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What can errors tell us about differences between monolingual and bilingual vocabulary learning?

Margarita Kaushanskaya

University of Wisconsin-Madison

Abstract

Error patterns in vocabulary learning data were used as a window into the mechanisms that underlie vocabulary learning performance in bilinguals vs. monolinguals. English-Spanish bilinguals ($n = 18$) and English-speaking monolinguals ($n = 18$) were taught novel vocabulary items in association with English translations. At testing, participants produced English translations for the newly-learned words. Findings revealed broad learning advantages in the bilingual data. Moreover, bilinguals made proportionately more deep (within-category) semantic errors than monolinguals when tested immediately after learning. We interpret these data to suggest that bilingual learners may encode the information associated with the novel words to a deeper semantic level than monolinguals.

Keywords

vocabulary learning; error analysis; semantics; translation; bilingualism

A number of studies have suggested that experience with learning a second language may facilitate the ability to acquire new linguistic information (e.g., Bartolotti, Marian, Schroeder, & Shook, 2011; Kaushanskaya, 2012; Kaushanskaya & Marian, 2009a) and as a result, bilingual individuals tend to outperform monolingual individuals on vocabulary learning tasks (e.g., Kaushanskaya, 2012; _Kaushanskaya & Marian, 2009a; Papagno & Vallar, 1995; Van Hell & Mahn, 1997).). However, although the bilingual advantages on vocabulary learning tasks have been found, the mechanisms that underlie these advantages remain elusive.

In previous work, two possibilities for the mechanisms that may underlie the bilingual advantages for vocabulary learning have been considered – phonological memory capacity and inhibitory control. While phonological memory capacity does not appear to be at the root of the bilingual advantages for novel vocabulary learning (Kaushanskaya, 2012; but see Papagno & Vallar, 1995), enhanced inhibitory control may contribute to the advantages observed for bilinguals on vocabulary learning tasks (Kaushanskaya & Marian, 2009b; Bartolotti & Marian, 2012). However, because bilinguals outperform monolinguals not only on the vocabulary learning tasks that entail control of interference (Bartolotti & Marian,

2012; Kaushanskaya & Marian, 2009b), but also on vocabulary learning tasks that do not involve processing of competing sources of information (Kaushanskaya, 2012), it is likely that mechanisms other than (or in addition to) inhibition play a role in bilingual word-learning performance. Here, we used error analyses of translation data (where learners translated newly-learned vocabulary items into English) to examine the mechanisms that may underlie the effects of bilingualism on vocabulary learning. Translation-like tasks have been frequently used in previous research to delineate the structure of the bilingual lexical system (e.g., Hatzidaki & Pothos, 2008; Kroll & Stewart, 1994, Sunderman & Kroll, 2006) and production error data have been widely utilized to pinpoint the stages in the lexical retrieval process (e.g., Caramazza, 1997; Goldrick, Folk, & Rapp, 2010; Rapp & Goldrick, 2000; Roelofs, 2007). In the present study, we used a translation task where participants translated the newly-learned words into their native language in order to examine the error patterns in bilinguals' vs. monolinguals' retrieval data. We used error type as a window into the levels of the lexical-semantic system at which the translation process was derailed in bilingual vs. monolingual learners. Different patterns of errors in bilingual vs. monolingual data would indicate differences in the mechanisms that underlie the encoding and retrieval process of the novel words in bilingual vs. monolingual learners.

Translation data have been used extensively in prior literature to explore the structure of lexical representations in bilingual speakers. For example, different patterns of translation vs. picture-naming performance in bilinguals have been used as evidence for the involvement of the semantic system in second-language (L2) processing (e.g., Kroll & Stewart, 1994). Within this line of research, Hatzidaki and Pothos (2008) have demonstrated that bilinguals tended to make semantic (i.e., meaning-related) errors when translating text from the native language (L1) into the L2 and lexical (i.e., form-related) errors when translating text from the L2 into the L1. These findings were interpreted to suggest that the semantic system is more activated by the native language than by the second language during translation tasks. Similarly, Sunderman and Kroll (2006) found that less proficient L2 speakers, but not more proficient L2 speakers, experienced interference from the L1 at the level of wordform during a translation-recognition task. They interpreted these findings to suggest that a less stable lexical-semantic network (as in the case of low-proficiency L2 learners) is especially vulnerable to interference at the level of lexical wordform knowledge. The findings from translation-type tasks in the bilingual lexical processing literature are complemented by the findings from the analyses of error data in naming.

A number of studies have used error data to cement theories of lexical access (Caramazza, 1997; Goldrick, Folk, & Rapp, 2010; Rapp & Goldrick, 2000; Roelofs, 2007) and of the working memory system (Acheson & MacDonald, 2009; Freedman, Martin, & Biegler, 2004; Page, Madge, Cumming, & Norris, 2007). Errors are known to be a rich source of information regarding where in the lexical retrieval process a break-down occurs in populations with naming deficits, including aphasia (e.g., Caramazza, Papagno, & Rumel, 2000; Cuetos, Aguado, & Caramazza, 2000; Howard & Gatehouse, 2006), Alzheimer's Disease (e.g., Balthazar, Cender, & Pereira Damasceno, 2008; Moreaud, David, Charnallet, & Pellat, 2001), and dyslexia (e.g., Colangelo, Buchanan, & Westbury, 2004). Typically, naming errors are classified in terms of the relationship between the produced response and the target response. Formal (or lexical) errors are thought to occur at the level of the word-

form, and reflect confusion between words that are similar at the surface (phonological) level (e.g., Balthazar, Cendes, & Damasceno, 2008; Caramazza, Papagno, & Rumel, 2000). Thus, if a participant produces the word “cable” instead of “table”, the response would be coded as a phonological error. Conversely, semantic errors are thought to occur at the conceptual level, and reflect confusion between words that are similar in meaning (e.g., Cuetos, Aguado, & Caramazza, 2000; Harley & MacAndrew, 2001; Howard & Gatehouse, 2006; McGregor, Friedman, Reilly, & Newman, 2002). Thus, if a participant produces the word “chair” instead of “table”, the response would be coded as a semantic error. Although production errors have been frequently used as evidence for the structure of the lexical system, there are only a handful of studies that have examined whether differences in the cognitive and/or linguistic profiles of the participants would influence the patterns of errors observed during lexical retrieval.

In one such study (e.g., Gershkoff-Stowe, 2002), older and more experienced children were compared with younger and less experienced children on the extent to which known words interfered with the children’s ability to retrieve the newly learned words. The findings were that older children showed less interference when retrieving new words than younger children. That is, increased experience with word-learning made children less vulnerable to the effects of lexical interference. Moreover, older children showed an increase in producing semantically related words as errors, perhaps because with experience, children develop wider semantic networks that are more robustly activated whenever a word must be retrieved. Similarly, Tokowicz, Michael, and Kroll (2004) showed that more experienced L2 speakers who had undergone a study-abroad experience made a larger number of meaning-based errors on a translation task where L1 words were translated into the L2 than less experienced L2 speakers. Crucially, this was only the case when the more experienced L2 speakers also had a larger working memory capacity. These findings indicate that higher expertise in a language coupled to a more robust cognitive system is conducive to using a word retrieval strategy where semantically related words are maintained in memory during L2 lexical processing. Together, these studies point to a possibility that increased learning experience (as in the case of bilingualism) may cause learners to encode novel words to a deeper semantic level. This was precisely the question examined in the present study.

