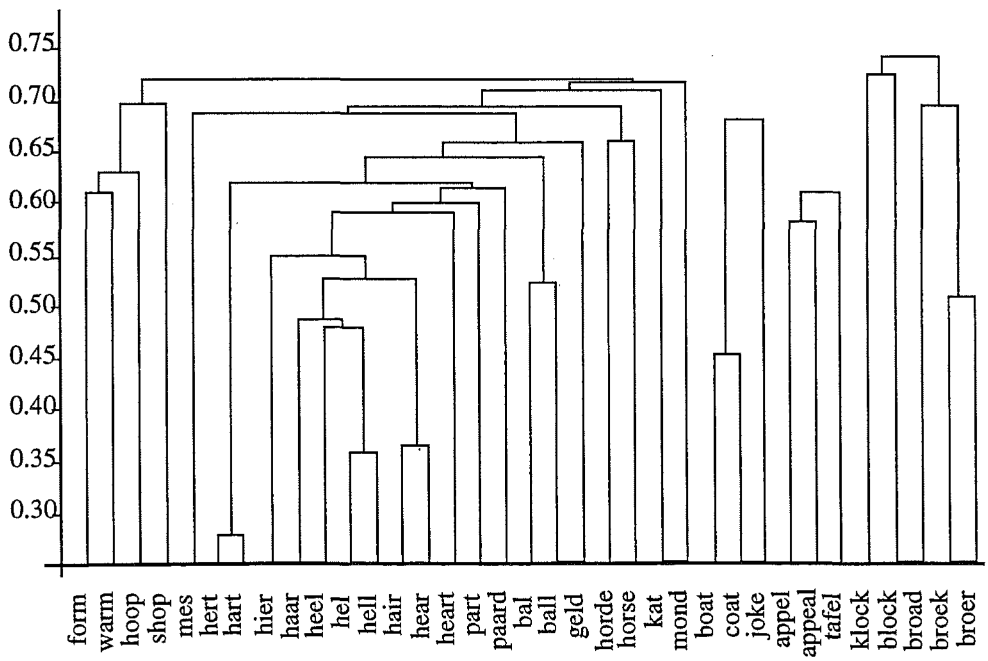

Figure 3. 4. Single-Linkage Clustering results for BAR 2

The figure shows that BAR 2 behaved like BAR 1, because words with similar forms were clustered together. The cluster distances ranged from 0.36 to 0.93, and below the mean distance (0.57) the following words are clustered:

(((hart hert) haar) ((hel hell) heel)))
(hair hear)
(boat coat)
(broek broer)
(bal ball)

The words were clustered independently of their language, although the first clusters formed ((*hart hert) (hair hear) (boat coat*)) are formed by words of the same language. This indicates that orthography and phonology interaction might act as an index for language specificity, as already suggested.

In order to illustrate the similarity and dissimilarity of the representation for words, Figure 3.5. following partially represents the patterns of activation in the hidden layer for the words within the cluster (*hel hell*) and the words *hell* and *kantoor*, not clustered. The cluster (*hel hell*) is one of the first clusters and it has been chosen because the two words within this clusters belong to different languages. In the left side of the figure, only the units highly activated (activation > 0.8) are distinguished with a pattern. In the right side of the figure, only the units weakly activated (activation < 0.2) are distinguished with a pattern.

