JOURNAL OF MEMORY AND LANGUAGE 33, 149–174 (1994)

Category Interference in Translation and Picture Naming: Evidence for Asymmetric Connections between Bilingual Memory Representations

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Three experiments are reported in which picture naming and bilingual translation were performed in the context of semantically categorized or randomized lists. In Experiments 1 and 3 picture naming and bilingual translation were slower in the categorized than randomized conditions. In Experiment 2 this category interference effect in picture naming was eliminated when picture naming alternated with word naming. Taken together, the results of the three experiments suggest that in both picture naming and bilingual translation a conceptual representation of the word or picture is used to retrieve a lexical entry in one of the speaker's languages. When conceptual activity is sufficiently great to activate a multiple set of corresponding lexical representations, interference is produced in the process of retrieving a single best lexical candidate as the name or translation. The results of Experiment 3 showed further that category interference in bilingual translation occurred only when translation was performed from the first language to the second language, suggesting that the two directions of translation engage different interlanguage connections. A model to account for the asymmetric mappings of words to concepts in bilingual memory is described.

At what level of representation are a bilingual's two languages interconnected? The answer to this question has been determined by assumptions that have been made about the structure of bilingual memory. Past research has debated whether the fluent bilingual possesses a common memory system for both languages or independent memory systems that correspond to each language (McCormack, 1977; Snodgrass, 1984). Studies reporting evidence for independence between a bilingual's two language representations (Brown, Sharma, & Kirsner, 1984; Gerard & Scarborough, 1989; Kirsner, Smith, Lockhart, King, & Jain, 1984; Kolers, 1963; Scarborough, Gerard, & Cortese, 1984) suggest that associations between lexical units in each language are the basis for the interlanguage connection. In contrast, studies reporting evidence for shared conceptual knowledge underlying a bilingual's two languages (Altarriba, 1990; Chen & Ng, 1989; Glanzer & Duarte, 1971; Meyer & Ruddy, 1974; Schwanenflugel & Rey, 1986; Tzelgov & Henik, 1989) suggest that links between words in each language and concepts provide the basic form of interconnection.

More recent research has proposed a resolution to this ongoing debate by arguing that both the common and independent

This research was supported in part by Grant MH44246 from the National Institute of Mental Health and Grant DBS-9211863 from the National Science Foundation. A preliminary version of Experiments 1 and 2 was presented at the 1989 Meeting of the American Psychological Society, and a preliminary version of Experiment 3 was presented at the 1990 Meeting of the Psychonomic Society. The research for Experiment 3 was conducted while the first author was a Fellow at the Netherlands Institute for Advanced Study, Wassenaar, The Netherlands. The support and resources of that institution are gratefully acknowledged. We thank Jeanette Altarriba, Annette de Groot, Robert Dufour, Wido La Heij, Mary Potter, David Rosenbaum, and Alexandra Sholl for very helpful comments on an earlier version of the paper. We especially thank Annette de Groot and Anny Bosman for the generous use of their laboratory at the University of Amsterdam and for assistance with preparation of the Dutch materials and computer program, Janet Smith, Catharine Elsinger, and Oysim Chin for research assistance at Mount Holyoke, and Caroline van Heugten for transcribing the tapes of the Dutch subjects in Experiment 3. Address reprint requests to Judith F. Kroll, Department of Psychology and Education, Mount Holyoke College, South Hadley, MA 01075. e-mail: jkroll@mhc.mtholyoke.edu.

Accepted by Dr. Shoben.

0749-596X/94 $6.00

memory models are correct but that they describe the architecture of the bilingual's memory at two different levels of representation which are hierarchically related (Potter, 1979; Snodgrass, 1984). Words in each of a bilingual's two languages are thought to be stored in separate lexical memory systems, whereas concepts are stored in an abstract memory system common to both languages. This class of hierarchical models can account for a wide variety of findings, including the general result that tasks that appear to reflect the form properties of words tend to produce evidence in favor of separate representations, but tasks that reflect meaning tend to produce evidence in favor of a common underlying semantic representation (Durgunoglu & Roediger, 1987; Smith, 1991; Tzelgov & Henik, 1989; Weldon & Roediger, 1987).

One consequence of conceptualizing the structure of bilingual memory in hierarchical terms is that the question of how a bilingual's two languages are connected again becomes more complex. Either or both of the alternatives described above—lexical links between the independent lexical systems or links through the common conceptual system—could mediate activity between the two languages. Potter, So, von Eckhardt, and Feldman (1984) addressed this issue by contrasting two models of interlanguage connection—word association and concept mediation. The models are shown in Fig. 1. The word association model assumes that second language words are associated to first language words and that only through first language mediation can second language words gain access to concepts. In contrast, the concept mediation model assumes that second language words directly access concepts.

To test these alternative proposals, Potter et al. (1984) compared bilingual translation performance to picture naming. Many past studies have shown that words in the first language are named approximately 250 ms faster than pictures in the first language (e.g., Potter & Faulconer, 1975; Smith & Magee, 1980; Theios & Amrhein, 1989). The additional time to name pictures has been interpreted as a reflection of the fact that pictures require access to concepts prior to naming whereas words do not. The logic of the Potter et al. (1984) experiments was to use the assumption that picture naming requires conceptual access as a tool to understand translation performance. The two models make different predictions about translation and picture naming in the second language. The word association model predicts that translation from the first language (L1) to the second (L2) should be faster than picture naming in L2. The model assumes that translation from L1 to L2 relies on lexical links and can thus bypass conceptual access. However, picture naming, which requires conceptual access, should first be mediated through conceptual memory and then through the first

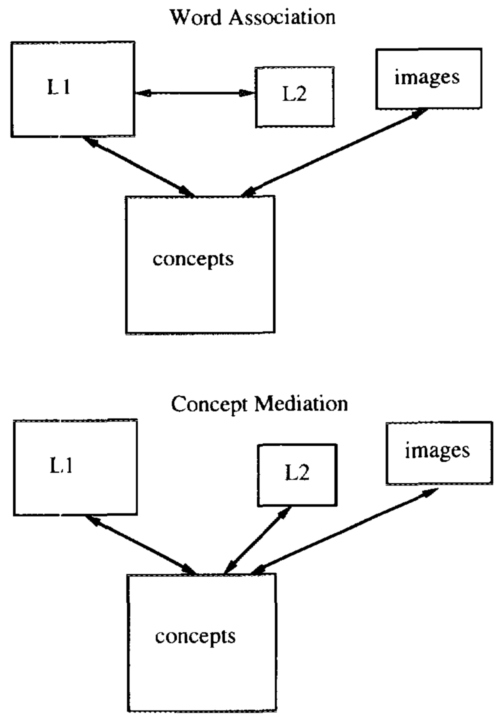

FIG. 1. Two models of language interconnection in which second language (L2) words are associated to first language (L1) words (Word Association) or directly linked to concepts (Concept Mediation).

language; only then can the link from L1 to L2 be retrieved. The concept mediation model predicts that translation into L2 and picture naming in L2 should be similar because both require conceptual access prior to retrieval of the L2 word. According to the concept mediation model, any differences between translation into L2 and picture naming in L2 should be attributable to differences in the representation of the respective surface forms.

Potter et al. (1984) compared translation and picture naming in L2 in a group of highly fluent Chinese–English bilinguals. The results provided clear support for the concept mediation model. The times to translate and to name picture in L2 were very similar; if anything, picture naming was slightly faster than translation, a result that directly contradicts the prediction of the word association model. Potter et al. (1984) also tested a group of less proficient bilinguals to see if the level of fluency in L2 determined the form of interlanguage connection. Surprisingly, the results for a group of less fluent English–French bilinguals followed virtually the same pattern, supporting the concept mediation model.

A number of recent studies have challenged the conclusion that concepts universally mediate the connections between a bilingual's two languages regardless of the level of second language expertise. Kroll and Curley (1988) speculated that Potter et al.'s (1984) less fluent bilinguals, although less proficient than the highly fluent group, may have passed an early critical period of second language development in which lexical links mediate the processing of second language words. To test this hypothesis, they replicated the Potter et al. (1984) study but used a wider range of bilingual subjects, including some who had studied L2 for less than 2 years. The results provided support for the developmental hypothesis. Subjects who had studied L2 for less than 2 years produced data consistent with the word association predictions; for them, translation into L2 was faster than picture naming in L2. Subjects who had studied L2 for more than 2 years produced a pattern of results that replicated those reported by Potter et al. (1984), suggesting that they were conceptually mediating L2 words. The overall pattern of results thus supported the proposal that there is a developmental shift in second language learning from reliance on word-to-word connections to reliance on concepts.[1] The same pattern of results was also reported by Chen and Leung (1989).

