Cross-Linguistic Similarities Aid Third Language Learning in Bilinguals

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Abstract

Learning a new language involves significant vocabulary acquisition. Learners can accelerate this process by relying on words with native-language overlap, such as cognates. For bilingual third language learners, it is necessary to determine how their two existing languages interact during novel language learning. A *scaffolding* account predicts transfer from either language for individual words, whereas an *accumulation* account predicts cumulative transfer from both languages. To compare these accounts, twenty English-German bilingual adults were taught an artificial language containing 48 novel written words that varied orthogonally in English and German wordlikeness (neighborhood size and orthotactic probability). Wordlikeness in each language improved word production accuracy, and similarity to one language provided the same benefit as dual-language overlap. In addition, participants' memory for novel words was affected by the statistical distributions of letters in the novel language. Results indicate that bilinguals utilize both languages during third language acquisition, supporting a scaffolding learning model.

Keywords: Bilingualism; Language learning

Introduction

Knowledge of multiple languages is a desirable skill. Eighty percent of Americans (Rivers, Robinson, Harwood, & Brecht, 2013) and 84% of Europeans (European Commission Special Barometer, 2006) believe that adults should be fluent in a second language, but multilingual rates are far lower than desired levels. Bilingualism in the United States is estimated at 20-26% (United States Census Bureau, 2007), and even in the European Union, where primary and secondary school instruction in two foreign languages is widespread, only 56% of adults report fluency in a second language (European Commission Special Barometer, 2006).

One factor that makes language learning difficult for adults is prior language knowledge. In particular, first language (L1) experience tends to sharpen the mind to features and regularities of future L1 input, such as word forms (Schmitt, 1997). A consequence of this linguistic sharpening is that adults become particularly attuned to learning new vocabulary in their native language (Long & Shaw, 2000). Throughout life, people rapidly learn new vocabulary; a professional psycholinguist quickly learns words like morpheme, electroencephalogram, or aphasia. Because of their similarity to existing words and patterns, acquisition comes relatively seamlessly, even to people who may have struggled to learn a foreign language.

While linguistic sharpening can facilitate acquisition of native-like words, it can also interfere with learning of words that do not match native language patterns. This has important implications for novel language learning, because lexical similarity drops across languages. Written English words, for example, have on average 5-7 times fewer neighbors (i.e., words that differ in a single letter) in related languages like Dutch, French, German, or Spanish than they do English neighbors (Marian, Bartolotti, Chabal, & Shook, 2012). Thus, when attempting to learn a new language, the L1 is less likely to confer a benefit.

When overlap between languages does exist, it can be a powerful tool. For example, cognates, which overlap in both form and meaning across languages, are easier to acquire (De Groot & Keijzer, 2000). Partial similarity is also beneficial, with learners better able to retrieve words with L1-familiar patterns during immediate recall (Storkel, Armbrüster, & Hogan, 2006; Thorn & Frankish, 2005). Novel words' L1 overlap can be characterized in several different ways; two useful metrics are neighborhood size and orthotactic probability. A broad definition of a word's neighborhood size is the number of known words that differ from it in the substitution, addition, or deletion of a single letter, and orthotactic probabilities calculate how often individual letters or sequences of letters are used in a language.

Complete word learning is a complex, protracted process, and only after a period of memory consolidation is a new word fully integrated into the lexicon (Gaskell & Dumay, 2003). Acquisition of a word's form, though, occurs relatively quickly, making form a useful target for investigating the initiation of word learning. The mechanism by which form similarity benefits language learning is the focus of the current investigation. In this study, we compare two possible models for how long-term knowledge affects novel vocabulary learning: the Scaffolding and the Accumulation models.

