

## Second-Language Sound Learning in Children and Adults: Learning Sounds, Words, or Both?

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### 1. Introduction

What factors influence children's and adults' production of second-language sound segments (or "sounds" for short)? Previous research has identified at least two, among others. The first factor, "cross-language similarity," refers to how perceptually similar sounds are in a native (L1) and second (L2) language. That is, the degree of perceived dissimilarity (or similarity) between L1 and L2 sounds determines how L2 sounds are perceived and produced (Flege, 1995). For example, Japanese learners may produce the English /ɹ/ more accurately than the English /l/ (Flege, Takagi, & Mann, 1995) because they are more likely to perceptually differentiate the English /ɹ/, but not /l/, from the Japanese /r/ (Aoyama, Flege, Guion, Yamada, & Akahane-Yamada, 2002). Japanese learners may also produce the English /t/ more accurately than the English /θ/ because they are more likely to perceptually equate the English /t/, but not /θ/, with the similar Japanese /t/ (Guion, Flege, Akahane-Yamada, & Pruitt, 2000). L2 production thus depends on the perceived distance between L1 and L2 sounds. That is, depending on the particular relationship between individual L1 and L2 sounds, cross-language similarity can either help or hinder L2 production.

The second factor that influences L2 production is related to the phonetic, syllabic, phonotactic, or prosodic "context" in which L2 sounds occur. That is, learners may have difficulty producing an L2 sound when it occurs in the context of certain sounds or in certain word- or phrase-stress conditions (Strange, Akahane-Yamada, Kubo, Trent, et al., 1998). It is known, for example, that English liquids differ in phonetic realization in word-initial and word-final position and, perhaps because of this, Japanese adults differ in the ability to produce /ɹ/-/l/ distinctions as a function of word position (Bradlow, Pisoni, Akahane-Yamada, & Tohkura, 1997). Both factors—perceived cross-language similarity and phonetic context—may be thought of as segmental or "sound-related" factors.

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In addition to these sound-related factors, lexical or word-related factors may also influence the production of L2 sounds. Examples of such factors are "word frequency" and "word familiarity." (Word frequency refers to the frequency with which words are used in a language, whereas word familiarity is a subjective index of how often speakers have experienced words.) Children and adults are sensitive to these factors in their L1, producing sounds more accurately and rapidly in more frequent (and familiar) than less frequent (and less familiar) words (Munson, 2001; Vitevitch, Luce, Charles-Luce, & Kemmerer, 1997). This suggests that children and adults learn something about sounds from (mere) experience with words. In fact, in L1 development, children appear to first learn words as whole phonological units and only later to "decompose" them into individual sounds (Menn, 1981).

Are lexical factors as important in L2 learning as they appear to be in L1 development? Do children and adults also learn something about L2 sounds from experience with L2 words? Relatively few studies have so far addressed such questions. One study examined adult Japanese speakers' perception of the English /ɹ/-/l/ contrast (Flege, Takagi, & Mann, 1996). The speakers tended to correctly identify the /ɹ/ and /l/ tokens (i.e., as /ɹ/ and /l/) more often when they occurred in words that were more familiar to the speakers than their minimal pairs (i.e., when the /ɹ/ in *room* was paired with low-frequency *loom* and the /l/ in *lip* was paired with low-frequency *rip*). Another study examined adult Spanish speakers' production of the word-initial English /t/ (Flege, Frieda, Walley, & Randazza, 1998). The voice-onset-time values in the speakers' productions did not appear to depend on any of the lexical factors examined (age of acquisition, cognate status, word familiarity). These findings suggest that it is not yet possible to draw firm conclusions as to whether, or to what extent, learners' experience with particular lexical items influences their production and perception of phonetic segments making up those items. Clearly, more research is needed to determine how lexical and segmental factors influence L2 learning and to extend investigation of these factors from adults to children and to learners differing in L2 experience.

The present study was thus undertaken to answer two related questions: (1) How do lexical and segmental factors influence L2 learning by children and adults? and (2) Does this influence differ depending on children's and adults' amount of experience with L2 sounds and words? Two experiments were conducted. Experiment 1 examined how two segmental (cross-language similarity, syllabic context) and two lexical (word frequency, word familiarity) factors influenced native Korean child and adult learners' production of 8 English vowels in 24 words after a relatively short exposure to English. Experiment 2 examined how these same factors influenced child and adults learners' production of the same vowels after a longer exposure to English. Overall, this study sought to determine the extent to which L2 learning may be characterized by "sound learning," "word learning," or both.