In addition to contrasting the performance of more and less fluent bilinguals, Kroll and Curley (1988) included a second test of the concept mediation model. They argued that if fluent bilinguals were conceptually mediating L2 words, then it should be possible to obtain direct evidence of having accessed conceptual or semantic information during translation by manipulating a variable that should influence the speed of conceptual access. Subjects names words, translated words, and named pictures in L1 and L2 under two different list conditions. In one, the lists of words or pictures were semantically categorized; in the other, the lists contained a mixed set of exemplars from a number of different semantic categories. Kroll and Curley (1988) predicted that only bilingual subjects who were relatively fluent in L2, and hence concept mediators, should benefit from the semantic organization of the list.

The results were counterintuitive. The translation performance of the more fluent subjects was indeed influenced by the semantic organization of the list, but the effect was one of interference rather than facilitation. Fluent subjects took longer to translate into L2 when the list was semantically categorized than when it was ran-

[1] We are restricting our discussion to bilinguals who acquired L2 in late childhood or early adulthood in a context in which L1 was already clearly established and for the most part after any biologically sensitive or critical period in development had occurred. One difference between adult and child bilinguals is that for adults most new L2 words correspond to concepts that have already been acquired.

domly mixed. Similarly, it took all subjects longer to name pictures in L1 when the list was categorized than when it was randomly mixed. This pattern of results supported the claim that there was a developmental shift from word association to concept mediation because only the more fluent subjects, whose overall data provided support for concept mediation, also showed category inference in translation. Still, it was puzzling that there was category interference rather than category facilitation.

The finding that semantically organized lists produced category interference in picture naming is reminiscent of other interference phenomena (e.g., Brown, 1981). For example, in Stroop-type picture naming tasks distractor words that are semantically related to the target picture produce greater interference than unrelated words (Glaser & Dungelhoff, 1984; Levelt, Schreifers, Vorberg, Meyer, Pechman, & Havinga, 1991; Lupker, 1982; La Heij, 1988; Rayner & Springer, 1986; Smith & Magee, 1980). Under similar conditions for word naming, the speed of naming a target word is virtually uninfluenced by the properties of word distractors (Glaser & Glaser 1989; Kroll & Potter, 1977; La Heij, Happel, & Mulder, 1990). The pattern of results is consistent with the proposal that picture naming requires conceptual access whereas word naming does not. However, that difference alone does not specify the locus of the semantic interference effect in picture naming.

Vitkovitch and Humphreys (1991), examining errors made in a speeded picture naming task, concluded that the locus of interference in picture naming is in a stage of retrieving the target picture's name. They found that subjects were more likely to make naming errors for pictures with low frequency than with high frequency names and were more likely to make perseverative errors when picture primes were semantically related to target pictures. These results provide converging evidence to suggest that the common locus giving rise to interference and errors in picture naming is in the mapping between semantic representations and lexical entries. Of special interest is that it is just this mapping that is similar for picture naming and bilingual translation according to the concept mediation model. In both picture naming and translation the concept must be retrieved first and then used to access a specific lexical entry which provides the necessary information to speak the name. Consistent with this interpretation, La Heij, de Bruyn, Elens, Hartsuiker, Helaha, and van Schelven (1990) have described semantically based interference effects in a translation Stroop task that are almost identical to those obtained in the picture–word version of the task.

The goal of the present experiments was to replicate the category interference effect in picture naming and translation and then to use it as a tool to investigate the structure of bilingual memory. Although the data reported by Kroll and Curley (1988) suggest that there should be category interference in picture naming and translation, the results are not conclusive because in that study the form of the list was a between-subject factor and the total size of the fluent bilingual subject sample was small. In addition, it is possible that the bilingual context of that experiment influenced performance in L1 as well because the time to name words and pictures in L1 was somewhat longer than in other published reports for the same conditions.

Experiment 1: Naming Pictures in Categories

The goal of the first experiment was to see whether the category interference effect in picture naming observed by Kroll and Curley (1988) under between-subject conditions could be replicated within-subjects when subjects used only their first language to respond. The basic design of the experiment was simple. Subjects named briefly presented pictures or words one at a time. The pictures and words were blocked into lists that were either semantically categorized or randomly mixed.

Method

Stimulus materials. The pictures were 120 line drawings of objects from 12 semantic categories (clothing, body parts, musical instruments, kitchen items, transportation, tools, buildings, household objects, fruits, toys, animals, and food). The words were the names of the objects in English. The word frequency of the object names ranged from 0 to 413 times per million with a mean of 31.7 (Francis & Kučera, 1982). Categorized lists of words and pictures were constructed such that each list included between 2 and 4 categories. All of the members of a given category appeared in sequence within the list. Four lists of 30 items each were generated for pictures and a corresponding set of four lists was generated for words. A set of randomized lists was constructed such that each random list of pictures or words contained exemplars from each of the semantic categories in a random order. The modality of each list was blocked so that pictures and words never appeared in the same list. Examples of the categorized stimulus lists are shown in Fig. 2.

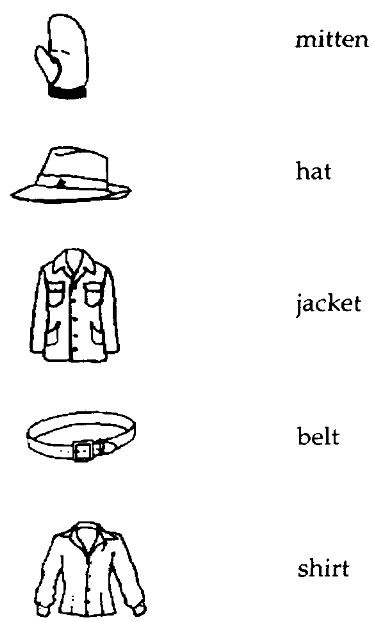

FIG. 2. Examples of categorized picture and word lists used in Experiment 1.

Apparatus and procedure. Stimulus words and pictures were presented one at a time in one field of a three and one-half field tachistoscope (Scientific Prototype Model N-1000). A second field contained a fixation point. Prior to the presentation of the word or picture there was a 100-ms warning tone followed by a 400-ms delay. During this initial 500-ms period the fixation field remained in view. Immediately following the delay period the word or picture target was presented for 500-ms. A voice-activated relay (Scientific Prototype audio threshold detection relay, 761 G) stopped a counter (Scientific Prototype Model N-1002) that was activated at the onset of the target display. Each subject viewed four lists: categorized words, categorized pictures, randomized words, and randomized pictures. Different versions of the stimulus materials were constructed to ensure that subjects would receive different words and pictures in the categorized and randomized conditions and that no word or picture would be repeated for a given subject. The order of lists was counterbalanced across subjects. Subjects were instructed to name the word or picture as rapidly and as accurately as possible. Naming latencies were measured to the nearest millisecond.

Following the naming trials, subjects were given an incidental recall task in which they were asked to write down as many words or picture names as they could remember from the experiment. They were given 3 min for the incidental recall task.

Subjects. Sixteen undergraduate college students participated in the experiment for course credit. All subjects had normal or corrected-to-normal visual activity and were native English speakers.

Results and Discussion

Analyses of variance were performed on mean naming latencies, percentage error,

TABLE 1

MEAN RESPONSE LATENCIES (IN MILLISECONDS) AND PERCENTAGE ERRORS (AS SHOWN IN PARENTHESES) TO NAME WORDS AND PICTURES IN EXPERIMENTS 1 AND 2 IN CATEGORIZED AND RANDOMIZED LIST CONTEXTS AND MEAN PERCENTAGE INCIDENTAL RECALL IN EXPERIMENT 1

	Target modality	
List Condition	Words	Pictures
Experiment 1: Blocked modality		
Categorized lists	514 (0.0%)	819 (7.3%)
Mean % recall	18.5%	43.2%
Randomized lists	516 (0.0%)	783 (6.4%)
Mean % recall	13.3%	27.4%
Magnitude of category interference	−2 ms	36 ms
Experiment 2: Alternating modalities		
Categorized lists	549 (2.1%)	792 (14.7%)
Randomized lists	542 (2.3%)	798 (11.4%)
Magnitude of category interference	7 ms	−6 ms

and percentage incidental recall.[2] The means are shown in Table 1 for the four conditions of Experiment 1.