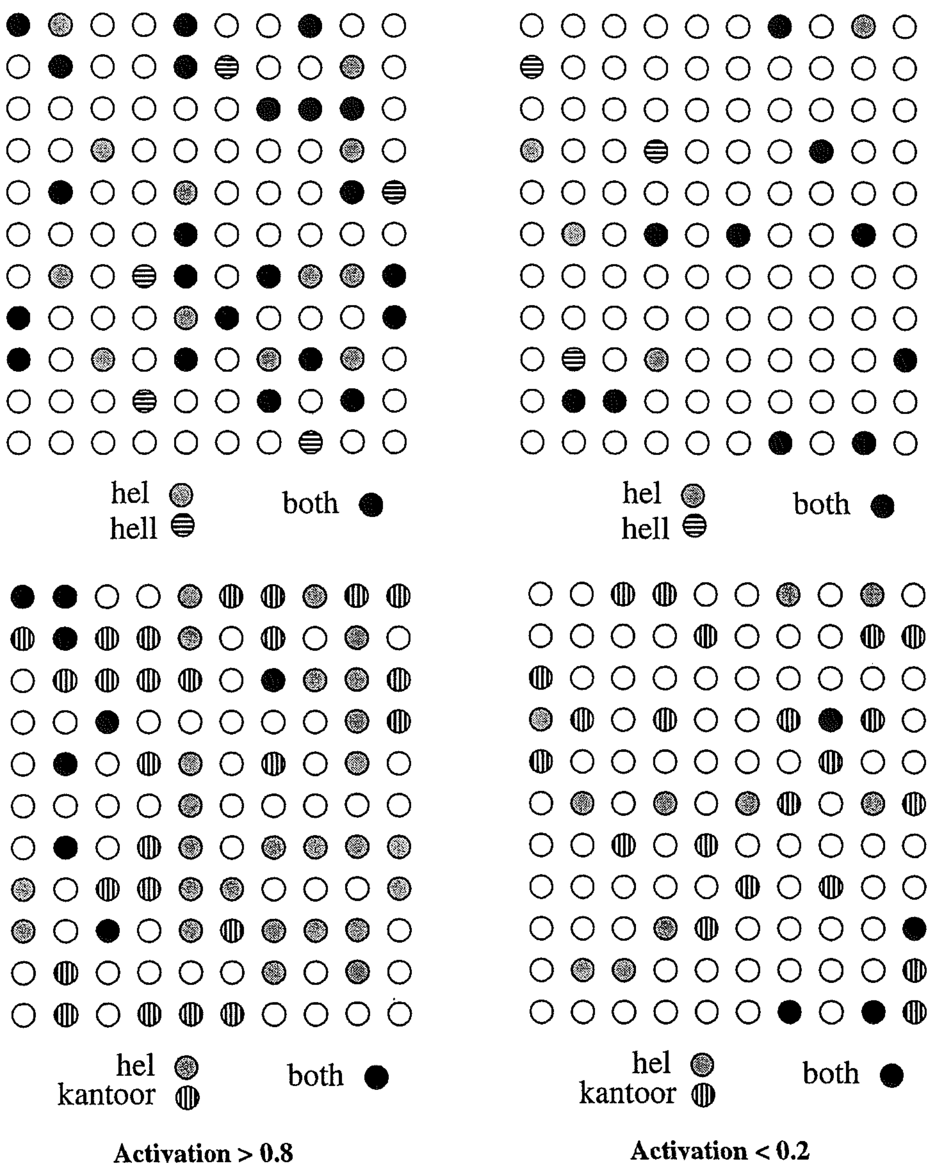

Figure 3. 5. Activation patterns in the hidden units for *hel, hell* and *kantoor*

The similarity in the activation patterns of *hel* and *hell* is very clear. The activation pattern of *hel* has 34 units with high activation and 14 with low activation. The activation pattern of *hell* has 27 units with high activation and 13 with low activation. Moreover, both patterns share 22 high activation units and 10 low activation units.

The two graphics in the bottom of the figure illustrate the activations for *hel* and *kantoor*, words that are not clustered. The activation pattern of *kantoor* has 32 units with high activation and 25 with low activation. As it can be seen, *hel* and *kantoor* share only 8 highly activated units and 4 lowly activated units.

This section provided evidence that the model builds up its internal representations of words according to the formal similarity of words. How these representations relate to the experimental findings presented in the previous sections is evaluated in the next Subsection 4.2.

4.2. Comparing BAR 2 with Experimental Data

The most relevant feature in the internal representations of BAR is that they capture the orthographic and phonological similarities of words within and between languages. Accordingly, words that have similar orthography and phonology are represented by a similar pattern of activation. Because the model is concerned only with the lexical level of representation and does not store any information about meaning, these words can be either cognate translations or words without any semantic relationship.

The experiments presented in the previous sections did not find evidence supporting a facilitation effect of primes that have only a formal similarity with the targets. For this reason, a strong correlation between the data and the internal representations of BAR 2 is not expected. Nevertheless, a Spearman Rank correlation was performed on the data obtained in the experiments and the internal representations of BAR, which is described next.

