

**CONTEXT- AND EXPERIENCE-BASED EFFECTS
ON THE LEARNING OF VOWELS IN A SECOND LANGUAGE**

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The objective of the present study was to investigate how adult language learners perceive the relationship between native (L1) and second-language (L2) vowels in different phonetic contexts and how L2 experience influences this ability. Previous research has revealed that, in their perception of this relationship, L2 learners may erroneously perceive — as distinct L1 phonemes — what are actually allophones (i.e., context-determined phonetic realizations of phonemes) in their L2 and that the amount of L2 experience may affect the extent to which they do so. Two hypotheses were proposed. The first hypothesis was that inexperienced L2 learners would perceive allophones of a given L2 phoneme as being distinct phonemes in their L1. The second hypothesis was that, unlike inexperienced learners, more experienced L2 learners would perceive various allophones of a given L2 phoneme as being instantiations of a *single* phoneme in their L1. Results provided support for both of these hypotheses. The findings of the present study thus provide important insights into the role of phonetic context and experience in L2 vowel learning and into the dynamic and often complex nature of the interaction between L1 and L2 phonetic systems.

0. Introduction

Ever since Uriel Weinreich described three major ways in which a bilingual's two language systems could interact, researchers have attempted to study this interaction in both bilinguals and second-language learners (e.g., Flege 1999; Mack in press). In L2 speech learning, this interaction may manifest itself as the influence of a native language (L1) on a second language (L2). The question of when and to what extent this influence occurs remains as compelling today as it was when discussed by Weinreich (1953) nearly five decades ago.

Specifically, some researchers have shown that the extent to which an L1 phonetic system influences that of an L2 can depend on the perceived relationship between L1 and L2 sounds (Best 1995; Best, McRoberts, & Goodell 2001; Flege 1995). At least in the beginning stages of L2 speech learning, how L2 sounds are perceived seems to be determined by how closely they are identified with L1 sounds (Best et al. 2001; Guion, Flege, Akahane-Yamada, & Pruitt 2000). What is not well understood, however, is how the L1/L2 perceptual relationship evolves and how it relates to the development of the L2 phonetic system as second-language learning progresses. Thus, this study was undertaken to answer two questions: (1) How do inexperienced L2 learners perceive the relationship between L1 and L2 sounds? and (2) how do more experienced L2 learners do so as a function of L2 experience?

Studies of how inexperienced L2 learners (those with minimal or, in the parlance of some researchers in cross-language studies, even *no* L2 experience) perceive the relationship between L1 and L2 sounds have yielded interesting findings. That is, with even minimal amounts of experience in an L2, learners may be able to detect differences between acoustically similar L1 and L2 sounds. Moreover, they can perceive allophonic variants in their L2 (i.e., variants in the context-dependent phonetic realizations of meaningfully distinct abstract units of speech, or phonemes), but their ability to do so seems to be influenced by the phonetic environment in which those variants occur (Mann 1986; Polka 1995; Strange, Akahane-Yamada, Kubo, Trent, Nishi, & Jenkins 1998; Strange, Akahane-Yamada, Kubo, Trent, & Nishi 2001). For example, Steensland (1981) found that judgments of the similarity between the Russian vowel /e/ and a number of Swedish vowels, made by native speakers of Swedish unfamiliar with Russian, depended on the phonetic context in which the Russian vowel occurred. Similarly, Strange et al. (1998, 2001) observed that word-level effects (vowel length and word length) as well as discourse-level effects (whether sounds occurred in disyllabic words or in sentences) influenced how native Japanese speakers perceived the relationship between native and non-native sounds with which they were unfamiliar. (See related findings in Schmidt 1996.) These studies thus suggest that inexperienced learners of an L2 are sensitive to fine-grained acoustic and/or phonetic properties in L2 sounds.

Experiments conducted by other researchers (e.g., Bradlow, Pisoni, Akahane-Yamada, & Tohkura 1997; Lively, Logan, & Pisoni 1993; Mochizuki 1981) provide further support for the notion that contextual (stimulus-dependent) effects are relevant in the learning of an L2 sound system. For example, it has been found that native Chinese speakers of English, most of whom were inexperienced in English, could more accurately distinguish between voiced and voiceless stop consonants in word-initial than in word-final position (Flege & Wang 1989; Flege, Munro, & Skelton 1992). Likewise, when trained to distinguish between English /θ/ and /ð/ in word-initial position (as in the words *think* and *this*, respectively), native French listeners cannot always distinguish them when they occur in other syllable positions, such as word-finally (Morosan & Jamieson 1989). These and the results of similar studies (e.g., Crowther & Mann 1992; Polka 1991, 1992)

suggest that L2 learners may attend to (non-meaningful) allophonic variants — thus functioning unlike native speakers and many experienced L2 learners who essentially learn to ignore such variants — and, in so doing, may actually perceive L2 allophones as being instantiations of sounds that are phonemically distinct in their L1. That is, they may equate non-meaningful context-dependent phonetic variants in L2 speech sounds with meaningful context-free representations of L1 sound categories.

