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FORM–MEANING MAPPING IN VOCABULARY ACQUISITION IN A SECOND LANGUAGE

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The mapping of lexical form to meaning is an important part of vocabulary acquisition in a second language (L2). This study examines the proposition that L2 lexical forms are often mapped to the existing semantic content of their first language (L1) translations rather than to new semantic specifications of their own. Native and nonnative English speakers were asked to perform two semantic judgment tasks in which they had to determine the degree of semantic relatedness of English word pairs (experiment 1) or to decide whether two English words were related in meaning (experiment 2). The nonnative speakers, but not the native speakers, were found to provide higher rating scores on or responded faster to L2 word pairs sharing the same L1 translations than to L2 word pairs that do not. The finding is interpreted as strong evidence in support of the presence of L1 semantic content in L2 lexical entries.

One of the most essential tasks of vocabulary acquisition in an L2 is the mapping of lexical forms to meanings. Among many other things, knowing a word means that a learner recognizes a letter string as a legitimate word in the target language and knows the meaning of this letter string. However, this mapping process has been widely assumed rather than treated as a central topic

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for investigation in the study of L2 vocabulary acquisition. Many questions related to this mapping process deserve greater attention if we are to better understand the psycholinguistic processes and mechanisms involved. One such question is what semantic information is used in the mapping process. The question may be formulated in a number of ways, depending on one's theory of lexical and conceptual representations: If one assumes that meaning is an integral part of the information represented in lexical entries, as Levelt's (1989) model of lexical representation does, then one may ask what semantic information gets integrated in the L2 lexical entry. If one adopts a hierarchical model in which lexical and conceptual representations are treated as two separate levels, and no meaning is represented in lexical entries (e.g., the revised hierarchical model of Kroll & Stewart, 1994, and Kroll & de Groot, 1997; the distributed conceptual feature model of de Groot, 1992, and Kroll & de Groot), then the question becomes what concepts are mapped to L2 words.

Conceivably, L2 lexical forms can be mapped to new meanings or concepts developed in the process of L2 vocabulary acquisition or to the meanings or concepts already in the existing semantic or conceptual system. Similarly, either new meaning created in the L2 learning process or the existing meaning can be integrated in L2 entries, if one adopts Levelt's (1989) model.[1] Both possibilities are acknowledged in the SLA literature. Many L2 vocabulary acquisition studies examine the acquisition of new meanings (e.g., Bogaards, 2001; Ellis, 1995). The basic assumption underlying these studies is that new meanings are learned in the process of L2 vocabulary acquisition and used in the mapping process. The mapping of L2 words to the existing meanings or concepts has also been long recognized. For example, Ausubel (1964) suggested over 30 years ago that learning an L2 should be easier for adults than for children because adults "need not acquire thousands of new concepts but merely the new verbal symbols representing these concepts" (p. 421).

More recently, some researchers have suggested that L2 words are initially mapped to the existing concepts. As one's L2 experience and proficiency increase, a process of conceptual restructuring takes place that eventually leads to the remapping of linguistic forms to new concepts (Giacobbe, 1992; Ringbom, 1983). The mapping of L2 words to restructured concepts is also recognized in de Groot's distributed conceptual feature model (de Groot, 1992; Kroll & de Groot, 1997), which postulates that an L2 word may be mapped to a different set of conceptual features if its meaning is not identical to that of its L1 translation. Thus, this model allows the recombination or restructuring of conceptual features in the process of L2 vocabulary acquisition.[2]

The question is: To what extent are adult L2 learners successful in this remapping process? This question is addressed in a recent psycholinguistic model of adult L2 vocabulary acquisition (Jiang, 2000), based on Levelt's (1989) model of lexical representation, in which each root word has a lexical entry in the mental lexicon and each lexical entry contains four types of information in its two components: semantic and syntactic information in the lemma component, and morphological and formal information in the lexeme

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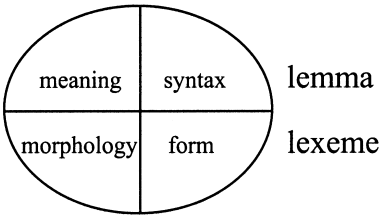


Figure 1. The lexical entry in the mental lexicon (based on Levelt, 1989).

component (see Figure 1). On this model, most L2 words go through two stages in lexical development. At the initial stage, an L2 lexical entry is established in the L2 lexicon and contains only formal specifications about a word and a pointer that picks out its L1 translation. In other words, L2 words are initially mapped to L1 translations, not to meaning directly. Each time an L2 word is encountered, its L1 translation is activated to provide lemma information (i.e., meaning and syntax). The information in the lexeme—morphology, pronunciation, and orthography—is gradually deactivated because it does not assist L2 word use. With increased experience in L2, which means increased coactivation of L2 words and their L1 lemma information, a strong link is established between L2 words and the lemma component of their L1 translations. That is, L2 words are no longer mapped to L1 translations but to L1 meaning directly. In terms of Levelt's model of lexical representation, L1 lemma information can be said to have been copied into the L2 lexical entry from its L1 translation and become part of the lexical knowledge represented in L2 entries. It is this lemma information that mediates L2 word use. We can call this unique process of form–meaning mapping in L2 vocabulary acquisition "L1 lemma copying" and the resulting lexical use "L1 lemma mediation."

Jiang's (2000) model further suggests that once L1 semantic information has entered L2 lexical entries and occupied the lemma space, it is very hard for new meanings to get in. The semantic information that is copied from the L1 translation stays in the L2 lexical entry and continues to mediate L2 word use even with continued exposure to the L2. As a result, even highly proficient L2 users will use L2 words on the basis of the semantic specifications of their L1 translations. This idea of continued L1 lemma mediation in L2 lexical performance represents a pessimistic answer to the form-mapping question raised previously. That is, the form–meaning remapping suggested by some researchers or the recombination of conceptual features envisaged in de Groot's (1992) model may not always take place successfully.