The Scaffolding model predicts that the ability to create a direct association between a newly-encountered word and an existing word or concept drives memory strength. Novice learners rely heavily on L1 translations during L2 vocabulary learning (Liao, 2006; Schmitt, 1997), which anchors the relatively weak novel word to a strong existing memory. In the Revised Hierarchical Model of bilingual language processing, these word-to-word associations are strongest at the onset of L2 learning (Kroll & Stewart, 1994). Beyond translation equivalents, other lexical associations can be used to remember discrete aspects of a word. For example, the keyword learning method (Shapiro & Waters, 2005) is a pedagogical approach that emphasizes using a known word as a form intermediary between a novel word and its meaning (e.g., the word steel can be used to remember the phonological form of the French word *stylo*, meaning pen). A novel word with a more native-like form is more likely to have closely related L1 keywords available that the learner can select from to create a personally meaningful association. The scaffolding account thus emphasizes the learner's ability to directly utilize their existing linguistic framework during language acquisition.

In contrast, the Accumulation model proposes that a novel word's consistency with lexicon-wide patterns affects the fidelity with which it is represented in short-term memory and retrieved from long-term memory. When a new word is first encountered, it is vulnerable to disruption, but rehearsal processes maintain the trace in the phonological loop until it can be stored in memory. How well information is represented and maintained in the phonological loop is affected by interactions with prior knowledge, as detailed in Baddeley's Working Memory model (Baddeley, 1986). As applied to word learning, this long term knowledge may be used to enhance the strength of the initial temporary storage during encoding (Gathercole, 2006). Novel words with more native-like features are easier to repeat and maintain in working memory, because the sequencing of their letters or sounds is more predictable. In addition, newly-learned words that are composed of high probability patterns can benefit more from redintegration, the process of reconstructing a partially decayed short-term memory using long-term knowledge. Thus, a word that was incompletely encoded may nevertheless be accurately produced, reinforcing the target representation. To again use the French word *stylo* as an example, it contains common English bigrams *st* and *lo*, and the frequency of these features can facilitate accurate encoding and retrieval. These sub-lexical effects are distinct from the one-to-one whole word associations that drive learning in the scaffolding model.

In order to compare the Scaffolding and Accumulation models of word learning, we make use of a population with unique language experience and investigate acquisition of a third language in bilingual adults. We taught English-German bilinguals 48 words in an artificial language that varied orthogonnaly in their similarity to English and German. The two models make different predictions for how the three languages interact during word learning and retrieval. The scaffolding account predicts comparable learning benefits for novel words that resemble one or both known languages, because a single lexical-level link to existing knowledge is sufficient to advance learning. For each new word, quality links in either language may be available, but only one is utilized. In contrast, the accumulation account predicts tiered learning, where novel words that resemble both known languages are learned better than those that resemble a single language. This pattern is driven by cumulative sublexical frequency effects from each known language.

Methods

Participants

Twenty English-German bilinguals participated for monetary compensation. Informed consent was obtained in accordance with Northwestern University's IRB. After the experiment, participants completed the Language Experience and Proficiency Questionnaire (LEAP-Q, Marian, Blumenfeld, & Kaushanskaya, 2007) to assess proficiency, age of acquisition, and percentage of current usage for each language. Participants also completed the LexTALE in English and German, which assesses vocabulary knowledge based on lexical decision accuracy (*LexTALE*, Lemhöfer & Broersma, 2012) (Table 1).

Table 1: Bilingual language backgrounds, mean and SD.

Measure	English	German
Proficiency (1-10)	9.50 (0.72)	8.27 (1.52)
Age of Acquisition	3.84 (5.04)	10.74 (7.69)
Current Usage (%)	75.47 (19.30)	16.18 (13.51)
Vocabulary Size (0-100)	95.22 (4.99)	77.35 (14.58)