In the present work, we tested whether during novel vocabulary learning bilingual learners (a) would demonstrate higher learning rates than monolingual learners and (b) would demonstrate an error pattern distinct from one observed for monolingual learners. The bilingual individuals in this study were all native speakers of English who acquired Spanish as their second language. Word-learning advantages have been observed in classroom learners of a second language (Kaushanskaya & Rechtzigel, 2012) as well as in simultaneous bilinguals (Kaushanskaya & Marian, 2009), and therefore it was expected that bilinguals would demonstrate better word-learning performance than monolinguals in the present study.

The vocabulary learning task implemented in our study entailed learning new vocabulary items in association with their English translations. Thus, testing bilinguals who were native speakers of English allowed for a meaningful comparison with monolingual speakers of English, since both groups engaged in a word-learning task where they mapped novel words

onto their *native-language* translation equivalents. At testing, participants were required to produce English translations for the newly-learned vocabulary items. Thus, our testing measure required that participants retrieved semantic information associated with the new vocabulary. Two types of errors were therefore of interest. The first error type involved confusion between two similarly-sounding new vocabulary items, where a participant produced an English translation for a novel word that was phonologically similar to the target vocabulary item. We termed these types of errors *surface* errors. For example, if the participants translated the novel word “tafun” (meaning *morning*) as *sign*, it was coded as a surface error because the novel word for *sign* was “gafun.” The second error type involved production of an English word that was semantically related to the target translation, and was not conditioned by superficial similarity between phonologically-similar novel words. We termed these types of errors *deep semantic* errors. For example, if the participant translated the novel word “unef” (meaning *leg*) as *arm*, it was coded as a deep semantic error.

In line with prior work (e.g., Balthazar, Cendes, & Damasceno, 2008; Caramazza, Papagno, & Rumel, 2000), we viewed surface errors as arising from the breakdown at the level of the phonological forms of the novel words. That is, in order to make a surface error, a participant would have to mis-map the novel word onto a phonologically-similar novel word, and the translation of the non-target, phonologically-similar novel word would then interfere with the ability to retrieve the target translation. Conversely, consistent with previous studies (e.g., Cuertos, Aguado, & Caramazza, 2000; Harley & MacAndrew, 2001; Howard & Gatehouse, 2006; McGregor, Friedman, Reilly, & Newman, 2002), we viewed deep semantic errors as arising from the breakdown at the level of the semantic network associated with the novel words. That is, in order to make a deep semantic error, a participant would have to activate the correct mapping between the novel word and its English translation, although the retrieval of the exact translation would be derailed. For instance, one possibility is that while the activation of the correct English translation had taken place, other English words that were part of the same semantic network interfered with the selection of the target word. Another possibility is that the novel word activated the broad semantic network associated with the novel word *before* activating the precise link between the novel word and its translation equivalent, and a semantic neighbor rather than the correct translation won out the selection race during production (because of some psycholinguistic characteristic, such as frequency or recency of use). If increased learning experience (i.e., bilingualism) yields a heightened awareness of semantic information associated with the novel words, bilingual learners would be more likely to make *deep* semantic errors during the translation task than monolingual learners.

Method

Participants

Eighteen bilingual speakers of English and Spanish, and 18 monolingual speakers of English participated in the study. All participants were residents of the United States, attending the University of Wisconsin-Madison at the time of the study. Because most individuals are exposed to at least some foreign language instruction in school, the demarcation between

monolingual and bilingual participants was based on degree of second language experience. For the purposes of the present study, monolingual participants were defined as those individuals who were either never exposed to a foreign language, or were only exposed to the foreign language in school; who self-rated their understanding ability in a foreign language as no higher than 2 “low” on the scale from zero “none” to 10 “perfect”; who never spent time in a foreign-speaking country; and who were not exposed to a foreign language at all on the daily basis at the time of the study. The resulting group of monolingual participants recruited for the present study was therefore quite homogeneous with regard to foreign language experience. Of the 18 participants, 6 reported absolutely no exposure to a language other than English, and the remaining 12 participants reported classroom exposure to a foreign language in high school (11 Spanish, and 1 French). These 12 participants reported that their average level of understanding their second language was 1.38 ($SD = .12$) on the scale from zero to 10.

Bilingual participants were native speakers of English who acquired Spanish, their second language, on average at 8.21 years of age ($SD = 4.87$). The age of Spanish acquisition varied widely within this group of bilingual participants, with some participants acquiring Spanish rather early in life (before 3 years of age) in home contexts, and some acquiring Spanish later in life, in school contexts. Age and context of Spanish language acquisition were not used as inclusionary criteria when selecting bilingual participants for this study because word-learning advantages have been observed for both simultaneous bilinguals who acquired their two languages in the home (Kaushanskaya & Marian, 2009), and for sequential bilinguals who acquired their second language through classroom instruction (Kaushanskaya & Rehtzigel, 2012; Kaushanskaya, Yoo, & Van Hecke, 2013). Instead, bilingual participants were selected on the basis of current language proficiency, consistent current daily use of Spanish, and a history of immersion in a Spanish-speaking country. Only individuals who self-reported Spanish speaking proficiency levels of at least 6 (“more than adequate” on the scale from zero-“none” to 10-“perfect”) were included in the study. Furthermore, only individuals who reported being exposed to Spanish at least 5% of the time on the daily basis, and who reported having been immersed in a Spanish-speaking country for at least 3 months were included in the study. Thus, at the time of the study, bilinguals reported their proficiency in Spanish to be on average, 6.86 ($SD = 1.41$) for speaking, 7.36 ($SD = 1.55$) for understanding, and 6.14 ($SD = 2.48$) for reading. They were on average exposed to their L2 Spanish 6.25% of time on a daily basis ($SD = 4.54$), and preferred to speak it on a daily basis 19.44% of the time ($SD = 20.11$). When asked to rate various contributors to their acquisition of Spanish on the scale from zero “not a contributor” to 10 “most important contributor”, the participants in the present study rated interactions with friends as the most significant contributor ($M = 6.50$, $SD = 3.85$), and reading as the second most significant contributor ($M = 4.75$, $SD = 3.33$). The Language Experience and Proficiency Questionnaire (Marian, Blumenfeld, & Kaushanskaya, 2007) was used to collect these self-reported data.

Bilingual and monolingual participants did not differ in age, years of education, performance on an English receptive vocabulary measure (PPVT-III), a measure of English reading fluency (Reading Fluency sub-test of the Woodcock Johnson Tests of Achievement-II), measures of phonological short-term memory (Digit Span and Nonword Repetition subtests

of the Comprehensive Test of Phonological Processing) and measures of nonverbal IQ (Spatial Relations and Visual Matching subtests of the Woodcock Johnson Tests of Cognitive Abilities-II). See Table 1 for the demographic characteristic of the two groups.