What evidence is there to support the continued mapping of L2 words to L1 meanings and, thus, the prolonged L2 word use mediated by L1 meanings? One line of evidence comes from lexical errors in L2 production. Even ad-

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vanced L2 learners have been found to make word-choice errors on high-frequency words, in particular when a lexical distinction is made in the L2 but not in the L1. The examples in (1) illustrate errors of this sort.

(1) a. *He bit himself in the language*. (cf. *tongue*; Ringbom, 1983, p. 208)
b. *I'm sorry I interrupted you*. (cf. *interfered with*; Olshtain & Cohen, 1989, p. 64)[3]
c. *I go to the oven in the morning to buy bread*. (cf. *bakery*; Zughoul, 1991, p. 50)

These sentences were produced by Finnish, Hebrew, and Arabic native speakers, respectively. The intended words are provided in parentheses. The cause of the errors is the same: A lexical distinction is made in the L2 but not in the L1. *Language* and *tongue* share the same Finnish translation *kieli*; *interrupt* and *interfere with* both translate as *lehafria* in Hebrew; *oven* and *bakery* have a single Arabic translation *furn*. Under such circumstances, two L2 words are mapped to the same semantic information of the shared L1 translation, making it very hard for the L2 users to semantically distinguish the two L2 words and use them correctly in L2 production. The presence of such L1-related lexical errors on high-frequency, "easy" words (see also Altenberg & Granger, 2001) in advanced L2 users' performance provides direct evidence for the failure of form–meaning remapping in L2 vocabulary acquisition.

Although these errors clearly indicate the use of L2 words based on L1 lemma information, error evidence alone is hardly sufficient to substantiate the L1 lemma mediation claim made in Jiang's (2000) model. For one thing, these lexical errors do not always occur, particularly in advanced L2 users. The absence of such errors could be considered evidence for successful form–meaning remapping. Thus, more reliable and consistent evidence, other than lexical transfer errors, is needed to support the L1 lemma mediation claim.

The purpose of the present study is to obtain such evidence in an experimental setting. The study capitalizes on the fact that a pair of semantically related words or synonyms in one language may have a single or different translation in another language. The two English words *question* and *problem*, for example, are typically translated into a single Chinese word *wenti*. The English words *interrupt* and *interfere*, on the other hand, are often translated into two different Chinese words, *daduan* and *ganrao*, respectively. The critical stimuli of this study consisted of these two types of English word pairs: same-translation pairs and different-translation pairs. The former included English word pairs whose two members share the same Chinese translations. The different-translation pairs included word pairs whose two members are usually translated into different Chinese words. These two sets of English word pairs are comparable in their degree of semantic relatedness as judged by English native speakers.

If the semantic specifications represented in L2 entries come from their L1 translations, as the L1 lemma mediation hypothesis claims, these two sets of word pairs would differ in terms of the semantic overlap between the two

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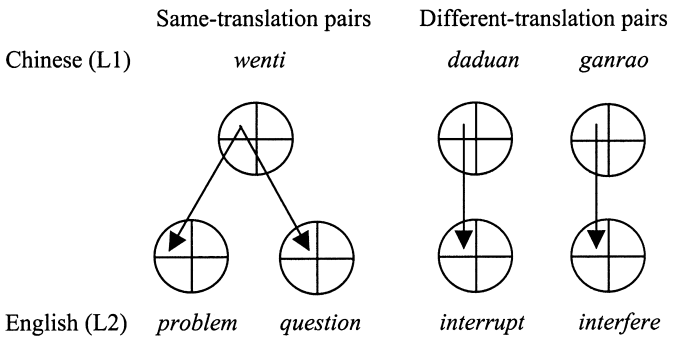


Figure 2. The difference in the degree of semantic overlap between same-translation and different-translation pairs.

members of each pair. The two words of any same-translation pair, for example, *problem* and *question*, would share very similar or identical semantic content because their semantic content is copied from the same L1 translation. The two members of a different-translation pair, for example, *interrupt* and *interfere*, would have a lower degree of semantic overlap because their semantic content comes from two different L1 translations. This difference is illustrated in Figure 2. Consequently, if L2 learners are asked to rate the degree of semantic relatedness of these word pairs, the L1 lemma mediation hypothesis predicts that they should rate same-translation pairs as more related than different-translation pairs, even though their degree of semantic relatedness is comparable, as judged by native speakers. However, if form–meaning remapping has taken place successfully and L2 entries now contain the new semantic information acquired through the use of the L2, then nonnative speakers should rate these two types of word pairs as equally related, as native speakers do. Their rating performance should not be affected by whether these word pairs share the same L1 translation. Thus, the L1 lemma mediation hypothesis can be tested by comparing native and nonnative speakers' semantic judgment performance on these two types of word pairs.

EXPERIMENT 1

The purpose of this experiment was to test the L1 lemma mediation hypothesis in a semantic judgment task. In this task, English word pairs were presented to Chinese–English bilinguals who were asked to rate their degree of semantic relatedness. To complete the task, semantic information must presumably be retrieved from L2 lexical entries and then matched to determine their degree of relatedness. A higher rating score is given to a word pair that has a higher degree of semantic overlap and a lower score to a word pair with a lower degree of semantic overlap.

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When L2 word pairs that are comparable in semantic relatedness but that differ in translation status are given to L2 users for the rating task, the L1 lemma mediation hypothesis makes the following two predictions: (a) There will be no difference in native speakers' rating scores on the two types of word pairs; and (b) Chinese–English bilingual speakers will provide higher rating scores for the same-translation pairs than for the different-translation pairs.

To ensure the examination of lexical development and processing beyond the initial stage, advanced ESL speakers and high-frequency words were involved in this and the next experiment. A group of English native speakers also participated in the experiment; their performance served to make sure that the two types of word pairs were indeed comparable in semantic relatedness.