However, these contextual effects are not limited to learners with minimal L2 experience. Indeed, Takagi & Mann (1995) found that, even with over 20 years of L2 experience in English, the Japanese-English participants in their study did not discriminate between English /ɹ/ and /l/ in word-initial, word-medial, and word-final position with equal accuracy. That is, these participants learned to discriminate between the English liquids /ɹ/ and /l/ when they occurred in word-final position but — regardless of their amount of L2 experience — they could not discriminate between /ɹ/ and /l/ when these consonants (or more accurately, when their phonetic instantiations) occurred word-initially.

But why should certain L2 contrasts be treated selectively (such as the English /ɹ/-/l/ contrast when presented to Japanese learners)? That is, why are some sounds perceived accurately only in some phonetic contexts but not in others? It is here maintained that such a disparity in perceptual accuracy occurs when sound units in the L2 — in this example, English /ɹ/ and /l/ — are perceptually mapped onto either *one* phoneme (i.e., are treated as members of one category) in the L1, as seems to occur when /ɹ/ and /l/ occur word initially, or onto *two* phonemes (i.e., are treated as members of two categories) in the L1, as seems to occur when /ɹ/ and /l/ appear word-finally.

It is important to note that, in the present study, mapping refers to the way in which phonetic units in one language are associated, either implicitly at the mental level or explicitly in formal experimental tasks, with phonetic units in another. For example, an inexperienced L2 learner of English whose L1 is French might, when presented with the English vowel /ɪ/ as in *fish*, map it onto the French vowel /i/, as in *fiche*, since /ɪ/ is nonoccurrent in French but is acoustically similar to /i/. This has been demonstrated in a study in which native Japanese speakers not familiar with English mapped English (L2) consonants onto Japanese (L1) sounds (Takagi 1993). These Japanese speakers identified both English /ɹ/ and /l/ with the Japanese liquid /r/ when they occurred in word-initial position. However, when these two English consonants appeared in word-final position, they identified the English /ɹ/ more often with the Japanese /a/, and the English /l/ with the Japanese /ru/. This finding suggests that these native Japanese speakers, all of whom had had minimal experience in English, may have perceived the English /ɹ/ in these two contexts not as allophones of a single L1 phoneme, but as instantiations of two distinct L1 phonemes.

Thus how L2 units are mapped, relative to the learners' L1 system, seems to be crucially influenced by the phonetic context in which those units occur, since phonetic context alters the acoustic properties of sounds and hence can affect their

perceptual salience and status. More specifically, the acoustic properties of sounds are often strongly affected by the context in which they occur. Thus, although the word-medial [i] in *bead* and the word-final [i] in *lucky* are both phonetic realizations of a single phoneme — the English vowel /i/ — they are quite different at the acoustic level. Consequently, inexperienced L2 learners, unlike native speakers and at least some experienced L2 learners, may perceive the different phonetic realizations (allophones) of a given L2 phoneme as distinct L1 phonemes rather than the allophones of a single L2 phoneme that they actually are.

Thus of interest in the present study are two major questions: (1) How does phonetic context influence the way in which inexperienced L2 learners perceive the relationship between L1 and L2 sounds? and (2) do more experienced L2 learners perceive this relationship in a manner that is systematically different from the way in which inexperienced learners do? Two hypotheses are proposed. The first hypothesis is that inexperienced L2 learners will perceive the relationship between L1 and L2 sounds in a way that depends upon the phonetic context in which L2 sounds occur. For example, inexperienced L2 learners may perceive the English [ɹ] as in *rock* as being more representative of a corresponding L1 phoneme than the English [ɹ] as in *car*, or they may perceptually equate these two phonetic instantiations of the English /ɹ/ with two separate L1 phonemes (e.g., the word-initial English /ɹ/ could be treated by Japanese learners as the Japanese phoneme /r/, and the word-final English /ɹ/ could be treated as the Japanese phoneme /a/, as some research has previously demonstrated). This finding may indicate that inexperienced L2 learners are unable to ignore non-meaningful variations in L2 sounds and may thus treat allophones of a given L2 sounds as two (or theoretically, even more) separate L1 phonemes.

