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Word learning in adults with second language experience: Effects of phonological and referent familiarity

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Abstract

Purpose—The goal of this research was to examine whether phonological familiarity exerts different effects on novel word learning for familiar vs. unfamiliar referents, and whether successful word-learning is associated with increased second-language experience.

Method—Eighty-one adult native English speakers with various levels of Spanish knowledge learned phonologically-familiar novel words (constructed using English sounds) or phonologically-unfamiliar novel words (constructed using non-English and non-Spanish sounds) in association with either familiar or unfamiliar referents. Retention was tested via a forced-choice recognition-task. A median-split procedure identified high-ability and low-ability word-learners in each condition, and the two groups were compared on measures of second-language experience.

Results—Findings suggest that the ability to accurately match newly-learned novel names to their appropriate referents is facilitated by phonological familiarity only for familiar referents but not for unfamiliar referents. Moreover, more extensive second-language learning experience characterized superior learners primarily in one word-learning condition: Where phonologically-unfamiliar novel words were paired with familiar referents.

Conclusions—Together, these findings indicate that phonological familiarity facilitates novel word learning only for familiar referents, and that experience with learning a second language may have a specific impact on novel vocabulary learning in adults.

Current cognitive theories suggest that information processing involves wide interactive networks of activations both within and across the phonological and the semantic levels of processing (e.g., Acheson, Postle, & MacDonald, 2010; McClelland & Elman, 1986; Mirman, McClelland, & Holt, 2005; Rapp & Goldrick, 2000). Moreover, it is well known that acquisition of new information is embedded within the existing system of knowledge such that previous learning experiences constrain and guide subsequent learning (e.g., Finn & Hudson Kam, 2008; Lany & Gómez, 2008; Reber, 1989). Yet, the questions of how acquisition of forms interacts with acquisition of referents during lexical learning and of whether previous learning experience can facilitate subsequent learning have rarely been posed. The present study was motivated by two research questions: First, we examined whether the effects of phonological familiarity on adults' word learning dissociate for familiar vs. unfamiliar referents. Second, we tested whether the degree of learning

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experience (operationalized as the degree to which learners were familiar with a second language) was associated with adults' word-learning performance.

Phonological Familiarity Effects in Novel Word Learning

Previous extensive work examining the effect of phonological familiarity on word-learning suggests that learners retain phonologically-familiar material (i.e., material that conforms to the phonological patterns of their language) more successfully than phonologically-unfamiliar material (e.g., Ellis & Beaton, 1993; Gathercole & Baddeley, 1990; Gathercole, Frankish, Pickering, & Peaker, 1999; Gathercole, Willis, Emslie, & Baddeley, 1991; Papagno & Vallar, 1992; Service & Craik, 1993; Storkel, 2001; Storkel, Armbrüster, & Hogan, 2006). This relative ease of learning phonologically-familiar novel words (compared to phonologically-unfamiliar novel words) is known as the phonological familiarity effect. Phonological familiarity effects in word-learning have been localized to the involvement of long-term phonological knowledge (both lexical and sub-lexical) in the acquisition process (Gathercole & Baddeley, 1990; Service & Craik, 1993). In connectionist models of language processing, phonological familiarity is equated with phonological frequency (e.g., Dell, 1988; Gupta & MacWhinney, 1997; Magnuson, et al., 2003; McClelland & Elman, 1986), and phonological familiarity effects are construed in terms of resting-activation thresholds in the lexical system (e.g., Gupta & MacWhinney, 1997; Storkel & Morrisette, 2002). That is, sounds that are frequently encountered in the ambient language have higher resting-activation thresholds than sounds that are rarely encountered. As a result, words that contain commonly-encountered sound-sequences are benefited during processing and learning compared to words that contain rarely-encountered sound-sequences. However, it is presently unclear whether such phonological familiarity effects can be obtained when the familiarity of the referent is also manipulated in the word-learning task.

Current theories of information processing strongly suggest that all learning and processing is supported by interactive networks of activations across levels of processing (e.g., Acheson, Postle, & MacDonald, 2010; McClelland & Elman, 1986; Mirman, McClelland, & Holt, 2005; Rapp & Goldrick, 2000; Rapp & Samuel, 2002). For example, the connectionist models of lexical production propose that semantic and phonological aspects of a word are activated simultaneously (e.g., Dell, Chang, & Griffin, 1999), and similarly, the connectionist models of lexical perception posit interactive and bi-directional connections between the semantic and the phonological processing levels (e.g., Plaut & Kello, 1999). These interactive computational approaches to cognitive processing are theoretically appealing because they reflect the bidirectional connectivity that characterizes human neural processing (e.g., Felleman & Van Essen, 1991) and can account for the behavioral findings in language processing. For example, Rapp and Samuel (2002) found that adults generated missing words in sentences according to both the semantic and the phonological features of the preceding linguistic context. Similarly, Acheson, Postle, and MacDonald (2010) found that the phonological similarity effect on a list memory task (where participants had to recall previously-presented words), was stronger for concrete words than for abstract words. Therefore, it seems clear that in lexical processing, the phonological and the semantic information levels interact. However, such interactive cognitive theories have rarely been applied to questions regarding lexical learning. In the present study, we tested adult learners'

ability to establish connections between novel words and their semantic referents. We aimed to examine both the phonological and the semantic influences on lexical learning within the connectionist framework of language processing by testing whether phonological familiarity effects (better retention of phonologically-familiar than of phonologically-unfamiliar novel words) would diverge for familiar referents (pictures of familiar animals) and unfamiliar referents (pictures of unfamiliar aliens). Manipulating phonological familiarity across the different levels of referent familiarity also enabled us to examine the effects of previous second-language learning experience on word-learning in the different word-learning conditions.

Effect of Learning Experience on Learning

It is understandable that increased experience with a particular set of words improves their retention. What is less clear is whether increased learning experience exerts a broad facilitation effect on learning of information that has not been specifically trained. Although the idea that learning begets learning is not new, demonstrating generalization effects in learning has not been easy. Some evidence for such effects of prior learning experience on subsequent learning comes from studies that have shown that experience with multiple languages can facilitate adults' ability to acquire novel words (e.g., Kaushanskaya, 2012; Kaushanskaya & Marian, 2009a; 2009b; Kaushanskaya & Rechtzigel, in press; Papagno & Vallar, 1995; Van Hell & Mahn, 1997). For example, highly experienced learners (defined as adults who have acquired three or more languages) were found to outperform inexperienced learners (defined as speakers of a single language) on simple word learning tasks where foreign vocabulary items were paired with native-language translations (e.g., Papagno & Vallar, 1995; Van Hell & Mahn, 1997). However, because nearly all previous studies have tested highly proficient, lifelong multilingual speakers, it remains unknown what specific aspects of acquiring a second language yield the broad advantages for learning. Moreover, because all previous studies tested learning using one particular word-learning paradigm where novel words were taught in association with their native-language translations, it remains unknown whether the effects of prior learning experience on subsequent learning generalize to other learning scenarios. The manipulation of phonological and referent familiarity in the present study enabled us to examine the effects of prior learning experience on word-learning across different learning conditions. The inclusion of participants with variable levels of second-language knowledge enabled us to examine the specific factors associated with L2 acquisition that would lead to learning advantages observed in experienced learners.

In selecting the variables associated with the second language (L2) experience that would be characteristic of successful word-learners, we relied on the available theoretical knowledge regarding L2 acquisition, and specifically on the factors known to lead to successful L2 acquisition in adults. Age of L2 acquisition (AoA, e.g., Hyltenstam & Abramsson, 2003) in particular has emerged as an important factor in predicting the success of second-language acquisition. For instance, a robust relationship exists between the age at which a learner was exposed to L2 and the ultimate L2 attainment level (e.g., Birdsong, 2005; Birdsong & Molis, 2001; Johnson & Newport, 1989). Although the precise nature of this relationship is still debated (e.g., Bialystok & Hakuta, 1999; Johnson & Newport, 1989), the finding that earlier

exposure to the second language leads to more successful L2 acquisition is well established (e.g., Birdsong, 2005; Flege, Yeni-Komishian, & Liu, 1999).

