Language Dominance Modulates Cross-language Lexical Interaction in Late Immersed Bilinguals

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Abstract

Languages differ in the way they package elements of the world into words, which poses a challenge for bilinguals. We examined word use patterns for common household objects for late-immersed Chinese-English bilinguals to investigate how the bilingual lexical network develops when the first language is fully mature at the time of second-language immersion. We found changes to both first- and second-language word use with increased English dominance, indicating continued plasticity and mutual influence.

Keywords: bilingualism; word learning; word use; lexicon; categorization.

Introduction

Second-language learning research traditionally examined transfer from the first language (L1) to the second (L2) assuming a stable L1. Separately, language attrition research examined changes to L1 in the face of L2 dominance. Only recently has it been appreciated that L1 and L2 may exert mutual influences, and that performance in each may best be understood by studying their interplay across conditions of learning and use (Schmid & Köpke, 2007).

Most inquiry from this new perspective has focused on phonology and morpho-syntax. These domains are considered to engage procedural memory and potentially be affected by phenomena such as critical periods for learning. In contrast, the lexicon is considered to be stored in declarative memory, with performance subject to standard memory parameters such as frequency of retrieval (e.g., Ullman, 2004). But appropriate use of words depends on much more than retrieval of word forms. Languages differ in the way they package elements of the world into words. For instance, in English, upholstered seats for one person receive the same name as hard wooden seats for one person (*chair*), whereas in Mandarin they receive the same name as upholstered seats for several (*safa*). Even cognates show differing patterns. In Spanish, a Coke bottle is *botella* but a baby bottle is *mamadera*, and a tennis ball is not a *bola* but a *pelota*.

These subtle differences can be thought of in terms of a lexical network in which the conceptual level of representation includes features, instances, and associations rather than unitary concept nodes. Associated word forms of the two languages can have different patterns of connection to elements of the conceptual layer (Ameel, Storms, Malt, & Sloman, 2005; Pavlenko, 2009; Van Hell & de Groot, 1998). Given this model, influences of one language on the other can be conceived as changes to the weights on connections between word forms and elements of the conceptual layer. When a new L2 word form is taught as, or implicitly assumed to be, a translation equivalent of an L1 word, the network will set initial weights to match those of the L1 word. With experience, the connection weights might be adjusted to more closely match those of native L2 speakers. However, cross-connections between words might cause adjustments to the L1 connection weights as well, shifting them away from those of native L1 speakers.

The theoretical issues raised about bi-directional influence in phonology and morpho-syntax (e.g., Schmid, 2011; Köpke, Schmid, Keijzer, & Dostert, 2007) are closely echoed for lexical knowledge when framed in these terms. A potential key variable on the degree of mutual influence is age of acquisition. The network's weight configurations may stabilize after mastery of L1 and become resistant to change. If L2 is introduced after the network has stabilized, and if the L2 connection patterns initially reflect those of L1, two consequences may result. First is difficulty adjusting the L2 weights toward the L1 standard. Second is that the L1 will be protected from an influence of L2 -- because weights for the L1 words are resistant to change, and also because the L2 weights will diverge little from L1 weights and so have little potential to influence L1 weights. This situation resembles a critical period effect with regard

to acquisition of the L2. Because it also entails protection of the L1 from change, though, it may better be framed in terms of entrenchment of the network. The effects of L1 lexical entrenchment have begun to been tested in connectionist models. Zhao and Li (2010) simulated early versus late bilingual learners and found significant differences between them with regard to the organization of word classes.

A different possibility is that the network may not exhibit stabilization that is resistant to change after the initial L1 learning. In that case, with sufficient input at any time of exposure, the L2 connection weights may be gradually shaped to a close approximation of those of native speakers. This requires that the network be never fully committed to the weight configurations even later in learning. The degree to which a network should be flexible versus committed poses a classic 'stability-plasticity' dilemma in computational modeling (see Li, Farkas, & MacWhinney, 2004). Under this scenario, because of cross-connections between the L1 and L2 lexicons, the more the L2 weights diverge from initial L1 settings, the greater the impact on L1 usage may be. Conversely, predominant use of the L1 may leave L1 patterns largely intact. This possibility is compatible with suggestions that continued use of L1 protects it against attrition. However, because the more one language is used, the less the other must be, it also implies the trade-off that greater preservation of the L1 patterns will entail lesser progression in the L2.