The second hypothesis is that more experienced L2 learners will perceive the relationship between L1 and L2 sounds in a manner that is less dependent upon the phonetic context in which L2 sounds occur. For example, more experienced L2 learners may perceive the English [ɹ] in *rock* and the English [ɹ] in *car* as being similar to a single related L1 phoneme, such the Japanese /r/. This finding may indicate that more experienced L2 learners ignore non-meaningful context-dependent variants in L2 sounds and may thus perceive L2 sounds as native speakers do. Overall, understanding how inexperienced and more experienced L2 learners treat the relationship between L1 and L2 sounds in different phonetic contexts may thus indicate how L2 sounds are perceived as L2 learning progresses and may explain why some L2 sounds seem more learnable than others.

To test these hypotheses, two experiments were conducted. Experiment 1 was designed to determine how inexperienced L2 learners perceive the relationship between L1 and L2 sounds in specific L2 phonetic contexts. In this experiment, native Korean speakers with minimal English experience were asked to map English (L2) vowels onto Korean (L1) vowels and rate the similarity between them. Experiment 2 was designed to determine how more experienced L2 learners perceive the relationship between L1 and L2 sounds, also in specific L2 contexts. In this experiment, an additional group of Korean learners of English was asked to perform the same tasks as those performed by the participants in Experiment 1.

However — unlike the participants in Experiment 1 — those in Experiment 2 differed with respect to their amount of L2 (English) experience. That is, they were selected and subsequently categorized into three groups based upon their amount of experience with English as a second language. In both experiments, amount of experience in the L2 was operationalized as the language learners' years of residence in the U.S.

1. Experiment 1: Context-dependent effects on the relationship between L1 and L2 sounds as perceived by inexperienced L2 learners

The objective of Experiment 1 was to determine how inexperienced Korean learners of English perceive the relationship between English and Korean vowels in different phonetic contexts. It was hypothesized that inexperienced Korean learners of English would perceive the relationship between L1 and L2 sounds in a way that depends upon the phonetic context in which L2 sounds occur.

1.1 Materials

The vowels used in this experiment included the following four pairs of phonemically contrasting English vowels: /i/-/ɪ/, /u/-/ʊ/, /a/-/ʌ/ and /æ/-/ɛ/. These vowel pairs were chosen because they are often confused by Korean learners of English in perception and production (Flege, Bohn, & Jang 1997; Ingram & Park 1997). Furthermore, comparing perceptual similarity between a number of vowels in English and Korean, both of which have large vowel inventories, permitted the (potential) emergence of a variety of cross-linguistic perceptual relationships.

To determine how Korean learners of English perceive the relationship between English and Korean vowels in different phonetic contexts, English vowels were placed in five CVC phonetic contexts — /h_d/, /b_d/, /b_t/, /l_C/, and /n_C/ (Table 1). Careful consideration was given to the stimulus words.

Table 1. Stimulus words used in Experiment 1

Context	/i/	/ɪ/	/u/	/ʊ/	/a/	/ʌ/	/æ/	/ɛ/
b_t	beat	bit	boot	book	bought	but	bat	bet
b_d	bead	bid	bood	good	pod	bud	bad	bed
h_d	heed	hid	who'd	hood	hot	hut	had	head
n_C	neat	knit	nuke	nook	not	nut	gnat	net
l_C	leak	lick	Luke	look	lock	luck	lack	let

Specifically, the /h_d/ context was chosen because it is often used in speech perception studies due to its relative neutrality (e.g., Hillenbrand, Getty, Clark, & Wheeler 1995). That is, the voiceless glottal fricative /h/ usually exerts little influence on the acoustic properties of the following vowel (Olive, Greenwood, & Coleman 1993). The /b_d/ and /b_t/ environments were chosen so that the way in which word-final voicing affects the perceived relationship between English and Korean vowels could be assessed. (All Korean stop consonants are devoiced word-finally.) In addition, English vowels are systematically shorter before voiceless than before voiced stop consonants (House & Fairbanks 1953), at least in stressed prepausal conditions (Mack 1982), and Korean vowels are often shorter than Eng-

lish vowels (Sohn 1999). Thus, it was believed that the English vowels might be perceived as being more similar to Korean vowels in the /b_t/ than the /b_d/ context because word-final voicing violates a phonetic rule in Korean.

Finally, the contexts /l_C/ and /n_C/ were chosen so that the effect of pre-vocalic liquid and nasal contexts could be evaluated cross-linguistically. Because both of these sound types exert a strong influence upon the acoustic properties of post-consonantal vowels (Kewley-Port 1995), the relationship between English and Korean vowels might be perceived in these two contexts unlike the way in which they are perceived in the other contexts. In addition, although the phoneme /l/ exists in Korean, it appears rarely in word-initial position and primarily in borrowings from English (Sohn 1999). By contrast, the word-initial /n/ is quite productive in Korean. Thus, it was believed that the English vowels could be perceived as being more similar to Korean vowels in the /n_C/ than in the /l_C/ context because, in Korean, /l/ occurs word initially much less often than does /n/.