The sets of words selected for this test were drawn from the words that were in both the set of stimuli for the experiments and the training sets of BAR. Thus, the sets consisted of pairs of words, prime and target. In the set corresponding to Experiment 1 (English primes and Dutch targets), the analysis was performed on 7 pairs of words from the false-friend condition, 6 pairs of words for the cognate condition, 6 pairs of words for the non-cognate condition, and 9 pairs of words for the control condition. In the set corresponding to Experiment 2 (Dutch primes and English targets), the analysis was performed on 6 pairs of words for the false-friend condition; 6 pairs of words for the cognate condition; 6 pairs of words for the non-cognate condition; and 11 pairs of words for the control condition[1].

The measures to compare were the mean reaction times obtained for each pair in the experiments, and the euclidean distances of the internal representation for each word[2]. The following tables 3.17 and 3.18 contain the pair of words (prime and target); the mean reaction time obtained for each pair, and the euclidean distance between the representations of both words in BAR 2

1. BAR 2 is not affected by word frequency, and this is shown by its performance on words of low and high frequency is similar. For this reason the difference between the cognate and non-cognatelists is obliterated in the present analysis.
2. For BAR 1 the clustering distances for this comparison were used. For BAR 2 were used the euclidean distances, since they are more accurate: The clustering distances are a relative measure that depends on the set of words selected for the clustering analysis; euclidean distances provide the real distances between the representations of the two words.

	PRIMES	TARGETS	Mean R.T.	euclidean distance
false friends	appeal	APPEL	556.700000	0.0214
	broad	BROER	516.777778	0.0252
	hear	HAAR	517.810000	0.0232
	part	HART	570.750000	0.0256
	block	KLOK	516.555556	0.0265
	less	MES	562.000000	0.0276
	warm	VORM	638.122222	0.0306
cognates	ball	BAL	557.911111	0.0196
	brother	BROER	468.953333	0.0340
	hair	HAAR	490.100000	0.0239
	heart	HART	498.300000	0.0262
	hell	HEL	551.262500	0.0137
	form	VORM	517.810000	0.0284
non-cognates	money	GELD	470.000000	0.0404
	joke	GRAP	516.122222	0.0340
	office	KANTOOR	512.888889	0.0432
	horse	PAARD	491.900000	0.0333
	mirror	SPIEGEL	488.777778	0.0370
	shop	WINKEL	514.900000	0.0431
control	fire	BAL	533.625000	0.0375
	task	BROEK	481.555556	0.0369
	time	BROER	479.125000	0.0405
	coat	GRAP	605.555556	0.0366
	boat	HAAR	530.788889	0.0370
	law	MES	579.730000	0.0348
	nature	VARKEN	501.600000	0.0412
	king	VORM	516.444444	0.0409
	year	WINKEL	491.750000	0.0431

Table 3.17. Experiment 1 (English Primes/Dutch targets) reaction times and BAR 2 euclidean distances for the pairs of words

	PRIMES	TARGETS	Mean R.T.	euclidean distance
false-friends	hier	HAIR	550.000000	0.0249
	hert	HEART	563.400000	0.0242
	heel	HELL	601.666667	0.0212
	horde	HORSE	581.700000	0.0242
	mond	MONEY	583.333333	0.0306
	hoop	SHOP	533.250000	0.0252
cognates	bal	BALL	556.125000	0.0196
	broer	BROTHER	524.333333	0.0340
	vorm	FORM	532.991250	0.0284
	haar	HAIR	546.111111	0.0239
	hart	HEART	538.666667	0.0262
	hel	HELL	557.214444	0.0137
non-cognates	paard	HORSE	542.666667	0.0333
	grap	JOKE	547.992222	0.0340
	spiegel	MIRROR	545.142857	0.0370
	geld	MONEY	531.444444	0.0404
	kantoor	OFFICE	599.428889	0.0432
	winkel	SHOP	511.000000	0.0431
control	dik	BALL	588.300000	0.0310
	tafel	BROTHER	568.300000	0.0374
	muis	FORM	599.770000	0.0346
	fiets	HAIR	535.857143	0.0379
	mond	HEART	553.777778	0.0358
	kat	HELL	559.428571	0.0320
	prooi	HORSE	539.900000	0.0342
	koffie	MIRROR	641.321667	0.0402
	regen	MONEY	529.555556	0.0395
	rivier	OFFICE	529.555556	0.0410
	nacht	SHOP	553.300000	0.0359

Table 3.18. Experiment 2 (Dutch primes/English targets) reaction times and BAR 2 euclidean distances for the pairs of words

As expected, the Spearman rank correlation coefficient between these measures gave negative values, significant in the case of Experiment 1 ($p < 0.05$) and not significant in the case of Experiment 2 ($p = 0.171$). These resuls are discussed in next Subsection 4.3.