Materials

Forty-eight orthographic CVCC words were created in an artificial language. The novel words' English and German wordlikeness were calculated as composite scores of English and German orthographic neighborhood size and orthotactic probability (sum of grams and sum of bigrams), calculations from CLEARPOND (Marian et al., 2012), and English and German word similarity judgments obtained from English-German bilinguals (N = 10, ratings on scales of 1-5). Words were divided into four groups based on median splits of the English and German wordlike composites. Fourteen words had both high English and high German wordlikeness (E+G+, e.g., *nist* or *baft*), ten had high English but low German wordlikeness (E+G- e.g., *sumb* or *gonk*), eleven had low English but high German wordlikeness (E-G+ e.g., *gach* or *kenf*), and the remaining thirteen had low English and German wordlikeness (E-G- e.g., *gofp* or *kowm*). Each novel word was paired with a color line drawing from the revised Snodgrass and Vanderwart picture set (Rossion & Pourtois, 2004). Pictures were chosen to be highly recognizable (naming reliability: M = 99.1%, SD = 2.0%, Bates et al., 2003), and did not overlap orthographically or phonologically in English or German with their paired novel-language words. The names of pictures used in each of the four conditions did not differ on lexical frequency, orthographic or phonological neighborhood size, or gram, bigram, phoneme, or biphone probabilities in English or German (calculations from CLEARPOND, Marian et al., 2012).

Procedure

Participants began training with a single exposure block of 48 randomized trials to familiarize them with the novel language. In each exposure trial, a picture was presented in the center of the computer screen, and the written novel-language target appeared below the picture. Trials advanced automatically after two seconds. Following the exposure block, participants performed five blocks of word recognition with feedback, and five blocks of word production with feedback, alternating between the two tasks.

Word learning: Recognition. In 48 recognition trials, a random target picture and three randomly selected foil pictures were displayed in the four corners of the screen, and the written target word appeared in the center of the screen. The participant clicked on the picture that matched the word; accuracy and response time were recorded. After making a response, the three foils disappeared, and the target picture and written word remained onscreen for 1000 ms to facilitate continued learning, followed by a 1000 ms inter-trial interval.

Word learning: Production. In 48 production trials, a random target picture was presented in the center of the screen. The participant typed the name of the picture in the new language and accuracy was recorded (RTs were not analyzed due to the continuous response nature of typing in the task). After making a response, the picture and the participant's answer remained on the screen, and the correct name of the target was printed below the participant's response for 1000 ms as corrective feedback, followed by a 1000 ms inter-trial interval. After completing all 48 trials, a new testing block of recognition and production began. After the fifth series of recognition and production blocks the experiment concluded.

Data Analysis

Accuracy in each task was automatically scored by the computer. Response times in the recognition task were measured from the onset of the display until the participant clicked on a picture. RT analyses were performed on correct responses only, in order to control for accuracy differences between blocks and conditions. Outlier RTs within each combination of Block and Condition were identified and replaced with the threshold value (Mean + 2SD).

Change across blocks in recognition accuracy and RT, and in production accuracy was analyzed using growth curve analysis (Mirman, Dixon, & Magnuson, 2008), a form of multilevel regression that simultaneously estimates the effects of individuals and of experimental manipulations on time-course data. Accuracy and RT were fit with two model levels. The Level-1 submodels captured the effect of time on changes in the dependent measure over the course of training using second-order orthogonal polynomials. The intercept term describes the overall height of the curve, the linear term reflects the slope, and the quadratic term reflects the curvature. The Level-2 submodels capture the effects of experimental manipulations and individuals on each of the time terms present in the Level-1 model through a combination of population means, fixed effects, and random effects. In the current study, the fixed effects corresponded to English- and German-wordlikeness. The random effects captured individual deviances from the global mean and condition means. The effects of individual differences in English and German background on learning were assessed by correlating each measure with individuals' random effect estimates in each model.

The base Level-2 model included all time terms, fixed effects of English and German proficiency, and random effects of participant and participant-by-condition on all time terms. Additional Level-2 models were built that added three fixed effects of English wordlikeness (E+/E-), German wordlikeness (G+/G-), and their interaction to each time variable in turn. A significant improvement in model fit (a Chi-squared test on the change in model fit using -2LogLikelihood) indicates an effect of condition on independent properties of the curve (i.e., height, slope, or curvature). Parameter-specific *p*-values were estimated by using a normal approximation, treating the *t*-value from the model as a *z*-value.