Reaction times. The results replicated the well known word advantage in naming: on the average, words were named 286-ms faster than the corresponding pictures, $F(1,15) = 337.41, p < .001$. The critical result, however, was a significant interaction between the type of list (categorized or randomized) and stimulus modality (word or picture), $F(1,15) = 5.27, p < .05$. It took 36-ms longer to name pictures in the categorized lists than in the randomized lists, and this difference was significant in a Newman–Keuls test, $q(2,15) = 4.31, p < .01$. Word naming, however, was uninfluenced by the list context in which naming was performed, $q(2,15) < 1$. The main effect of type of list was only marginally significant, $F(1,15) = 4.3, p < .055$.

Percentage errors. The overall error rate was low (3.4%). As might be expected, there were more errors in naming pictures (6.8%) than in naming words (0%), $F(1,15) = 33.5, p < .001$. This difference did not, however, depend on whether the list was categorized or randomized, and the interaction between modality and list type did not approach significance, $F(1,15) < 1$. There was also no main effect of type of list, $F(1,15) < 1$.

Percentage recall. Past research has shown that pictures are remembered better than words (e.g., Paivio, 1986; Shepard, 1967). The incidental recall performance in Experiment 1 replicated this often-observed result; 35.3% of the pictures were recalled, whereas only 15.9% of the words were recalled, $F(1,15) = 52.43, p < .001$. There was also a main effect of type of list, $F(1,15) = 8.55, p < .01$, such that more items were recalled from categorized lists ($M = 30.8$) than from randomized lists ($M = 20.3$). Finally, there was a significant interaction between modality and list type, $F(1,15) = 4.72, p < .05$. Newman–Keuls tests on this interaction revealed that the categorized list advantage in recall was not significant for words, $q(2,15) = 2.32, p > .05$, but was highly significant for pictures, $q(2,15) = 6.67, p < .01$.

The pattern of results from Experiment 1 showed that pictures produced category interference when they were named in a semantically organized list. In contrast, words did not show sensitivity to the semantic context of the list, consistent with the claim that word naming reflects activity primarily at a lexical level of processing (Balota & Chumbley, 1984; Forster, 1981; Seidenberg, Waters, Sanders, & Langer, 1984). Because recall is also thought to be sensitive to conceptual factors, the finding that picture recall was influenced by the semantic context whereas word recall was not provides further evidence that picture naming requires concept mediation but word naming does not.

Why was there category interference for naming pictures but category facilitation for recall? We hypothesized that the cate-

[2] It was not possible to compute item means in Experiment 1 because of the form in which the data were stored.

gory interference effect in picture naming was due to increased conceptual activation that acted to engage a multiple set of corresponding lexical representations, thereby producing interference in the retrieval of a single best lexical candidate as the name. The process of resolving the increased ambiguity about the picture's name may also produce deeper processing for the picture, additional retrieval cues, and hence better recall.

Types of errors. If our explanation about the category interference effect is correct, then we might also expect the kinds of naming errors subjects produced when they incorrectly named a picture to reflect the increased activation of alternative lexical candidates. Because subjects in Experiment 1 produced relatively few errors, it was not possible to conduct a complete analysis of error types.[3] However, we examined the errors subjects did make to see if there was an increased probability of producing related lexical candidates under the categorized list conditions. The total corpus of errors in picture naming was sorted into three categories: incorrect production of the name of a previously seen picture, incorrect production of a name of a different exemplar from the same semantic category, and failure to produce any response within 5 s. The number of naming errors of the first two types did not differ for the categorized and randomized conditions. Subjects rarely named the previous picture ($n = 5$ for the categorized lists and $n = 4$ for the randomized lists). They were more likely to incorrectly name a same-category member ($n = 13$ for the categorized lists and $n = 16$ for the randomized lists) but the frequency of errors was similar in both conditions. However, there was a difference in the frequency of failures to respond. Subjects were more than twice as likely to fail to produce a response in the categorized conditions ($n = 24$) than in the randomized conditions ($n = 10$). Although these data are based on a relatively small sample of errors, they are consistent with the hypothesis that the interference generated by categorized lists influenced the process of producing the correct lexical entry.

Experiment 2: Naming Pictures and Words in Alternation

The results of Experiment 1 replicated the category interference effect in picture naming reported by Kroll and Curley (1988). The results also showed that the category interference effect can be obtained using a within-subject design. We suggested earlier that the source of semantic interference in picture naming is in the mapping between semantic representations and lexical entries. If this interpretation is correct, then repeated access to concepts within the same semantic category should increase activation at the conceptual level and produce corresponding activation at the lexical level. If the task is to choose a single lexical entry that is the best name for the pictured object, then the additional activation should produce competition among close alternatives, and hence interference, rather than facilitation.

In the second experiment we tested this hypothesis by spacing picture naming trials and thereby reducing the requirement for repeated conceptual access. Subjects named the pictures and words used in Experiment 1 in lists that were again semantically categorized or randomly mixed. However, each list alternated between words and pictures from trial to trial. For example, in a categorized list a subject might name a picture of a mitten, read the word "hat" aloud, name a picture of a jacket,

[3] Brown (1981) examined successive interference over trials. In the present study, although it would have been theoretically interesting, it was not possible to perform a similar analysis because the size of each category was constrained by the number of pictureable objects with high name agreement, resulting in categories with differing numbers of exemplars. In addition, the particular tachistoscopic procedure we used involved constructing fixed lists that were counterbalanced over subjects rather than randomized trials per list. The order of presentation was thus confounded with particular category exemplars.

read the word "belt" aloud, and so forth. A great deal of evidence suggests that word naming can be accomplished without conceptual access (e.g., Lupker, 1984; Potter, Kroll, Yachzel, Carpenter, & Sherman, 1986). Therefore, the strict alternation of words and pictures in Experiment 2 should maintain the same level of lexical activation within lists but diminish the degree of conceptual activation relative to Experiment 1. If category interference in picture naming is a result of selecting a lexical candidate amidst greater lexical activation, then we would expect to find the same interference effect in Experiment 2 as observed in Experiment 1. If, however, the category interference effect results from increased conceptual activation and its lexical consequences, then we would expect the effect to be substantially diminished in Experiment 2 as compared to that in Experiment 1.

Method

Stimulus materials. The stimulus materials were identical to those described for Experiment 1 with a single change. Each of the lists contained alternating trials of words and pictures. The order of alternation was counterbalanced across stimulus lists.

Apparatus and procedure. The apparatus and procedure were similar to those described for Experiment 1. There were some changes, however. Subjects were instructed to name aloud whatever stimulus appeared and were told to anticipate that the stimulus modality would alternate from trial to trial. They again named words and pictures in four lists, of which two were categorized and two were randomized. In addition, the incidental recall task was not given at the end of the session.

Subjects. Sixteen undergraduate college students participated in the experiment for course credit. All subjects had normal or corrected-to-normal visual acuity and were native English speakers.

Results and Discussion

Analyses of variance were performed on mean naming latencies and percentage errors. The means are shown in Table 1.

Reaction times. Word naming was again reliably faster than picture naming (by approximately 250-ms), $F(1,15) = 150.87, p < .001$ in the analysis by subjects, and $F(1,238) = 932.95, p < .001$ in the analysis by items. However, the category interference effect in picture naming was completely absent under the alternation conditions. The interaction between stimulus modality (word or picture) and type of list (categorized or randomized) was not significant, $F(1,15) = 1.02, p < .10$ for subjects, and $F(1,238) < 1$, for items. The type of list had no overall effect on naming either words or pictures, $F(1,15) < 1$ for subjects, and $F(1,238) < 1$ for items.

Percentage errors. The overall error rate was higher in Experiment 2 (7.6%) than in Experiment 1 (3.4%), but as in Experiment 1, there were more errors in picture naming (13.1%) than in word naming (2.2%), $F(1,15) = 34.22), p < .001$. Although there were slightly more errors in picture naming under the categorized conditions, the interaction between type of list and stimulus modality was not significant, $F(1,15) = 3.01, p > .10$.

The main result of Experiment 2 was that the category inference effect in picture naming was eliminated when picture naming alternated with word naming. A second aspect of the results was that a comparison of Experiments 1 and 2 showed that the alternation of word and picture naming produced a cost in the speed of word naming. Word naming was approximately 35 ms longer in the mixed modality lists of Experiment 2 than in the blocked conditions of Experiment 1. However, picture naming took approximately the same time in the two experiments. The cost to word naming is consistent with the interpretation that word and picture naming require different processing. The results of Experiment 2 suggest that it is not simply increased lexical activation that produces category interference in picture naming. Rather, continuous access to related concepts produces increased activation at the conceptual level which makes it more difficult to then select the single lexical entry that best names the picture.