The role of L2 proficiency in shaping the effects of bilingualism on cognition has also been documented. For example, the degree of L2 proficiency modulates the extent to which the two languages in the bilingual cognitive system interact (e.g., Blumenfeld & Marian, 2007), as well as the extent to which bilingualism affects cognitive processing (e.g., Bialystok & Feng, 2009). There is also evidence that the degree to which a learner is immersed in the L2 (e.g., Carroll, 1967; Flege et al., 1999), the extent of L2 exposure (e.g., Birdsong, 2005; Genesee, 1985; Kohnert, Bates, & Hernandez, 1999; Weber-Fox & Neville, 1999), and the extent of ongoing L2 use (e.g., Flege, MacKay, & Piske, 2002; Jia et al., 2002) influence attained L2 competence. In the present study, we examined whether superior word-learners would be characterized by increased experiences with a second language, and operationalized L2 experience in terms of dimensions previously identified as relevant to L2 competence, including: (1) age of L2 acquisition; (2) L2 proficiency and L2 preference; and (3) extent of current L2 immersion across various contexts.

The Current Study

In the current study, we tested learners' ability to establish connections between novel phonological wordforms and their semantic referents, and examined the effects of phonological familiarity on novel word learning across two levels of referent familiarity: Familiar referents and unfamiliar referents. We also examined whether more successful word-learners would be characterized by increased experience with a second language. In accordance with theories of lexical processing that construe the interaction between the phonological and the semantic levels of information as mutually reinforcing and bidirectional (e.g., Dell, Chang, & Griffin, 1999), and in accordance with previous findings of phonology-semantics interactions in lexical processing (e.g., Acheson, Postle, & MacDonald, 2010), we predicted that phonological familiarity effects in learning would be stronger for familiar referents than for unfamiliar referents. We reasoned that presentation of familiar (but not of unfamiliar) referents would activate the phonological, lexical, and the semantic systems of the native language. If phonological and semantic levels of processing interact during lexical learning, presentation of familiar phonological information would resonate stronger with the other levels of processing for familiar referents than for unfamiliar referents, yielding stronger phonological familiarity effects during learning.

We manipulated phonological familiarity in a binary manner, where novel words that were phonologically-familiar contained phonemes that were part of the English inventory (the native language for all participants), and the novel words that were phonologically-unfamiliar contained phonemes that were not part of the English phonemic inventory (i.e., they were perceptually different from any phoneme in English). Thus, we were able to manipulate phonological familiarity in a categorical manner that reflected an ecologically-viable distinction between learning new words in one's native language vs. an unfamiliar foreign language. This type of phonological-familiarity manipulation, where novel words containing only familiar-native phonemes (+P novel words) were contrasted with novel words containing unfamiliar-foreign phonemes (−P novel words) has been shown to yield

phonological familiarity effects in word-learning (e.g., Kaushanskaya, 2012; Kaushanskaya & Yoo, 2011; Kaushanskaya, Marian, & Yoo, 2011; Morra & Camba, 2009). Because we aimed to ensure that the phonological familiarity manipulation would not be affected by experience with a language where our unfamiliar phonemes would in fact be familiar to the learners, we limited the participants only to those who had experience with Spanish, and constructed the phonologically-unfamiliar novel words to include phonemes that would not occur in either the English or the Spanish phonetic inventory. That is, the unfamiliar phonemes would be unfamiliar to speakers of English and to speakers of Spanish. Therefore, any effects of experience with Spanish observed in our data should not be rooted in the experience with Spanish per se, and instead, should be a reflection of increased learning experience, in general.

Because we manipulated phonological familiarity as a categorical variable (familiar-native vs. unfamiliar-foreign), we manipulated referent familiarity in a similarly dichotomous manner. Participants acquired phonologically-familiar or phonologically-unfamiliar novel words in association with pictures of familiar animals (e.g., squirrel, lion, etc.) vs. pictures of unfamiliar aliens. This ensured that in both learning conditions, learners were exposed to meaningful categories (animals and aliens). A similar approach to manipulating referent familiarity was undertaken by Barcroft and Sunderman (2008), who taught adult participants novel words in association with either the pictures of real objects or with the pictures of non-objects. We predicted that phonological familiarity effects would be stronger when the novel words were learned in association with familiar referents than with unfamiliar referents.

In order to examine the association between second-language experience and word-learning, we median-split the learners into high-ability and low-ability learners based on their performance on the retention measure for each of the word-learning conditions. The participants had varying levels of experience with Spanish as the second language. The aspects of L2 experience which have been shown to predict L2 performance, including age of L2 acquisition (e.g., Hyltenstam & Abramsson, 2003), L2 proficiency and preference (e.g., Blumenfeld & Marian, 2007), and L2 exposure (e.g., Carroll, 1967; Flege, Frieda, & Nozawa, 1997; Flege et al., 1999), were used as the dependent variables, and word-learning performance (more successful vs. less successful) was used as a grouping, independent variable. We hypothesized that if any of these experiences are key in the formation of bilingual advantages for learning, superior word-learners would be characterized by increased values on these dimensions of L2 experience.

Method

Participants

Eighty-one participants were recruited from the undergraduate student population of the University of Wisconsin-Madison. Forty participants (17 males) were randomly assigned to learn phonologically-familiar novel words (+P), and 41 participants (18 males) were assigned to learn phonologically-unfamiliar novel words (−P). The two groups were tested on a range of linguistic and cognitive measures to ensure comparability. In addition, all participants were required to fill out the Language Experience and Proficiency Questionnaire (Marian, Blumenfeld, & Kaushanskaya, 2007), which was used to ensure that

all participants acquired English as their native language, and that the only type of second-language experience was associated with exposure to Spanish.

Standardized Testing—Each participant was administered an extensive battery of language and cognitive tests. Receptive vocabulary skills were measured using the Peabody Picture Vocabulary Test III (*PPVT-III*; Dunn & Dunn, 1997), and expressive vocabulary skills were measured using the Expressive Vocabulary Test (*EVT*; William, 1997). Participants' reading abilities were measured using the Reading Fluency sub-test of the Woodcock-Johnson Tests of Achievement-II (Woodcock, McGrew, & Mather, 2001). Short-term memory was measured using the Digit Span and the Nonword Repetition subtests of the Comprehensive Test of Phonological Processing (*CTOPP*; Wagner, Torgesen, & Rashotte, 1999). Working memory was measured using the Backward Digit Span Subtest of the Woodcock Johnson Tests of Cognitive Abilities-II. Participants' spatial and visual skills were measured using the Spatial Relations and the Visual Matching sub-tests of the Woodcock-Johnson Tests of Cognitive Ability-II (Woodcock, McGrew, & Mather, 2001). Both subtests index non-verbal intelligence. The precise values associated with participants' linguistic and cognitive performance can be found in Table 1. Independent-samples *t*-tests were used to compare the participants assigned to the +P condition and the participants assigned to the −P condition on demographic characteristics to confirm that random assignment to condition yielded comparable groups of participants. The two groups of participants did not differ with regards to demographic information, performance on English language tasks, non-linguistic cognitive measures, and phonological memory measures (all p values > 0.1).