Materials

The phonological inventory used in the present study was developed by Kaushanskaya and Marian (2008) to examine the effects of phonological familiarity on word learning, and was also used extensively in subsequent studies of monolingual and bilingual word learning (Kaushanskaya, 2012; Kaushanskaya & Marian, 2009a; 2009b). This inventory includes 8 sounds (4 vowels and 4 consonants) that are part of the English phonological inventory. It includes vowels /ɑ/, /e/, /i/, and /u/, and consonants /f/, /n/, /t/, and /g/. These eight phonemes were used to construct 48 monosyllabic and disyllabic novel words. Novel words were recorded by a male native English speaker and paired with their English “translations”. The novel words followed English syllabic structure (CVC, CVCV, and CVCVC) and were phonotactically-probable in English (sum of phoneme frequencies = 1.14, $SE = .06$; sum of biphone frequencies = 1.00, $SE = .003$, according to Vitevitch & Luce, 2004). The English words that served as translation equivalents were selected based on the frequency of use (calculated using Frances & Kucera, 1982), with the majority of translations falling within high frequency ranges. All 48 English translations referred to concrete, imageable objects with frequent English names. This stimulus set is ideally suited to examine error patterns in word-learning performance because the phonological inventory is limited to only 8 sounds, and therefore, the novel words are highly phonologically-confusable. Furthermore, the English translations, by virtue of referring to concrete objects, are likely to activate a wide semantic network that would engender semantic errors. Therefore, the likelihood of occurrence of surface errors and deep semantic errors would be high enough to enable the analyses of error patterns in the learning data.

None of the novel words were phonologically similar to their English translations. However, 9 out of 48 items (19%) were cognates with Spanish (See Appendix A for the full stimulus list). Cognate status was not an initial consideration when designing the stimuli; however, because cognates enjoy privileged status in bilingual language processing (Costa, Caramazza, & Sebastian-Galles, 2000), it was important to examine whether elimination of these items from the analyses would change the results. All the statistical analyses were therefore conducted on a reduced set of items that did not include cognates. The results stayed exactly the same, and therefore, the analyses reported below contain all 48 items.

Procedure

Word learning.—Participants heard the novel word pronounced twice over headphones, and saw its written English translation on the computer screen. Each pair was presented twice during each learning phase in a random order. Participants were instructed to repeat the novel word and its English translation out loud three times.

Translation testing.—Participants’ memory was tested using a translation task immediately after learning and after a 1-week delay. Participants heard the novel word and were instructed to produce its English translation into a microphone. Participants were

specifically instructed to guess the English translation even if they could not remember it, and were explicitly discouraged from making an “I don’t know” response, or from skipping an item. This procedure was instituted to maximize the number of analyzable errors in the translation data. The order of items on the translation task was randomized for each participant.

Standardized testing.—Each participants was administered an array of standardized language and memory measures in a randomized order. The following measures were administered: (1) The Peabody Picture Vocabulary Test III (PPVT-III), a standardized test measuring receptive word knowledge in English (Dunn & Dunn, 1997) indexing a participant’s ability to map an auditory target word to one of four pictures. (2) The Digit Span and the Nonword Repetition subtests of the Comprehensive Test of Phonological Processing (CTOPP, Wagner, Torgesen, & Rashotte, 1999), indexing participants’ phonological short-term memory. On the Nonword Repetition subtest of the CTOPP, the stimuli consist of pseudowords that follow English phonological and phonotactic patterns, increasing in length from 1 to 9 syllables. (3) The Reading Fluency sub-test of the Woodcock-Johnson Tests of Achievement-II, measuring the speed and accuracy of reading in English. (4) The Spatial Relations and the Visual Matching subtests of the Woodcock-Johnson Tests of Cognitive Abilities-II, measuring the efficiency of nonlinguistic processing and indexing nonverbal IQ.

Coding of Error Data

Translation data were first coded for accuracy, and proportion correct scores were obtained. All incorrect translations were further coded for two types of errors – *surface* errors and *deep semantic* errors. Surface errors were defined as errors where the produced English translation was associated with a novel word that was phonologically-similar to the target. Two novel words were considered to be phonologically similar when they shared at least 60% of their phonemes (2 out of 3 phonemes for monosyllabic novel words or 3 out of 5 phonemes for bi-syllabic novel words), three consecutive phonemes, or two initial phonemes in the first syllable for the two-syllable words. These criteria were developed by Dell et al. (1997) and used successfully to code surface errors in production data by Caramazza, Papagno, and Rumel (2000). For example, the word “tafun” was considered to be phonologically-similar to the word “gafun”, but not to the word “gena.” Therefore, if a learner translated “tafun” as “sign” rather than “morning”, it was coded as a surface error. Deep semantic errors were defined as errors where the produced English translation was a category superordinate, coordinate, subordinate, or associate to the target English translation (per Caramazza, Papagno, and Rumel, 2000). For example, when a learner produced the English word “arm” in response to the cue “unef”-leg, it was coded as a deep semantic error. Approximately 10% of the translation data (from 2 randomly-selected monolinguals and 2 randomly-selected bilinguals) were blind-coded by a second independent coder. Reliability of coding data was 100% for both surface errors and for deep semantic errors.

Analyses

The data were first screened for normality using the Shapiro-Wilk test. All dependent variables, including accuracy data and error data, were normally distributed based on the

Shapiro-Wilk test (p values $> .3$). In order to examine whether a bilingual advantage for novel word learning would be demonstrated in the current sample of participants, translation accuracy data were analyzed via a 2×2 Anova with group (bilingual, monolingual) as the between-subjects variable, and session (immediate vs. delayed) as a within-subjects independent variable. Follow-up post-hoc comparisons examined whether bilinguals and monolinguals differed with respect to translation accuracy both at immediate and at delayed testing.

In order to examine whether bilinguals and monolinguals would demonstrate different patterns of errors during translation performance, error data were analyzed via a $2 \times 2 \times 2$ Anova with group (bilingual, monolingual) as a between-subjects variable, and session (immediate vs. delayed) and error type (surface vs. deep) as within-subjects independent variables. For these analyses, proportion of errors (number of surface errors divided by the total number of errors and number of deep semantic errors divided by the total number of errors) served as the dependent variable. Proportions rather than raw numbers were analyzed because we expected bilinguals to make fewer errors than monolinguals, and therefore, analyses of raw error data would only reveal that fact. Deriving proportion data enabled us to adjust for group differences in error rates, and allowed us to examine the error patterns across groups in a meaningful manner. Note that in all error analyses, the proportion of surface errors and deep semantic errors was calculated out of total number of errors, and thus did not add up to 100%. Errors other than the surface errors and the deep semantic errors were of little theoretical interest and therefore, were not considered in the analyses. Other errors included null responses, “I don’t know”/“skip” responses, and default responses (where a participant would produce a single English translation, e.g. “bird”, for every novel word they could not retrieve).

Results

Translation Accuracy Analyses.