4.3. Discussion

The negative results obtained with the Spearman Correlation Rank were expected since the factors used to represent the words in BAR 2 are the orthographic and phonological information, which seem to have a weak facilitation effect in the data obtained in the experiments. The results of Experiment 2 showed the cognate effect but no effect of Form Similarity (see Table 3.11, p. 145). The results in Experiment 1, in contrast, did not show any effect of form facilitation, not even for cognate primes (see Table 3.4, p. 137). These different results from the two experiments were explained by the effect of the priming direction.

The priming direction cannot be reflected in the BAR model. It could be only represented in a model able to simulate the priming paradigm; that is, a model that could incorporate a representation of time in order to reproduce the serial presentation of prime and target. This feature requires a different network architecture, and a possible pertinent suggestion is the architecture proposed by Elman (1990) for the recurrent networks, where the processing of a new input pattern is affected by the patterns presented before. The representations of BAR cannot be tested following any particular order because time is not reflected on its structure.

Nevertheless, as discussed in Section 3.2.3. General Discussion in the present Chapter, the importance of the priming direction could have been intensified in the experiments by the methodology used. This methodology could also be responsible for the lack of effect observed for the Form Similarity factor, which certainly needs further exploration.

Another factor that can influence the lack of correlation between the data and the internal representations of the model is word frequency. In the BAR model, word frequency is treated as an intervening factor during the training phase, since the probability of each word being presented to the network is a function of its frequency. But at the end of the training phase word frequency does not affect the performance of the network anymore: word frequency affects the learning speed for each pattern, but the final result does not vary. In contrast, the reaction times of subjects on targets are influenced by word frequency.

The important aspect of BAR is that it predicts the cognate effect in terms of formal facilitation. On the other hand, if there is no empirical evidence proving that the factor form similarity can generate facilitation by itself, the model will have to be modified to account for the fact that words with similar form and meaning are represented in a similar way, whereas words with only similar form are not. In this case, the modifications to the BAR model could take two directions, roughly incorporating two hypotheses about the cognate effect presented in Sections 2 and 3 (Empirical Research on the Cognate Effect and Introducing a New Factor on the Study of the Cognate Effect). These two hypotheses will be called the Lexical Hypothesis and the Semantic Hypothesis.

The Lexical Hypothesis is that of Beauvillain (1992), who claims that cognate words share a single representational node in the lexicon. This hypothesis has been supported by Garcia-Albea et al. (1985), Alpitsis (1990), and Sanchez-Casas et al. (1992), among others.

In spite of the fact that BAR does not have a lexicon with local representations, the representation of morphology at the lexical level could be incorporated by means of giving morphological information to the network through the input layer, including a new set of input units representing morphology[1]. With this input structure, the internal representations in the hidden layer would be built up according to three types of information: orthography, phonology and morphology. Just as internal representations in BAR are similar for words akin in terms of orthography and phonology, the activation patterns of the hidden units in this hypothetical network would be similar for words akin in terms of orthography, phonology and morphology.

The so-called Semantic Hypothesis is that proposed by De Groot (De Groot and Nas, 1991; De Groot, 1992), and has been supported by Keatley and De Gelder (1992); Keatley et al. (1994) and Dufour and Kroll (1995). This hypothesis suggests that cognate words share a representational node at the conceptual level, whereas non-cognate words have different representational nodes at the conceptual level.

This hypothesis seems counter-intuitive from the theoretical approach that claims that words are represented by nodes. It is difficult to support the idea that bilingual speakers have language-specific representations for their concepts. It would imply that for Dutch-English speakers '*bread*' and '*brood*' correspond to a single concept, whereas '*car*' and '*auto*' correspond to two different concepts. Again, the inconveniences of such a hypothesis grow when thinking of multilingual speakers: a speaker of Dutch, English, French and Spanish should have four different concepts, corresponding to the non-cognate translations '*car*', '*auto*', '*voiture*' and '*coche*'.