Results

Word Production

Word production accuracy improved from 10.3% (SD = 14.8) to 66.3% (SD = 26.1) over blocks one to five.

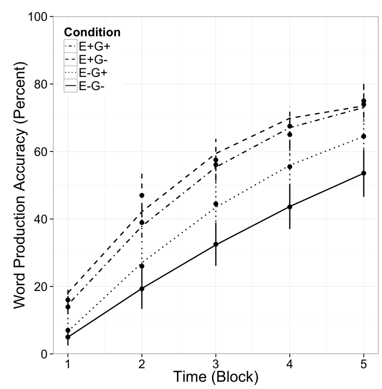

Figure 1: Novel word production accuracy (dots indicate observed values, and vertical lines standard error) and best fit quadratic growth curve models. Both English and German wordlikeness increased overall accuracy (intercept height), but the two factors did not have an additive effect.

The production accuracy model (Figure 1) was improved by adding English and German wordlikeness to the intercept (ΔLL = 25.82, $\chi^2(3) = 51.64$, $p < .001$) and to the quadratic term (ΔLL = 4.89, $\chi^2(3) = 9.78$, $p < .05$). The overall height of the curve was increased by English (Estimate = 0.218, SE = 0.023, $p < .001$) and by German wordlikeness (Estimate = 0.087, SE = 0.023, $p < .001$), and there was a significant interaction between the two terms (Estimate = -0.117, SE = 0.033, $p < .001$). The combination of the two terms revealed that whereas Englishlikeness improved accuracy by 21.8% and Germanlikeness improved accuracy by 8.7% relative to the unwordlike baseline, they combined non-additively, as the E+G+ double-wordlike condition was only 18.8% above baseline. Additionally, the benefits of English and German wordlikeness were not equivalent, as the height of the learning curve for E-G+ words was significantly lower than both the E+G- words (Estimate = 0.131, SE = 0.023, $p < .001$) and the E+G+ words (Estimate = 0.101, SE = 0.023, $p < .001$).

The curvature of the learning gains over time (i.e., the quadratic term in the model) was significantly affected by Englishlikeness (Estimate = -0.098, SE = 0.033, $p < 0.01$), but not by Germanlikeness (Estimate = -0.045, SE = 0.033, n.s.). The baseline quadratic term was also not significant (Estimate = -0.029, SE = 0.031, n.s.), and together, these results indicate that whereas accuracy gains between blocks were nearly linear for baseline words, Englishlikeness had a non-linear effect on change in accuracy over time, with the largest accuracy gains between blocks occurring earlier during training.

Word Recognition

Participants' recognition accuracy improved from 61.6% (SD = 19.0) in the first block to 98.4% (SD = 3.7) in the fifth block. RTs became faster over time, from 3325 ms (SD = 593) in the first block to 2208 ms (SD = 493) in the fifth block.

The word recognition accuracy model (Figure 2) was improved by adding the wordlike predictors to the intercept (ΔLL = 4.52, $\chi^2(3) = 8.10$, $p < .05$). Englishlikeness raised the overall height of the curve (Estimate = .0.036, SE = 0.016, $p < .05$), reflecting consistently higher accuracy for the Englishlike words compared to un-Englishlike words of 3.6% over the course of training. For recognition RT (Figure 3), there was a significant improvement to the base model by adding English and German wordlikeness to the intercept (ΔLL = 22.16, $\chi^2(3) = 44.32$, $p < .001$). English wordlikeness reduced RT relative to baseline (Estimate = -0.406, SE = 0.061, $p < .001$), and there was a marginal decrease in RT by German wordlikeness (Estimate = -0.109, SE = 0.061, $p < .1$). Novel words that resembled English were thus correctly identified 406 ms faster than baseline words, whereas words that resembled German were identified 109 ms faster than baseline, with no interaction between the two factors. These wordlike increases were stable across training, even as RTs globally decreased by 1117 ms from blocks one to five.