## 2. Experiment 1: Vowel Production after 1 Year in the U.S.

### 2.1. Method

Experiment 1 examined the production of English vowels by Korean adults and children who had lived only briefly (about 1 year) in the U.S. The aim was to determine if the learners' production accuracy was consistent, or whether it varied across (a) the perceived similarity between English and Korean vowels, (b) the context in which vowels occur, (c) word frequency and/or (d) familiarity.

**Table 1: Stimuli Used in Experiments 1 and 2**

/i/	/ɪ/	/e/	/æ/	/u/	/ʊ/	/ʌ/	/ɑ/
beat	bit	pet	bat	boot	book	bud	pot
bead	big	bed	bad	bood	good	bug	pod
heat	hid	head	hat	hoop	hood	hut	hot

Experiment 1 (and also Experiment 2) examined 8 English vowels (/i/, /ɪ/, /e/, /æ/, /u/, /ʊ/, /ʌ/, /ɑ/) in 24 CVC words (Table 1). The participants were 10 native Korean children (designated "Child+1") who had lived in the U.S. for about 1 year (range: 0;5-1;8), and 10 native Korean adults ("Adult+1") who had lived in the U.S. for about 7 months (range: 0;1-1;9). Ten age-matched native English adults ("NE Adult") and 10 children ("NE Child") also participated as controls (Table 2).

**Table 2: Characteristics of Participants in Experiments 1 and 2**

	CA <sup>a</sup>	AOA <sup>b</sup>	RES <sup>c</sup>	K. Use <sup>d</sup>	E. Rate <sup>e</sup>
Adult+1 (10)	22.8 (1.6)	22.2 (1.4)	0.6 (0.5)	56%	5.0 (1.5)
Child+1 (10)	8.8 (1.1)	7.8 (1.3)	1.0 (0.5)	68%	4.4 (2.5)
Adult+7 (10)	28.0 (7.0)	21.6 (5.3)	6.9 (3.3)	61%	6.7 (1.8)
Child+7 (10)	16.1 (4.0)	9.0 (2.3)	7.1 (3.6)	48%	7.4 (1.6)
NE Adult (10)	20.7 (1.4)				10.0 (0.0)
NE Child (10)	8.6 (0.5)				9.4 (0.5)

<sup>a</sup>Chronological age, in years. <sup>b</sup>Age of arrival in the U.S., in years. <sup>c</sup>Length of U.S. residence, in years. <sup>d</sup>Percent of daily Korean use. <sup>e</sup>English self-rating on a scale from 1 to 10. Note: Standard deviations appear in parentheses.

A picture-naming task was used to elicit the words in Table 1. The participants were first familiarized with picture names and were then asked to spontaneously name the pictures as they were presented in 3 random iterations. Each participant's spontaneous productions of the words were later randomly presented to 10 native English listeners from Utah (trained in phonetics) who transcribed the vowels, with no explicit instructions as to the intended vowel or word. The dependent variable was the number of listeners (maximum=10) who identified the vowel in each of the 24 words spoken by each participant as inten-

ded (e.g., transcribed the vowel in *bit* as /ɪ/).

## 2.2. Data Analysis

The production scores obtained for the two child groups (Child+1, NE Child) and the two adult groups (Adult+1, NE Adult) were examined in separate two-way repeated-measures analyses of variance (ANOVAs). Separate analyses were performed because the Korean adults and children differed along dimensions in addition to age of arrival in the U.S. (e.g., years of English education in Korea, amount of native-speaker input in the U.S.). In each ANOVA, native language (Korean vs. English) served as a between-subjects factor. Cross-language similarity, syllabic context, word frequency, and word familiarity served as within-subjects factors. Bonferroni tests (t-tests with  $\alpha$  adjusted for number of pairwise comparisons) were used to explore significant main effects and interactions.