Self-reported L2 Experience—Every participant self-identified as a native speaker of English. Spanish was the second language for every participant who reported an L2-learning experience. The Language Experience and Proficiency Questionnaire (*LEAP-Q*; Marian, Blumenfeld, & Kaushanskaya, 2007) was used to elicit data regarding each participant's L2 experiences. The *LEAP-Q* was developed to enable researchers to collect valid and reliable self-reports of language ability from multilingual unimpaired adult participants. The self-ratings of the various L2 experiences on the *LEAP-Q* have been found to be highly congruent with the objective measures of language ability (Marian, Blumenfeld, & Kaushanskaya, 2007). In the present study, participants reported the age at which Spanish was acquired, self-rated Spanish proficiency across the domains of speaking, understanding, and reading, and identified the extent to which they were currently exposed to Spanish across various context (including in conversations with friends; in family contexts; while watching TV; etc.). The precise self-reported values associated with L2 experience can be found in Table 2. Independent-samples *t*-tests were used to compare the participants assigned to the +P condition and the participants assigned to the −P condition on L2 characteristics. The two groups did not differ in self-reported L2 experiences (all p values > 0.1). Therefore, random assignment of participants to groups was successful in eliminating any potential discrepancies in L2 experiences across the two groups.

Materials

Auditory Stimuli—Phonologically-familiar (+P) novel words were selected from a set of nonword stimuli developed by Gupta et al. (2004). The nonwords in this database are controlled for phonological properties, and come in sets that are equated for consonant-onset characteristics and neighborhood density. For our task, we chose 24 pairs of bi-syllabic English pseudowords that all followed a CVCVC syllable structure. The pairs were matched on length, stress patterns, phonotactic probability, and phonological neighborhood density. Phonologically-unfamiliar (−P) stimuli were constructed by modifying the 24 pairs of nonwords selected for the +P condition to include non-English phonemes. Five non-English consonants (/χ/, /ʈ/, /ɖ/, /ʐ/, /ʁ/) and four non-English vowels (/ɨ/, /y/, /oː/, /ja/) replaced English consonants and vowels in phonologically-familiar words. A similar procedure was used successfully before with both children (e.g., Morra & Camba, 2009) and with adults (e.g., Kaushanskaya & Yoo, 2010) to precisely manipulate the phonological familiarity of the novel words. Crucially, the non-English sounds used to construct the phonologically-unfamiliar novel words in the present study are not characteristic of the phonemic inventory of Spanish. The number of non-English phonemes per word was matched across the pairs of words in each of the two lists of novel words. See Appendix A for the full list of the auditory stimuli used in the current study.

All the auditory stimuli were recorded by a native female speaker of English and edited to match in duration and intensity. The female speaker chosen to record the stimuli was a native speaker of English, with no working knowledge of Spanish. Prior to the recording session, she was extensively trained on the pronunciation of all the novel words. All the stimuli were recorded in the sound-proof booth at 20kHz sampling rate, and were normalized to 70dB amplitude using Praat. These auditory stimuli were piloted with ten monolingual English-speaking adults and 10 English-Spanish bilingual adults who did not participate in the main experiment. Pilot participants listened to each nonword (with presentation of +P and −P novel words blocked and order of block presentation counterbalanced across participants), and were asked to rate each novel words on a Likert scale where 1 was equal to “does not sound like a possible English word” and 7 was equal to “sounds like a possible English word.” −P stimuli were rated as significantly less “English-sounding” ($M = 2.14$, $SD = 1.45$) than +P stimuli ($M = 6.21$, $SD = 2.24$), $p < 0.01$, and no differences were found between ratings obtained from monolingual and bilingual speakers ($p > 0.1$).

Visual Stimuli—Twenty-four pictures of familiar animals were chosen from the International Picture Naming Database (Székely et al., 2004) for the familiar-referent (+R) task. Twenty-four pictures of unfamiliar aliens were chosen from Gupta et al. (2004) database for the unfamiliar-referent (−R) task. The alien stimuli developed by Gupta et al. (2004) were designed to represent a meaningful category with each individual exemplar having no preexisting individual name. The original database included 144 alien stimuli that were constructed to vary along three dimensions: head shape, appendage type, and number of arms. The 24 alien pictures we selected were chosen to be maximally distinct from each other (i.e., any two pictures did not share more than one attribute). All visual stimuli were black-and-white pictures that were matched in size, shading and thickness of lines.

The data regarding the pictures' visual complexity were collected from thirty-two monolingual adult speakers of English who did not participate in the main experiment. Visual complexity ratings were collected based on a procedure established by Snodgrass and Vanderwart (1980) that was successfully used to index visual complexity by a number of previous studies (e.g., Alario & Ferrand, 1999; Forsythe, Mulhern, & Sawey, 2008; Himmanen, Gentles, & Sailor, 2003). Each participant was asked to rate the visual complexity of each picture (animal and alien) on a scale from 1 (very simple) to 7 (very complex). Participants were instructed to rate the complexity of the drawing itself (rather than the real-life correlate it represented) based on the amount of detail and the intricacy of lines in the picture. Animal and alien pictures were presented in separate blocks, with order of pictures in a block randomized for each participant, and order of block-presentation counterbalanced across participants. This manner of presentation reflected the learning procedure, where novel words were taught in association with animals vs. aliens in two different sessions.

The norming procedure indicated that animal pictures were rated as less visually-complex ($M = 3.94$, $SD = 1.17$) than alien pictures ($M = 4.63$, $SD = 0.92$), $t(46) = 2.64$, $p = 0.03$. This finding was not surprising since visual complexity tends to be confounded with familiarity (e.g., Alario & Ferrand, 1999; Snodgrass & Vanderwart, 1980), with pictures that are less familiar also judged to be more visually complex. Because animal and alien pictures differed in visual complexity ratings, the analyses of word-learning data were conducted separately for familiar referents (animals) and unfamiliar referents (aliens).

Procedure

Teaching Phase—In both the +P and the −P groups, participants learned 24 novel words paired with familiar referents (animals), and 24 novel words paired with unfamiliar referents (aliens) in two different learning sessions scheduled at least one week apart. The presentation of animals vs. aliens was blocked. The order of presentation (animals vs. aliens first) was counterbalanced across participants; similarly, novel-word lists were counterbalanced across participants (i.e., half of the participants learned list A in association with animals and list B in association with aliens, and half of the participants did the reverse). For all learning trials, participants heard the novel word presented twice via headphones, and saw the corresponding picture in the middle of the computer screen. The picture remained on the screen for 6 seconds. Participants were directed to memorize the novel words and their meanings; participants were also instructed to not say anything out loud during the learning procedure.

Testing Phase—Immediately after the learning phase, participants were tested on their memory for the novel words using a forced-choice recognition task. Participants were presented with an array of four pictures (animals or aliens), and were instructed to pick a picture that corresponded in meaning to the novel word that was paired with it at learning. The position of the correct picture on the display varied randomly across trials. The foils were all pictures presented at learning. Participants were instructed to match the correct picture to the novel word as quickly as possible. The accuracy on the forced-choice

recognition task was indexed by proportion of correctly identified pictures out of the total of 24 trials.

Standardized Testing and L2-Experience Questionnaire—The standardized measures were administered to each participant in a random order, across the two sessions. Participants filled out the Language Experience and Proficiency Questionnaire (*LEAP-Q*; Marian, Blumenfeld, & Kaushanskaya, 2007) prior to the first testing session, to ensure their status as native English speakers with experience of learning Spanish as the second language.

Analyses

Two sets of analyses were conducted. First, to examine the effects of phonological familiarity on novel word-learning at different levels of referent familiarity, forced-choice recognition-accuracy data were analyzed using independent-samples *t*-tests, with phonological familiarity (+P vs. −P) as the between-subjects independent variable. Both by-subject (t_1) and by-item (t_2) analyses were conducted, in order to confirm that the effects generalized across all the participants as well as across all the stimuli. Partial η^2 (or η_p^2) indexed the effect size in the *t*-tests. The interpretation of η_p^2 relies on the following cut-offs: the minimum effect size representing a significant effect should be at least 0.04; η_p^2 of 0.25 represents a moderate effect; and η_p^2 of 0.64 represents a strong effect (Ferguson, 2009).