Using a distributed representations model this hypothesis could be

1. Obviously the difficulty to be solved in such a model would be how to represent morphology

incorporated by developing the general framework for language processing proposed by Seidenberg & McClelland (1989) (see Figure 2.2. General Framework for Language Processing proposed by Seidenberg & McClelland, in Chapter 2, p. 53). Within this framework, Seidenberg & McClelland define three levels of processing: the lexical level, the semantic level, and the context level. Because the processing in the model is assumed to be interactive, it can be predicted that information of these three levels would be represented in the hidden layers. Thus, the hidden layer corresponding to the lexical level would be a representation of orthography, phonology and meaning.

Summarizing: if, as proposed in the literature, the factor causing the cognate effect is the interaction of form and meaning, the BAR model could account for this effect by modifying its structure. The fact that the results of BAR 2 do not match those obtained from empirical studies does not invalidate the main assumption of the model, that is, that distributed representations account better for the cognate effect than local representations. Moreover, the hypotheses proposed to describe the cognate effect are more plausible when adapted to the distributed representations framework.

Conclusions

The objective of this project was to present a model of bilingual lexical access specifically able to account for two different aspects: the process of learning new words, and the cognate effect, a cross-language effect that has been reported in the recent literature of bilingual research. The model proposed is the Bilingual Access Representations model (BAR), which has been described and tested in the previous pages of this work.

The model was developed following a connectionist approach. A connectionist network with three layers of units was implemented and tested. The input layer of the network consists on three sets of units, which receive orthographic information, phonological information, and language information. The input units are connected to a layer of hidden units, which creates an internal representation of each lexical entry with the three types of information provided by the input units. Thus, the pattern of activation of the hidden units reflects the orthographic and phonological features of each word.

This hidden layer is the main characteristic of the model. It can be identified with the lexical level of language processing,,but it is not a lexicon in the sense that each word does not have a single node of representation. The representation of lexical entries in the model is distributed throughout the units of this layer. Such a representation has two advantages with respect to local representation that are especially desirable for the modelling of learning new words. First, the model does not need to create a new representational node for each new word acquired. Secondly, because distributed representations capture the orthographic and phonological features of the words, similar words are represented by a similar pattern of activation.

The implementation and testing of BAR was realized in two phases. The first version (BAR 1) indicated the cognitive validity of the model in terms of learning and internal representations, but its learning rates were too low to consider the model suitable. The second version of BAR (BAR 2) incorporated some changes both in the training procedure and in the coding of the input/output information.

The training procedure of BAR 2 was changed with respect to BAR 1 in that the size of the training sets was different. The size of the Dutch training set was doubled (8000 words), thus allowing a better learning of Dutch orthography and phonology interaction. This change was reflected especially on the learning of low frequency words. The performance of the network after the monolingual training clearly advantaged BAR 1 in the general learning rates.

The coding for the input and output was adjusted in order to fit the actual goals of the project[1], while using a different scheme that resulted in better learning of long words. The phonological coding of input and output was improved by incorporating articulation features in the coding for each phoneme[2]. This new coding was shown to be useful during the second phase of training: the errors

1. As mentioned in Chapter 2, the first coding adopted was oriented towards the goal of learning the past tense of English words.
2. BAR could be adapted to model orthography in a better way by coding it according to graphic features, as in the IA model of McClelland and Rumelhart (1981).

made in the English words were mostly substitutions of English phonemes (not present in Dutch phonotactic constraints) by similarly articulated Dutch phonemes. This feature of BAR opens further lines of research, that might explore the possibilities of the model for simulating second language vocabulary acquisition. The model could be tested by comparing the phonological errors made by the network in different epochs of training with the errors made by second language learners in different stages of learning.

But the possibilities of further exploring BAR not only apply to the bilingual field but also to the general research on language processing. These possibilities are discussed next.

The BAR model follows the main directions of the Word Recognition and Naming model proposed by Seidenberg and McClelland (1989), but it differs from it in many important respects. A feature that gives BAR an advantage to the original model of Seidenberg and McClelland is the encoding used in the model. The syllabic templates that encode the input for BAR provide to the input units structural information about the words that is transmitted to the hidden units. At the same time, the output of the network can be decoded in the opposite way to input coding; thus providing real information about the performance of the network on each word.

Another aspect that distinguishes BAR from the model of Seidenberg and McClelland (1989) is that the network is provided with both orthographic and phonological information. This enlarges the possibilities for training the network in the monolingual mode: the model could be trained in two phases, giving first only phonological input and secondly orthographic and phonological input altogether. This training could explore the feasibility of the model in simulating both speech acquisition and the acquisition of writing.