A 2×2 Mixed Anova with group (bilingual, monolingual) and testing session (immediate vs. delayed) as the independent variables yielded a main effect of testing session, $F(1, 35) = 61.78$, $p < .001$, $\eta_p^2 = .65$, and a main effect of group $F(1, 35) = 8.62$, $p < .01$, $\eta_p^2 = .20$. The interaction between group and session was not significant, $F(1, 35) = .27$, $p = .61$. Bilingual participants ($M = .39$, $SE = .04$) outperformed monolingual participants ($M = .22$, $SE = .04$), and both groups were more accurate at producing English translations for novel words at immediate testing ($M = .38$, $SE = .03$) than at delayed testing ($M = .23$, $SE = .03$). See Figure 1 for the visual representation of translation accuracy data.

Error Analyses.

A $2 \times 2 \times 2$ Mixed Anova with group (bilingual, monolingual), session (immediate, delayed) and error type (surface, deep) as the independent variables yielded a main effect of testing session, $F(1, 34) = 21.88$, $p < .001$, $\eta_p^2 = .40$, a main effect of error type, $F(1, 34) = 54.35$, $p < .001$, $\eta_p^2 = .62$, and a significant three-way interaction among group, testing session, and error type, $F(1, 34) = 25.60$, $p < .01$, $\eta_p^2 = .44$. Collapsing across groups and error types, participants produced a larger proportion of surface and deep errors (relative to all errors) at

immediate ($M = .14$, $SE = .02$) than at delayed testing ($M = .08$, $SE = .01$). Collapsing across groups and sessions, participants produced a larger proportion of surface errors ($M = .17$, $SE = .02$) than deep semantic errors ($M = .05$, $SE = .01$). In order to identify the locus of the three-way interaction, two types of analyses were conducted. First, error patterns were examined within each group separately. Second, error patterns were compared across the two groups.

When monolinguals were considered separately, a number of notable error patterns were observed. Participants produced a larger proportion of surface errors immediately after learning ($M = .24$, $SE = .03$) than after a 1-week delay ($M = .07$, $SE = .01$), paired-samples $t(17) = 5.98$, $p < .001$, whereas the reverse was the case for deep semantic errors.

Monolingual learners produced a larger proportion of deep semantic errors after a 1-week delay ($M = .07$, $SE = .02$) than immediately after learning ($M = .02$, $SE = .01$), $t(17) = 2.78$, $p < .05$. Further, monolinguals produced a larger proportion of surface errors than deep semantic errors immediately after learning, $t(17) = 9.87$, $p < .001$. However, the proportions of surface errors and deep semantic errors were comparable at delayed testing, $t(17) = .03$, $p = .97$.

When bilinguals were considered separately, surface errors patterned similarly to those observed for monolinguals. That is, just like monolinguals, bilinguals produced a larger proportion of surface errors immediately after learning ($M = .26$, $SE = .06$) than after a 1-week delay ($M = .10$, $SE = .02$), paired-samples $t(17) = 2.74$, $p < .05$. Moreover, similar to monolinguals, bilingual learners produced a larger proportion of surface errors than deep semantic errors immediately after learning, $t(17) = 4.02$, $p < .01$, but the proportions of surface and deep semantic errors were comparable at delayed testing, $t(17) = 1.01$, $p = .33$. However, *unlike* monolinguals, bilinguals produced a similar proportion of deep semantic errors immediately after learning ($M = .04$, $SE = .01$) and after a 1-week delay ($M = .07$, $SE = .02$), $t(17) = 1.59$, $p = .13$.

The second set of follow-up analyses was used to contrast bilingual and monolingual error patterns. These analyses revealed that bilingual learners produced a larger proportion of deep semantic errors than monolingual learners at immediate testing, independent-samples $t(35) = 1.93$, $p < .05$. All other comparisons revealed comparable error patterns in the bilingual and monolingual learners, $p > .7$.

Discussion

Previous studies have shown that bilinguals tend to outperform monolinguals on vocabulary learning tasks (e.g., Kaushanskaya, 2012; Kaushanskaya & Marian, 2009a; Papagno & Vallar, 1995; Van Hell & Mahn, 1997). However, absolute differences between bilinguals and monolinguals on a single learning task are largely uninformative with regard to the mechanisms that may underlie these bilingual advantages. *Why* are bilinguals better than monolinguals at learning new vocabulary? Here, we used an error analysis to examine the possibility that bilinguals may be able to encode the newly-learned vocabulary items to a deeper semantic level than monolinguals. We predicted that if this was indeed the case, then bilinguals would make more deep semantic errors than monolinguals, proportionately-

speaking. Our findings broadly support this hypothesis. We found that bilinguals produced fewer errors overall on the retention task, confirming bilingual advantages for vocabulary learning. Notably, we also found that when errors were analyzed in a way that corrected for the absolute differences in number-of-errors data between bilinguals and monolinguals, distinct error patterns were observed in bilingual vs. monolingual learners, suggesting that vocabulary learning may rely on somewhat distinct mechanisms in learners with different language-learning experiences.

The finding that bilingual participants in the present study outperformed monolingual participants on the vocabulary learning task is broadly in line with prior studies suggesting bilingual word-learning advantages (Kaushanskaya, 2012; Kaushanskaya & Marian, 2009a; 200b; Papagno & Vallar, 1995; Van Hell & Mahn, 1997). Notably, we found that beyond broad differences in word-learning performance between bilinguals and monolinguals, the two groups differed in their error patterns. The two error types that were considered were surface errors and deep semantic errors. While monolingual learners made more deep semantic errors at delayed testing than immediately after learning, bilingual learners made the same proportion of deep semantic errors at delayed and at immediate testing. Moreover, bilinguals made proportionally more deep semantic errors than monolinguals immediately after learning. Crucially, a week after learning took place, both monolinguals and bilinguals demonstrated similar proportions of deep and surface errors, and did not differ from each other. Given the nature of the vocabulary retention measure, where participants translated newly-learned vocabulary items into English, both surface errors and deep semantic errors reflected a breakdown in the process of retrieving the meanings for the newly-learned vocabulary items. However, the level at which this breakdown originated differed for the two error types.

The surface errors occurred because the target novel word was confused for a different novel word that was phonologically-similar to it. In this sense, the surface errors in the present study were similar to phonological errors identified by prior studies where instead of the target word, a phonologically-similar non-target word was produced (e.g., Balthazar, Cendes, & Damasceno, 2008; Caramazza, Papagno, & Rumel, 2000). Conversely, the deep semantic errors occurred because although the target novel word was mapped to the correct semantic space, its exact translation was not retrieved. It is difficult to precisely identify the cause behind such semantic mis-mappings. For instance, it may be that a semantic neighbor of the target English word enjoyed higher levels of activation (for whatever reason), and thus won out in the race for lexical selection during testing. Whatever the explanation, for the deep semantic error to occur, the novel word necessarily must have been mapped either onto its correct English translation, or on the correct semantic space that the English translation occupied. In this sense, the deep semantic errors in the present study were similar to semantic errors identified by prior studies where instead of the target word, a semantically-related non-target word was produced (e.g., Cuetos, Aguado, & Caramazza, 2000; Harley & MacAndrew, 2001; Howard & Gatehouse, 2006; McGregor, Friedman, Reilly, & Newman, 2002).