Experiment 3: Category Interference in Bilingual Translation

The first two experiments replicated the category interference effect in picture naming and showed that it could be eliminated when picture naming alternated with word naming. Given these outcomes, we set two goals for Experiment 3. First, we wanted to determine whether category interference would occur in bilingual translation with a sample of highly fluent bilingual subjects. All of the evidence we have reviewed thusfar suggests a common source of interference for picture naming and translation in that both tasks share the requirement that concepts must be accessed and then used to activate and select an appropriate lexical candidate for production.

Our second goal was related to an observation we have made repeatedly in other studies of bilingual translation: Bilingual subjects can translate from L2 to L1 more quickly than from L1 to L2. Unpublished data from Kroll and Curley (1986) and from Kroll and Stewart (1989) are shown in Table 2 as a function of the direction of translation and the fluency of the subjects. The specific details of these two experiments differ, but the main point is that in each experiment subjects performed the translation task in both directions and the results were always the same: Subjects were consistently faster to translate into the first language than into the second language. This translation asymmetry requires modification of both the concept mediation and word association models shown in Fig. 1. Each of those models makes differential predictions about translation into L2 and picture naming in L2, but neither model specifies any directional asymmetry. In past studies we considered the possibility

TABLE 2

Data from Kroll and Curley (1986) and Kroll and Stewart (1989) on the Time to Perform Bilingual Translation (in Milliseconds) as a Function of the Direction of the Translation Task

Study	Direction of translation	
	L1 to L2	L2 to L1
Kroll and Curley (1986)[a]		
More fluent subjects	1729	1318
Less fluent subjects	2079	1596
Kroll and Stewart (1989)		
More fluent subjects	1267	1175
Less fluent subjects	1612	1230

[a] In each of these studies L1 was English and L2 was German. Data are shown for more and less fluent subjects in each study.

that it was harder to access the pronunciation of an L2 word than of an L1 word. However, when we compared translation performance with naming performance on the same words, we found that subjects were somewhat slower to name L2 words, but the magnitude of the difference between L1 and L2 naming was small relative to the difference between the two forms of translation. We hypothesized (Kroll & Sholl, 1991, 1992; Kroll & Stewart, 1990) that the two forms of translation reflect two distinct routes to translation: Translation from L2 into L1 is accomplished on a lexical basis, whereas translation from L1 to L2 requires concept mediation. The process of concept mediation should require additional time for the same reason that pictures take longer to name than words, and thus the time to translate from L1 to L2 should be longer than the time to translate from L2 to L1.

To accommodate the translation asymmetry, Kroll and Stewart (1990) proposed a revised version of the hierarchical model (see Fig. 3). According to the model, both lexical and conceptual links are active in bilingual memory, but the strengths of the links differ as a function of fluency in L2 and relative dominance of L1 to L2. As shown in Fig. 3, L1 is represented as larger

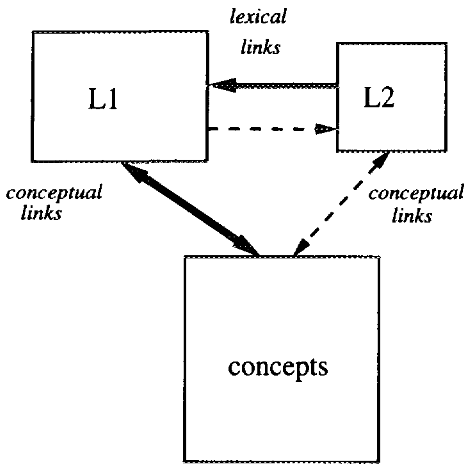

FIG. 3. Revised hierarchical model of lexical and conceptual representation in bilingual memory.

than L2 because for most bilinguals, even those who are relatively fluent, more words are known in the native than in the second language. Lexical associations from L2 and L1 are assumed to be stronger than those from L1 to L2 because L2 to L1 is the direction in which second language learners first acquire the translations of new L2 words. The links between words and concepts, however, are assumed to be stronger for L1 than for L2.

According to this asymmetric strength model, when a person acquires a second language beyond a stage of very early childhood, there is already a strong link between the first language lexicon and conceptual memory. During early stages of second language learning, second language words are attached to this system by lexical links with the first language. As the individual becomes more proficient in the second language, direct conceptual links are also acquired. However, the lexical connections do not disappear when the conceptual links are established. The model also assumes that both lexical and conceptual links are bidirectional, but that they differ in strength. The lexical link from L2 to L1 is assumed to be stronger than the lexical link from L1 to L2 because L2 words were initially associated to L1. Likewise, the link from L1 to conceptual memory is assumed to be stronger than the link from L2 to conceptual memory.

A clear implication of the claim that there are two routes to translation is that the two directions of translation should differ in the degree to which they are influenced by conceptual factors. Translation from L1 to L2 should be sensitive to the manipulation of semantic or conceptual information, whereas translation from L2 to L1 should be relatively independent of this type of manipulation. In Experiment 3 we asked whether there would be category interference in translation. The model makes the clear prediction that category interference should occur for fluent bilingual subjects only when they translate from L1 to L2.

In addition to comparing the two directions of translation when they are performed in categorized and randomized lists, we also included a set of naming conditions to evaluate the role of lexical-level processing in L1 and L2. Finally, we gave an incidental recall at the end of the experiment to further assess the consequences of having performed translation in both directions. The model predicts that recall following translation from L1 to L2 should be better than recall following translation from L2 to L1 because translation from L1 to L2 requires concept mediation.

Method

Stimulus materials. An example of the materials used in the present experiment is shown in Fig. 4. The complete set of words in Dutch and English is given in the Appendix. The materials consisted of 144 nouns, 18 words from each of eight semantic categories (weapons, vegetables, furniture, birds, clothing, fruits, animals, and vehicles). Each stimulus list contained 18 words in either Dutch or English. The mean frequency of words in Dutch was 10.6, with a range from 0 to 119, in a corpus of 620,000 words (Uit den Boogaart, 1975). The mean frequency of the words in English was 16.9, with a range from 0 to 127, in a corpus of

CATEGORIZED LISTS		RANDOMIZED LISTS	
English	Dutch	English	Dutch
dress	jurk	orange	sinaasappel
suit	pak	lion	leeuw
shoes	schoenen	ambulance	ziekenauto
coat	jas	lemon	citroen
jacket	colbert	skates	schaatsen
boots	laarzen	grapes	druiven
shirt	rok	bicycle	fiets
sweater	trui	raft	vlot
gloves	handschoenen	jacket	colbert
slippers	slippers	cherry	kers
sandals	sandalen	dog	hond
scarf	sjaal	suit	pak
trousers	broek	horse	paard
blouse	bloes	coat	jas
hat	hoed	strawberry	aardbei
stocking	kous	shoes	schoenen

FIG. 4. Examples of categorized and randomized Dutch and English word lists used in Experiment 3.

approximately a million words (Francis and Kučera, 1982).[4] The mean length of the words in Dutch was 5.98 letters with a range from 2 to 14 letters. The mean length of the words in English was 5.71 letters with a range from 3 to 11 letters. The categorized lists contained 18 same-category exemplars, as in the list of clothing shown in the left-hand columns. The randomized lists also contained 18 words and were created from the categorized lists so that no more than five items drawn from a given category were present and the order of presentation was randomized. Different versions of the stimulus materials were constructed to ensure that subjects would receive different words in the categorized and randomized conditions and that no words would be repeated within or across language for a given subject. Two lists of 18 practice words were constructed, one in Dutch and one in English, to be presented at the onset of the experiment. The practice always matched the conditions of the first list.