Method

Participants. Twenty-five Chinese–English bilingual speakers and 27 English native speakers participated in this experiment. Twenty-one of the bilingual speakers were graduate students from mainland China studying at the University of Arizona at the time of testing. The remaining four were also from mainland China but had recently graduated from the University of Arizona. They all had TOEFL scores of 550 or higher when they were admitted into their graduate programs. They had received an average of 10.4 years of formal training in English. Their average length of residence in the United States was 1.8 years.[4] The native speakers included 20 undergraduate students enrolled in a freshman composition course and seven graduate students enrolled in a psycholinguistics course at the University of Arizona.

Materials. The materials for the semantic-relatedness judgment task included 80 English word pairs. Given that the quality of the test materials was critical for the purpose of this study, careful procedures were followed in the construction of the materials. The 80 word pairs came from an initial list of 120 high-frequency English word pairs constructed by the present author, a native speaker of Chinese. To determine whether an English word pair shares the same Chinese translation, the 240 words were randomized and given to three Chinese–English bilingual speakers who were asked to provide the first Chinese translation to come to mind for each English word. When all three informants translated the two members of a pair into the same Chinese equivalent, this pair was put into the "same-translation" set. If two or more different translations were given to the two members, this pair went to the "different-translation" set. This procedure produced 49 "same-translation" pairs and 62 "different-translation" pairs. (The other nine pairs were harder to classify because of problems such as a missing translation or self-correction by the informants and were therefore discarded.) These two sets of word pairs were then given to five native speakers of English who were asked to rate their degree of

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Table 1. Examples of the English word pairs used in experiment 1

Same-translation pairs		Different-translation pairs	
English word pair	Chinese translation	English word pair	Chinese translation
problem–question	*wenti*	painter–artist	*huajia–yishujia*
practice–exercise	*lianxi*	advice–suggestion	*quangao–jianyi*

semantic relatedness. Based on their ratings, 80 pairs, comprising 40 from each set, that were matched in semantic relatedness were chosen and used in this and the next experiment (see Appendix). Some examples of these word pairs are given in Table 1.

Procedure. The participants performed the task individually. The 80 pairs of English words were printed on two sheets of paper in a random order. Each pair was followed by a 5-point rating scale. In the written instructions given to the participants, they were asked to rate the semantic relatedness of each pair—with 5 indicating the strongest relation and 1 the weakest—by circling the corresponding number after each pair. They were told that all the pairs were related in meaning but that their degrees of relatedness varied. They were also asked to rely on their intuitions while performing the task. After completing the task, the Chinese–English bilinguals were asked to complete a questionnaire about their English learning background.

Results and Discussion

After the raw data were collected, two average rating scores were calculated for each word pair, one for native speakers and the other for nonnative speakers. An average rating score was then calculated for each word-pair type for each participant group. These four average scores are presented in Table 2.

A two-way ANOVA was carried out to examine the data, with pair type (same-translation vs. different-translation pairs) and participant type (native vs. nonnative speakers) as variables. It produced main effects for both pair type and participant type. The same-translation and different-translation pairs received an average rating score of 3.58 and 3.35, respectively, on the 5-point scale; the difference was significant, $F(1, 78) = 5.87$, $p < .05$. Additionally, nonnative participants tended to provide a higher rating score (3.67) than native speakers (3.26); this difference was also significant, $F(1, 78) = 52.08$, $p < .05$. There was also a significant interaction effect between the two variables, $F(1, 78) = 22.05$, $p < .05$, which suggests that the two groups of participants showed distinctive patterns of performance in the rating task and that the pair-type effect came from the nonnative participants only.

Two separate one-way ANOVAs, one for each participant group, confirmed

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Table 2. Average rating scores for each word-pair type by NNS and NS participants in experiment 1

Pair type	Nonnative speakers	Native speakers
Same translation	3.92	3.25
Different translation	3.42	3.28

this analysis. The .03 difference between the two types of word pairs found for native speakers was not significant, $F(1, 78) = 0.06$, $p = .82$. In contrast, the pair-type effect for the nonnative speakers was significant, $F(1, 78) = 30.19$, $p < .05$.

The results of experiment 1 show that whether an L2 word pair shares a single L1 translation does not affect native speakers' performance in the rating task. A lack of significant differences in the rating scores between these two types of word pairs further suggests that these two sets of word pairs are comparable in their degree of semantic relatedness, which is consistent with the initial ratings by the five NS informants. Whether an L2 word pair has a single L1 translation, however, affected the rating performance by the nonnative speakers. As the L1 lemma mediation hypothesis predicts, the Chinese ESL participants provided a significantly higher rating score for the same-translation pairs than different-translation pairs.

Although the findings of experiment 1 are consistent with the L1 lemma mediation hypothesis, there are two potential problems that have to be resolved before one can interpret the findings as evidence in support of it. One problem arises from the fact that most same-translation items received rating scores of less than 5 points. If the semantic specifications of two members of a same-translation pair are copied from the same L1 translation and thus are identical, then we would expect L2 speakers to give them a score of 5 or close to 5. However, very few same-translation pairs received a score close to 5. Most of them (75%) received a score between 3.7 and 4.6. The highest score was 4.68 for the item *chance–opportunity*.

One explanation for this discrepancy may lie in the possible involvement of conscious knowledge about L2 words in the rating task on the part of the nonnative speakers. Instead of relying solely on the semantic information retrieved from the L2 lexical entries, which would in theory lead to a 5-point rating score for every same-translation pair, at least some L2 speakers may have also utilized their conscious knowledge about these words while performing the task. Take the pair *lend–borrow*, for example. This item received an average score of 2.95 from Chinese participants. It is one of only two same-translation pairs that received an average rating score of less than 3, the other being *day–date* (2.74). Although *lend* and *borrow* share the same Chinese translation *jie*, the difference between them is easy to capture and is often

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explicitly described and practiced in formal instruction (e.g., Lu, 1998, p. 56). Note that such conscious knowledge often highlights the differences between these words because the knowledge about their differences is critical for the correct use of these words. Faced with same-translation pairs like this, it is reasonable to expect the Chinese participants to use their conscious knowledge of English in their rating performance, which would result in a lower rating score for these pairs.