The finding that both monolingual and bilingual participants made more surface errors than deep semantic errors immediately after learning indicates that for *all learners* at this initial

stage of the learning process, retrieval was most derailed at the level where new vocabulary items were mapped onto their phonological forms. However, bilingual learners made proportionately more deep semantic errors than monolinguals at immediate testing. Given the pathway required to make a deep semantic error, this finding suggests that bilingual participants in the present study must have necessarily mapped the novel vocabulary items to their correct semantic spaces more successfully than monolinguals. That is, bilingual participants in the present study may have been more effective at capitalizing on the links within their native-language lexical-semantic system than monolinguals. Having successfully mapped the novel vocabulary items to their appropriate semantic spaces however, bilingual participants experienced interference in the retrieval process, and this interference must have arisen at the semantic, rather than the phonological level. These findings may be interpreted to indicate that bilingual participants were able to encode novel vocabulary items deeper (i.e., to the semantic level) than monolinguals immediately upon learning.

The conclusion that bilingual learners may encode linguistic information to a deeper semantic level than monolingual learners is logical in light of previous studies indicating that more experienced learners, i.e. older children (e.g., Gershkoff-Stowe, 2002) and expert L2 speakers (Tokowicz, Michael, & Kroll, 2004) tend to retrieve and organize lexical information along semantic similarities. Interestingly, in the Tokowicz, Michael, and Kroll (2004) study, experienced L2 speakers made a larger number of meaning-based errors than inexperienced L2 speakers only when the experienced speakers also had better cognitive abilities (i.e., larger working memory capacity). Previous work has suggested that bilinguals may have a larger working memory capacity than monolinguals (Kaushanskaya, 2012; Kroll et al., 2002; Yoo & Kaushanskaya, 2012), although the findings are by no means conclusive (e.g., Fernandes, et al., 2007; Kaushanskaya, Blumenfeld, & Marian, 2011). In the present study, bilinguals and monolinguals were matched on their cognitive characteristics, including verbal memory measures and non-verbal intelligence. Yet, because only short-term memory skills (rather than working memory skills) were tested in the present study, a possibility remains that the differences in error patterns observed for bilingual and monolingual participants at immediate testing are a reflection of between-group differences in working memory rather than the amount of learning experience. However, since word-learning performance is generally thought to rely on short-term memory, especially memory for sequential information (e.g., Gupta, 2003; Majerus, Poncelat, Elsen, & Van der Linden, 2006; Majerus, Poncelat, Greffe, & Van der Linden, 2006), and since in the present study bilinguals and monolinguals were matched on their digit-span performance – a measure of short-term serial-order recall – it is likely that the distinct error patterns observed for the bilinguals and the monolinguals are a result of differences in language learning experience rather than memory capacity between the two groups

Theories of bilingual lexical processing such as the Revised Hierarchical Model (e.g., Kroll, Van Hell, Tokowicz, & Green, 2010) provide a useful framework for explaining why bilingual participants may be more prone to deep semantic errors when translating novel words into the native language than monolinguals. There is general evidence to indicate that as bilinguals gain proficiency in their L2, lexical access in the L2 becomes more semantically mediated (e.g., Kroll & Stewart, 1994; Sunderman & Kroll, 2006). It is

possible that the experience of acquiring a second language generally shapes the lexical-semantic system to become more efficient at establishing a link between new lexical information (e.g., new phonological wordforms) and the semantic level (e.g., the English translation and its surrounding semantic network). As a result, bilingual learners acquiring new words would be more likely than monolingual learners to form the *correct* link between the new vocabulary items and their English translations. The resulting outcome would then be a general bilingual advantage on the translation task, and a larger proportion of deep semantic errors produced by the bilingual learners when incorrect translations are retrieved.

A related, but separable factor that may be at the root of the bilingual / monolingual differences in vocabulary-learning abilities and translation-error patterns is the fact that many words are not exact translations across languages – a phenomenon labeled “translation ambiguity”. Translation ambiguity poses processing challenges (Degani & Tokowicz 2010a), as well as learning challenges (Degani & Tokowicz, 2010b; Degani, Tseng, & Tokowicz, 2014). For instance, Degani and Tokowicz (2010b) have demonstrated that novice adult language learners struggled when learning translation-ambiguous Dutch words compared to translation-unambiguous Dutch words. It was especially difficult for the learners to learn two different but synonymous Dutch words that mapped onto a single English word (form-ambiguous items), although they also struggled to learn two different Dutch words that mapped to two different meanings of a single English word (homophones, or meaning-ambiguous items). In the present stimulus set, many English translations were ambiguous in relation to Spanish, and both form ambiguity and meaning ambiguity were present. For instance, the English word “leg” has a number of different Spanish translations that convey the different senses and contexts of use that are all semantically related. Conversely, the English word “rose” is a homophone with two different meanings (one related to the noun meaning “flower” and one related to the verb meaning “ascended”), and thus has two different Spanish translations that are entirely semantically unrelated.

Translation ambiguity is common across languages (Degani & Tokowicz, 2010b) and its abundant presence in our stimulus list may have served to influence bilinguals’ vocabulary learning performance. Interestingly, an intuitive prediction regarding the effect of translation ambiguity on our results is that bilinguals should have had more difficulty learning the novel vocabulary items than monolinguals. That is, because translation-ambiguous items pose a learning challenge, and because many English translations in the present study were translation-ambiguous, bilinguals should have had more difficulty mapping novel wordforms onto them than monolinguals. Yet, we observed the exact opposite result – bilinguals overall had an easier time with the vocabulary learning task monolinguals. It is difficult therefore to interpret our findings as reflecting ambiguity influences, although one possibility could be that increased prior encounters with ambiguity facilitate one’s ability to accommodate to ambiguity during a novel vocabulary learning task. That is, because bilinguals but not monolinguals have encountered cross-linguistic ambiguity as well as within-language ambiguity in *two* languages, they may have been better able to map novel labels onto their English translations (at least when these meaning-ambiguous) than monolinguals, thus driving the overall group differences. This may also explain why bilinguals were more likely than monolinguals to make proportionately more deep semantic errors than monolinguals at

immediate testing – their semantic spaces for the English translations (at least for the ambiguous items) would be wider than those of the monolinguals.

We would pose two caveats to this interpretation of the results. First, although this reasoning may explain why bilinguals would outperform monolinguals when learning novel words that map onto English homophones, it would not explain why bilinguals would outperform monolinguals on other novel words, and especially those that are form-ambiguous across their two languages (which constitute the majority of our stimulus set). Second, across the two groups, the same, English-specific coding criteria were applied when coding errors. That is, when coding deep semantic errors, we only took into account the dominant meanings of the English homophones (i.e., the meaning of *flower* but not of *ascended* for “rose”), and we only took into account the English, and not the Spanish lexical-semantic networks, when coding for deep semantic errors. This should have minimized any effects of ambiguity on error results. Unfortunately, the small number of ambiguous vs. unambiguous items and an inability to equate these items on psycholinguistic characteristics prevent any empirical analyses that would test the effect of ambiguity on vocabulary learning performance in this study. It is however the natural next step in this line of research, and it is imperative that the role of translation ambiguity in bilinguals’ vocabulary learning performance be examined.