Two sets of words were examined to evaluate *perceived cross-language similarity* (or “similarity” for short). One set of words contained English vowels (/i/, /ɪ/, /u/, /a/) that were judged by Korean participants in an earlier study (Baker, Trofimovich, Mack, & Flege, 2002) to be relatively similar to Korean vowels. The other set contained English vowels (/ʌ/, /ʊ/, /æ/, /ɛ/) that were judged to be relatively dissimilar to the closest Korean vowel. In the earlier study, Korean adults and children identified each similar vowel with a single Korean vowel on average 79% and 66% of the time, respectively, and each dissimilar vowel with a single Korean vowel 59% and 41% of the time.

The Speech Learning Model (SLM) proposes that, in early stages of L2 learning, learners are likely to produce L2 sounds that are similar to L1 sounds more accurately than those that are relatively dissimilar from the closest L1 sound (e.g., Flege, 1995). (The model predicts, however, that dissimilar sounds will ultimately be produced more accurately than the similar ones because, by hypothesis, perceived cross-language dissimilarity promotes category formation.) As already mentioned, the Koreans had lived in the U.S. for only about 1 year, and so might be regarded as relatively inexperienced in English. The participants should therefore produce English vowels judged to be relatively similar to Korean vowels more accurately than English vowels judged to be relatively dissimilar from the closest Korean vowel (cf. Trofimovich, Baker, & Mack, 2001).

For analyses by *syllabic context* (hereafter, “context”), the words were divided into three sets, containing either voiced-final (“C\_C<sub>voice+</sub>,” n=8), voiceless-final (“C\_C<sub>voice-</sub>,” n=7), or /h/-initial (“h\_C,” n=8) words (Table 1). (Note: The word sets differed in other ways as well; e.g., the /h/-initial words ended in /v/, /d/, and /p/.) Whereas the voiceless glottal fricative /h/ exerts little influence on the acoustic properties of the following English vowel (Olive, Greenwood, & Coleman, 1993), word-final stops systematically influence English vowels. That

is, English vowels are shorter before voiceless than voiced stops (House & Fairbanks, 1953), at least in stressed, prepausal positions (Mack, 1982). The SLM hypothesis regarding similarity (which refers only to segments, not “segments-in-contexts”) might be extended in the following way: L2 sounds will be produced more accurately by inexperienced L2 learners if sounds occur in a familiar than an unfamiliar context. If so, then the participants should produce English vowels more accurately before voiceless word-final stops (which exist in Korean) than before voiced word-final stops (which do not).

For analyses by *text frequency* (Kucera & Francis, 1967), the words were divided into two sets, with one set containing 12 words (*pot, beat, heat, hat, bad, head, bit, hot, big, bed, book, good*) of relatively high frequency (mean: 211; range: 28-807) and the other 12 words (*bud, pod, hut, pet, bat, bug, hid, bug, bead, boot, booted, hood, hoop*) of relatively low frequency (mean: 7; range: 1-18). If word frequency influences L2 production, the participants should produce English vowels more accurately in high- than low-frequency words.

For analyses by *word familiarity*, the words were divided into two sets, based on the Korean participants’ rating of the 24 words on a scale between 1 (“I don’t know the word”) and 7 (“I know the word very well”). (Following the practice of Bradlow & Pisoni, 1999, these ratings will be referred to as “subjective word familiarity” ratings.) One set thus contained 12 relatively familiar words (*pot, beat, heat, hat, bad, head, bit, hot, big, bed, book, good*) and the other set contained 12 relatively unfamiliar words (*bead, hoop, hid, bug, bud, hut, booted, pod, boot, hood, pet, bat*). For the children, mean ratings for the familiar and unfamiliar sets were 6.3 (range: 5.7-7.0) and 4.5 (range: 1.7-6.2), respectively; for the adults, they were 6.9 (range: 6.1-7.0) and 5.3 (range: 2.7-7.0), respectively. If familiarity influences L2 production, the participants should produce English vowels more accurately in familiar than unfamiliar words.

## 2.3. Results

### 2.3.1. Effect of Segmental and Lexical Factors

*Similarity.* The NE Child group received higher mean-accuracy scores than the Child+1 group did, both for similar (99% vs. 75%) and dissimilar vowels (93% vs. 67%). The ANOVA examining these scores yielded significant main effects of language [ $F(1,18)=23.0$ ,  $p<.001$ ] and similarity [ $F(1,18)=14.1$ ,  $p<.001$ ] but no significant language  $\times$  similarity interaction. The Child+1 group produced vowels significantly less accurately than the NE Child group ( $p<.001$ ). Neither group’s scores differed as a function of similarity.