The vowel stimuli were produced by three functionally monolingual male speakers of American English from the Pacific Northwest whose average age was 24, with a range of 22 to 26. These three speakers were chosen because none of them had studied a second language beyond the level of high-school language courses, none had lived outside the U.S., none had received any formal training in phonetics or linguistics, and all spoke the standard variety of General American English.

A Shure unidimensional head-mounted microphone (model: SM10A) and Sony DAT tape recorder (model: TCD-D8) were used to record the three speakers as they produced three iterations of the 40 monosyllabic English stimulus words. Recording of each speaker took place in a sound-attenuated booth in the Phonetics Laboratory of the University of Illinois at Urbana-Champaign. The 40 stimulus words were typewritten on individual cards, randomized, and presented in the carrier phrase, *I say ___ for you*. Sentences appeared on cue cards placed, one at a time (with one sentence per card) on a table in front of the speakers. The speakers were asked to produce each sentence at a normal speaking rate. ESPS/Waves+ signal analysis software was used to excise each stimulus word from its carrier phrase. Subsequently, the stimulus words were subjectively evaluated by the first two authors and the best token of each word was selected for inclusion in the experiment. Questionable tokens were judged for inclusion by the third author. The resulting 120 words (40 words \times 3 speakers) were digitized at 16 kHz, ramped off during the first and last 15 msec to eliminate any audible clicks, and normalized for peak intensity and perceived loudness.

To further validate the quality of the stimuli, the 40 stimulus words were presented in individual listening sessions to 10 monolingual native English speakers with no training in phonetics or linguistics. A forced-choice identification and a goodness-rating task were administered using a personal computer and presentation software (Smith 1997). The native English speakers were asked to identify the vowels /i/, /I/, /u/, /U/, /a/, /A/, /æ/, and /E/ presented in the stimulus words. Because of the difficulty of orthographically representing isolated English vowels,

the English words *seat*, *sit*, *soup*, *took*, *sock*, *suck*, *sat*, and *set* were presented on a computer screen as response alternatives. Specifically, the native English speakers were told to select that word containing the vowel most similar to the one they had just heard. The procedure was as follows: Each speaker heard a stimulus word and then identified the vowel in it. Next, each speaker heard the same stimulus word but this time rated its goodness on a 7-point scale. On this scale 1 indicated that the vowel sounded very dissimilar from, and 7 indicated that the vowel sounded very similar to, the vowel in the English word they had heard in the identification task.

Those words which were not identified accurately at least 95% of the time and were not rated with at least an average of 5 on the 7-point goodness-rating scale were replaced by other stimulus words and were re-tested using 10 other native English speakers with the same qualifications and the same procedure as those described above. These resulting stimulus words were used for Experiment 1, described below.

1.2 Participants

There were 10 adult participants in Experiment 1 — 4 male and 6 female — ranging in age from 24 to 33 years, with a mean age of 29. All were native speakers of the Seoul dialect of Korean and all had resided in the U.S. from 3 weeks to 5 months, with a mean length of residence (LOR) of 3 months. Participants were recruited through written announcements placed in various locations in the community, such as churches, businesses, and the University of Illinois. The participants (hereafter, Korean monolinguals) were not enrolled as students, nor did they work outside the home, so they had had minimal exposure to English in the U.S., and had also had an average of fewer than 2 months of formal instruction in English. At the time of testing, 5 were enrolled in a beginning course in an English-language program or a similar course given by the local school district.

The participants provided self-ratings of their English proficiency on a 10-point scale on which 1 corresponded to 'I don't know any English', and 10 corresponded to 'I am a native speaker of English'. The mean self-rating in English was 3.4, with a range of 2 to 4. The participants also provided self-ratings of their Korean proficiency on a comparable 10-point scale. The mean self-rating in Korean was 10, with none of the participants giving himself/herself a value below 10. None could carry out even a simple conversation in English. Because the participants' English proficiency was so low, all testing instructions were translated into Korean, which they were told to read prior to testing.

1.3 Procedure

The participants were tested individually in a quiet location using the same personal computer and stimulus presentation software (Smith 1997) previously utilized in presenting stimuli to the monolingual native English speakers who had validated the stimulus words. All participants were tested at the University of Illinois at Urbana-Champaign. The English CVC stimulus words were randomly presented 240 times (40 words \times 3 speakers \times 2 repetitions) over stereo headphones

(Sennheiser Model HD 535). The participants performed a forced-choice cross-language mapping task and a similarity-rating task.