Language Proficiency

The random effect terms in the accuracy and RT models quantify how much individual participants' performances deviated from the group mean. We correlated the random effects with measures of language aptitude and relative language balance.

Relative differences in proficiency were associated with differences between Englishlike and Germanlike learning rates. Specifically, for production accuracy, higher proficiency in English relative to German was associated with larger slopes (faster learning rate) for the Englishlike relative to the Germanlike words, and conversely, higher relative German proficiency was associated with a faster learning rate for the Germanlike words (r = .479, R2 = .217, $p < .05$).

Overall proficiency was associated with recognition accuracy. English vocabulary size (LexTALE score) was correlated with a higher intercept (r = .647 ,R2 = .419, $p < .01$) and

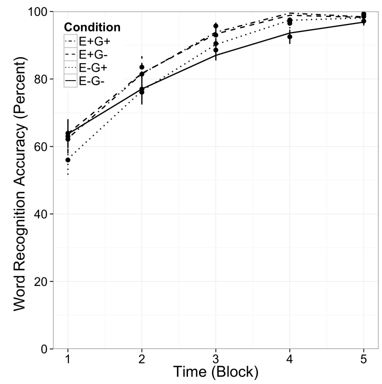

Figure 2: Novel word recognition accuracy (dots indicate observed values, and vertical lines standard error) and best fit quadratic growth curve models. English wordlikeness increased overall accuracy (intercept height).

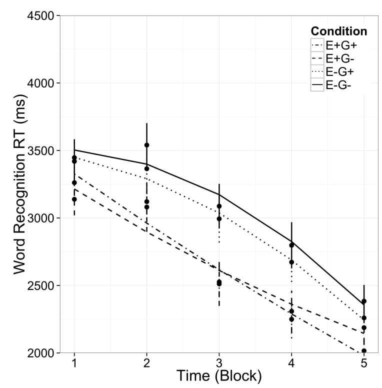

Figure 3: Novel word recognition RT (dots indicate observed values, and vertical lines standard error) and best fit quadratic growth curve models. English wordlikeness decreased overall response time across blocks and there was a marginal effect of German wordlikeness (intercept height).

a shallower slope (r = -.624, R2 = .389, $p < .01$). English and German self-rated proficiencies were each marginally correlated with higher intercepts (English proficiency, r = .423, R2 = .179, $p < .1$; German proficiency, r = .407, R2 = .221, $p < .1$) and shallower slopes (English proficiency, r = -.470, R2 = .166, $p < .05$; German proficiency, r = -.433, R2 = .187, p = .05). In each case, greater language knowledge increased accuracy; the shallower slopes reflect reaching ceiling performance.

Discussion

In the current study, we found that lexical similarity to a single known language improved bilinguals' learning of novel written words as much as simultaneous overlap with two known languages. These results indicate that vocabulary learning in a third language benefits from each language, and that bilinguals can flexibly transfer L1 and L2 knowledge to the L3 as appropriate at early stages of instruction. The lack of an additive learning benefit for words with close lexical neighbors and familiar patterns in both languages suggests that early vocabulary transfer may occur through a process of linking novel words to anchors in a single language. This process most closely resembles the scaffolding model of word learning, with limited evidence for the accumulation model.

Two tasks, word recognition and production, were used to asses complementary aspects of novel word learning. The recognition task probed the formation of word-meaning links, whereas the production task assessed recollection of an exact L3 written word form. Recognition accuracy was high even after a single training exposure. In the first block, participants recalled roughly 30 of the 48 pairs correctly, and quickly approached ceiling performance. English, but not German, wordlikeness increased overall accuracy across training relative to baseline words. In addition, participants with larger English vocabularies performed better on the task, with higher accuracies across training. Marginal correlations between individuals' proficiency in either language and accuracy suggest the possibility of a generalized vocabulary size benefit on recognition learning. For word recognition, there is more support for an effect of English similarity than of German; this difference between languages reflects the overall higher English proficiency in our sample. Because the novel words were presented in their entirety during the recognition task, accurate performance depended not on memory for wordforms, but on the link between form and meaning.