The NE Adult group received higher scores than the Adult+1 group for similar (96% vs. 63%) and dissimilar vowels (94% vs. 51%). The ANOVA comparing these scores yielded significant main effects of language [ $F(1,18)=428.4$ ,  $p<.001$ ] and similarity [ $F(1,18)=13.1$ ,  $p<.01$ ] and a significant language  $\times$  similarity interaction [ $F(1,18)=7.7$ ,  $p<.025$ ]. The Adult+1 group produced vowels

less accurately than the NE Adult group ( $p < .001$ ). The Adult+1 group produced similar vowels more accurately than dissimilar vowels ( $p < .01$ ).

**Context.** The NE Child group scored higher than the Child+1 group for vowels in the C\_C<sub>voice+</sub> (97% vs. 73%), C\_C<sub>voice-</sub> (97% vs. 72%), and h\_C (95% vs. 68%) contexts. The ANOVA examining these scores yielded a significant main effect of language [ $F(1,18)=23.9$ ,  $p < .001$ ] but no main effect of context and no language  $\times$  context interaction. The Child+1 group produced vowels significantly less accurately than the NE Child group ( $p < .001$ ). Neither group's scores differed as a function of context.

The NE Adult group scored higher than the Adult+1 group for vowels that occurred in the C\_C<sub>voice+</sub> (95% vs. 65%), C\_C<sub>voice-</sub> (93% vs. 59%), and h\_C (95% vs. 48%) contexts. The ANOVA comparing these scores yielded significant main effects of language [ $F(1,18)=565.1$ ,  $p < .001$ ] and context [ $F(2,36)=6.1$ ,  $p < .01$ ] and a significant language  $\times$  context interaction [ $F(2,36)=7.9$ ,  $p < .001$ ]. The Adult+1 group produced vowels less accurately than the NE Adult group ( $p < .001$ ), and more accurately in the C\_C<sub>voice+</sub> than h\_C context ( $p < .01$ ).

**Frequency, familiarity.** The NE Child group scored higher than the Child+1 group, both for vowels in high- (98% vs. 73%) and low- (94% vs. 69%) frequency words and vowels in more (97% vs. 72%) and less (95% vs. 70%) familiar words. The NE Adult group scored higher than the Adult+1 group, for vowels in high- (96% vs. 58%) and low- (94% vs. 56%) frequency words and vowels in more (95% vs. 56%) and less (95% vs. 59%) familiar words. ANOVAs examining these scores, however, yielded no significant main effects of frequency or familiarity and no significant interactions with the language factor.

### 2.3.2. Interaction between Segmental and Lexical Factors

Previous analyses compared the production of vowels that differed along several dimensions, which may have been confounded. Therefore, in an attempt to reduce the effect of possible confounds, the word sets were subdivided further. Words containing similar and dissimilar vowels were subdivided according to frequency (yielding 4 sets of 6 words) and familiarity (yielding 4 additional sets). Similarly, words classified by syllabic contexts were subdivided according to frequency (yielding 6 sets of 4 words) and familiarity (yielding 6 additional sets). This resulted in 4 combinations of segmental and lexical factors: (1) frequency  $\times$  similarity, (2) frequency  $\times$  context, (3) familiarity  $\times$  similarity, (4) familiarity  $\times$  context (Table 3). The production scores for each of the participant groups were submitted to two-way repeated-measures ANOVAs in which similarity, context, frequency, and familiarity served as within-subjects factors.