Another possible cause of these lower scores may be that multiple translations exist for same-translation pairs. Although these pairs share the same translation as judged by the three Chinese–English bilingual informants, other translations exist as well. For example, the same Chinese translation *lianxi* was provided for *practice* and *exercise* in the pretest, and thus these words were put in the same-translation set. However, to some Chinese–English bilinguals, the first translation for *exercise* may be *duanlian* (which suggests physical exercise), not *lianxi* (as in a grammar exercise). This may be true for some other same-translation pairs. That is, the same-translation status of the same-translation items is relative. Some same-translation items may be different-translation items to some participants, leading to an overall score of less than 5 points. Either way, a score less than 5 points for the same-translation pairs constitutes no difficulty for interpreting the findings as support for the L1 lemma mediation hypothesis.

A potentially more damaging problem for such an interpretation has to do with the assumption that the nonnative speakers' rating performance is primarily determined by the retrieval and matching of semantic specifications from L2 lexical entries. It is possible that these participants translated the English words into Chinese words while performing the task. If two words were given the same Chinese translation, they would receive a higher score. Otherwise, a lower score would be assigned—that is, the rating performance was based on whether the two English words activated the same Chinese translation, and thus had nothing to do with the semantic specifications represented in L2 entries. This possibility raises a genuine concern especially when one considers the offline nature of the task, which gives participants enough time for the translation process. This problem is dealt with in experiment 2 through the use of an online semantic judgment task.

EXPERIMENT 2

The purpose of experiment 2 was twofold. The first aim was to provide further evidence for the L1 lemma mediation hypothesis using a different paradigm. The second was to address the translation concern previously discussed by means of an online semantic judgment task. In this task, each test item consisted of two English words that were or were not related in meaning. The participants were asked to determine, as quickly as possible, if the two English words were related in meaning or not. Their reaction times and error rates were recorded. The advantage of this online task was that the speed re-

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quirement minimized the possibility that participants would translate while performing the task.

Several steps are conceivably involved in such an online semantic judgment task: The participants have to recognize the words, retrieve the semantic specifications of each word, compare the semantic content retrieved, reach a decision, and execute the decision. We can assume that the first and second steps are serial because no meaning will be retrieved or activated before a word is recognized. However, the retrieval and comparison of meaning can occur simultaneously. As the bits of semantic information are coming in from the two opened lexical entries, they are immediately compared. The two steps can occur simultaneously in the sense that the comparing step need not wait until all the semantic information becomes available.

Two further assumptions can be made about the task. First, participants' responses will be determined by the result of the comparison. A "yes" response is made when similar semantic content is found in the comparing procedure; otherwise, a "no" response is given. More importantly, the degree of semantic overlap between two words will presumably affect participants' response time. A "yes" response can be reached more quickly when the meanings of two words are identical or highly related than when the two words are less related. This is so because when the meanings of two words are identical, it is easier to identify a shared semantic element or to identify enough semantic overlap to reach the threshold for a "yes" response. In the case of less related words, the first semantic information retrieved and compared may not be the related elements, and a "yes" response will be delayed until a shared element or enough shared information is found.

Given these assumptions about the mechanism of the online semantic judgment task, the L1 lemma mediation hypothesis predicts that Chinese ESL speakers should respond to the same-translation pairs faster than to the different-translation pairs. However, no such difference should be found in native speakers because, for native speakers, these two sets of word pairs are similar in the degree of semantic relatedness.

Additionally, two further predictions can be made. First, we expect native speakers to respond faster than nonnative speakers because native speakers would be faster at any one or all of the first three steps involved in performing a semantic judgment task. It was also expected that both groups of participants would respond to related items faster than unrelated items because a "no" response will be given only after all semantic elements are checked. In contrast, a "yes" response can be reached as soon as certain semantic elements match.

Method

Participants. Eighteen Chinese–English bilingual speakers and 18 native speakers of English participated in this experiment. The nonnative speakers came from the same population as those in experiment 1, except some of

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them were studying in a graduate program at Auburn University at the time of testing. They had the same 550 TOEFL requirement for admission into a graduate program. They received an average of 9.4 years of formal instruction in English. Their average length of residence in the United States was 1.3 years. The native speakers were students enrolled in an undergraduate linguistics course at Auburn University.

Materials. The stimuli included 80 semantically related English word pairs and 80 unrelated pairs (see Appendix). The related pairs were the same 40 same-translation pairs and 40 different-translation pairs used in experiment 1. The unrelated pairs were constructed for this experiment.

Procedures. Each test item consisted of two English words presented at the center of a computer screen side by side and separated by two character spaces. The two words were presented simultaneously for 1,670 ms. The participants were tested individually, each receiving a different, randomized list of 160 test items. They were asked to determine if the two English words presented on the screen were related in meaning and then to indicate their judgment by pressing one of two buttons, one for a positive response and the other for a negative response. They were also instructed to respond as quickly and accurately as possible. Instructions were given both orally and on the screen before the test. Eighteen practice items preceded test trials. After each response, feedback about correctness and response latencies was given on the screen. The response latency was the duration between the appearance of a test item on the screen and the pressing of a response button by the participant. Participants' response latencies and error rates were recorded by a computer. The test program was written and administered with DMASTR, a psycholinguistic experimentation software package developed by Kenneth Forster and Jonathan Forster at the University of Arizona.[5]

Results and Discussion

In analyzing the results of experiment 2, only correct responses were included, and outliers were treated by setting them equal to cutoffs established at two standard deviations above or below the mean for each participant. This procedure affected 3.9% of the total data. Two analyses of variance (ANOVA) were performed, one treating participants as a random effect (F_1), the other treating items as a random effect (F_2). The average reaction times and error rates from the two groups of participants are presented in Table 3.