Second, to examine what second language (L2) experiences characterized superior word-learners, a median split designated high-accuracy and low-accuracy learners on the forced-choice recognition task. For each word-learning condition, independent-samples t-tests compared the high-performance to the low-performance participants with group as the independent between-subjects variable. The aspects of participants' L2 acquisition history were entered as the dependent variables. These variables were: Age of L2 Acquisition; ratings of L2 proficiency and L2 preference; ratings of L2 exposure across various contexts. Analyses were conducted by-subject because L2 experiences are meaningful only at the participant level.

Results

Forced-choice recognition-accuracy analyses

Forced-choice recognition accuracy rates were first compared against chance performance, defined at 0.25. Accuracy rates in the familiar referent condition were found to be above chance levels, both for the phonologically-familiar novel words (t (23) = 24.57, $p < 0.0001$) and the phonologically-unfamiliar novel words (t (23) = 18.80, $p < 0.0001$). Similarly, accuracy rates in the unfamiliar referent condition were found to be above chance levels, both for the phonologically-familiar novel words (t (23) = 7.63, $p < 0.0001$) and the phonologically-unfamiliar novel words (t (23) = 11.08, $p < 0.0001$).

Forced-choice recognition accuracy data were further analyzed using independent-samples *t*-tests with phonological familiarity (+P vs. −P) as the between-subjects independent variable. These comparisons revealed that when learning novel words for familiar referents (animals),

participants benefited from phonological familiarity associated with the novel words, with phonologically-familiar novel words (M = 0.68, SD = 0.08) recognized more accurately than phonologically-unfamiliar novel words (M = 0.60, SD = 0.09). This effect was significant by subject (t_1 (80) = 2.12, $p < 0.05$, $\eta_p^2 = 0.05$) and by item (t_2 (47) = 2.77, $p < 0.05$, $\eta_p^2 = 0.25$). However, when learning novel words associated with unfamiliar referents (aliens), participants were equally accurate at matching phonologically-familiar (M = 0.43, SD = 0.13) and phonologically-unfamiliar (M = 0.44, SD = 0.08) novel words to their corresponding pictures. The effect of phonological familiarity for unfamiliar referents was not significant either by subject (t_1 (80) = 0.31, $p = 0.76$, $\eta_p^2 = 0.001$) or by item (t_2 (47) = 0.29, $p = 0.78$; $\eta_p^2 = 0.004$). See Figure 1 for the visual representation of these results.

L2-related experience analyses

In order to examine whether L2 experience characterizes high-ability learners in each word-learning condition, independent-samples analyses were conducted with group (high-ability vs. low-ability) as a between-subjects independent variable. The median-split procedure based on forced-choice recognition-accuracy data was used to divide participants into high-ability and low-ability groups for each word-learning condition. The median-split procedure was undertaken separately for each condition, and different sub-groupings of high-ability and low-ability learners were identified for each condition. The L2-experience-related data served as dependent variables.

+P+R Condition—To confirm that the median-split procedure yielded significant differences in word-learning performance across the high-ability (n = 22) and the low-ability (n = 18) groups, we conducted independent-samples t-tests. These comparisons showed that the high-ability group (M = 0.80, SD = 0.09) outperformed the low-ability group (M = 0.53, SD = 0.10) on the forced-choice recognition measure, t (38) = 9.02, $p < 0.001$. High-ability and low-ability learners in the +P+R Condition did not differ on any L2-related characteristics (all $p > 0.1$).

+P-R Condition—To confirm that the median-split procedure yielded significant differences in word-learning performance across the high-ability (n = 19) and the low-ability (n = 22) groups, we first contrasted the two groups on the forced-choice recognition measure. Independent-samples t-tests confirmed that the high-ability group (M = 0.59, SD = 0.13) outperformed the low-ability group (M = 0.29, SD = 0.10), t (40) = 8.60, $p < 0.001$. Independent-samples t-tests that contrasted high-ability and low-ability participants on L2-related data yielded no significant differences between the two groups on any measure associated with L2 experience (all $p > 0.1$).

−P+R Condition—To confirm that the median-split procedure yielded significant differences in word-learning performance across the high-ability (n = 20) and the low-ability (n = 21) groups, we first contrasted the two groups on the forced-choice recognition measure. Independent-samples t-tests confirmed that the high-ability group (M = 0.76, SD = 0.11) outperformed the low-ability group (M = 0.44, SD = 0.07), t (40) = 10.70, $p < 0.001$. Independent-samples t-tests that contrasted high-ability and low-ability participants on L2-related data yielded a number of significant differences between the high-ability and the

low-ability groups in the L2-experience domain. Specifically, the high-ability group was characterized by higher degree of current L2 exposure (t (40) = 2.16, $p < 0.05$), higher self-rated preference to speak L2 (t (40) = 2.24, $p < 0.05$), higher self-rated L2 speaking proficiency (t (40) = 2.20, $p < 0.05$), as well as by higher extent of current exposure to television (t (40) = 2.60, $p < 0.01$), radio/music (t (40) = 2.69, $p < 0.01$), and reading (t (40) = 2.12, $p < 0.05$) in the L2. For the exact values associated with these comparisons, see Table 3.

−P-R Condition—To confirm that the median-split procedure yielded significant differences in word-learning performance across the high-ability (n = 21) and the low-ability (n = 18) groups, we first contrasted the two groups on the forced-choice recognition measure. Independent-samples t-tests confirmed that the high-ability group (M = 0.57, SD = 0.15) outperformed the low-ability group (M = 0.29, SD = 0.07) on the matching-accuracy measure, t (38) = 7.39, $p < 0.001$. Independent-samples t-tests that contrasted high-ability and low-ability participants yielded only a single significant difference between the two groups. Specifically, high-ability participants in the −P-R condition reported higher L2 reading preference (M = 4.42, SD = 7.36) than the low-ability participants (M = 0.25, SD = 0.58), t (38) = 2.26, $p < 0.05$.

Discussion

In the present study, we tested adult learners' ability to establish connections between novel words and their semantic referents, and examined the effect of phonological familiarity on novel word learning at different levels of referent familiarity. We also tested the role of second-language experiences in adults' word-learning performance. We manipulated phonological familiarity in a categorical manner, and contrasted the learning of phonologically-familiar and of phonologically-unfamiliar novel words in association with pictures of familiar referents and unfamiliar referents. We also tested whether increased learning experience gained through exposure to a second language would characterize high-ability learners. The findings revealed that phonological familiarity exerted a stronger effect on novel word learning when novel words were acquired in association with familiar referents (e.g., bɔmoʊ̯g - "lion" vs. bo:mo: χ - "lion") than when they were acquired in association with unfamiliar referents. The results also showed that L2 experiences were characteristic of high-ability learners primarily in one word-learning condition: Where participants were taught phonologically-unfamiliar novel words in association with familiar referents.

The phonological familiarity effect observed here is broadly in line with previous studies that have documented facilitation effects associated with phonological familiarity (e.g., Roodenrys & Hinton, 2002; Storkel, 2009; Storkel, Armbrüster, & Hogan, 2006; Vitevitch, 2002). However, we observed significant phonological familiarity effects in the forced-choice recognition-accuracy data only for the familiar-referents condition, and not for the unfamiliar-referent condition. This finding is likely an outcome of the cascading activation dynamics in the lexical system, and is consistent with the theoretical models of language processing that envision interactive activation dynamics between the different levels of the lexical system (e.g., Dell, Chang, & Griffin, 1999; Plaut & Kello, 1999). When semantic

information associated with the familiar referents is activated, their phonological forms are likely to be activated as well, thus galvanizing the native-language phonological network, and enabling phonological familiarity to exert its effects. In the case of unfamiliar referents, the pictures of aliens would not activate the native-language lexical-semantic system or the native-language phonological network, thus yielding flat effects of phonological familiarity in the unfamiliar referent condition.