Apparatus and procedure. The experiment was entirely within-subject so that all subjects translated and named words in each of the four conditions illustrated in Fig. 4. Each word was presented on a Macintosh Plus computer screen until the subject named or translated it. The subject's spoken responses were registered by a microphone that activated a voice-operated relay. Latencies were recorded to the nearest millisecond. In the naming conditions subjects were instructed to pronounce aloud the word on the computer screen in the language in which it appeared. In the translation conditions subjects were instructed to translate the word on the screen from the language in which it appeared to the other language. Subjects were asked to avoid saying "uhm" while they thought of the translation as this would trigger the voice key. In addition, they were told to either guess the correct translation or to say "no" (in Dutch or English) if they did not know the translation in the other language. Subjects were given an initial practice list of 18 words in a condition that matched the condition of the first experimental list. The entire session was tape recorded so a fluent Dutch–English speaker could later transcribe subjects' responses. At the very end of the experiment the subjects were given

[4] The Dutch frequency values are more relevant in this study because the subjects were native Dutch speakers living in The Netherlands. Although these subjects regularly read and speak in English it is in the context of a Dutch university where Dutch is the dominant language.

an incidental recall task in which they were asked to recall as many words as possible in the language in which the words were presented.

Subjects. The subjects were 24 fluent Dutch–English bilinguals who were students at the University of Amsterdam. They received course credit for their participation. At the end of the experimental session they were given a language experience questionnaire in which they were asked to list the languages they knew and the context in which they learned them and to rate their ability to read and speak in English. Although the subjects were not balanced bilinguals (Dutch was their native and dominant language), the ratings they provided confirmed their relative fluency in English. The subjects' average ratings of their ability to read and speak English on a 10-point scale was 7.0 and 6.79, respectively. On average, the subjects first began to speak English at 12.25 years and to read English at 12.88 years. (English is taught in Dutch schools at age 10 or 11).

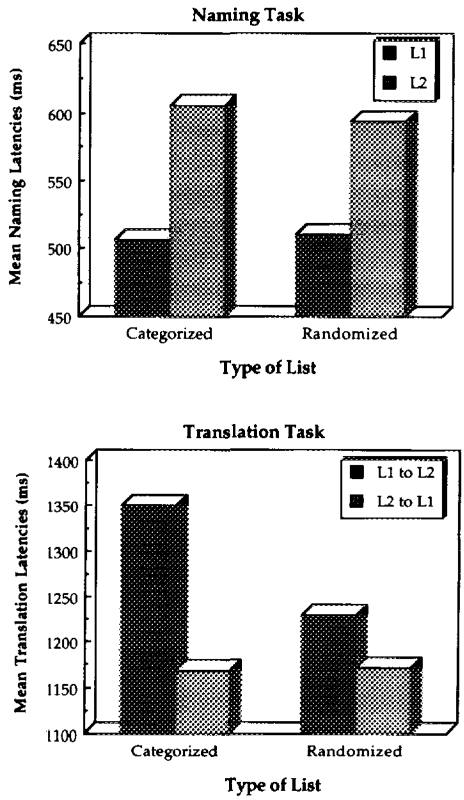

FIG. 5. Mean naming and translation latencies (in milliseconds) in Experiment 3 as a function of the language in which the words were presented and the type of list context (categorized or randomized). For subjects in Experiment 3, L1 was Dutch and L2 was English.

Results and Discussion

Analyses of variance were performed on mean RTs, percentage accuracy, and percentage recall for naming and translation.

Naming and translation latencies. Mean naming and translation latencies are shown in Fig. 5 as a function of the language in which the words were presented and whether the lists were categorized or randomized. As expected, naming times were shorter than translation times; the difference was approximately 670 ms. The task difference was significant in analyses by subjects, $F(1,23) = 226.63, p < .001$, and in analyses by items, $F(1,143) = 811.37, p < .001$. Naming latencies were approximately 91 ms longer in English (L2) than in Dutch (L1) and translation latencies were approximately 119 ms longer to translate from L1 to L2 than those to translate from L2 to L1. The interaction between the language in which the target word was presented (L1 or L2) and task (naming or translation) was also significant in analyses by subjects, $F(1,23) = 21.20, p < .001$, and in analyses by items, $F(1,143) = 28.64, p < .001$. The pattern of translation data thus replicates the translation asymmetry found in previous studies (Kroll & Curley, 1986; Kroll & Stewart, 1989) in that translation from L1 to L2 was reliably longer than translation from L2 to L1.

Based on the revised hierarchical model, we predicted that the time to translate from L2 to L1 would be faster than the time to translate from L1 to L2 and that semantic context would affect only translation from L1 to L2, the conceptually mediated route to translation, but not L2 to L1. The data shown in Fig. 5 support both of these predictions. The question of interest, given that we were able to replicate the translation asymmetry, was whether the two directions of translation were differentially sensitive to the effects of semantic context. If L1 to L2 was longer than L2 to L1 because the L1 to L2 translation route required concept mediation, then translation from L1 to L2 should also have been influenced by the semantic context of the lists in which translation was performed. However, if translation from L2 to L1 was performed lexically, it should not have been influenced by semantic context, and, naming latencies should also have been independent of the semantic form of the list. The data shown in Fig. 5 support each of these predictions. The interaction between task, language, and type of list context was not reliable in the overall analysis by subjects, $F(1,23) < 1$, but was reliable in the analysis by items, $F(1,143) = 4.28, p < .05$. A series of Newman–Keuls comparisons were not significant for either of the two languages ($q < 1$ in both cases). The overall naming differences between the two languages reflects the fact that Dutch was the dominant language for these subjects, but the absence of an effect of context in both languages suggests that the process of naming, although slower in L2, was fundamentally the same when subjects named words in Dutch or in English. For translation, the Newman–Keuls test for the effect of list type when translating from L2 to L1 was not significant, $q(2,143) = 5.04, p < .01$. Thus, as predicted, there was no effect of the type of list for naming in either language. For translation, there was a category interference effect when translation was performed in the direction that was hypothesized to require concept mediation. Translation from L2 to L1 was immune to the effects of list context, consistent with the hypothesis that translation in this direction can be accomplished at a level of lexically mediated connections between the two languages.

Accuracy. The mean accuracy scores are shown in Table 3 as a function of the task (naming or translation), the type of list (categorized or randomized), and the language of the target (L1 or L2). As expected, accuracy was much higher in the naming task ($M = 96.4\%$) than in the translation task ($M = 57.4\%$), $F(1,23) = 478.47, p < .001$. There was also a significant effect of target language, $F(1,23) = 6.48, p < .05$, that was qualified by a significant interaction between task and target language, $F(1,23) = 25.10, p < .001$. Newman–Keuls tests on this interaction showed that the tendency to name more accurately in L1 was not reliable, $q(2,24) = 2.10, p > .05$. However, subjects were consistently more accurate in translating from L2 to L1 than in translating from L1 to L2, $q(2,24) = 7.69, p < .01$.

TABLE 3
MEAN PERCENTAGE ACCURACY TO PERFORM NAMING AND TRANSLATION TASKS IN EXPERIMENT 3 AS A FUNCTION OF THE TYPE OF LIST CONTEXT (CATEGORIZED OR RANDOMIZED) AND THE TARGET LANGUAGE (L1 OR L2)

	Naming task	Translation task
Categorized lists		
L1	98.4	52.5
L2	96.1	67.4
Randomized lists		
L1	97.7	50.0
L2	93.3	59.5

It is important to note that the accuracy values shown in Table 3 for the translation conditions underestimate subjects' translation performance. Although we cautioned subjects not to say "uhm" before they produced a translation, on 9.4% of the trials that were counted as errors in this analysis because of this unwanted response, they ultimately produced the correct translation. This class of errors was equally likely to occur in all of the translation conditions.[5]

Recall. The mean percentage recall data following naming and translation are shown

[5] We plan to analyze the nature of the errors subjects made in translation in conjunction with a larger corpus of such translation errors gathered from other studies we have performed. The largest category of errors in the present experiment was "don't know" (for L1 to L2, $M = 70\%$ of the total errors and for L2 to L1, $M = 55\%$ of the total errors). We hope to be able to develop a categorization scheme for error types that will distinguish more sensitively among errors based on form and errors based on meaning.

in Table 4 as a function of the type of list (categorized or randomized) and target language (L1 or L2). Incidental recall was higher for words that were translated (M = 19.1%) than for words than were named (M = 8.4%), $F(1,23) = 48.42$, $p < .001$, and also was higher for words seen in categorized lists (M = 16.4%) than for words seen in randomized lists (M = 11.2%), $F(1,23) = 6.08$, $p < .05$. There was also an interaction between the type of list and the language in which the target words were seen, $F(1,23) = 5.53$, $p < .05$. Although the three-way interaction between type of list, target language, and task did not reach significance $F(1,23) = 2.39$, $p > .05$, the pattern of results shown in Table 4 suggests that the interaction between type of list and target language was attributable to translation rather than naming. For translation, this interaction reflected the differential effect of the categorized list on the direction of translation: Recall for words translated from L1 to L2 was 13.8% better in the categorized than in the randomized list context. However, recall for words translated from L2 to L1 was only 2.8% better in the categorized than in the randomized list context.