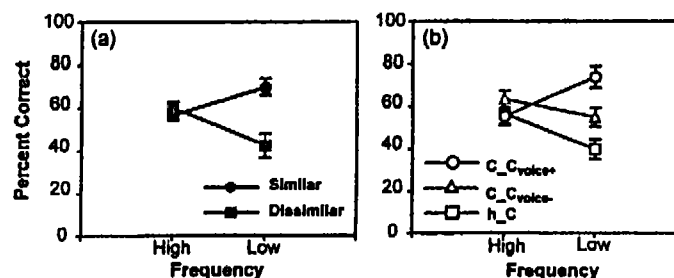
These analyses revealed that cross-language similarity and syllabic context affected the production of vowels by the Korean adults (Adult+1), but not children. However, as shown in Figure 1, the effects of similarity and context on the adults' production were confined to low-frequency and less familiar words. (For

the Adult+1 group, the ANOVAs yielded 4 significant interactions: frequency  $\times$  similarity [ $F(1,9)=27.6$ ,  $p < .001$ ], frequency  $\times$  context [ $F(2,18)=8.6$ ,  $p < .01$ ], familiarity  $\times$  similarity [ $F(1,9)=28.1$ ,  $p < .001$ ], and familiarity  $\times$  context [ $F(2,18)=4.3$ ,  $p < .05$ ].) The Adult+1 group's production thus differed as a function of similarity only in low-frequency (similar: 70%; dissimilar: 43%) and less familiar (similar: 77%; dissimilar: 41%) words ( $p < .01$ ). The Adult+1 group's production also differed as a function of context only in low-frequency (C<sub>voice+</sub>: 74%; h\_C: 40%) and less familiar (C<sub>voice+</sub>: 74%; h\_C: 41%) words ( $p < .01$ ).

**Table 3: Characteristics of Word Sets Used for Analyses of Interactions**

	Similarity		Syllabic Context		
	Similar	Dissimilar	C_C <sub>voice+</sub>	C_C <sub>voice-</sub>	h_C
High frequency <sup>a</sup>	131	292	359	98	177
Low frequency <sup>a</sup>	4	10	4	13	7
<b>More familiar<sup>b</sup></b>					
Child+1	6.5	6.2	6.3	6.8	6.3
Adult+1	6.8	7.0	7.0	6.9	6.8
<b>Less familiar<sup>b</sup></b>					
Child+1	3.9	5.0	3.4	5.3	4.4
Adult+1	4.3	5.5	3.8	4.6	5.5

<sup>a</sup>Text frequency, occurrences per million. <sup>b</sup>Mean word familiarity, rating 1-7.



**Figure 1. Korean Adults' (Adult+1) Production of English Vowels in High- and Low-Frequency Words by (a) Similarity and (b) Context**

### 2.4. Discussion

This experiment revealed that lexical and segmental factors affected how the Korean adults—but not the Korean children nor the native English children and adults—produced English vowels. The Korean adults showed effects of cross-language similarity and syllabic context. That is, they produced similar vowels more accurately than dissimilar vowels, and vowels in some contexts more accurately than in others. The Korean adults also showed frequency and familiarity effects. That is, whenever English vowels occurred in low-frequency and

less familiar words, the adults obtained higher production scores for similar than dissimilar vowels, and higher scores for vowels in the  $C_{\text{voice+}}$  than  $h\_C$  context. Stated differently, when vowels occurred in high-frequency and more familiar words, the adults were able to “overcome” the effects of cross-language similarity and context (i.e., L1-based factors affecting L2 production). These findings suggest that, as L2 learning progresses and knowledge of the L2 lexicon increases, the effect of developing lexical knowledge on segmental production may be more evident for adults than children.

The results of Experiment 1 raise the following question: Does more extensive experience with L2 sounds and words affect children’s and adults’ L2 production? That is, do lexical and segmental factors influence how children and adults who are exposed to an L2 for a longer period of time produce L2 sounds? It is likely that, with a longer L2 exposure (and thus a more extensive experience with L2 sounds and words), children will again show no, and adults will demonstrate reduced, effects of the lexical and segmental factors examined in this study. A second experiment was conducted to test this hypothesis.

### 3. Experiment 2: Vowel Production after 7 Years in the U.S.

#### 3.1. Method

Experiment 2 examined the production of English vowels by Korean adults and children who had lived in the U.S. for about 7 years. The assumption was that the participants examined here had spoken and heard English more often than the Korean participants in Experiment 1. Thus, the aim was to determine if these relatively experienced Korean speakers of English would produce English vowels consistently or whether, after 7 years of U.S. residence, they would still show the influence of (a) similarity, (b) context, (c) frequency, and/or (d) familiarity.