The current findings suggest that phonological familiarity effects in novel word learning are more likely to emerge when the novel word maps onto a referent that has a salient lexical-semantic representation in the native language. This interpretation of stronger phonological familiarity effects in the familiar referent condition is in line with previous studies where interactions between the phonological and the semantic levels of the cognitive system have been found (e.g., Acheson, Postle, & MacDonald, 2010; McClelland & Elman, 1986; Mirman, McClelland, & Holt, 2005; Rapp & Goldrick, 2000; Rapp & Samuel, 2002). However, it is important to note that the patterns of findings observed here may be specific to word-learning situations where retention is probed using forced-choice recognition measures. It has been suggested that recognition-based retention measures like the one used here primarily assess the ability to retrieve *conceptual* information associated with the stimulus rather than the ability to retrieve *phonological* information associated with the stimulus (e.g., Storkel & Maekawa, 2005). Therefore, it is possible that testing measures like naming, that probe the ability to retrieve the phonological wordform (for example, picture naming) would be less susceptible to phonological/referent familiarity interactions effects than testing measures like forced-choice recognition task used in the present study. Moreover, experimental studies of word learning indicate that comprehension-based retention measures are generally easier than production-based retention tasks (e.g., Hahn & Gershkoff-Stowe, 2010; Kaushanskaya & Yoo, 2011). Simply put, comprehension places fewer demands on the learner than production. While production requires the learner to generate a response, comprehension requires the learner to identify the correct response given several options. Thus, there has to be a stronger activation of the word to enable successful production (e.g., Capone & McGregor, 2005). It is possible that the difficulty level of the retrieval task affects the robustness of phonological familiarity effects during word learning, and that relatively easy tasks like the recognition measure used here are more sensitive to the phonology-semantics interactions than the more demanding tasks. Future work would need to contrast a recognition measure with a production measure in order to examine whether the phonological familiarity/referent familiarity interaction observed in the present work would generalize to other measures of lexical retention.

The manipulation of phonological familiarity across the different levels of referent familiarity enabled us to examine the effects of L2-acquisition experience on word-learning in different learning conditions. We observed that successful performance on one learning task in particular (where phonologically-unfamiliar novel words were learned in association with familiar referents) was linked with increased L2 experience. Specifically, when learners in the −P+R condition were split into a high-ability and a low-ability subgroups, the high-ability learners were found to have more L2-related experiences than the low-ability learners. Although higher L2 experience also characterized high-ability learners in the −P-R

condition, the effect was limited to a single L2-related variable (namely, L2 reading preference). Moreover, no L2-related variables appeared to characterize high-ability learners in the two phonologically-familiar word-learning scenarios. Therefore, increased L2 experience was associated with superior word-learning when the learning task most resembled L2 acquisition, i.e., where phonologically-unfamiliar words were learned in association with familiar referents.

The finding that the L2 experience may be associated with improved word-learning is consistent with previous research that observed facilitation effects of bilingualism for novel word learning (e.g., Kaushanskaya & Marian, 2009; Papagno & Vallar, 1995). Moreover, this finding suggests that experience with a second language does not necessarily have to result in full bilingualism to exert a facilitation effect on word-learning, as the vast majority of the participants in the current study were not fully bilingual. However, the finding that L2 experience is associated with improved learning for only one of the word-learning conditions is somewhat at odds with previous studies on the bilingual effects in word-learning. There is at least one study where a significant facilitation effect of bilingualism was observed when *phonologically-familiar* novel words were learned in association with familiar referents (e.g., Kaushanskaya, 2012). The conclusion was that bilingualism facilitates learning in general, and that the effects of bilingualism on word learning are not constrained by the phonological properties of the novel words. If this is indeed the case, why was L2 experience associated primarily with learning in a −P+R word-learning condition in the present study? It is possible that while bilingualism exerts a general facilitation effect on learning, the effects of L2-related experiences on learning are more constrained. That is, it may be that only full bilingualism yields general learning effects, with *any* learning facilitated by bilingualism. However, it is likely that one does not need to be fully bilingual in order for the effects associated with second language acquisition to facilitate the learning process. These effects may be significantly restricted, and only reveal themselves in learning situations that resemble L2 acquisition. That is, a smaller degree of learning practice (as a result of L2 exposure that has not resulted in full bilingualism) may also facilitate learning but only in situations that have been practiced. In the future studies, it may therefore be productive to consider the effects of bilingualism on word-learning in a graded manner rather than the categorical manner.

The examination of multiple factors associated with L2 experiences enabled us to begin pinpointing the precise aspects of second language acquisition that may lead to the overall learning benefits. In selecting the L2-experience factors, we were guided by the extensive literature on the role of age of L2 acquisition (Birdsong, 2005; Birdsong & Molis, 2001; Flege, Yeni-Komishian, & Liu, 1999; Johnson & Newport, 1989), L2 proficiency (e.g., Bialystok & Feng, 2009; Blumenfeld & Marian, 2007), and extent of current L2 exposure (e.g., Carroll, 1967; Birdsong, 2005; Genesee, 1985; Kohnert, Bates, & Hernandez, 1999; Weber-Fox & Neville, 1999) in second-language processing. We reasoned that the L2-related factors that would characterize high-ability learners study would be crucial to engendering the positive effects of L2 experience on subsequent learning. Only one factor was revealed to characterize high-ability learners in *two* word-learning conditions – that of L2 preference. The high-ability learners in the *−P+R* condition were found to have higher

preference for speaking L2 than the low-ability learners, and the high-ability learners in the −*P*-*R* condition were found to have higher preference for reading L2 than the low-ability learners. Language preference indexes a speaker's subjective feelings towards a particular language (e.g., Marian & Neisser, 2000), and in the present study, participants who reported high levels of L2 preference may have been especially motivated to learn a foreign language. Therefore, it is possible that this variable factored into improved word-learning performance in the −*P*+*R* and the −*P*-*R* conditions because these conditions resembled foreign language acquisition the most.

In contrast to the −*P*-*R* condition, improved word-learning performance in the −*P*+*R* condition was associated not only with increased preference for the L2, but also with higher degree of current L2 exposure, higher self-rated L2 speaking proficiency, and higher extent of self-reported current exposure to television, radio/music, and reading in the L2. These variables indexed the extent to which participants were comfortable with Spanish, and the degree to which they were immersed in Spanish at the time of the study. Therefore, our findings indicate that superior word-learning performance in the −*P*+*R* condition (the condition that most closely resembles second language acquisition) is associated with increased exposure to the second language. Conversely, earlier age of L2 acquisition was not associated with superior word-learning performance. This finding was unexpected as earlier L2 acquisition has been linked to both successful L2 use, and to stronger bilingual advantages. For example, Luk, De Sa, and Bialystok (2011) found stronger bilingual advantages on a cognitive control task in early bilinguals (adults who acquired their second language prior to 10 years of age) than in late bilinguals (adults who acquired their second language after 10 years of age). Perhaps earlier acquisition of a second language (and thus a more protracted period of bilingual language usage) is crucial to the formation of bilingual advantages for cognitive control, while more extensive L2 exposure and higher L2 proficiency are crucial to the formation of bilingual advantages for lexical learning.