Separate analyses of variance were performed on the recall data for naming and translation to examine this interaction more closely. The separate analyses confirmed the differential pattern for recall following the two tasks. For recall following naming, neither of the main effects (of type of list or language of naming) was significant: $F(1,23) = <1$ for type of list and $F(1,23) = 2.44$, $p > .05$ for language. Furthermore, the interaction between type of list and language was not significant, $F(1,23) = <1$. For recall following translation, however, there was a significant effect of the type of list, $F(1,23) = 4.65$, $p < .05$ and a significant interaction between the type of list and the target language, $F(1,23) = 6.72$, $p < .05$. Newman–Keuls tests showed that there was a highly significant effect of the type of list on recall following translation from L1 to L2, $q(4,24) = 6.45$, $p < .01$, but no effect of type of list on recall following translation from L2 to L1, $q(2,24) = 1.28$, $p > .05$. Thus, the direction of translation that was hypothesized to require concept mediation produced a category interference effect in production but a category advantage in recall. The direction of translation that was hypothesized to be lexically mediated was insensitive to the effects of semantic context in production and also in recall.

TABLE 4

MEAN INCIDENTAL RECALL FOLLOWING NAMING AND TRANSLATION TASKS IN EXPERIMENT 3 AS A FUNCTION OF THE TYPE OF LIST CONTEXT (CATEGORIZED OR RANDOMIZED) AND THE TARGET LANGUAGE (L1 OR L2)

	Naming task	Translation task
Categorized lists		
L1	8.6	25.6
L2	10.3	20.9
Randomized lists		
L1	5.5	11.8
L2	9.3	18.1
Magnitude of category advantage		
L1	3.1	13.8
L2	1.0	2.8

Overall, then, the results of Experiment 3 support the predictions of the revised asymmetric hierarchical model. Translation from L1 to L2 required concept mediation and therefore took longer to perform than translation from L2 to L1 and was also influenced by the presence of semantic context. Translation from L2 to L1 appeared to be lexically mediated, and, like naming, was uninfluenced by the semantic context in which the task was performed.

The effect of cognate status. A question that arises about the pattern of results is whether it describes performance on cognates and noncognates equally well. The materials used in Experiment 3 included words that were cognates in English and Dutch. In the most extreme cases, the translations were the same word (e.g., bed/bed). However, some nonidentical translations still shared aspects of form (e.g., spinach/spinazie) or represented a regular transformation from one language to the other (e.g., tiger/tijger). The question of whether the process of translation is the same or different for cognates and noncognates is theoretically interesting because some past research suggests that cognates may be the only words across languages that share the same lexical and/or conceptual representations (e.g., D. Bradley, personal communication, November 8, 1991; de Groot & Nas, 1991; Sánchez-Casas, Davis, & García-Albea, 1992). If cognates share lexical representations or have privileged access to the lexical representations in the other language, then it should be possible to bypass concept mediation altogether when translating from L1 to L2. For the conditions of the present experiment, the prediction is that no category interference should be observed for translating cognates from L1 to L2 under the same conditions that produce interference for translating noncognates. The overall interference effect observed for translating from L1 to L2 in Experiment 3 may have been attributable to the effect for the noncognates because there were more noncognates than cognates in the items we used. To see if this was the case, an additional analysis was performed to determine the effect of cognate status on translation and naming. It was first necessary, however, to determine which of the 144 words used in Experiment 3 were cognates.

Past research on bilingual memory has defined cognate status in a variety of ways. In the present work we developed a subjective measure to determine which of the 144 words were cognates. Seventeen native English speakers who did not know either Dutch or German were presented with the list of words in Dutch and were asked to guess the English translations. The Dutch words were presented in semantically categorized clusters (e.g., the 18 vegetable words in Dutch were listed under the English category title "vegetables"). Subjects were told that we expected there to be many words for which they would have no idea what the translation was. They were told not to be concerned about these items but simply to guess the translation. After the data were collected, we calculated the percentage of subjects who were able to correctly guess the English translations of the Dutch words. We set a criterion such that any word that was correctly guessed by 50% or more of the subjects was called a cognate. This criterion resulted in 44 cognates that were guessed by more than 50% of the subjects (M = 86%) and 100 noncognates that were guessed by fewer than 50% of the subjects (M = 10%).[6] To see whether any other factors were confounded with cognate status we computed the mean word length and frequency for the cognates and noncognates. For none of the variables was there a significant difference between the two types of words: word frequency in Dutch, $t_{141} = -.67$, $p > .05$ (noncognate mean frequency = 9.37 versus cognate mean frequency = 11.59); word frequency in English, $t_{125} = -.21$, $p > .05$ (noncognate mean frequency = 17.22 versus cognate mean frequency = 16.25); word length in Dutch, $t_{142} = -.60$, $p > .05$ (noncognate word length = 5.9 versus cognate word length = 6.2); word length in English, $t_{142} = -.40$, $p > .05$ (noncognate word length = 5.7 versus cognate word length = 5.8).[7]

Translating cognates. An analysis of variance was performed on item means for translation latencies including cognate status, direction of translation, type of list, and language as variables. These data are shown in Table 5. Cognate status had a significant effect on translation latencies, $F(1,142) = 6.51$, $p < .05$. On the average, cognates were translated 131 ms faster than noncognates. However, the critical predic-

[6] The 44 words identified as cognates are marked with an asterisk in the Appendix.

[7] The degrees of freedom were slightly different in the word frequency analyses because there were a few missing entries.

TABLE 5
MEAN TRANSLATION AND NAMING LATENCIES (IN MILLISECONDS) IN EXPERIMENT 3 AS A FUNCTION OF THE COGNATE STATUS OF THE WORD, TYPE OF LIST CONTEXT (CATEGORIZED OR RANDOMIZED), AND TARGET LANGUAGE (L1 OR L2)

	Naming task	Translation task
Categorized lists		
Cognates		
L1	518	1265
L2	625	1053
Noncognates		
L1	500	1388
L2	597	1220
Randomized lists		
Cognates		
L1	505	1166
L2	578	1072
Noncognates		
L1	512	1257
L2	600	1216

tion, that cognates would not show the category interference effect in translating from L1 to L2, was not supported. There were no interactions between cognate status and any of the other variable ($F < 1$ for all relevant interactions). Although cognates were translated more quickly than noncognates, they produced virtually the same category interference effect observed for noncognates, suggesting that concept mediation was mandatory when translating from L1 to L2.[8] The data given in Table 5 show that cognate status was additive with the other results we have described. For cognates and noncognates alike, translation was faster from L2 to L1 than translation from L1 to L2, and the presence or absence of category interference was determined by the direction of translation, not the cognate status of the words.

Naming cognates. A similar analysis was performed on the item means for naming latencies to see whether cognate status facilitated lexical retrieval. If cognates share a lexical-level representation across languages, then naming should be facilitated for cognates, particularly in the case of naming L2 words, because it should be possible to take advantage of greater automaticity in retrieving L1 words. However, if cognates share only a conceptual-level representation across languages, there should be no difference between cognates and noncognates as naming does not appear to require conceptual access. The data for the naming task are also shown in Table 5. The striking result is that there was an overall interaction between cognate status and type of list context, $F(1,142) = 6.68$, $p < .05$. Newman–Keuls tests showed that for noncognates there was no effect of the semantic context of the list, consistent with the findings of previous studies suggesting that naming can be accomplished at a lexical level without semantic influence, $q(2,142) = 1.48$, $p > .05$. For cognates, however, there was a significant category interference effect such that cognates were named more slowly in the categorized than in the randomized lists, $q(4,142) = 6.36$, $p < .01$.