Specifically, the Korean monolinguals were asked to map the English vowels /i/, /ɪ/, /u/, /ʊ/, /a/, /ʌ/, /æ/, and /ɛ/ presented in the stimulus words onto one of the 10 vowels of standard Korean (/i/, /o/, /ɪ/, /y/, /œ/, /ɛ/, /ɛ/, /ʌ/, /a/, /u/) and to rate the similarity between them. The Korean vowel response alternatives were displayed in Hangeul characters on a computer screen. The Korean monolinguals were told to select that Korean vowel most similar to the English vowel in the stimulus word and then to rate how similar the English vowel sounded to the chosen Korean vowel. The procedure was as follows: Each participant heard a stimulus word and then mapped the vowel in it onto a Korean vowel (i.e., selected the Korean vowel that sounded most similar to the vowel in the English word that had been presented auditorily). Next, each participant heard the same stimulus word but this time rated the similarity of the English vowel to the Korean vowel on a 7-point scale. On this scale 1 indicated that the vowels across the two languages sounded very dissimilar and 7 indicated that the vowels sounded very similar. The participants had unlimited time to map the vowels and to provide similarity-rating judgments but were not permitted to change their responses after they were given. Before testing, the participants were given a 10-item practice session to familiarize them with the procedure.

1.4 Data analysis

Both the cross-language mapping and similarity-rating data were collected to obtain valid and reliable estimates of each participant's perception of the relationship between L1 and L2 sounds. In the cross-language mapping task, responses were scored by computing how many times each participant mapped a particular English vowel onto any of the ten Korean vowels cited above. For example, the number of times each participant mapped the English /i/ onto the Korean /i/ was tabulated, as well as the number of times this same English vowel was mapped onto the nine other Korean vowels. Likewise, the similarity-rating responses were scored by computing each participant's rating of the similarity between each English vowel and each Korean vowel. The mapping data and the similarity-rating responses were omitted from the analysis if a participant failed to perform either the mapping or similarity rating. (This occurred rarely — i.e., only in 1.3% of the cases.) Averages for vowel mapping and similarity-rating responses were obtained for vowels produced by all three speakers in all five phonetic contexts. Mapping and similarity-rating responses were also tabulated for each phonetic context and were compared using analyses of variance (ANOVAs) and, for pairwise comparisons, the Bonferroni test (a t-test with the alpha level adjusted for the number of pairwise comparisons).

1.5 Results

In response to six of the eight English vowels used in this study — /i/, /ɪ/, /u/, /ʊ/, /a/, and /ʌ/ — the Korean monolinguals chose a single (modal) Korean response alternative a majority of the time (at least 71% of the time) and rated this alternative as being most similar to each of the above six English vowels (with an aver-

age rating of 5.4 to 6.0 on a 7-point scale). By contrast, they mapped English /æ/ and /ɛ/ equally infrequently (between 37 and 54% of the time) onto both Korean /ɛ/ and /e/ and rated English /æ/ and /ɛ/ as being equally similar (with an average rating of 5.2 to 5.7 on a 7-point scale) to both Korean /ɛ/ and /e/ (Table 2).

Table 2.

Mean percent of times (out of a possible total of 300) each English vowel was mapped onto its two modal (most frequently chosen) Korean vowels (with similarity ratings appearing in parentheses).

English	Vowel		Modal responses
	English	Korean	
/i/	→	/i/	95 (6.0)
	→	/y/	5 (5.3)
/ɪ/	→	/i/	80 (5.6)
	→	/ɨ/	4 (4.9)
/ɛ/	→	/e/	38 (5.2)
	→	/ɛ/	54 (5.3)
/æ/	→	/ɛ/	45 (5.7)
	→	/e/	37 (5.5)
/u/	→	/u/	85 (5.4)
	→	/ɨ/	13 (4.0)
/ʊ/	→	/u/	71 (5.4)
	→	/ɨ/	16 (4.5)
/a/	→	/a/	78 (5.8)
	→	/ʌ/	17 (5.0)
/ʌ/	→	/ʌ/	73 (5.5)
	→	/a/	21 (5.8)

1.5.1 Effect of phonetic context

Analysis of the Korean monolinguals' mapping and similarity ratings in each phonetic context revealed that context *did* affect how frequently Korean monolinguals mapped six of the English vowels (/i/, /ɪ/, /u/, /ʊ/, /a/, and /ʌ/) onto their Korean modal response alternatives and how they rated the similarity between them. By contrast, phonetic context *did not* affect how frequently Korean monolinguals mapped the English /æ/ and /ɛ/ onto the Korean /ɛ/ and /e/ or how they rated the similarity between them.

Specifically, a two-way 5×8 (context \times vowel) ANOVA comparing Korean monolinguals' mapping revealed a significant main effect for vowel [$F(7,63) = 14.83, p < .001$] and for context [$F(4,36) = 8.69, p < .001$], as well as a significant context \times vowel interaction [$F(28,252) = 8.99, p < .001$]. Subsequently, one-way ANOVAs comparing the mapping frequency for each English vowel in the five phonetic contexts revealed a significant effect for phonetic context for six (/i/, /ɪ/, /u/, /ʊ/, /a/, and /ʌ/) of the eight vowels. (In each analysis, the obtained p-value was less than .01.)