One limitation of this study is its inability to examine the effects of referent familiarity on novel word learning. The categorical manipulation of referent familiarity obligated us to use two sets of pictures that differed from each other not only in their familiarity, but also in their visual complexity. Although it is possible to match two sets of familiar pictures on measures of visual complexity (e.g., Donderi, 2006; Szekely & Bates, 2000), it is difficult to match a set of unfamiliar pictures and a set of familiar pictures on visual complexity. This is because visual complexity and familiarity ratings are confounded with each other in picture processing (e.g., Alario & Ferrand, 1999; Snodgrass & Vanderwart, 1980). Future studies in this line of research may be able to directly account for the visual complexity characteristics of the picture stimuli by manipulating referent familiarity in a graded rather than continuous manner, and by using *only* familiar referents or *only* unfamiliar referents to represent the referent familiarity continuum. For example, one way in which referent familiarity has been conceptualized in previous research was through the use of semantic associates (e.g., Buchanan, Westbury, & Burgess, 2001; Nelson, McKinney, Gee, & Janczura, 1998; Nelson, Schreiber, & McEvoy, 1992; Storkel & Adlof, 2009; Yates, Locker, & Simpson, 2003). Future studies may be able to use a similar approach and manipulate phonological familiarity in novel word learning by pairing phonologically-familiar and phonologically-

unfamiliar novel words with pictures of unfamiliar objects that are matched in visual complexity but that differ in their semantic set size.

In conclusion, the present study documented phonological familiarity effects in novel word learning, but only when the novel words were associated with familiar referents, and not when they were associated with unfamiliar referents. The findings also revealed that high word-learning ability was associated with increased levels of L2-experience, albeit primarily in the word-learning condition that most resembled second-language acquisition. We interpret these findings within interactive models of lexical processing and learning, where the resemblance of the novel word to known words at the multiple levels of the system can facilitate retention, and where practice with learning through L2 acquisition can facilitate retention of unpracticed items, possibly through mobilizing the existing lexical-semantic network to learn more efficiently.

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References

Acheson DJ, Postle BR, MacDonald MC. The interaction of concreteness and phonological similarity in verbal working memory. Journal of Experimental Psychology: Learning, Memory, and Cognition. 2010; 36:17–36.

Alario FX, Ferrand L. A set of 440 pictures standardized for French: Norms for name agreement, image agreement, familiarity, visual complexity, image variability, and age of acquisition. Behavior Research Methods, Instruments, & Computers. 1999; 31:531–552.

Barcroft J, Sunderman G. Learning new words for objects and nonobjects. The Mental Lexicon. 2008; 3:325–348.

Bialystok E, Feng X. Language proficiency and executive control in proactive interference: Evidence from monolingual and bilingual children and adults. Brain and Language. 2009; 109:93–100. [PubMed: 18834625]

Bialystok, E.; Hakuta, K. Confounded age: Linguistic and cognitive factors in Click for Articleage differences for second language acquisition. In: Birdsong, D., editor. Second Language Acquisition and the Critical Period Hypothesis. Mahwah, NJ: Lawrence Erlbaum Associates; 1999.

Birdsong, D. Interpreting age effects in second language acquisition. In: Kroll, J.; DeGroot, A., editors. Handbook of Bilingualism: Psycholinguistic Perspectives. Oxford: Oxford U. Press; 2005. p. 109-127.

Birdsong D, Molis M. On the evidence for maturational effects in second language acquisition. Journal of Memory and Language. 2001; 44:235–249.

Blumenfeld H, Marian V. Constraints on parallel language activation in bilingual spoken language processing: examining proficiency and lexical status using eye-tracking. Language and Cognitive Processes. 2007; 22:633–660.

Buchanan L, Westbury C, Burgess C. Characterizing semantic space: Neighborhood effects in word recognition. Psychonomic Bulletin & Review. 2001; 8:531–544. [PubMed: 11700905]

Capone NC, McGregor KK. The effect of semantic representation on toddlers' word retrieval. Journal of Speech, Language, and Hearing Research. 2005; 48:1468–1480.

Carroll, J. The foreign language attainments of language majors in the senior year: A survey conducted in US colleges and universities. Cambridge, MA: Harvard University Press; 1967.

Dell GS. The retrieval of phonological forms in production: Tests of predictions from a connectionist model. Journal of Memory and Language. 1988; 27:124–142.

Dell GS, Chang F, Griffin ZM. Connectionist models of language production: Lexical access and grammatical encoding. Cognitive Science. 1999; 23:517–542.

Donderi DC. An information theory analysis of visual complexity and dissimilarity. Perception. 2006; 35:823–835. [PubMed: 16836047]

Dunn, LM.; Dunn, LM. Peabody Picture Vocabulary Test. 3. Circle Pines, MN: American Guidance Service; 1997.

Ellis NC, Beaton A. Factors affecting the learning of foreign language vocabulary: Imagery keyword mediators and phonological short-term memory. The Quarterly Journal of Experimental Psychology. 1993; 46A:533–558. [PubMed: 8378553]

Felleman DJ, Van Essen DC. Distributed hierarchical processing in the primate cerebral cortex. Cerebral Cortex. 1991; 1:1–47. [PubMed: 1822724]

Ferguson CJ. An effect size primer: A guide for clinicians and researchers. Professional Psychology: Research and Practice. 2009; 40:532–538.

Finn AS, Hudson Kam CL. The curse of knowledge: First language knowledge impairs adult learners' use of novel statistics for word segmentation. Cognition. 2008; 108:477–499. [PubMed: 18533142]

Flege JE, Frieda A, Nozawa T. Amount of native-language (L1) use affects the pronunciation in an L2. Journal of Phonetics. 1997; 25:169–186.

Flege JE, MacKay IA, Piske T. Assessing bilingual dominance. Applied Psycholinguistics. 2002; 23:567–598.

Flege JE, Yeni-Komshian GH, Liu S. Age constraints on second-language acquisition. Journal of Memory and Language. 1999; 41:78–104.

Forsythe A, Mulhern G, Sawey M. Confounds in pictorial sets: The role of complexity and familiarity in basic-level picture processing. Behavior Research Methods. 2008; 40:116–129. [PubMed: 18411534]

Gathercole SE, Baddeley AD. The role of phonological memory in vocabulary acquisition: A study of young children learning new names. British Journal of Psychology. 1990; 81:439–454.

Gathercole SE, Frankish CR, Pickering SJ, Peaker S. Phonotactic influences on short-term memory. Journal of Experimental Psychology: Learning, Memory, and Cognition. 1999; 25:84–95.

Gathercole SE, Willis C, Emslie H, Baddeley AD. The influences of number of syllables and wordlikeness on children's repetition of nonwords. Applied Psycholinguistics. 1991; 12:349–367.

Genesee F. Second language learning through immersion: A review of U.S. programs. Review of Educational Research. 1985; 55:541–561.

Gupta P, MacWhinney B. Vocabulary acquisition and verbal short-term memory: Computational and neural bases. Brain & Language. 1997; 59:267–333. [PubMed: 9299067]

Gupta P, Lipinski J, Abbs B, Lin PH, et al. Space aliens and nonwords: Stimuli for investigating the learning of novel word-meaning pairs. Behavior Research Methods, Instruments, & Computers. 2004; 36:599–603.

Hahn ER, Gershkoff-Stowe L. Children and adults learn actions for objects more readily than labels. Language Learning and Development. 2010; 6:283–308.

Himmanen SA, Gentles K, Sailor K. Rated familiarity, visual complexity, and image agreement and their relation to naming difficulty for items from the Boston Naming Test. Journal of Clinical and Experimental Neuropsychology. 2003; 25:1178–1185. [PubMed: 14566589]

Hyltenstam, K.; Abrahamsson, N. Maturational constraints in second language acquisition. In: Doughty, C.; Long, M., editors. Handbook of second language acquisition. Malden, MA: Blackwell; 2003. p. 539-588.

Jia G, Aaronson D, Wu Y. Long-term language attainment of bilingual immigrants: Predictive variables and language group differences. Applied Psycholinguistics. 2002; 23:599–621.