The production task, in contrast, was designed specifically to probe participants' memories for the actual written forms in the artificial language. With only a single picture prompt, the participant's task was to type the matching word from memory. In this task, we saw evidence for strong effects of wordlikeness both in English and in German. All three wordlike conditions (E+G+, E+G-, and E-G+) had higher curve heights than the baseline (E-G-) words, indicating higher accuracy throughout the experiment. However, the combination of English and German wordlikeness was not additive, as the E+G+ words were no different from the better of the two single-wordlike conditions, E+G-. This pattern of results provides support for the scaffolding account, by which the novel words received a benefit to learning if they overlapped with at least one of bilinguals' known languages, but received no additional benefit for overlapping both languages.

Bilingual third language learners appear to be especially sensitive to perceived overlap, and will transfer vocabulary knowledge from their two languages preferentially based on typological similarity, regardless of other factors like age of acquisition (Cenoz, 2003). As a result, we would expect participants in the current study to transfer knowledge from the language of overlap for E+G- or E-G+ words, and either language for E+G+ words. In post-experiment debriefings, 95% of participants reported using a keyword learning method (Shapiro & Waters, 2005) to learn words' meanings by creating a mental image linking the meaning and word via a similarly spelled existing word. Participants' use of English and German anchors tended to overlap with the target word's proscribed category. For example, to learn that the novel E+G- word *sumb* meant *fork*, one participant imagined counting the *sum* total of forks in a drawer. Another participant learned that that the E-G+ word *kenf* meant *goat* by thinking of a goat eating *senf*, the German word for mustard. Words that resembled both English and German, like the word *duch* meaning *eyeglasses*, were sometimes learned through an English linking word (a *duck* wearing glasses), but other times a German link (using glasses to read a *buch*, the German word for book). By not limiting themselves to a single language of transfer, learners were able to maximize the benefits they gained from their existing knowledge. This pattern would also predict language-specific benefits for English or German monolinguals, and comparable performance between monolingual and bilingual groups on dual-overlap E+G+ words.

While both languages provided benefits to memory for novel word forms, the sizes of the effects were not equivalent. English wordlikeness, compared to German, had a larger effect on overall production accuracy, and led to a slightly different curvature over the course of training. These patterns are consistent with participants' proficiency asymmetry. Although participants were highly proficient in both languages, all participants were currently living and working in the United States, and had slightly higher English proficiency. Second language proficiency can affect the degree to which it influences third language learning (Hammarberg, 2001), and accordingly, the largest accuracy gains were seen for English wordlikeness. At the individual level, however, we found that learning patterns were influenced by relative proficiencies in English and German. Bilinguals with higher proficiency in English learned to produce the Englishlike words at a faster rate than the Germanlike words, while the opposite was true for those with higher proficiency in German. This difference may reflect either the relative ease of acquisition of individual words, or an attention allocation strategy that prioritized words resembling the learner's dominant language.

To conclude, we found evidence for effects of wordlikeness in each of a bilinguals' two languages on third language orthographic word learning. Memory for word forms was often improved by linking novel vocabulary to existing lexical anchors in either language, depending on the similarity of the novel word to lexical patterns in English and German. Importantly, a novel word's similarity to both of a bilingual's known languages does not provide an additional learning benefit beyond similarity to a single language, suggesting that orthographic knowledge does not necessarily combine additively during third language learning. These results provide support for the scaffolding account of word learning, in which existing language knowledge provides a framework upon which novel words in another language can be built, accelerating early stages of language acquisition. The persistance of these similarity effects on lexical integration and long-term retrieval will be a critical test in applying these findings to language instruction. Foreign language instruction has long placed a premium on total immersion, but there is growing evidence that comparisons to the native language can benefit learning (Lin, 2015). We demonstrate here the learning benefits to be gained by utilizing areas of overlap between a known and a novel language.

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