Yet a third possibility is that if the acquired L1 pattern does not resist change, the network will, under the influence of L2 input, arrive at a configuration for both languages that is a compromise between L1 and L2 patterns. In this case, patterns of usage may not fully match those of monolingual speakers of either language. Ameel et al. (2005) found a convergence of this sort for Belgian early bilinguals who grew up with both French and Dutch. It may be less likely to be found for late bilinguals, having one well-established language before substantial exposure to the second. Conversely, the patterns of the two languages may be functionally separable for late bilinguals, allowing mastery of native -like patterns for both given sufficient exposure to each. This outcome may be most likely under conditions where the languages are dissimilar overall and/or in terms of naming patterns within a domain, yielding weaker cross-connections as L2 learning takes place.

We focus here on late L2 learners to examine plasticity of the network after L1 is well-established. In related work, Malt & Sloman (2003) found that, for immersed L2 users of English, elements of non-native usage patterns for concrete nouns in the L2 persisted for many years despite evolution toward more native-like usage. On the other hand, Pavlenko and Malt (2011) found evidence for some L2 impact on L1 word use in Russian immigrants to the U.S. who continued to speak Russian at home. These bilinguals treated several L1 Russian terms for drinking vessels as if they were more equivalent to English terms than did largely monolingual speakers in Russia. The L2 influence on L1 was greatest for those who came to the U.S. in early childhood, but some influence was seen even for those who arrived after age 18. These results point toward limited but continued plasticity of the network. Malt and Sloman's study did not isolate late learners, however, and neither study looked at performance in L1 and L2 in relation to each other, or at outcomes as a function of language dominance or attainment. Malt and Sloman's participants came from many L1 backgrounds, creating variable L1-L2 similarity, whereas Pavlenko and Malt's Russian-English language pairing can be considered to involve languages of intermediate similarity.

The current study investigated naming patterns for common household objects by native speakers of Chinese attending school in the U.S. They named the objects in both English and Chinese, in separate sessions. Participants had arrived no earlier than age 15, thus having a mature L1 at the time of immersion. They varied in the extent to which they had become more English-dominant. Their two languages are dissimilar on many dimensions from syntax to writing systems, and the naming patterns in this domain are dissimilar. We asked three questions that will shed light on fundamental aspects of how bilingual patterns of word use develop for dissimilar languages under conditions of late L2 immersion. These are:

(1) What constrains learning of subtle aspects of **L2** word use patterns given mature L1 knowledge at time of immersion? Can L2 usage evolve toward native-like patterns as a function of experience, even in light of a mature L1, or will entrenched L1 knowledge defeat re-shaping of L2 word usage patterns?

(2) How stable are **L1** usage patterns when L2 immersion occurs after L1 is mature? In particular, are highly entrenched L1 patterns immune to an L2 influence, or does the impact vary depending on L2 experience?

(3) If progress in L2 mastery is observed and linked to the extent of L2 dominance, does it have a negative relation to the preservation of the native L1 patterns, or do they vary independently?

Method

Sixty-two Lehigh University students, native speakers of Mandarin, participated. All used English on a daily basis. Average age of immersion in English was 21, with a minimum of 15. Mean self-rated proficiency for English was 4.94 on a 7-point scale; for Chinese, 6.92. Twenty-five largely monolingual speakers of Mandarin resident in China and 28 largely monolingual speakers of English resident in the U.S. served as comparison groups.