Interestingly, differences in error patterns between bilinguals and monolinguals were observed only at immediate testing, but not at delayed testing. That is, at delayed testing, both the bilingual and the monolingual learners demonstrated a comparable proportion of deep semantic errors to surface errors, and no differences between groups in the proportion of deep semantic errors produced was found. These differences in error patterns at immediate vs. delayed testing are due to the fact that while monolingual participants produced a larger proportion of deep semantic errors at delayed than at immediate testing, bilingual participants produced the same proportion of deep semantic errors at delayed and at immediate testing. The increase in the proportion of deep semantic errors produced by monolingual learners after a week-long delay may reflect semantic consolidation processes that have taken place in the lexical-semantic system.

Previous studies have shown that learners require time to consolidate newly-acquired novel words into the existing lexical system (e.g., Clay, Bowers, Davis, & Hanley, 2007; Dumay & Gaskell, 2007; Magnuson, et al., 2003; Tamminen & Gaskell, 2008). For example, in auditory learning, Gaskell and Dumay (2003) found that exposure to novel wordforms (e.g., *cathedruke*) changed the speed with which learners responded to related known lexical items (e.g., *cathedral*), but only after a week-long consolidation period (i.e., competition effects were not obtained immediately after learning). Similarly, for orthographic learning, Clay et al. (2007) found that newly-learned novel words interfered with native-language picture naming (in the Picture-Word Interference task) one week after the initial learning had taken place, but not immediately after learning. Therefore, new words require time to be integrated into the existing lexical-semantic system, and to begin to compete for selection with previously known lexical items (e.g., Bowers, Davis, & Hanley, 2005; Davis et al., 2008; Tamminen & Gaskell, 2008). In the present study, the increase in the proportion of deep semantic errors made by monolingual speakers from immediate to delayed testing may be

interpreted to suggest that it took time for the consolidation of the novel words into the native-language semantic system to occur. By the same token, the finding that bilingual speakers had a larger proportion of deep semantic errors than monolingual at immediate testing suggests that integration of novel words into the native-language semantic system occurred earlier in bilinguals than in monolinguals. It is important to not over-interpret these data, since shifts in error patterns with time are only indirectly indicative of consolidation processes. Furthermore, while prior studies of lexical consolidation have tested the degree to which novel words interact with the established lexical representations, in the present study we inferred that consolidation may have contributed to our results based on the degree to which the known words interfered with the retrieval of the novel words' translations. Therefore, future studies would need to use tasks similar to ones used by Gaskell and colleagues (e.g., Dumay & Gaskell, 2007; Tamminen & Gaskell, 2008) to examine the consolidation of novel words in the lexical-semantic system of bilingual vs. monolingual learners directly.

Finally, in interpreting the findings related to the error data in the present study, one of the main challenges is the entangled nature of bilingualism and learning outcomes. That is, it may be that better word-learners (independent of language background) are more sensitive to the semantic information associated with the novel words, thus making proportionately more semantic errors. Because bilinguals in the present study demonstrated better vocabulary learning than monolinguals, the differences between the two groups in error patterns may reflect this learning differential. The best experimental strategy for dealing with such a possibility would be to conduct a series of follow-up studies where bilinguals and monolinguals are allowed to reach the same criterion in translation accuracy, and only then probe for error rates on tasks that target phonological vs. semantic levels of encoding. In the context of the available data however, there are two ways to examine this possibility.

First, we conducted correlation analyses relating translation accuracy and error rates in the two groups of participants. These analyses revealed that for the monolinguals, the only significant relationship was observed between immediate translation accuracy and proportion of surface errors at immediate testing ($r = 0.59, p < .05$). For the bilinguals, a similar relationship was found between immediate translation accuracy and proportion of surface errors at immediate testing ($r = 0.54, p < .05$). However, there was also a relationship observed between delayed translation accuracy and proportion of deep errors ($r = 0.60, p < .05$). Although these findings cannot be readily used to separate the effects of bilingualism from the effects of learning ability on error data, they do indicate that superior vocabulary-learning in the bilingual group (at least as indexed by the ability to retrieve English translations long-term) may in fact be linked to the semantically-grounded learning mechanism.

Second, we conducted analyses on sub-groups of monolinguals and bilinguals who were matched one-by-one on their translation accuracy at immediate testing. The matching procedure yielded 11 participants per group whose immediate translation accuracy was equivalent ($M_{monolingual} = .35, SD = .17$; $M_{bilingual} = .34, SD = .17$), $t(20) = .10, p = .92$. The two groups also did not differ in their delayed translation accuracy, $t(20) = 1.21, p = .24$. We then used non-parametric *Mann-Whitney U-tests* to examine whether these two

matched groups of participants would demonstrate distinct error patterns. We found that the groups did not differ in the proportions of surface errors at the immediate testing, $p = .70$. However, the groups did differ significantly in the proportion of deep errors at the immediate testing, $p < .05$, with bilinguals producing a larger proportion of deep semantic errors ($M = .04$, $SD = .02$) than monolinguals ($M = .02$, $SD = .03$). The groups did not differ significantly in the error data at delayed testing ($p > 0.5$ for both surface and deep errors), although there was a trend for bilinguals to produce a larger proportion of deep semantic errors ($M = .23$, $SD = .15$) than monolinguals ($M = .16$, $SD = .11$). These results should be interpreted conservatively, given the small sample sizes and the post-hoc nature of the analyses. Nevertheless, they provide evidence that the error patterns do in fact differentiate bilinguals and monolinguals with comparable levels of vocabulary learning performance.

In conclusion, the present study suggested that bilingual and monolingual learners may differ in their ability to encode new vocabulary items. While bilinguals generally translated the newly-learned words into English with higher accuracy than monolinguals, they also made proportionately more deep semantic errors at immediate testing than monolinguals. The possible mechanisms behind the different error patterns observed for the two groups may be related to bilinguals' greater overall language-learning experience, as well as their greater experience with lexical ambiguity. Although future studies would be necessary to delineate the precise relationship between learning performance and error type, our follow-up analyses indicate that bilingualism rather than superior learning was at the core of the distinct error patterns in the bilingual vs. the monolingual group. We therefore conclude that the mechanisms behind the bilingual advantages for novel word learning are rooted in bilinguals' greater sensitivity to the semantic information associated with the novel words, and in the faster consolidation process whereby the novel words are integrated into the existing semantic network.

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References

- Acheson DJ, & MacDonald MC (2009). Twisting tongues and memories: Explorations of the relationship between language production and verbal working memory. *Journal of Memory and Language*, 60, 329–350. [PubMed: 21165150]
- Balthazar MLF, Cendes F., & Damasceno BP (2008). Semantic error patterns on the Boston Naming Testing in normal aging, amnesic mild cognitive impairment, and mild Alzheimer's Disease: Is there semantic disruption? *Neuropsychology*, 22, 703–709. [PubMed: 18999343]
- Bartolotti J, & Marian V (2012). Language learning and control in monolinguals and bilinguals. *Cognitive Science*, 36, 1129–1147. [PubMed: 22462514]
- Bartolotti J, Marian V, Schroeder SR, & Shook A (2011). Bilingualism and inhibitory control influence statistical learning of novel word forms. *Frontiers in Psychology*, 2, 1–10. [PubMed: 21713130]
- Bowers JS, Davis CJ, & Hanley DA (2005). Interfering neighbors: The impact of novel word learning on the identification of visually similar words. *Cognition*, 97, B45–B54. [PubMed: 15925358]
- Caramazza A (1997). How many levels of processing are there in lexical access? *Cognitive Neuropsychology*, 14, 177–208.