If the effect of categorizing the list was to increase top-down activation from concepts to lexical entries, then category interference in naming cognates may have resulted because the corresponding lexical entry in the other language was activated jointly by bottom-up activation from the target word and by top-down activation from the category. This pair of influences would create a computational problem because many of the cognates, although related in form, map to distinct pronunciations. Thus, it may not be helpful to activate a similar lexical form if it yields a different pronunciation. In fact, this situation may produce the greatest interference

[8] It is possible that we would eliminate the category interference effect for cognates in the L1 to L2 translation condition if they were blocked. Randomly mixing cognates with noncognates may make it difficult to take advantage of shared lexical representations on some of the trials only. However, the fact that translation was faster overall for cognates than that for noncognates suggests that some aspects of their special status were available, even under the mixed conditions.

at the lexical level. It may also explain why cognates were subject to category interference in translation from L1 to L2. If cognates provided a reliable cue to all feature of the lexical representation in the other language, then it would make sense to be able to take advantage of lexical similarity and to override concept mediation. This process might be something like the process of naming by analogy, which has been suggested as a lexical strategy for naming nonwords (e.g., Humphreys & Evett, 1985). If cognates do not reliably map all lexical features between languages, however, then it may be risky to adopt a purely lexical strategy in translation.

Previous cross-language research using the lexical decision task has provided conflicting evidence on the issue of whether common lexical features are accessed across languages. On the one hand, some studies (e.g., Altenberg & Cairns, 1983; Nas, 1983) suggest that it is impossible to ignore lexical features in one language while processing the other language. However, other studies (e.g., Gerard & Scarborough, 1989; Scarborough et al., 1984) suggest that each language maintains separate lexical representations. Gerard and Scarborough (1989) showed that homographic noncognates (words like "soy" that have similar form but different meaning in English and Spanish) are processed independently. They found that the frequency effect associated with such words was determined by the language in which a lexical decision task was performed. The very existence of homographic noncognates provides another reason why translation strategies cannot be based on lexical form alone, because words that resemble each other do not reliably correspond to the same meaning.

A strong source of evidence for at least some cross-language shared lexical-level features for cognates comes from studies using the masked priming paradigm in cross-language lexical decision (D. Bradley, personal communication, November 8, 1991; de Groot & Nas, 1991; Sánchez-Casas, Davis, & Garcia-Albea, 1992). Sánchez-Casas et al. (1992) showed that cognate translation produced as much priming under masked conditions as literal repetitions of the target word. However, in the same study, orthographically matched control words did not produce priming. There are at least two differences between those studies and the present experiment that may account for some of the different results. First, in masked priming, subjects are unaware of the language of the prime. From the subject's point of view, masked priming is a monolingual task. In the present experiment subjects were always aware of the bilingual nature of the tasks. Second, in the lexical decision task used in masked priming studies, subjects were not required to access the phonology as overt naming was not a requirement. In both the naming and translation tasks of the present experiment subjects were required to produce the word in either the same or the other language. Thus, in masked priming only the common orthographic features provide a reliable cue to the lexical status of the target word, whereas in naming and translation the phonological features are also relevant.[9]

[9] A post hoc analysis was performed to test the hypothesis that the effect of cognate status in naming and translation depends on whether the cognates map onto lexical representations that have similar or dissimilar phonology across languages. A fluent Dutch–English speaker rated the 44 cognate word pairs according to how similar the pronunciations were for the translation equivalents. After matching for word frequency, there were 20 words that were categorized as dissimilar and 19 words that were considered similar. The similarity of pronunciation affected only naming in L2. In L1, cognate naming latencies were not influenced by the less dominant representation in the L2 lexicon (Similar = 513 ms; Dissimilar = 517 ms). However, when naming L2 cognates, the presence of conflicting phonology in L1 produced interference (Similar = 565 ms; Dissimilar = 660 ms). This post hoc analysis is obviously tentative but it does suggest that cognate status based on orthography alone is not a sufficient measure of the degree to which two words share lexical representations across languages.

General Discussion

The three experiments described here show that there is category interference when pictures are named in semantically categorized lists (Experiment 1), that this category interference is eliminated when picture naming alternates with word naming (Experiment 2), and that a bilingual translation task which requires processing that is formally analogous to picture naming also produces category interference (Experiment 3). The findings go beyond past research in demonstrating that the analogy between picture naming and translation is limited to translation from the bilingual's first language into the second. We have hypothesized that only this translation process requires concept mediation. Translation from the second language to the first is both faster than translation from the first language to the second and is not susceptible to the effects of category interference, consistent with the claim that translation in this direction can be accomplished at a lexical level. Furthermore, words that are cognates in Dutch and English, although translated more rapidly than noncognates, also produce category interference when translation is performed from L1 to L2. This result demonstrates that the availability of shared lexical features does not necessarily imply that concept mediation can be overridden.

Evaluating the Revised Hierarchical Model

The results of Experiment 3 supported the predictions of the revised model of bilingual memory representation shown in Fig. 3. Translation from L2 to L1 was faster than translation from L1 to L2, as it should be if the former task could be accomplished by accessing lexical-level language connections whereas the latter task required concept mediation. In addition, there was category interference only for the conceptually-based translation from L1 to L2. Translation from L2 to L1 was performed similarly in categorized and randomized list conditions. The conditions that produced category interference in translation also selectively produced category facilitation in recall, demonstrating the expected advantage of having translated by conceptual rather than lexical mediation. The analysis of naming latencies in Dutch and in English also supports the assumption of the model that the L2 lexicon is smaller and requires additional access time. The analysis of the cognate data in particular suggests an asymmetry in lexical processing consistent with the claim that the lexical connections are stronger from L2 to L1 than from L1 to L2. Naming latencies in L1 were unaffected by whether L2 cognates shared phonological features. In contrast, naming latencies in L2 were long when an L1 cognate had a different pronunciation, and they were fast when an L1 cognate had the same pronunciation. If the lexical connections from L1 to L2 are weaker than those from L2 to L1, and if translation from L1 to L2 requires conceptual access, as we have suggested, then the finding that cognates, like noncognates, produced category interference in translation from L1 to L2 can be explained by the fact that cognate words in L1 do not automatically activate their L2 lexical representations.

In other work we have considered a number of additional predictions based on the asymmetry model. One hypothesis concerns the course of second language development. If second language learners acquire lexical links between L2 and L1 before they are able to conceptually mediate L2, as previous research has suggested (Chen & Leung, 1989; Kroll & Curley, 1988), then they should be able to quickly and accurately translate from L2 to L1 before they can do the same from L1 to L2. In other words, the difference between the translation performance of less and more fluent bilinguals should be greater for translation from L1 to L2 than for translation from L2 to L1. This is precisely the result we have obtained in other studies in which we have compared the translation performance of more and less fluent bilinguals (e.g., Kroll & Sholl, 1991; Kroll & Stewart, 1989). The result supports the notion that it is the ease of accessing connections between L2 words and concepts that changes most dramatically as proficiency in L2 increases.

Evidence for Asymmetric Cross-language Priming

Thusfar we have restricted our evaluation of the revised model to data from naming and translation tasks. Another importance source of evidence concerning the form of connection between languages in bilingual memory comes from studies of semantic priming. If semantic priming effects reflect facilitation in access to semantic relations, then finding cross-language semantic priming would suggest that the same underlying semantic or conceptual relations are activated regardless of the language in which the prime and target words appear. In general, this expectation has been supported (e.g., Kirsner et al., 1984; Meyer & Ruddy, 1974; Schwanenflugel & Rey, 1986). The finding of cross-language semantic priming is similar to the finding of cross-modal priming between pictures and words (e.g., Kroll, 1990; Kroll & Potter, 1984; Vanderwart, 1984). Finding symmetric cross-language semantic priming is problematic for the revised model because the model predicts that L1 primes should activate concepts and produce semantic priming for L2 target words more often than L2 primes should activate concepts and produce semantic priming for L1 words. However, recent bilingual priming studies have been critical of the methods used in these earlier studies (e.g., Altarriba, 1990; Keatley, Spinks, & de Gelder, 1994) and have shown that when steps are taken to minimize the use of strategies (e.g., by having a short SOA between the prime and target and by reducing the proportion of related trials), the predicted asymmetry is obtained: There is, in fact, more priming from L1 to L2 than from L2 to L1.[10] This asymmetry is of course consistent with our model and with the results reported here for naming and translation.