Stimuli for assessing naming patterns consisted of 67 pictures of objects for preparing and serving foods and 73 pictures of objects for holding and dispensing products such as health and beauty aids, cleaners, and foods (see Ameel et al., 2005). For brevity we call the first the *dishes* set and the second the *bottles* set, but each contained many objects with other names, as reported below.

Figure 1. Sample pictures from the dishes set.

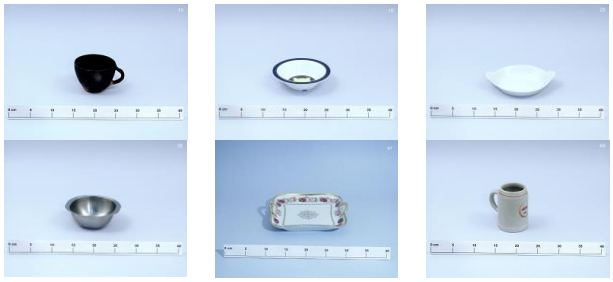
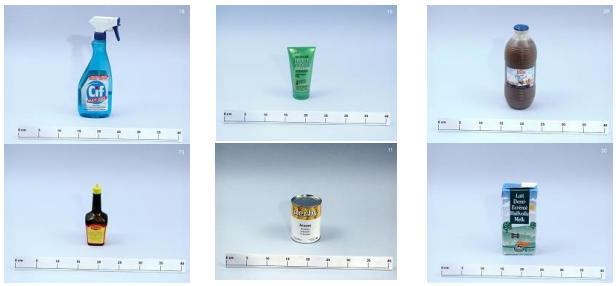


Figure 2. Sample pictures from the bottles set.



Each set of pictures was presented on a web page. Instructions indicated (in English or Mandarin, depending on test session) that for each picture, they should give whatever name seemed best or most natural, and that their response could be one word or more than one. The photos followed, with each accompanied by a response box into which participants typed their choice of name.

Monolingual speakers of English and of Mandarin each participated in only one experimental session in which they viewed the web pages (with order balanced across participants) and typed in their responses to the pictures.

Bilinguals participated in three sessions. In the first, conducted in English, they filled out an extensive language history questionnaire (in English) that asked for information such as age of exposure to English, years of formal instruction, age of immersion, years of immersion, and other aspects of language experience and usage. They then completed an English word/non-word discrimination task as one measure of English proficiency. The second session was also conducted in English, always by a native speaker, and participants' responses were in English. Participants first completed the naming task for the two stimulus sets (with order balanced across participants). Additional measures of proficiency and current language accessibility were then taken including a speeded picture-naming task and a verbal fluency task in which they were asked to list all the exemplars they could to each of three prompts (*Clothing*, *Transportation*, and *Food*) in 60 seconds each. Last, they told the story depicted in a wordless picture book to the experimenter. The final session was conducted in Mandarin by a native speaker of Mandarin and took place at least one week after the second. The same tasks were completed in the same order, with responses in Mandarin.

Results

Monolingual naming patterns. We first tabulated the names produced by monolingual speakers of each language to determine the most common ("dominant") name for each picture. Those names, along with how many objects of the set had each listed name as dominant, are presented in Tables 1 and 2. The tables show that the lexical categories of the two languages do not have a simple relation for either stimulus set. For both, each language has one broad term that covers 1/3 or more of the objects, but these terms do not correspond closely to one another: Objects labeled by a single term in one language are distributed across several in the other. This is also true for most of the other terms that cover multiple objects of the set. These complex relations pose a challenge for the L2 learner. The neatest mapping across languages is the close correspondence of Mandarin *bei* to the combined English *cup*, *mug*, and *glass*. However, in this case, an L1 speaker of Mandarin must still learn to segment a broader category into several narrower ones.

For the dishes stimulus set, the number of terms that are dominant for at least one object is similar between the two languages, with 9 for English and 8 for Mandarin. For the bottles set, however, English has 13 compared to Mandarin's 5. The greater number of discriminations, along with absence of a clean mapping between any major terms, may make acquiring English naming patterns for the bottles set more challenging for Mandarin-English bilinguals. At the same time, if dissimilarity decreases cross-connections to the L1, it may exert less influence on the L1.