A two-way 5×8 (context \times vowel) ANOVA was also conducted to compare the Korean monolinguals' similarity ratings for the English and Korean vowels. It revealed a significant main effect for vowel [$F(7,63) = 2.25, p < .05$] and for context [$F(4,36) = 3.19, p < .025$], as well as a significant context \times vowel interaction [$F(28,252) = 2.39, p < .001$]. However, one-way ANOVAs comparing the similarity ratings for each English vowel in the five phonetic contexts revealed that the effect of phonetic context was statistically significant only for the English vowel /ɪ/ [$F(4,32) = 3.47, p < .05$].

Context-based comparisons further revealed that, in the /l_C/, /n_C/, and /b_d/ environments, the Korean monolinguals were less likely to map English vowels onto their first most frequent Korean response alternatives and were instead more likely to map English vowels onto their second most frequent Korean response alternatives. In particular, Korean monolinguals were less likely to map the four English vowels /i/, /ɪ/, /a/, and /ʌ/ onto the Korean /i/, /i/, /a/, and /ʌ/, respectively, in the /l_C/ than in any other context. They were also less likely to map the English /ɪ/, /ʌ/, and /u/ onto the Korean /i/, /ʌ/, and /u/, respectively, in the /n_C/ than in any other context. Finally, they were less likely to map the English /u/ and /ʊ/ onto the Korean /u/ in the /b_d/ than in any other context.

1.6 Discussion

Results of Experiment 1 revealed that the Korean monolinguals perceived the relationship between six of the eight English vowels and their Korean modal response alternatives more dissimilarly in some phonetic contexts than in others.¹ (It should be noted that this result, in large part, obtained in the analysis of cross-language mapping but not in the analysis of similarity ratings. The procedure of cross-language similarity rating used in the present study may thus not have been sufficiently sensitive to detect context-based differences in the perception of the relationship between L1 and L2 sounds by the Korean monolinguals.)

That is, the Korean monolinguals were less likely to equate English vowels with their Korean modal response alternatives when these English vowels occurred in certain phonetic contexts. Notably, such phonetic contexts included those which heavily influenced the acoustic properties of adjacent vowels (/n_C/) or which violated the phonotactic constraints of Korean (/l_C/ and /b_d/). This finding is consistent with the results of previous studies demonstrating that inexperienced L2 learners are sensitive to non-meaningful context-dependent variants in L2 sounds (i.e., L2 allophones) when identifying L2 vowels with L1 vowels (e.g., Strange et al. 1998, 2001).

The results of Experiment 1 are consistent with the hypothesis that inexperienced L2 learners perceive the relationship between L1 and L2 sounds more dissimilarly in some phonetic contexts than in others, suggesting that they may have treated allophones of L2 vowels as separate L1 phonemes. For example, the Korean monolinguals mapped the English /a/ most frequently onto the Korean /a/ in every context except /l_C/. In this context, they mapped the English /a/ most frequently onto the Korean /ʌ/. That is, the Korean monolinguals perceived the English /a/ as one Korean phoneme in the /l_C/ context and another Korean phoneme

in the other contexts. Phonetic context likewise affected five other of the eight English vowels in this experiment. This result supports the hypothesis that inexperienced L2 learners are influenced, in vowel perception, by the context in which vowels occur and that they may treat allophones of a given L2 vowel as distinct phonemic representations of given L1 vowels.

The results of Experiment 1 thus raise the following question: Do more experienced L2 learners also perceive L2 vowels as inexperienced L2 learners do? That is, do more experienced L2 learners perceive L2 allophones as L1 phonemes in a context-dependent manner? A negative answer to this question would suggest that more experienced L2 learners learn to ignore non-meaningful variations in L2 sounds and that they (thus) perceive L2 sounds as native speakers do. To test this hypothesis, a second experiment was conducted.

2. Experiment 2: Context-dependent effects on the relationship between L1 and L2 sounds as perceived by experienced L2 learners

The objective of Experiment 2 was to determine how experienced Korean learners of English perceive the relationship between English and Korean vowels in different phonetic contexts. If experienced L2 learners recognize how L2 allophones relate to each other and their phonemic categories, they should be less affected by phonetic context in their perception of this relationship. That is, more experienced L2 learners should perceive L2 vowels as members of the same L1 category regardless of the phonetic context in which L2 vowels occur. This finding may thus demonstrate that more experienced L2 learners ignore non-meaningful context-dependent variants in L2 sounds and perceive L2 sounds as native speakers do.