The participants were 10 Korean children and 10 adults (Child+7, Adult+7) who had resided in the U.S. for about 7 years (ranges: 4;5-15;8 and 5;0-15;2, respectively). These participants arrived in the U.S. at the same age as the Korean participants examined in Experiment 1 (Table 2). This experiment used the same materials and procedures as described earlier for Experiment 1. As in Experiment 1, the data for the Korean adults and children were examined separately because the adults and children differed along dimensions in addition to age of arrival in the U.S. (e.g., amount of native-speaker input in the U.S.).

#### 3.2. Results

##### 3.2.1. Effect of Segmental and Lexical Factors

*Similarity.* The NE Child group scored higher than the Child+7 group, both for similar (99% vs. 89%) and dissimilar (93% vs. 84%) vowels. The ANOVA examining these scores yielded significant main effects of language [ $F(1,18)=8.0, p<0.025$ ] and similarity [ $F(1,18)=10.5, p<0.01$ ], but no significant language ×

similarity interaction. The NE Child group produced similar vowels more accurately than the Child+7 group ( $p<0.01$ ). Neither group’s scores differed as a function of similarity.

The NE Adult group received higher scores than the Adult+7 group, for both similar (96% vs. 73%) and dissimilar (94% vs. 69%) vowels. The ANOVA comparing these scores yielded a significant main effect of language [ $F(1,18)=89.7, p<0.001$ ], but no main effect of similarity and no language × similarity interaction. The Adult+7 group produced vowels less accurately than the NE Adult group ( $p<0.001$ ). Neither group’s scores differed as a function of similarity.

*Context.* The NE Child group scored higher than the Child+7 group, at least for vowels in some contexts:  $C\_C_{\text{voice+}}$  (97% vs. 91%),  $C\_C_{\text{voice-}}$  (97% vs. 83%),  $h\_C$  (95% vs. 83%). The ANOVA examining these scores yielded significant main effects of language [ $F(1,18)=8.6, p<0.01$ ] and context [ $F(2,36)=7.2, p<0.01$ ] and a significant language × context interaction [ $F(2,36)=4.2, p<0.025$ ]. The Child+7 and NE Child groups’ scores differed significantly only for vowels in the  $C\_C_{\text{voice-}}$  context. The Child+7 group produced vowels more accurately in the  $C\_C_{\text{voice+}}$  than  $C\_C_{\text{voice-}}$  and  $h\_C$  contexts ( $p<0.01$ ).

The NE Adult group scored higher than the Adult+7 group for vowels in the  $C\_C_{\text{voice+}}$  (95% vs. 78%),  $C\_C_{\text{voice-}}$  (93% vs. 64%), and  $h\_C$  (95% vs. 67%) contexts. The ANOVA examining these scores yielded significant main effects of language [ $F(1,18)=94.0, p<0.001$ ] and context [ $F(2,36)=9.1, p<0.001$ ] and a significant language × context interaction [ $F(2,36)=6.3, p<0.01$ ]. The Adult+7 group produced vowels less accurately than the NE Adult group in all contexts ( $p<0.001$ ). The Adult+7 group’s production was more accurate in the  $C\_C_{\text{voice+}}$  than  $C\_C_{\text{voice-}}$  and  $h\_C$  contexts ( $p<0.01$ ).

*Frequency.* The ANOVA comparing the NE Child and Child+7 groups’ scores for vowels in high- (98% vs. 87%) and low- (94% vs. 85%) frequency words yielded a significant main effect of language [ $F(1,18)=8.5, p<0.01$ ] but no main effect of frequency and no language × frequency interaction. The Child+7 group produced vowels in high-frequency words less accurately than the NE Child group ( $p<0.01$ ). Neither group’s scores differed as a function of frequency.

The ANOVA comparing the NE Adult and Adult+7 groups’ scores for vowels in high- (96% vs. 74%) and low- (94% vs. 68%) frequency words yielded a significant main effect of language [ $F(1,18)=88.9, p<0.001$ ] but no main effect of frequency and no language × frequency interaction. The Adult+7 group produced vowels less accurately than the NE Adult group ( $p<0.001$ ) and neither group’s scores differed as a function of frequency. (No analyses by familiarity were performed because the participants rated all words as “familiar.”)