Table 1a: Distribution of names across the 67 pictures of the dishes set, grouped by English.

English	Mandarin
27 bowl	19 wan, 3 pen, 1 pan, 1 die, 1 bei, 1 yao, 1 yan hui gang
12 mug	12 bei
9 cup	9 bei
8 dish	3 pan, 3 yan hui gang, 2 pen
6 plate	4 pan, 2 die
2 glass	2 bei
1 pot	1 guo
1 jar	1 wan
1 tray	1 pan

Table 1b: Distribution of names across the 67 pictures of the dishes set, grouped by Mandarin

Mandarin	English
24 bei	12 mug, 9 cup, 2 glass, 1 bowl
20 wan	19 bowl, 1 jar
9 pan	4 plate, 3 dish, 1 tray, 1 bowl
5 pen	3 bowl, 2 dish
4 yan hui gang	3 dish, 1 bowl
3 die	2 plate, 1 bowl
1 guo	1 pot
1 yao	1 bowl

Table 2a: Distribution of names across the 73 pictures of the bottles set, grouped by English.

English	Mandarin
37 bottle	33 ping, 3 tong, 1 he
7 can	3 ping, 2 tong, 1 guan, 1 he
6 container	3 he, 2 ping, 1 tong
5 box	5 he
4 jar	2 ping, 1 guan, 1 he
4 tube	4 guan
3 stick	2 ping, 1 guan
2 case	2 he
1 basket	1 he
1 canister	1 he
1 carton	1 he
1 grinder	1 ping
1 shaker	1 ping

Table 2b: Distribution of names across the 73 pictures of the bottles set, grouped by Mandarin.

Mandarin	English
44 ping	33 bottle, 3 can, 2 stick, 2 jar, 2 container, 1 grinder, 1 shaker
16 he	5 box, 3 container, 2 case, 1 bottle, 1 carton, 1 jar, 1 basket, 1 can, 1 canister
7 guan[1]	4 tube, 1 jar, 1 stick
6 tong	3 bottle, 2 can, 1 container

What constrains L2 learning given mature L1 knowledge at time of immersion? Can L2 usage evolve toward native-like patterns as a function of L2 language experience, or will entrenched L1 knowledge defeat re-shaping of word usage patterns? Naming performance of each participant for each stimulus set was assessed using a measure of individual agreement with monolingual name choice across all pictures of the set. For each object, the bilingual was credited for the name produced for it proportional to the number of monolingual English speakers who produced that name. For instance, if a given object was called *bottle* by 80% of monolingual speakers, *jar* by 10%, *container* by 5%, and *jug* by 5%, then a bilingual who called it *bottle* received a score of .8, one who called it *jar* received a score of .1 and so on. A 0 was assigned for responses not produced by any monolingual speaker. An individual's scores for the 67 dish pictures and 73 bottles pictures were each averaged to produce a summary value for each person for each set. As a baseline for comparison, we also calculated the mean level of agreement for individual monolingual speakers of English with their own monolingual group for each stimulus set.

[1] Because responses were typed in pinyin, we cannot distinguish *guan* with tone 3 from *guan* with tone 4, but for our stimuli, most or all are likely to be *guan4*.

To evaluate whether language experience – in particular, the dominance of one language over the other in current usage – influences match to the monolingual pattern, bilinguals were divided into two groups according to the extent to which English had become dominant for them. To do so, all the individual language performance measures other than naming responses were correlated with one another and with responses to the various language history questions. The relative number of items produced to the category prompt *Clothing* in English vs. Mandarin correlated significantly with more other measures (20 out of 36) than any other performance measure and was selected as the basis for grouping. To the extent that the bilinguals can retrieve more English than Mandarin words for items of clothing in 60 seconds, their English can be assumed to be more highly activated than their Mandarin.