A two-way ANOVA procedure was adopted first for the analysis of the overall effects of participant type (native vs. nonnative speakers) and relatedness (related vs. unrelated word pairs). Data from all 160 items were included in this analysis. There was a main effect of participant type in reaction time. It took native speakers and nonnative speakers an average of 949 ms and 1,226 ms, respectively, to respond to the test items. The 277-ms difference was significant in both subject analysis (F_1) and item analysis (F_2), $F_1(1, 34) = 28.87$,

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Table 3. NNS and NS participants' reaction times and error rates in experiment 2

	Nonnative speakers		Native speakers	
Pair type	Related	Unrelated	Related	Unrelated
Same translation	1076 (8.3)	1319 (12.6)	878 (12.4)	1000 (10.8)
Different translation	1190 (13.6)		919 (7.9)	
Difference	114		41	

Note. Reaction times are in milliseconds; error rates are percentages within parentheses.

$p < .05$; $F_2(1, 158) = 862.93$, $p < .05$. This difference is expected if we assume that native speakers are faster at any one or all of the first three steps involved in making semantic judgments. There was a difference of 1.32% in error rates between native speakers (10.45%) and nonnative speakers (11.77%), but this difference was not significant by either analysis, $F_1(1, 34) = 0.86$, $p = .36$; $F_2(1, 158) = 1.15$, $p = .29$.

As expected, there was also a main effect of relatedness in reaction time. Related pairs (1,016 ms) were responded to 143 ms faster than unrelated pairs (1,159 ms), and the difference was significant, $F_1(1, 34) = 106.58$, $p < .05$; $F_2(1, 158) = 94.47$, $p < .05$. The difference of 1.11% in error rates was not significant (both F values < 1).

Of greater interest is how the participants responded to the two types of related pairs. For that purpose, the data from the 80 related items were analyzed in a two-way ANOVA, with participant type (native vs. nonnative speakers) and pair type (same-translation vs. different-translation pairs) as variables. Again, there was a main effect of participant type in reaction times for these 80 related items. Nonnative speakers took 234 ms longer than native speakers, and this difference was significant, $F_1(1, 34) = 25.84$, $p < .05$; $F_2(1, 78) = 144.99$, $p < .05$. No significant main effect of participant type was found in error rate. There was also a significant main effect of pair type. Participants took an average of 977 ms and 1,055 ms to respond to the same- and different-translation pairs, respectively, and the 78-ms difference was significant by both subject and item analyses, $F_1(1, 34) = 61.40$, $p < .05$; $F_2(1, 78) = 16.77$, $p < .05$.

Very critical to the purpose of this experiment, there was also a significant interaction between participant type and pair type in reaction time, $F_1(1, 34) = 13.76$, $p < .05$; $F_2(1, 78) = 4.76$, $p < .05$, which suggests that the 114-ms difference between the same- and different-translation pairs produced by the nonnative speakers was significantly greater than the 41-ms difference produced by the native speakers. There was also a significant interaction between the two variables in error rate, $F_1(1, 34) = 16.48$, $p < .05$; $F_2(1, 78) = 9.52$, $p < .05$.

Two separate one-way ANOVAs were carried out, one for native speakers and the other for nonnative speakers. For native speakers, the 41-ms pair-type

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effect was significant by subject analysis, $F_1(1, 17) = 20.37$, $p < .05$, but not by item analysis, $F_2(1, 78) = 2.14$, $p = .15$. The error-rate data showed the same pattern, $F_1(1, 17) = 9.76$, $p < .05$; $F_2(1, 78) = 2.76$, $p = .10$. In contrast, the 114-ms difference produced by nonnative speakers was significant in both subject and item analyses, $F_1(1, 17) = 42.12$, $p < .05$; $F_2(1, 78) = 15.01$, $p < .05$. Nonnative speakers also produced a significant pair-type effect in error rate, $F_1(1, 17) = 7.50$, $p < .05$; $F_2(1, 78) = 6.16$, $p < .05$. This difference in error rates suggests that nonnative speakers are more likely to judge a related pair as unrelated if two words do not share the same translation.

The results of the analysis taken as a whole are consistent with the predictions of the L1 lemma mediation hypothesis. The nonnative speakers responded to the same-translation pairs significantly faster than to the different-translation pairs. Even though there was also a pair-type effect in the NS data, the effect was significantly smaller. However, two issues need to be addressed before these results can be taken as evidence for L2 lexical processing mediated by L1 semantic content. One is how successful the online task was in preventing the participants from translating. The other is whether there are other factors that may have contributed to the pair-type effect found in nonnative speakers.

One of the purposes of experiment 2 was to deal with the translation problem in experiment 1. How successful was such an online task in preventing participants from translating? Although we can never be absolutely sure that the participants were not translating, a comparison of the native and nonnative speakers' reaction times suggests that the involvement of translation was not very likely. There was a 234-ms difference on the related items between native and nonnative speakers in this experiment, with reaction times of 899 ms and 1,133 ms, respectively. We can consider 899 ms as the average amount of time a native speaker needs to recognize two words, retrieve and compare the semantic information, make a decision, and execute a response. Jiang (1999) found that Chinese–English bilingual speakers from the same population, with comparable English proficiency and English learning background as the nonnative participants of the present study, were found to be 100–150 ms slower than native speakers in performing a single-word lexical decision task. This difference in reaction times may reflect the average difference in the amount of time needed to recognize a word between native and nonnative speakers of this population (i.e., graduate students from mainland China with an average length of residence in the United States of less than 2 years). One would expect the difference in response latency between the native and nonnative speakers to be approximately twice as much in this experiment because each test item consisted of two words. The 234-ms difference is well within this range. If translation was involved in the nonnative speakers' performance, a much greater difference in reaction times between the two groups would have been expected.