Visual Similarity Effects in Picture Processing

The fact that category interference occurs for both picture naming and bilingual translation also has important implications for evaluating the role of visual similarity in picture categorization. Previous research has shown that pictures can sometimes be categorized more quickly than words (e.g., Pellegrino, Rosinski, Chiesi, & Siegel, 1977; Potter & Faulconer, 1975; Rosch, 1975). One explanation for the picture advantage in categorization is that visual features provide reliable cues to superordinate category membership. Thus, vegetables look more like other vegetables than like animals. Snodgrass and McCullough (1986) showed that deciding whether a category exemplar was a member of a target category was faster when the nontarget category was visually dissimilar to the target category than when the target and nontarget categories were visually similar. A number of recent papers, however, have argued that these similarity effects are, at least in part, semantically mediated. For example, Walls and Siple (1987) and Job, Rumiati, and Lotto (1992) have shown that effects of visual similarity of the referent can be obtained for words as well as pictures. The finding in the present experiments that category interference occurs for both picture naming and translation further suggests that visual similarity alone cannot explain the picture advantage in categorization. If the category interference effect occurs for pictures because same-category pictures re-

[10] In a recent bilingual semantic priming study (Kroll, Sholl, Altarriba, Luppino, Moynihan, & Sanders, 1992) we found that semantic priming from L2 to L1 was primarily attributable to lexical-level associations between highly associated prime-target pairs. Pairs related only at a conceptual level by same category membership that were not also highly associated did not produce semantic priming for L2 words.

semble each other, then no category interference effect would have been expected in bilingual translation in the absence of those visual cues. The presence of similar category interference effects in both tasks strongly suggests that the common mappings between semantic representations and lexical entries are responsible for the observed interference.[11]

It is possible, of course, that category interference reflects both visual similarity effects and semantic-to-lexical mapping effects in picture naming. Although the translation latencies in Experiment 3 from L1 to L2 tended to be longer than picture naming latencies in Experiment 1 in L1, and those differences may have influenced the magnitude of the category interference effect, it is interesting to note that the interference effect was larger in translation than in picture naming. If the visual similarity effect added a component to the magnitude of interference in picture naming, then one might have expected the effects to be larger in picture naming than in translation. The larger effects in translation than in picture naming are consistent with the semantic-to-lexical mapping explanation. In particular, the strength of those mappings may be weaker when L2 is the output language, affording greater opportunity for interference.

[11] One danger in relying too heavily on comparisons of translation and picture naming is that it focuses attention on concrete words and concepts only. de Groot (1992) has recently shown that concrete words are translated more rapidly than abstract words matched on word length and frequency. Her work suggests that concrete words, and perhaps cognates, are the only types of words that may take advantage of a shared conceptual representation across languages. If abstract words correspond to distinct conceptual representations in different languages then lexical mediation may actually be a more common form of interlanguage connection than concept mediation.

Conclusions

The experiments we have reported show that there are category interference effects when picture naming and bilingual translation are performed in the context of semantically organized lists. We have argued that category interference occurs when conceptual activation in a specific semantic field creates difficulty in selecting a single lexical entry for production. We have also obtained evidence that suggests that, at least for relatively fluent but unbalanced bilinguals, there is an asymmetry between the two directions of translation that reflects differential reliance on lexical and conceptual activation during the translation process. The data we have presented support the claim that translation from the first language to the second is conceptually mediated, whereas translation from the second language to the first is lexically mediated. Taken together, the data support the predictions of a revised model of bilingual memory representation in which cross-language connections between lexical representations, and between lexical representations and concepts, are asymmetric. We believe that this proposal has important implications, not only for revealing aspects of translation performance, but also for illuminating the role of language dominance in determining the form of bilingual memory representations and for suggesting new directions for exploring the general course of second language acquisition.

Appendix

Semantic Categories and Word Frequencies of Dutch Words and Their English Translations

Category	Dutch targets	Dutch word frequency	English targets	English word frequency
Weapons	*speer	0	spear	3
	mes	11	knife	86

APPENDIX —*Continued*

Category	Dutch targets	Dutch word frequency	English targets	English word frequency
	vergif	0	poison	11
	touw	17	rope	19
	projectiel	0	missile	81
	*bajonet	0	bayonet	9
	pijl	10	arrow	20
	mortier	0	mortar	13
	zweep	0	whip	16
	zwaard	7	sword	12
	keten	5	chain	60
	dolk	0	dagger	1
	*tank	6	tank	30
	*bom	16	bomb	68
	*granaat	0	grenade	9
	*pistool	21	pistol	31
	stenen	11	bricks	24
	*kanon	0	cannon	4
Vegetables	*peterselie	8	parsley	1
	prei	0	leek	0
	*spinazie	0	spinach	2
	ui	11	onion	19
	sla	0	lettuce	0
	wortel	19	carrot	5
	kool	5	cabbage	4
	selderij	0	celery	4
	bloemkool	0	cauliflower	1
	erwten	0	peas	24
	andijvie	0	endive	0
	aardappel	17	potato	30
	paprika	7	pepper	13
	*tomaat	14	tomato	7
	*asperges	0	asparagus	1
	paddestoel	0	mushroom	4
	*bieten	0	beets	2
	*rabarber	0	rhubarb	2
Furniture	kleed	3	rug	17
	*klok	30	clock	28
	kastje	8	cabinet	22
	asbak	0	ashtray	1
	kast	24	closet	18
	kachel	15	stove	17
	gordijnen	0	curtains	21
	schommelstoel	0	rocker	5
	bank	50	bench	42
	*vaas	0	vase	15
	boekenkast	10	bookcase	3
	*dressoir	7	dresser	3
	plank	20	shelf	20
	*bed	115	bed	139
	krukje	0	stool	8
	lessenaar	0	desk	69
	spiegel	22	mirror	27
	stoel	79	chair	89
Birds	merel	6	blackbird	1
	eend	5	duck	6

APPENDIX —*Continued*

Category	Dutch targets	Dutch word frequency	English targets	English word frequency
	kraai	0	crow	2
	kip	19	chicken	49
	*zwaan	0	swan	4
	arend	0	eagle	12
	*buizerd	0	buzzard	0
	gans	0	goose	7
	*spreeuw	0	sparrow	1
	leeuwerik	0	lark	4
	struisvogel	0	ostrich	0
	*kardinaalvogel	22	cardinal	16
	kalkoen	0	turkey	4
	uil	10	owl	6
	roodborstje	0	robin	1
	duif	8	dove	4
	specht	0	woodpecker	1
	papegaai	0	parrot	2
Clothing	broek	27	trousers	10
	laarzen	0	boots	30
	hoed	39	hat	71
	handschoenen	8	gloves	16
	das	8	tie	27
	colbert	0	jacket	39
	kous	12	stocking	6
	jas	31	coat	52
	pak	27	suit	64
	hemd	12	shirt	29
	rok	22	skirt	22
	*sandalen	0	sandals	5
	schoenen	34	shoes	58
	*bloes	0	blouse	2
	trui	0	sweater	1
	jurk	10	dress	63
	*slippers	0	slippers	10
	sjaal	5	scarf	4
Fruits	druiven	0	grapes	10
	*grapefruit	0	grapefruit	3
	abrikoos	0	apricot	1
	perzik	0	peach	4
	pruim	0	plum	1
	*peer	1	pear	8
	*appel	11	apple	15
	vijg	0	fig	2
	rozijn	0	raisin	1
	*banaan	7	banana	5
	bes	6	berry	5
	*citroen	5	lemon	16
	mandarijn	0	tangerine	0
	aardbei	0	strawberry	2
	sinaasappel	7	orange	15
	framboos	0	raspberry	1
	kers	0	cherry	6
	*kokosnoot	0	coconut	10
Animals	hert	0	deer	13
	ezel	7	donkey	1

APPENDIX —*Continued*

Category	Dutch targets	Dutch word frequency	English targets	English word frequency
	koe	5	cow	46
	*kat	18	cat	42
	hond	57	dog	147
	*rat	16	rat	10
	*muis	6	mouse	20
	varken	5	pig	14
	konijn	6	rabbit	16
	schaap	8	sheep	24
	geit	8	goat	8
	*tijger	0	tiger	9
	*zebra	0	zebra	1
	vos	7	fox	11
	leeuw	12	lion	26
	*olifant	9	elephant	18
	paard	54	horse	203
	aap	20	monkey	10
Vehicles	brommer	9	motorcycle	0
	*metro	5	metro	3
	onderzeeer	0	submarine	35
	vlot	15	raft	5
	slee	0	sled	0
	locomotief	0	engine	69
	schaatsen	6	skates	1
	raket	13	rocket	22
	*zeilboot	0	sailboat	4
	*scooter	0	scooter	0
	*trein	44	train	86
	*schip	119	ship	126
	kano	0	canoe	8
	fiets	32	bicycle	7
	*kameel	0	camel	2
	*wagon	0	wagon	72
	ziekenauto	0	ambulance	7
	*boot	25	boat	123

Note. Asterisks denote words identified as cognates.

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(Received February 16, 1992)

(Revision received March 17, 1993)