The distribution of number of English minus Mandarin clothing items produced by each participant was examined for a break point. Participants assigned to the Higher English Dominance group (n = 27) had a mean value of 0.15 (s.d. 3.22), indicating that on average they produced about equal numbers in Chinese and English. Those assigned to the Lower English Dominance group (n = 35) had a mean value of -9.0 (s.d. 3.26), indicating that on average they produced 9 more in Chinese than English. Correspondingly, mean self-rated English proficiency for the Higher English Dominance group was 5.14 and for the Lower, 4.76. For Chinese self-ratings, it was 6.87 and 6.95 respectively. Table 3 presents the mean individual agreement scores of each speaker group to the monolingual English group for each stimulus set.

Table 3: Mean agreement scores of monolinguals and bilinguals to the monolingual English group.

	Monolingual English	Higher English Dom. Bilinguals	Lower English Dom. Bilinguals
Dishes	.58 (.04)	.50 (.04)	.44 (.07)
Bottles	.45 (.09)	.37 (.06)	.38 (.08)

An ANOVA with speaker group as a between-subjects factor showed a significant main effect of speaker group for both stimulus sets: $F(2,87) = 46.16$, $p < .0001$ for dishes; $F(2, 86) = 8.14$, $p < .001$ for bottles. Post hoc comparisons (LSD) showed that bilinguals differed significantly from monolinguals for both stimulus sets ($p < .001$). The effect of extent of English dominance differed by stimulus set, though. For dishes, the bilingual groups differed from each other ($p < .001$), but for bottles, they did not. Thus, the ability to progress toward an L2 native-like naming pattern differs by semantic domain.

For dishes, both bilingual groups differed from the monolinguals by greatly over-using *cup* and *plate* and under-using *mug* and *dish.* Higher English dominance bilinguals added to the dominant term list one word

dominant in monolingual usage for only one object (*pot*) and one dominant for two (*glass*), as well as a more important term, *mug*, dominant for 12 objects for the monolinguals. However, the bulk of their progress does not appear to be due to addition of these vocabulary words. Removing from the data the three stimuli that had monolingual dominant names of *pot* or *glass* leaves the scores virtually unchanged (.50 vs. .45). Furthermore, about 40% of lower English dominant bilinguals did produce *mug*, even though it was not dominant for any object for them. Looking only at the scores of those who did produce *mug* in each group, the mean score for lower English dominance was .47 and for higher English dominance was .52, maintaining the difference between groups. It appears that progress in matching monolingual patterns is largely due to more appropriate use of terms known to both groups.

For bottles, both bilingual groups differed from the monolinguals by greatly over-using *bottle* and, to a lesser extent, *box*, and by under-using *container*, *jar*, and several minor terms (dominant for monolinguals for only one to three objects of the set). As already noted, though, there was no sign of greater shaping of the word-object connections toward native-like with higher English dominance.

In short, these late bilinguals speaking two dissimilar languages do show movement toward overcoming entrenched L1 patterns as a function of language experience. However, they do so only for one of the domains, a point to which we will return.

How stable are L1 usage patterns when L2 immersion occurs after L1 is mature? In particular, are highly entrenched L1 patterns immune to an L2 influence, or does the impact vary depending on L2 experience? Performance on Mandarin naming was scored in the same way as for English naming. Table 4 presents the mean individual agreement scores of each speaker group to the monolingual Mandarin group for each stimulus set.

Table 4. Mean agreement scores of monolinguals and bilinguals to the monolingual Mandarin group.