A second issue related to the interpretation of the results is whether the translation status is the only factor that contributed to the pair-type effect, or

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Table 4. Average pair frequency, average word length, reaction times, and error rates on 60 items matched for overall frequency and word length in experiment 2

Pair type	Pair frequency	Word length	Reaction times and error rates	
			NNS	NS
Same translation	96.3	6.12	1075 (7.8)	886 (11.3)
Different translation	96.7	6.28	1174 (14.5)	895 (7.0)
Difference			99	9

Note. Word length is calculated by number of letters; reaction times are in milliseconds; error rates are percentages within parentheses.

if other factors were also involved. The involvement of other factors is highly likely when one considers that native speakers also showed a reaction-time difference between the two sets of word pairs. Because the two types of word pairs are comparable in semantic relatedness, as shown in experiment 1, the presence of a pair-type effect in the native participants, though small, suggests that the two sets of word pairs differ in some other ways than their translation status. Two likely candidates for such differences are frequency and word length, both of which have been shown to affect word-recognition time (Forster & Chambers, 1973; Frederikson & Kroll, 1976; Lee & Cochran, 2000). Given that the test materials were initially constructed for the offline task of experiment 1, they may not have been matched for frequency and word length. A check on the frequency of the test materials using the Brown corpus (Kucera & Francis, 1967) and word length (defined as the number of letters in a word) indeed showed that the two sets differ in these measures, with the same-translation pairs being of higher frequency than the different-translation pairs (144 vs. 98 occurrences per million words) and of shorter word length (an average of 5.7 vs. 6.9 letters per word). Thus, it is highly likely that the same-translation pairs were responded to faster because they are shorter and of higher frequency. This creates a problem for interpreting the nonnative speakers' results. If the frequency and word-length differences in the test materials could result in a pair-type effect in the native speakers' performance, then they might also be responsible (somehow in an inflated way) for the greater pair-type effect found in the nonnative speakers.

To examine if the nonnative speakers' results can be attributed to frequency and word-length differences in the materials, a reanalysis of the data was done. Sixty word pairs were chosen from the original 80 items such that the 30 pairs from each set were matched for overall frequency and word length (see Appendix). The data from these 60 items were included in the reanalysis, which is presented in Table 4.

As can be seen in Table 4, when the test materials are matched for frequency and length, the difference between the two types of word pairs almost disappears for native speakers. However, a robust difference remains for non-

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native speakers. A two-way ANOVA produced a main effect of participant type in reaction times in both subject and item analyses, $F_1(1, 34) = 25.24$, $p < .05$; $F_2(1, 58) = 235.38$, $p < .05$, and a main effect of pair type, $F_1(1, 34) = 28.58$, $p < .05$; $F_2(1, 58) = 4.41$, $p < .05$. No main effect was found in error rate. There was also a significant interaction of the two variables in reaction time, $F_1(1, 34) = 19.84$, $p < .05$; $F_2(1, 58) = 9.48$, $p < .05$.

Two separate one-way ANOVAs were done, one for the native speakers and the other for the nonnative speakers. The 9-ms difference in reaction times by native speakers was not significant (both F values < 1). The difference in their error rates was significant by subject analysis only, $F_1(1, 17) = 6.99$, $p < .05$; $F_2(1, 58) = 2.73$, $p = .11$. The 99-ms effect in reaction times produced by nonnative speakers, however, was significant by both analyses, $F_1(1, 17) = 31.92$, $p < .05$; $F_2(1, 58) = 12.03$, $p < .05$. The difference in accuracy was also significant, $F_1(1, 17) = 9.25$, $p < .05$; $F_2(1, 58) = 7.40$, $p < .05$.

The results of the reanalysis are similar to the results of the entire data set in several ways. Specifically, both analyses showed a significant interaction of the participant-type variable and the pair-type variable in reaction time, which suggests that native and nonnative speakers produced two distinctive patterns of performance on the two types of word pairs. The analysis of the data from both the entire set of items and the smaller set of matched items showed a significant pair-type effect in nonnative speakers' reaction times. More importantly, when the two types of word pairs were matched for frequency and length, the pair-type effect in response latencies disappeared for native speakers but remained for nonnative speakers. This suggests that the difference in reaction times between the two types of word pairs found in nonnative speakers cannot be attributed to the difference in frequency and length between the two sets of items. Thus, we can interpret the difference as a reflection of how semantic information is represented in the two types of word pairs in these nonnative speakers and, thus, as evidence for L1 lemma mediation.

GENERAL DISCUSSION

In this study, L2 word pairs of comparable semantic relatedness were found to produce differential semantic-relatedness rating scores and reaction times in L2 speakers, depending on whether the words share the same L1 translations. The same-translation pairs resulted in higher rating scores and faster response latencies than different-translation pairs. In contrast, their translation status did not affect English native speakers' performance. In light of the native speakers' performance, the difference found in L2 speakers' performance on the two sets of items cannot be attributed to the different degrees of semantic relatedness in these items. The difference cannot be accounted for by the difference in the frequency and word length of the stimuli either, as the reanalysis demonstrated. Based on a comparison of the reaction latencies by native and nonnative speakers, it is also reasonable to expect little overt translation process involved in the online task.

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I interpret the findings as compelling evidence for L1 involvement in lexical processing in L2. The difference in the rating scores and reaction latencies between the two types of word pairs would be hard to explain if one does not assume such involvement. I further argue that the L1 lemma mediation hypothesis provides a plausible explanation of the findings. According to this hypothesis, L2 lexical entries contain the semantic information copied from their L1 translations. When L2 words share the same L1 translation, their lexical entries also share the same semantic content. When the semantic content is retrieved and used for making semantic-relatedness judgments, these word pairs should lead to higher rating scores or faster reaction times. On the other hand, when an equally related L2 word pair has different L1 translations, different semantic content is copied into their entries, resulting in a lower rating score or longer reaction time.