Johnson JS, Newport EL. Critical period effects in second language learning: The influence of maturational state on the acquisition of English as a second language. Cognitive Psychology. 1989; 21:60–99. [PubMed: 2920538]

Kaushanskaya M. Cognitive mechanisms of word learning in monolingual and bilingual adults: The role of phonological memory. Bilingualism: Language and Cognition. 2012; 15:470–489.

Kaushanskaya M, Marian V. The bilingual advantage in novel word learning. Psychonomic Bulletin & Review. 2009a; 16:705–10. [PubMed: 19648456]

Kaushanskaya M, Marian V. Bilingualism reduces native-language interference in novel word learning. Journal of Experimental Psychology: Learning, Memory, & Cognition. 2009b; 35:829–835.

Kaushanskaya M, Marian V, Yoo J. Gender differences in adult word learning. Acta Psychologica. 2011; 137:24–35. [PubMed: 21392726]

Kaushanskaya M, Rechtzigel K. Concreteness effects in bilingual and monolingual word learning. Psychonomic Bulletin & Review. in press.

Kaushanskaya M, Yoo J. Rehearsal effects in adult word learning. Language and Cognitive Processes. 2011; 26:121–148.

Kohnert K, Bates E, Hernandez A. Balancing bilinguals: Lexical-semantic production and cognitive processing in children learning Spanish and English. Journal of Speech, Language, and Hearing Research. 1999; 42:1400–1413.

Lany J, Gómez RL. Twelve-month-old infants benefit from prior experience in statistical learning. Psychological Science. 2008; 19:1247–1252. [PubMed: 19121132]

Luk G, De Sa E, Bialystok E. Is there a relation between onset age of bilingualism and enhancement of cognitive control? Bilingualism: Language and Cognition. 2011; 14:588–595.

Magnuson JS, McMurray B, Tanenhaus MK, Aslin RN. Lexical effects on compensation for coarticulation: the ghost of Christmash past. Cognitive Science. 2003; 27:285–298.

Marian V, Blumenfeld HK, Kaushanskaya M. The Language Experience and Proficiency Questionnaire (LEAP-Q): Assessing language profiles in bilinguals and mutilinguals. Journal of Speech, Language, and Hearing Research. 2007; 50:940–967.

Marian V, Neisser U. Language-dependent recall of autobiographical memories. Journal of Experimental Psychology: General. 2000; 129:361–368. [PubMed: 11006905]

McClelland J, Elman J. The TRACE model of speech perception. Cognitive Psychology. 1986; 18:1–86. [PubMed: 3753912]

Mirman D, McClelland JL, Holt LL. Computational and behavioral investigations of lexically induced delays in phoneme recognition. Journal of Memory & Language. 2005; 52:424–443.

Morra S, Camba R. Vocabulary learning in primary school children: working memory and long-term memory components. Journal of Experimental Child Psychology. 2009; 104:156–178. [PubMed: 19515382]

Nelson DL, McKinney VM, Gee NR, Janczura GA. Interpreting the influence of implicitly activated memories on recall and recognition. Psychological Review. 1998; 105:299–324. [PubMed: 9577240]

Nelson DL, Schreiber TA, McEvoy CL. Processing implicit and explicit representations. Psychological Review. 1992; 95:322–348. [PubMed: 1594728]

Papagno C, Vallar G. Phonological short-term memory and the learning of novel words: The effects of phonological similarity and item length. Quarterly Journal of Experimental Psychology. 1992; 44A:44–67.

Papagno C, Vallar G. Verbal short-term memory and vocabulary learning in polyglots. Quarterly Journal of Experimental Psychology. 1995; 48A:98–107. [PubMed: 7754088]

Plaut, DC.; Kello, CT. The emergence of phonology from the interplay of speech comprehension and production: A distributed connectionist approach. In: MacWhinney, B., editor. The emergence of language. Mahwah, NJ: Erlbaum; 1999. p. 381-415.

Rapp B, Goldrick M. Discreteness and interactivity in spoken word production. Psychological Review. 2000; 107:460–499. [PubMed: 10941277]

Rapp DN, Samuel AG. A reason to rhyme: Phonological and semantic influences on lexical access. Journal of Experimental Psychology: LMC. 2002; 28:564–571.

Reber A. Implicit learning and tacit knowledge. Journal of Experimental Psychology: General. 1989; 118:219–235.

Roodenrys S, Hinton M. Sublexical or lexical effects on serial recall of nonwords? Journal of Experimental Psychology: Learning, Memory, & Cognition. 2002; 28:29–33.

Service E, Craik FIM. Differences between young and older adults in learning a foreign vocabulary. Journal of Memory and Language. 1993; 32:608–623.

Snodgrass JG, Vanderwart M. A standardized set of 260 pictures: Norms for name agreement, image agreement, familiarity, and visual complexity. Journal of Experimental Psychology: Human Learning and Memory. 1980; 6:174–215. [PubMed: 7373248]

Storkel HL. Phonotactic probability in language development. Journal of Speech, Language, and Hearing Research. 2001; 44:1321–1337.

Storkel HL, Adlof SM. The effect of semantic set size on word learning by preschool children. Journal of Speech, Language, & Hearing Research. 2009; 52:306–320.

Storkel HL, Armbrüster J, Hogan TP. Differentiating phonotactic probability and neighborhood density in adult word learning. Journal of Speech, Language, and Hearing Research. 2006; 49:1175–1192.

Storkel HL, Maekawa J. A comparison of homonym and novel word learning: The role of phonotactic probability and word frequency. Journal of Child Language. 2005; 32:827–853. [PubMed: 16429713]

Storkel HL, Morrisette ML. The lexicon and phonology: Interactions in language acquisition. Language, Speech, and Hearing Services in Schools. 2002; 33:24–37.

Székely A, Jacobsen T, D'Amico S, Devescovi A, et al. A new on-line resource for psycholinguistic studies. Journal of Memory and Language. 2004; 51:247–250. [PubMed: 23002322]

Van Hell JG, Candia Mahn AC. Keyword mnemonics versus rote rehearsal: Learning concrete and abstract foreign words by experienced and inexperienced learners. Language Learning. 1997; 47:507–546.

Vitevitch MS. The influence of phonological similarity neighborhoods on speech production. Journal of Experimental Psychology: Learning, Memory, and Cognition. 2002; 28:735–747.

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

Weber-Fox, C.; Neville, HJ. Functional neural subsystems are differentially affected by delays in 2nd language immersion. In: Birdsong, D., editor. Second language acquisition and the critical period hypothesis. Mahwah, NJ: Erlbaum; 1999. p. 23-38.

William, KT. Expressive Vocabulary Test. Circle Pines, MN: American Guidance Service; 1997.

Woodcock, RW.; McGrew, KS.; Mather, N. Woodcock-Johnson III. Itasca, IL: Riverside Publishing; 2001.