	Monolingual Mandarin	Higher English Dom. Bilinguals	Lower English Dom. Bilinguals
Dishes	.85 (.07)	.69 (.03)	.68 (.04)
Bottles	.86 (.06)	.63 (.09)	.68 (.06)

An ANOVA with speaker group as a between-subjects factor showed a significant main effect of speaker group for both stimulus sets: $F(2,84) = 100.94$, $p < .0001$ for dishes; $F(2, 82) = 73.44$, $p < .001$ for bottles. Post hoc comparisons (LSD) showed that bilinguals differed significantly from monolinguals for both stimulus sets (ps $< .0001$). This indicates that entrenched L1 patterns are not immune from an L2 influence, even under late immersion for bilinguals speaking dissimilar languages. Changes appear to be largely due to over-extension of *ping* and *guan* and under-extension of *he* and *tong*. The latter two may have particularly unclear relations to any English words (see Tables 2a and b).The effect of extent of English dominance again differed by stimulus set, though. For bottles, the bilingual groups differed from each other ($p < .01$); those with higher English dominance were further from the monolingual standard. For dishes, the groups did not differ. Whereas progression toward the **L2** standard with greater English dominance was shown for dishes, greater loss of agreement with the **L1** standard appears here for bottles.

If progress in L2 mastery is observed and linked to the extent of L2 dominance, does it have a negative relation to the preservation of the native L1 patterns, or do they vary independently? The data already presented suggest that they must vary independently, since bilinguals showed differential progress toward the L2 standard only for dishes and differential movement away from the L1 standard only for bottles. To further address this question, we correlated individual bilinguals' mean scores for English and Mandarin performance. For dishes, there was no relation between the two ($r = .10$, n.s.). For bottles, there was a small and marginally significant positive relation rather than a negative one ($r = .21$, $p = .06$). Overall, then, it appears that progress in one language does not mandate a declining performance in the other across the board with respect to naming patterns.

Discussion

We initially outlined several possibilities for how the bilingual lexical network might develop under conditions of late L2 learning. The data argue against the idea that the network stabilizes at an L1 configuration that both protects it against L1 change and prevents progress in L2 acquisition. The data also argue against a reciprocal relation where shifts toward the naming pattern of one language inevitably result in shifts away from the other. At the same time, there was no evidence for the full separation of the two language learning experiences (whereby there could be preservation of the L1 while also progressing toward L2). The current data are most compatible with the situation found in Ameel et al. (2005)'s data for simultaneous French-Dutch bilinguals in Belgium: The network adjusts weights for both languages such that convergence results, and the word usage patterns for each language are more similar for bilinguals than they are for two monolinguals of the corresponding languages.

This outcome is more surprising in the current context, given that the two languages were acquired asynchronously and are dissimilar on many dimensions, as well as having divergent naming patterns with no cognates that might promote incorrect assumptions of word-to-word equivalences. In light of the naming strategies adopted by the bilinguals in each language, though, it may be less surprising. For both L1 and L2, the trend was to over-extend the words that are prominent in the domain (covering a large

numbers of objects for monolinguals) and under-extend words used for smaller subsets of objects. We cannot ensure that our stimulus sets exactly match the distribution of objects in the real world, but we sampled widely and it is likely that, if anything, we somewhat over-represented less common object types. It is probably inevitable that bilinguals receive less of the input needed to maintain (for L1) or establish (for L2) appropriate connection weights to object types for the infrequent words, and will use these less. Some mutual influence may then be exerted across the word-object inputs more commonly encountered, such that the major categories come to resemble each other more.

The remaining critical question is why the two domains showed different outcomes for the effect of increased English dominance. The observed outcomes most likely do derive from the different L1-L2 relations in the two domains, as alluded to earlier. The agreement scores of the monolinguals show that Mandarin speakers use their dominant terms for both domains with a high degree of consistency. English speakers used theirs with much lower consistency, and the full sets of response shows many more uncommon terms (e.g., *cylinder*, *dispenser*, *vial*, *tub*, *tin*; *platter*, *saucer*, *trough*, *Tupperware*) used sporadically. The lower English consistency is especially pronounced for the bottles set. In addition, as noted earlier, this set lacks any terms having a neat mapping to the Chinese terms, whereas the dishes set at least has a fairly clean correspondence of *cup*, *mug*, and *glass* jointly to Chinese *bei*. For dishes, bilinguals may be able to make progress in the distinctions among *cup*, *mug*, and *glass* without reshaping their use of *bei*. For bottles, bilinguals are more likely to struggle to acquire the native-like distinctions without success because the input is so highly variable. Nevertheless, the more they tilt toward becoming English dominant, the less they are reinforcing their Chinese usage patterns, and those weaker word-object connection weights may further diminish.