2.1 Participants

Thirty Korean learners of English, all native speakers of the Seoul dialect of Korean, participated in Experiment 2. Participants were recruited using the same methods described above in Experiment 1. However, they were chosen based upon their amount of L2 experience, defined as length of residence in the U.S. and their age of L2 learning, defined as age at the time of arrival in the U.S. Length of U.S. residence was considered a valid measure of L2 linguistic experience because the participants were all students at a major university and were exposed to and used English on a daily basis (Flege & Liu 2000). Because age of L2 learning is also an important determinant of L2 speech-perception accuracy (Flege, MacKay, & Meador 1999; Mack in press), the groups were also matched for age at the time of L2 learning. Two groups of late L2 learners had been exposed to English in the U.S. as adults yet differed in their amount of English experience. (They had had three and ten years of experience in English, and they are henceforth referred to as the Late+3 and Late+10 groups, respectively.) By contrast, the early L2 learners (henceforth the Early+10 group) had been exposed to English prior to the age of 11 and had been in the U.S. for an average of 11 years — a length of time comparable to the U.S. residence of the Late+10 group. As had the Korean monolinguals in Experiment 1, the three groups of experienced L2 learners estimated their Eng-

lish proficiency on a 10-point rating scale. The Early+10 and Late+10 groups rated their English proficiency similarly, and their ratings were significantly higher than both the Late+3 group and the group of Korean monolinguals, as was revealed in a one-way ANOVA followed by Bonferroni test comparing the participants' self-ratings of English proficiency [$F(3,36) = 119.91, p < .001$] (Table 3).

Table 3.

Means for chronological age (Chron. Age), age of arrival in the U.S. (AOA), length of residence (LOR) in years, and participants self-ratings in English (Rate E.) and Korean (Rate K.). Standard deviations appear in parentheses.

Group	N	Chron. Age	AOA	LOR	Rate E.	Rate K.
K.mono. ²	10	29.3 (2.7)	29.0 (2.7)	0.3 (0.1)	3.4 (0.9)	10.0 (0.0)
Late+3	10	27.3 (3.5)	24.0 (3.7)	3.0 (0.4)	6.0 (0.9)	10.0 (0.0)
Late+10	10	32.1 (2.7)	21.4 (2.8)	9.8 (2.3)	7.6 (1.0)	10.0 (0.0)
Early+10	10	20.3 (1.6)	9.0 (1.2)	11.1 (1.9)	8.5 (1.3)	6.1 (1.5)

2.2 Materials and procedure

Experiment 2 utilized the same materials and procedures as documented above for Experiment 1.

2.3 Data analysis

The participants' mapping and similarity-rating responses were tabulated using the same procedure as in Experiment 1. Both mapping and similarity-rating responses were omitted from the analyses if the participant failed to perform either mapping or similarity rating. This occurred in only a small percentage of the cases for each group (i.e., Late+3: 0.5%, Late+10: 2.0%, Early+10: 0.7%). In the overall analysis, averages for vowel mapping and similarity-rating responses were obtained for the vowels in the words produced by all three speakers in all five phonetic contexts. In subsequent analyses, mapping and similarity-rating responses were tabulated in each phonetic context and were compared within and between the participant groups using one-way ANOVAs followed by Bonferroni tests.

2.4 Results

The three groups of experienced L2 learners overall mapped six of the eight English vowels (/a/, /ʌ/, /i/, /ɪ/, /u/, and /ʊ/) onto their Korean modal response alternatives and judged English /æ/ and /ɛ/ as being similar to both Korean /e/ and /ɛ/, in much the same manner as did the Korean monolinguals in Experiment 1 (Table 4).

Table 4.

Mean percent of times (out of a possible total of 300) each English vowel was mapped onto its two modal (most frequent) Korean vowels (with similarity ratings appearing in parentheses)