Yates M, Locker L, Simpson GB. Semantic and phonological influences on the processing of words and pseudohomophones. Memory and Cognition. 2003; 31:856–866. [PubMed: 14651294]

Appendix: Phonologically-Familiar and Phonologically-Unfamiliar Novel Words

	Phonologically-Familiar Novel Words		Phonologically-Unfamiliar Novel Words	
	List A	**List B**	**List A**	**List B**
1	bɔmoɣg	tɪmɔk	boːmoːχ	ʈɨmoːk
2	bɑkæs	bɔtif	boːkæʐ	boːʈif
3	taɻnɑf	gæbɛk	ʈɨnʌf	χjabɛk
4	dulɛk	tikɛs	ɖylɛk	ʈɛkɛʐ
5	tilɔɻ	daɻnum	ʈɛloʁ	ɖɨnym
6	pɑtæb	tɛbɔn	pyʈæb	ʈɛboːn

	Phonologically-Familiar Novel Words		Phonologically-Unfamiliar Novel Words	
	List A	**List B**	**List A**	**List B**
7	koˠnoˠv	kɑdaɻl	ko:no:v	kydɨl
8	dɪsɑt	beɪtɑl	dɛzˤyt̪	bjat̪yl
9	gætik	bitɛs	χjat̪ik	bit̪izˤ
10	piɻcɻ	tɑsɛn	pɨʁɔʁ	t̪yzˤɛn
11	gæsɛn	bæsɪm	χæzˤɛn	bæzˤɨm
12	kɔnit	keɪfeɪn	ko:nit̪	kjafjan
13	geɪgɛk	geɪpum	χjaχɛk	χjapym
14	bidɑs	bɔsæg	bɛɖo:zˤ	bɔzˤjaχ
15	teɪnɔm	poˠsɔf	t̪jano:m	po:zˤo:f
16	teɪsɔl	deɪniv	tjazˤo:l	ɖjaniv
17	dunɛm	poˠsɛg	ɖynɛm	po:zˤɛχ
18	tikis	boˠnid	t̪ɛkizˤ	bo:niɖ
19	gaɻlæt	daɻsɜˑ	χɨlæt̪	ɖɨzˤɜˑ
20	teɪnik	pirɑk	t̪janik	piʁyk
21	dɔsin	peɪtɔl	ɖo:zˤin	pjat̪o:l
22	dɔbeɪn	kinaɻɻ	ɖo:bjan	kinɨʁ
23	kaɻseɪd	toˠsoˠt	kizˤjaɖ	to:zˤo:t
24	kɔtin	paɻnɪt	ko:t̪in	paɻnɨt̪

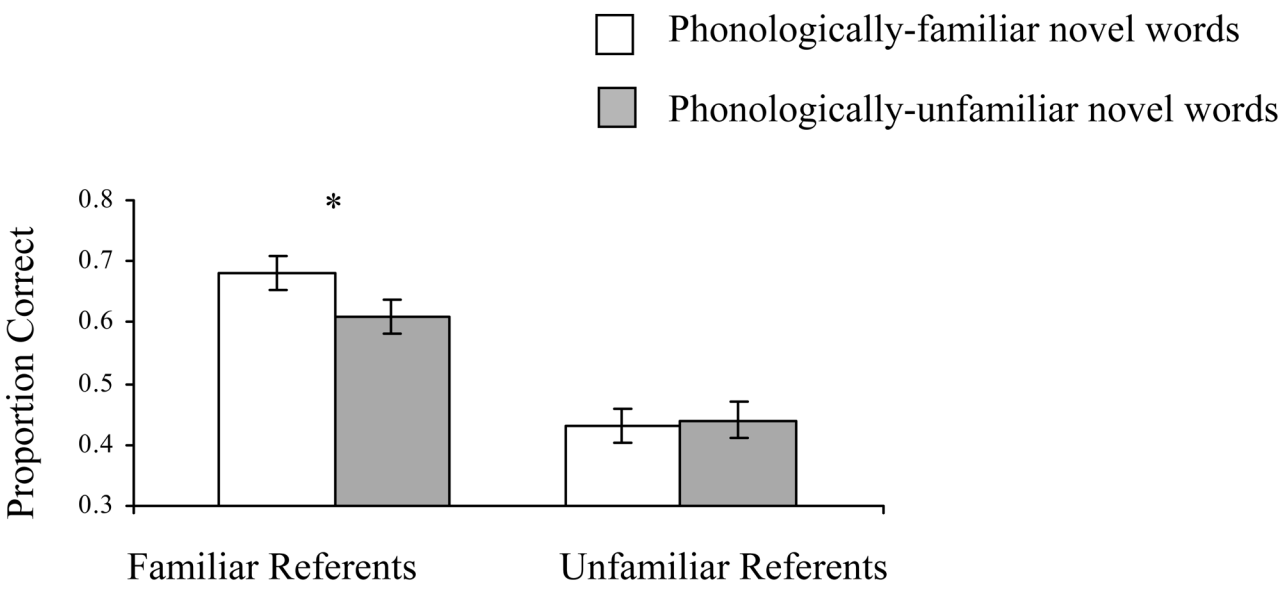

Figure 1.

Forced-choice recognition-accuracy comparisons across the four word-learning conditions (+P+R; +P-R; −P+R; and −P-R). Significant differences between conditions at $p < 0.05$ are marked by an asterisk.

Table 1

Participant Characteristics in Phonologically-Familiar vs. Phonologically-Unfamiliar Conditions (Means and SD values)

	Phonologically-Familiar Condition	Phonologically-Unfamiliar Condition
Age	22.23 (3.92)	22.29 (5.46)
Years of Education	15.59 (1.62)	15.44 (2.05)
PPVT-III (percentile)	74.71 (18.71)	71.16 (17.54)
EVT (percentile)	84.70 (18.11)	77.92 (19.98)
Reading Fluency (percentile)	78.39 (16.27)	77.00 (20.64)
Digit Span (percentile)	76.23 (19.53)	76.05 (18.86)
Nonword Repetition (percentile)	55.95 (23.26)	46.57 (25.13)
Dackward Digit Span (percentile)	73.77 (22.21)	70.38 (21.57)
Spatial Relations (percentile)	67.61 (18.46)	65.50 (18.21)
Visual Matching (percentile)	67.00 (22.24)	65.47 (20.90)

Table 2

L2-Related Experiences of Participants in Phonologically-Familiar vs. Phonologically-Unfamiliar Conditions (Means and SD values)

	Phonologically-Familiar Condition	Phonologically-Unfamiliar Condition
L2 Acquisition Age	11.92 (3.91)	11.57 (4.73)
Cumulative L2 Exposure (percent)	4.18 (8.34)	4.78 (7.52)
L2 Reading Preference	3.65 (10.89)	3.46 (8.35)
L2 Speaking Preference	9.68 (14.11)	7.16 (10.65)
Years in L2-speaking country	2.06 (6.60)	0.25 (0.66)
Years in L2-speaking family	1.32 (5.04)	0.97 (4.62)
Years in L2-speaking school	2.40 (4.46)	2.37 (4.10)
L2 Speaking Proficiency	3.84 (2.33)	4.44 (2.43)
L2 Understanding Proficiency	4.27 (2.50)	4.79 (2.76)
L2 Reading Proficiency	4.22 (2.62)	4.71 (2.53)
Current exposure to L2-speaking friends	1.84 (1.92)	1.57 (1.46)
Current exposure to L2 in the family	0.68 (1.94)	0.60 (1.63)
Current exposure to L2 via TV	1.32 (1.89)	1.09 (1.46)
Current exposure to L2 via Radio	1.57 (1.91)	1.71 (1.98)
Current exposure to L2 Reading	1.86 (2.03)	1.97 (2.11)

Note. L2 preference was measured on the scale from zero to 100 (with zero indicating no preference). L2 proficiency was measure on the scale from zero to 10 (with zero indicating no knowledge of the language). Current L2 exposure was measured on the scale from zero to 10 (with zero indicating no exposure).

Table 3

Comparisons between high-ability and low-ability learners in the −P+R condition on L2-related experiences (Means and SD values)

	High-Ability Learners	Low-Ability Learners
Cumulative L2 Exposure (percent)	7.21 (9.32)	2.06 (3.31)
L2 Speaking Preference	10.79 (12.44)	3.33 (6.80)
L2 Speaking Proficiency	5.21 (2.44)	3.47 (2.10)
L2 Understanding Proficiency	5.84 (2.75)	3.47 (2.20)
Current exposure to L2 via TV	1.63 (1.74)	0.44 (0.63)
Current exposure to L2 via radio	2.47 (2.32)	0.81 (0.91)
Current exposure to L2 reading	2.63 (2.39)	1.19 (1.42)