The current discussion has been framed in terms compatible with connectionist modeling. The network perspective provides a framing that links theoretical issues for the lexicon with those for phonology and morpho-syntax and highlights questions about bi-directional influence on patterns of word usage. Implementation is an important next step toward understanding the dynamics of lexical cross-language influence. Modeling stands to yield significant insights into the competition and representation of multiple languages in the bilingual mind (see Li, 2013 for a recent discussion). In naturalistic or experimental settings it is often difficult to bring learning variables under tight control, but these variables can be parametrically manipulated in a computational model. For instance, characteristics of the naming patterns, amounts of input in each language, proficiency or dominance in L1 or L2, and temporal characteristics of the input (blocked by language, as in a complete switch to L2, or intermixed as for immersed bilinguals who maintain contact with an L1 community) can be manipulated to make further predictions about what effects might emerge under what circumstances. Conversely, the behavioral data as reported here help inform the nature of the models to be developed.

Acknowledgments

This work was supported by a grant from the National Science Foundation (#BCS-1057855) to Barbara Malt and Ping Li. Eef Ameel is supported on a postdoctoral fellowship from the Fund for Scientific Research-Flanders. We thank Shijing Jiang, Zinan Jiang, Rachel Jobe, Gwendolyn Johnson, Lauren O'Brien, Nikolas Rivera, Aislinn Rowan, Shenchi Tian, and Rachel Williams for assistance with data collection and analysis, and Ben Zinszer for helpful discussion.

References

Ameel, E., Storms, G., Malt, B.C., and Sloman, S. A. (2005). How bilinguals solve the naming problem. *Journal of Memory and Language, 53*, 60-80.

Schmid, M. S. & Köpke, B. (2007). Bilingualism and attrition. In B. Köpke, M. S. Schmid, M. Keijzer, & S. Dostert (Eds.). *Language attrition: Theoretical perspectives. Amsterdam: John Benjamins.*

Köpke, B., Schmid, M.S., Keijzer, M., & Dostert, S. (Eds.). *Language attrition: Theoretical perspectives. Amsterdam: John Benjamins.*

Li, P. (2013). Computational modeling of bilingualism: How can models tell us more about the bilingual mind? *Bilingualism: Language and Cognition, 16,* 1-6.

Li, P., Farkas, I., & MacWhinney (2004). Early lexical acquisition in a self-organizing neural network. *Neural Networks, 17*, 1345-1362.

Malt, B. C. and Sloman, S. A. (2003). Linguistic diversity and object naming by non-native speakers of English. *Bilingualism: Language and Cognition, 6*, 47-67.

Pavlenko, A. (2009) Conceptual representation in the bilingual lexicon and second language vocabulary learning. In Pavlenko, A. (Ed.) *The bilingual mental lexicon: Interdisciplinary approaches*. Clevedon, UK: Multilingual Matters.

Pavlenko, A. & Malt, B.C. (2011). Kitchen Russian: Cross-linguistic differences and first-language object naming by Russian-English bilinguals**.** *Bilingualism: Language and Cognition, 14*, 19-45.

Schmid, M. (2011). *Language attrition*. Cambridge: Cambridge University Press.

Ullman, M. T. (2004). Contributions of neural memory circuits to language: The declarative/procedural model. *Cognition, 92*, 231-270.

Van Hell, J. G., & De Groot, A. M. B. (1998). Conceptual representation in bilingual memory: Effects of concreteness and cognate status in word association. *Bilingualism: Language and Cognition, 1*, 193–211.

Zhao, X., & Li, P. (2010). Bilingual lexical interactions in an unsupervised neural network model. *International Journal of Bilingual Education and Bilingualism, 13*, 505–524.