- Caramazza A, Papagno C, & Rumel W (2000). The selective impairment of phonological processing in speech production. *Brain and Language*, 75, 428–450. [PubMed: 11112296]
- Clay F, Bowers JS, Davis CJ, & Hanley DA (2007). Teaching adults new words: The role of practice and consolidation. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, 33, 970–976.
- Colangelo A, Buchanan L, & Westbury C (2004). Deep dyslexia and semantic errors: A test of the failure of inhibition hypothesis using a semantic blocking paradigm. *Brain and Cognition*, 54, 232–234. [PubMed: 15050781]
- Costa A, Caramazza A, & Sebastian-Galles N (2000). The cognate facilitation effect: implications for models of lexical access. *Journal of Experimental Psychology: Learning, Memory & Cognition* 26, 1283–1296.
- Cuetos F, Aguado G, & Caramazza A (2000). Dissociation of semantic and phonological errors in naming. *Brain and Language*, 75, 451–460. [PubMed: 11112297]
- Davis MH, Di Betta AN, Macdonald MJE, & Gaskell MG (2008). Learning and consolidation of novel spoken words. *Journal of Cognitive Neuroscience*, 21, 803–820.
- Degani T, & Tokowicz N (2010a). Semantic ambiguity within and across languages: An integrative review. *The Quarterly Journal of Experimental Psychology*, 63, 1266–1303. [PubMed: 19953429]
- Degani T, & Tokowicz N (2010b). Ambiguous words are harder to learn. *Bilingualism: Language and Cognition*, 13, 299–314.
- Degani T, Tseng AM, & Tokowicz N (2014). Together or apart: Learning of translation-ambiguous words. *Bilingualism: Language and Cognition*, 17, 749–765.
- Dell GS, Schwartz MF, Martin N, Saffran EM, & Cagnon DA (1997). Lexical access in aphasic and nonaphasic speakers. *Psychological Review*, 104, 801–838. [PubMed: 9337631]
- Dumay N, & Gaskell MG (2007). Sleep-associated changes in the mental representation of spoken words. *Psychological Science*, 18, 35–39. [PubMed: 17362375]
- Dunn LM, & Dunn LM (1997). *Peabody Picture Vocabulary Test* (3rd ed.). Circle Pines, MN: American Guidance Service.
- Fernandes MA, Craik F, Bialystok E, & Kreuger S (2007). Effects of bilingualism, aging, and semantic relatedness on memory under divided attention. *Canadian Journal of Experimental Psychology*, 61, 128–141 [PubMed: 17665753]
- Freedman ML, Martin RC, & Biegler K (2004). Semantic relatedness effects in conjoined noun phrase production: Implications for the role of short-term memory. *Cognitive Neuropsychology*, 2004, 245–265.
- Gershkoff-Stowe L (2002). Object naming, vocabulary growth, and the development of word retrieval abilities. *Journal of Memory and Language*, 46, 665–687.
- Goldrick M, Folk JR, & Rapp B (2010). Mrs. Malaprop's neighborhood: Using word errors to reveal neighborhood structure. *Journal of Memory and Language*, 62, 113–14. [PubMed: 20161591]
- Gupta P (2003). Examining the relationship between word learning, nonword repetition, and immediate serial recall in adults. *The Quarterly Journal of Experimental Psychology*, 56A, 1213–1236.
- Harley TA, MacAndrew SBG (2001). Constraints upon word substitution speech errors. *Journal of Psycholinguistic Research*, 30, 395–418. [PubMed: 11529522]
- Hatzidaki A, & Pothos EM (2008). Bilingual language representation and cognitive processes in translation. *Applied Psycholinguistics*, 29, 125–150.
- Howard D, & Gatehouse C (2006). Distinguishing semantic and lexical word retrieval deficits in people with aphasia. *Aphasiology*, 20, 921–950.
- Kaushanskaya M (2012). Cognitive mechanisms of word learning in bilingual and monolingual adults: The role of phonological memory. *Bilingualism: Language & Cognition*, 15, 470–489.
- Kaushanskaya M, Blumenfeld H, & Marian V (2011). The relationship between vocabulary and short-term memory measures in monolingual and bilingual speakers. *International Journal of Bilingualism*, 15, 408–425. [PubMed: 22518091]

- Kaushanskaya M, & Marian V (2008). Mapping phonological information from auditory to written modality during foreign vocabulary learning. *Annals of the New York Academy of Sciences, Special Issue on Neural Basis of Skill Acquisition, Reading, and Dyslexia*, 1145, 56–70.
- Kaushanskaya M, & Marian V (2009a). The bilingual advantage in novel word learning. *Psychonomic Bulletin & Review*, 16 (4), 705–710.
- Kaushanskaya M, & Marian V (2009b). Bilingualism reduces native-language interference in novel word learning. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, 35, 829–835.
- Kroll JF, & Stewart E (1994). Category interferences in translation and picture naming: Evidence for asymmetric connection between bilingual memory representation. *Journal of Memory and Language*, 33, 149–174.
- Kroll JF, Michael E, Tokowicz N, & Dufour R (2002). The development of lexical fluency in a second language. *Second Language Research*, 18, 137–171.
- Kroll JF, Van Hell JG, Tokowicz N, & Green DW (2010). The Revised Hierarchical Model: A critical review and assessment. *Bilingualism: Language and Cognition*, 13, 373–381.
- Magnuson JS, Tanenhaus MK, Aslin RN, & Dahan D (2003). The time course of spoken word learning and recognition: studies with artificial lexicons. *JEP: General*, 132, 202–227.
- Majerus S, Poncelet M, Elsen B, & Van der Linden M (2006). Exploring the relationship between verbal short-term memory for serial order and item information and new word learning in adults. *European Journal of Cognitive Psychology*, 18, 848–873.
- Majerus S, Poncelet M, Greffe C, & Van der Linden M (2006). Relations between vocabulary development and verbal short-term memory: The importance of short-term memory for serial order information. *Journal of Experimental Child Psychology*, 93, 95–119. [PubMed: 16154583]
- Marian V, Blumenfeld HK, & Kaushanskaya M (2007). The Language Experience and Proficiency Questionnaire (LEAP-Q): Assessing language profiles in bilinguals and multilinguals. *Journal of Speech, Language, and Hearing Research*, 50, 940–967.
- McGregor KK, Friedman RM, Reilly RM, & Newman RM (2002). Semantic representation and naming in young children. *Journal of Speech, Language, and Hearing Research*, 45, 332–346.
- Moreaud O, David D, Charnallet A, & Pellat J (2001). Are semantic errors actually semantic?: Evidence from Alzheimer's Disease. *Brain and Language*, 77, 176–186. [PubMed: 11300702]
- Page MPA, Madge A., Cumming, N., & Norris, G.G. (2007). Speech errors and the phonological similarity effect in short-term memory: Evidence suggesting a common locus. *Journal of Memory and Language*, 56, 49–64.
- Papagno C, & Vallar G (1995). Verbal short-term memory and vocabulary learning in polyglots. *Quarterly Journal of Experimental Psychology*, 48A, 98–107.
- Rapp B, & Goldrick M (2000). Discreteness and interactivity in spoken word production. *Psychological Review*, 107, 460–499. [PubMed: 10941277]
- Roelofs A (2007). A critique of simple name-retrieval models of spoken word planning. *Language and Cognitive Processes*, 22, 1237–1260.
- Sunderman G, & Kroll JF (2006). First language activation during second language lexical processing: An investigation of lexical form, meaning, and grammatical class. *Studies in Second Language Acquisition*, 28, 387–422.
- Tamminen J, & Gaskell MG (2008). Newly-learned spoken words show long-term lexical competition effects. *The Quarterly Journal of Experimental Psychology*, 61, 361–371. [PubMed: 17943648]
- Tokowicz N, Michael EB, & Kroll JF (2004). The roles of study-abroad experience and working-memory capacity in the types of errors made during translation. *Bilingualism: Language and Cognition*, 7, 255–272.
- Van Hell JG, & Candia Mahn AC (1997). Keyword mnemonics versus rote rehearsal: Learning concrete and abstract foreign words by experienced and inexperienced learners. *Language Learning*, 47, 507–546.
- Vitevitch MS, & Luce PA (2004). A web-based interface to calculate phonotactic probability for words and nonwords in English. *Behavior Research Methods, Instruments, & Computers*, 36, 481–487.
- Yoo J, Kaushanskaya M. (2012) Phonological memory in bilinguals and monolinguals. *Memory and Cognition*, 40, 1314–30. [PubMed: 22907206]