These findings are important for studying L2 vocabulary acquisition for several reasons. First, they provide converging evidence for L1 lemma mediation in L2 use, as instantiated in lexical transfer errors in L2 production such as those provided in (1). The significance of the findings also lies in the demonstration of L1 lemma mediation in an L2 processing task where no overt error is involved, which suggests that L1 lemma mediation is a normal state of lexical processing and production in L2. Furthermore, the findings demonstrate the usefulness of the paradigm adopted in this study as a more objective and reliable means of examining an otherwise evasive phenomenon.

Although the findings of this study provide further evidence for L1 lemma mediation, one question remains to be answered: How can one reconcile L1 lemma mediation with the fact that even beginning learners are able to use many L2 words without committing transfer errors and, as one's proficiency increases, lexical transfer errors usually decrease? Based on the absence or gradual elimination of transfer errors, one can argue that genuine semantic development and form–meaning remapping do take place in adult L2 learning and that new semantic information unique to L2 words does get integrated into L2 lexical entries.

Even though one can never rule out a certain level of semantic development in L2 acquisition, the absence of transfer errors alone does not necessarily constitute evidence for such development. First, as has been pointed out by some researchers (e.g., Singleton, 1999), transfer does not always lead to overt errors. A large number of words in one language may have a high level of semantic overlap with their translations in another language. For example, the English words *sun* and *eat* are likely to mean the same thing as their translations in another language. Most of the words that a beginning or intermediate L2 learner uses probably belong to this category. Thus, L1 lemma mediation does not necessarily lead to lexical errors. On the contrary, it facilitates the use of L2 words. Additionally, under many circumstances, a transfer error may be difficult to identify out of context. The example in (1b), *I'm sorry I interrupted you*, would be perceived as a perfectly grammatical sentence if we

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did not know the context in which it was said and the speaker's intended message (see Olshtain & Cohen, 1989).

Furthermore, a decrease in transfer errors may not necessarily imply a substantial change in the semantic content of L2 words but rather be a result of learning and using explicit lexical knowledge. For example, a Chinese ESL learner may have learned the two English words *hat* and *cap* through their association with the same L1 translation *maozi*. As a result, the two words are mapped to the meaning of this Chinese translation and are used interchangeably. He or she may later be told the difference between a *hat* and a *cap*. This knowledge enables the learner to use these words correctly under some circumstances. However, this correct use involves two steps: First, both *hat* and *cap* may first be activated because they have the same L1 semantic specifications that match the preverbal message; second, the lexical knowledge determines the correct word to use (Jiang, 2000). It has to be pointed out that such lexical knowledge does not have to be an integrated part of lexical entries or become part of one's automatic competence. Thus, the possession of such knowledge or a decrease in lexical errors as a result of applying such knowledge is not necessarily a reliable indication of the integration of new semantic content in lexical entries.

This analysis is consistent with the distinction between two types of linguistic knowledge widely acknowledged by L2 researchers. For example, Bialystok (1978) talked about implicit and explicit linguistic knowledge, Krashen (1981) about acquisition and learning, Ellis (1984) about analyzed–nonautomatic and unanalyzed–automatic forms of representation, and Hale (1988) about integrated linguistic competence and conscious intellectual understanding. An analysis of correct use of L2 words without the integration of new meanings or remapping is motivated by a similar distinction made in Jiang (2000) regarding the representation of lexical information in the L2. It has been suggested that lexical information can be represented within or outside lexical entries. What is represented within the lexical entry can be retrieved automatically in spontaneous communication. It is also stable and affects lexical processing in a consistent way. We can call such integrated information "lexical competence." What is represented outside a lexical entry, or lexical knowledge, may be stored in a general memory system and can also be retrieved in speech communication and contribute to speech production. However, its contribution to lexical production is not automatic or consistent. Instead, applying such knowledge is often an effortful process that requires attentional resources.

The inconsistency and self-correction found in L2 production provide support for such distinctions. L2 users are often found to vary in their accuracy or correctness in L2 production, depending on whether their attention is more focused on meaning or on form (e.g., Han, 2000; Salaberry & Lopez-Ortega, 1998). They have also been found to monitor their own L2 production and often correct their own errors covertly or overtly when they have the lexical

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knowledge and when attentional resources are available (e.g., Green & Hecht, 1993; Kormos, 2000). The inconsistency often reflects a lack of well-integrated competence. Self-correction at the lexical level can be viewed as a demonstration of the interplay of the lexical information represented both within and outside lexical entries. L1 lemma mediation may still be the normal state of affairs when lexical choice is often accompanied by self-correction. Thus, the key to the identification of genuine lexical development in L2 production is automaticity and consistency. Consistent, automatic, and error-free use of L2 words in natural, spontaneous communication may be an indication of the integration of new lemma information in L2 entries. Otherwise, it is what Krashen (1983) called "pseudo-acquisition," the transfer of L1 information that guides L2 use, or L1 lemma mediation in the present context.

CONCLUSION

L1 lemma mediation is intended to explain lexical processing and production in an L2. It may be considered the mechanism underlying lexical transfer, or what some researchers call semantic and conceptual transfer (e.g., Jarvis, 2000). It is highly probable, as rightly pointed out by Wode (1986), that different processes and mechanisms underlie crosslinguistic influence involving other aspects of language, such as pronunciation, grammar, and pragmatics. Furthermore, this hypothesis deals with the use of L2 words that are initially learned through association with L1 translations, particularly in adult L2 acquisition. Words that have no corresponding translations or concepts in the L1, or are not learned through lexical association for other reasons, may involve very different processes.