##### 3.2.2. Interaction between Segmental and Lexical Factors

Analyses of interactions between lexical and segmental factors were performed as in Experiment 1. These analyses revealed that syllabic context

affected the production of vowels by the Korean adults (Adult+7) but not children. However, the effect of context on the adults' production was confined to low-frequency words. (For the Adult+7 group, the ANOVAs yielded a significant frequency  $\times$  context interaction [ $F(2,18)=9.9, p<.001$ ].) The Adult+7 group's scores were higher for vowels in the C\_ C<sub>voice+</sub> than in the other two contexts ( $p<.01$ ) when these vowels occurred in low-frequency words (C<sub>voice+</sub>: 78%; C<sub>voice-</sub>: 64%; h\_C: 67%). This is the same pattern of results that was obtained for less experienced Korean adults in Experiment 1; see Figure 1(b).

### 3.3. Discussion

Results of this experiment revealed that only one factor affected how the Korean adults and Korean children produced English vowels. Korean adults and children who had lived in the U.S. for 7 years showed context effects, producing vowels more accurately in one lexical set (C\_ C<sub>voice+</sub>) than in the other two. It is uncertain why this finding was obtained. Perhaps hearing English vowels in words ending in /d/ (which does not terminate Korean words) called special attention to the vowels, or perhaps vowel lengthening before /d/ in English highlighted differences between English and Korean vowels. The important finding of this experiment was that the adults were able to overcome this effect of lexical set (roughly equivalent to phonetic context) when they produced vowels in high-frequency words. Thus, additional experience with L2 words may influence how adults produce L2 vowels.

Comparisons across the two experiments revealed significantly more accurate production by children and adults who had resided in the U.S. 7 vs. 1 year (children: [ $t(18)=2.5, p<.025$ ]; adults: [ $t(18)=4.6, p<.0001$ ]). The more experienced participants showed less variation in production accuracy across lexical set (i.e., context), similarity, lexical frequency, and familiarity than the relatively inexperienced participants did. One possible interpretation of these findings is that more generalized, abstract representations are developed for L2 sound segments during the course of L2 learning (Flege, 1995). Further work is needed to determine if lexical and syllabic context effects become smaller during L2 learning, and whether this diminution (if observed) is equal for children and adults.

### 4. General Discussion

The present study was conducted to answer two related questions: (1) How do lexical and segmental factors influence L2 learning by children and adults? and (2) Does this influence differ depending on children's and adults' amount of L2 experience? This study examined how cross-language similarity, syllabic context, word frequency, and subjective word familiarity influenced L2 production by children and adults exposed to the L2 for about 1 and 7 years.

Results of this study suggest that adult L2 learning can be characterized by

an interaction between lexical and segmental factors. Adult L2 production was influenced by cross-language similarity and context. Adult L2 production was also influenced by lexical frequency and familiarity, especially when segmental influences were particularly strong (i.e., for dissimilar L2 vowels or vowels in relatively "difficult" syllabic contexts). This finding is important to speech-learning research because it suggests that adults' word knowledge (indexed here by learners' subjective word familiarity) and their accruing experience with the L2 lexicon (indexed here by word frequency) may help them overcome (largely L1-based) segmental "constraints" on L2 learning.

Results of this study leave unanswered the precise contribution of lexical and segmental factors to child L2 learning. The effect of lexical and segmental factors on child L2 production was non-significant in this study. This finding might be due, at least in part, to the use of a relatively insensitive measure of vowel production accuracy. That is, lexical and segmental influences on child L2 production may have been detected had a more sensitive measure of production been obtained. Another reason for this finding might be related to differences in children's and adults' L2 experience. That is, the Korean children may have demonstrated less influence of lexical and segmental factors upon production because they had received more native-speaker input (e.g., while attending U.S. schools) and/or had progressed further in their learning of the English sound system than the Korean adults had. If this is indeed the case, then a hypothesis to be explored in further research is this: As L2 learning progresses, L2 segmental production should show progressively less influence of lexical and segmental factors. In any case, the Korean children examined here, but not the Korean adults, seemed to produce English vowels consistently, that is in a way that showed relatively little influence of lexical factors and syllabic context. In this sense, they resembled the native English children and adults.

In summary, the present study revealed a complex relationship between several factors involved in L2 learning and provided evidence that this relationship may differ in child and adult L2 learning. This finding underscores the importance of considering a variety of cognitive, linguistic, and experiential factors in the development of theories of child and adult second-language learning.

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