Wagner RK, Torgesen JK, & Rashotte CA (1999). Comprehensive Test of Phonological Processing. Pro-Ed, Inc.: Austin, TX.

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Figure 1. Translation accuracy data on the translation task at immediate testing and at delayed testing in bilinguals vs. monolinguals.

A. Surface Errors

B. Deep Semantic Errors

Figure 2.

Proportion of surface (Panel A) and deep semantic (Panel B) errors produced by bilingual and monolingual learners at immediate testing and at delayed testing.

Appendix: Novel Word and English Word Pairings

Novel Word	English Translation	Spanish translation	Novel Word	English Translation	Spanish Translation
tuf	*Cube	el cubo	gaf	Plum	la ciruela
gef	*Hockey	el hockey	naf	Zipper	el cierre, la cremallera
iguf	Boss	el jefe	ufag	*Cape	la capa (to wear); el cabo (geographic)
egun	Lawn	el césped; pasto	agut	Rope	la cuerda; la sogá; la reata; la amarra
etug	*Insect	el insecto	efun	Sunset	el anochecer, la puesta de sol
utaf	*Cigar	el cigarro; el puro	itug	Elbow	el codo (noun), codear/dar un codazo (verb)
efit	Ocean	el océano	aget	Sugar	el azúcar; cariño, amorcito, querido, corazón – terms of endearment
itun	Lawyer	el abogado	atuf	*Liquor	el licor; la bebida espirituosa; la bebida blanca
unef	Leg	la pierna; la pata for animal or table; tramo for leg of a flight; etapa for leg of a race	igan	Sky	el cielo
tugi	Rain	la lluvia (noun); llover (verb)	fagu	Song	la canción
figa	Sunburn	quemadura de sol (noun); quemarse/tostarse al sol (verb)	nafi	Laundry	la lavandería (place); la ropa sucia (dirty clothes to be washed); la colada, el lavado de ropa (chore, task of doing laundry)
funa	Bucket	la cubeta, el balde, el cubo, el tobo	guta	Rocket	el cohete
gitu	Hammer	el martillo; el martinete in music; martillar (verb)	fuṭa	Locker	la taquilla; el casillero; la bodega; el vestidor
fitu	*Cement	el cemento (noun); cementar (verb); also figurative meanings of verb (consolidar, fortalecer, afianzar, cimentar – diff from cementar)	negi	*Infant	el infante
feti	Chicken	el pollo (also “gallina” slang for coward and cowardly)	gena	Stomach	el estómago (organ); el abdomen/el vientre/la panza (stomach/belly on outside); tolerar/soportar (verb: to tolerate)
gafun	Sign	la señal (traffic notice); el anuncio/letrero (sign on store), el indicio (sign of something happening), signo/símbolo (character/symbol), seña (sign in sign language), firmar (verb, to sign)	gifet	*Park	el parque (noun); estacionar(se) (verb)
nigaf	Envelope	el sobre, envolver (verb)	taguf	Magazine	la revista; el tambor, el barrilete (related to guns)
gituf	Mouth	la boca; articular (verb)	nagut	Teeth	los dientes
tafun	Morning	la mañana	negif	College	la universidad; la facultad (division)
nafit	Book	el libro (noun), reservar (verb)	tagun	Road	la carretera; el camino (road, route)

Novel Word	English Translation	Spanish translation	Novel Word	English Translation	Spanish Translation
nefag	Beach	la playa (noun), encallar (verb: to wash up on beach)	nitug	*Coast	la costa; el litoral; rodar sin pedalear (verb: to coast), ir en punto muerto (verb: to coast for a car)
futin	Storm	la tormenta; atacar (verb: to attack)	gaten	Cloud	la nube; nublar (verb: to cloud/obscure); sombra (figurative threat;)
fanet	*Rose	la rosa (noun); se levantó (verb)	fitan	Ship	el barco; el carguero; el buque; enviar/remitir (verb, to ship)
nutig	Flame	la llama	figen	Steam	el vapor (noun); cocinar al vapor (verb: to steam in cooking)

Note: Cognate status of the English translations is marked by an asterisk*.

Table 1

Monolingual and Bilingual Participant Characteristics (Means and SD values)

	Monolinguals	English-Spanish Bilinguals	<i>t</i> values
Age	20.84 (1.58)	21.78 (4.51)	0.83
Years of Education	14.85 (1.34)	15.47 (1.69)	1.16
PPVT-III (percentile)	73.78 (18.16)	79.19 (13.92)	0.97
Digit Span (percentile)	80.17 (11.77)	84.94 (10.91)	1.22
Nonword Repetition (percentile)	32.56 (12.99)	35.50 (13.95)	0.64
Reading Fluency (percentile)	93.00 (10.77)	97.71 (3.79)	1.55
Spatial Relations (percentile)	89.44 (7.41)	91.64 (3.99)	1.83
Visual Matching (percentile)	90.25 (8.77)	93.36 (5.40)	1.19

Note. *t* values are based on independent-samples *t*-tests with group (monolingual; bilingual) as the between-subjects independent variable. None of the comparisons were significant, with all *p* values > 0.10.