One major difference between learning words with and without L2 translations and existing concepts is the extent of semantic or conceptual development accompanying the acquisition of these words. In contrast to L2 words with L1 translations, which can benefit from lexical transfer, semantic development is obligatory for L2 words without L1 translations to become a part of a learner's productive vocabulary. Semantic development has been shown to be a long and slow process (e.g., Verhallen & Schoonen, 1993). One can speculate that these words may take a considerably longer time to understand and even longer to appear in L2 production. However, without the influence from L1, once these words are acquired, they may function more or less like the words of one's L1 in terms of idiomaticity and automaticity. It has been suggested and shown that words of different types—for example, cognates and noncognates, or concrete and abstract words—may be represented in different ways in the bilingual lexicon (de Groot, 1993). Similarly, different types of L2 words may involve different processes of acquisition as well. This is an issue yet to be explored by L2 researchers.

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NOTES

1. Whether a distinction is to be made between meaning and concept, or between semantic and conceptual representations, is a much-debated issue. See Pavlenko (1999) and related commentary in the same journal for discussion of this issue.

2. An anonymous *SSLA* reviewer has suggested that a review of research on the bilingual lexicon be included in the introduction and noted that word-association and concept-mediation hypotheses are related to the issue of form–meaning mapping. There are, however, two potential difficulties in relating the bilingual lexicon research to the form–meaning mapping issue addressed by the present study. First, most bilingual lexicon models adopt a model of lexical representation different from the one adopted here. They explicitly or implicitly adopt a hierarchical model with two levels of representation: lexical and conceptual. No semantic component is included at the lexical level. Jiang's (2000) model, on the other hand, is based on Levelt's (1989) model, which included a semantic component in lexical entries. It is this semantic component that is the focus of this study. Second, the present study addresses the issue of what semantic information is integrated in L2 lexical entries in L2 vocabulary acquisition. It makes no claim about the connections between L2 and L1 words. The study of the bilingual lexicon, on the other hand, has been primarily concerned with the issue of how the two lexical systems are interconnected. Both the word-association and concept-mediation hypotheses deal with such interconnections. They do not speak directly to the issue of whether L2 words are mapped to new or existing concepts. The concept-mediation hypothesis, now widely accepted in bilingual lexicon research, postulates that L2 words are linked to conceptual representations directly and share the same conceptual system with the L1. However, this hypothesis makes no claim regarding whether L2 words are linked to the existing concepts in the shared conceptual system or to new concepts in the system. This issue has rarely been addressed in the bilingual lexicon literature.

3. Although the sentence is grammatical, the speaker intended to say "I am sorry I interfered with you." See Olshtain and Cohen (1989) for details.

4. Some of the nonnative speakers may not be native speakers of Mandarin but of another dialect of Chinese, such as the Wu dialect, though all were educated in the same official Chinese language, *putonghua*, and the written language is the same for all dialects of Chinese.

5. The software is available for free download at the DMASTR website at: http://www.u.arizona.edu/~kforster/dmastr/dmastr.htm.

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APPENDIX

Table A1. Stimulus materials

Related pairs		Unrelated pairs	
Same translation	Different translation	Same translation	Different translation
ability–competence*	achievement–success	matter–value	positive–quiet
chance–opportunity*	advice–suggestion*	surface–history	gain–remove
day–date	apology–regret*	society–moment	frame–loan
danger–risk*	artist–painter*	delay–century	judge–device
force–power	advantage–benefit	union–space	mission–humor
goal–aim*	behavior–action*	science–range	murder–breath
home–family*	condition–situation	separate–thick	unusual–empty
hope–wish*	concept–thought*	shelter–technique	relief–motion
mistake–error*	crop–harvest*	solid–different	save–dry
practice–exercise*	creation–invention	favor–struggle	flow–catch
problem–question*	discussion–debate	substantial–sufficient	career–origin
response–reaction*	dialogue–talk*	task–text	ancient–narrow
trip–journey*	door–gate*	welcome–send	unique–dead
criteria–standard*	decision–conclusion	connection–thinking	useful–legal
believe–trust*	example–model*	little–far	tension–payment
compare–contrast*	expert–authority*	state–overcome	mental–flat
doubt–suspect*	element–component*	contemporary–cool	mobile–soft
draw–paint	future–tomorrow*	credit–version	pick–bear
decrease–lower*	game–sport*	vision–citizen	occasion–notion
enjoy–like	hospital–clinic*	welfare–development	inner–loose
laugh–smile*	knowledge–information	comfort–comment	fundamental–gradual
look–watch*	machine–equipment*	package–concrete	generation–sake
occur–appear*	purpose–intention*	confusion–concentration	estate–soul
persist–insist*	report–statement	classic–painful	expense–agency
refuse–reject*	regulation–policy	number–support	absence–self
relate–connect*	seat–chair*	clerk–case	apply–tend
study–learn*	story–novel*	pressure–pattern	trend–pride
speak–say	theory–hypothesis*	panic–facility	fun–grace
take–fetch	table–desk*	fill–spread	grand–instant
real–true	control–manipulate*	fund–gas	curious–isolated
dark–black	exist–live*	source–station	deny–hurry
glad–pleased*	estimate–evaluate	general–sharp	cry–revenue
clever–smart*	find–discover*	temperature–motivation	award–extend
possible–likely*	organize–arrange*	government–system	aspect–variable
tall–high*	plan–design*	lead–left	worship–quantity
good–nice	reality–truth*	night–contact	split–reserve
accurate–precise*	receive–accept*	nothing–term	survival–network
stupid–foolish*	tell–inform*	certain–early	mature–logical
lend–borrow	anxious–worried*	country–industry	cast–raise
safe–secure*	noisy–loud*	market–speed	core–branch

Note. Word pairs included in the reanalysis in experiment 2 are followed by an asterisk.

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