Vowel		Group			
English	Korean	K. mono. ³	Late+3	Late+10	Early+10
/i/	→ /i/	95 (6.0)	98 (5.3)	98 (5.7)	100 (5.3)
	→ /y/	5 (5.3)	1 (6.3)	1 (4.3)	
/ɪ/	→ /i/	80 (5.6)	92 (4.7)	82 (4.9)	84 (4.0)
	→ /ɪ/	4 (4.9)	3 (2.8)	3 (2.9)	5 (2.2)
/ɛ/	→ /ɛ/	38 (5.2)	66 (5.2)	60 (5.1)	60 (5.1)
	→ /ɛ/	54 (5.3)	30 (4.8)	35 (5.1)	37 (4.6)
/æ/	→ /ɛ/	45 (5.7)	54 (5.1)	71 (5.3)	86 (4.4)
	→ /e/	37 (5.5)	33 (5.0)	21 (4.9)	11 (3.5)
/u/	→ /u/	85 (5.4)	94 (4.7)	89 (4.9)	95 (4.9)
	→ /ɪ/	13 (4.0)	4 (3.4)	6 (3.4)	4 (3.7)
/ʊ/	→ /u/	71 (5.4)	80 (4.5)	79 (4.5)	69 (4.4)
	→ /ɪ/	16 (4.5)	16 (3.8)	18 (3.8)	27 (4.3)
/ɑ/	→ /ɑ/	78 (5.8)	73 (5.1)	73 (5.5)	85 (4.9)
	→ /ʌ/	17 (5.0)	24 (4.6)	20 (3.9)	15 (4.1)
/ʌ/	→ /ʌ/	73 (5.5)	88 (4.9)	88 (5.1)	93 (5.0)
	→ /ɑ/	21 (5.8)	9 (5.3)	8 (5.1)	4 (3.4)

2.4.1 Effect of phonetic context

Analysis of the experienced L2 learners' patterns of cross-language mapping revealed that — as in Experiment 1 — the context in which the vowels occurred influenced the way in which the experienced learners mapped the English vowels onto their Korean modal (most frequent) response alternatives. A three-way $3 \times 8 \times 5$ (group \times vowel \times context) repeated-measures ANOVA yielded no significant main effect for group but a significant main effect for vowel [$F(7,252) = 109.26$, $p < .001$] and for phonetic context [$F(4,144) = 21.12$, $p < .001$], as well as a significant group \times vowel \times context interaction [$F(84,1008) = 2.86$, $p < .001$]. By contrast, statistical analysis of the participants' similarity ratings revealed that phonetic context did *not* yield significant differences in the participants' ratings of the English vowels and their Korean modal response alternatives. Thus, phonetic context did not influence the way in which the experienced learners rated the similarity between the English vowels and their Korean modal response alternatives.

More detailed analysis of performance within each of the three experienced learner groups was conducted to determine, specifically, how each group mapped the English vowels onto the Korean vowels in each of the five phonetic contexts. Thus, one-way ANOVAs were conducted to determine if, within each group, there were context-based differences in the mapping patterns. Results revealed that there was a significant difference, by vowel context, for six of the eight English vowels (/i/, /ɪ/, /u/, /ʊ/, /ɑ/, and /ʌ/) for the Late+3 group (in each analysis, the obtained p -value was less than .05 and was thus statistically significant), and for four of the

eight English vowels (/ɪ/, /ɑ/, /æ/, and /ɛ/) for the Late+10 group (in each of these analyses, the obtained p-value was less than .01), but not for the Early+10 group. Specifically, those L2 learners who had been exposed to English later in life perceived the relationship between the English and Korean vowels more dissimilarly in three of the five phonetic contexts (/l_C/, /b_d/, and /n_C/) (Table 5). These phonetic contexts included two which violated the phonotactic constraints of Korean (/l_C/ and /b_d/) and one (/n_C/) in which the medial vowel was probably quite strongly 'colored' by the acoustic properties of the word-initial sound — i.e., by the nasal consonant.

Table 5.

Phonetic context effects for each of three native Korean groups.

Group	Context		
	/l_C/	/n_C/	/b_d/
K.mono.	/i/, /ɪ/, /ɑ/, /ʌ/	/ɪ/, /ʊ/, /ʌ/	/u/, /ʊ/
Late+3	/ɪ/, /ɑ/, /ʌ/, /æ/, /ɛ/	/æ/, /ɛ/	/ʊ/
Late+10	/ɪ/, /ɑ/, /æ/, /ɛ/	/æ/, /ɛ/	—
Early+10	—	—	—

Presented in the above table are the three English phonetic (word) contexts which most strongly influenced how the L2 learner groups perceived English vowels. That is, the English vowels listed in each context column are those for which statistically significant effects for a particular phonetic context were obtained. Of special interest is the fact that, for the Late+10 group, relatively few English vowels (and, for the Early+10 group, *no* English vowels) revealed phonetic context effects. What this indicates is that the more experienced L2 learners — those with 10 years of experience in English — were less affected by phonetic context in their mapping of L2 onto L1 sounds than were the less experienced L2 learners. In fact, as can be seen, the (experienced) L2 learners in the Early+10 group perceived all L2 allophones of each of the English vowels in the present study as instantiations of L1 phonemes. Hence, in their perception of L2 vowels, they appeared not to be influenced by context-dependent acoustic differences and they responded to the vowels as native monolingual speakers would be expected to, perceptually 'ignoring' non-meaningful allophonic variations in phonetic instantiations of specific phonemes.

The assertion that the experienced learners were less affected in their perception of the English vowels by phonetic context than were the inexperienced learners gains further support in statistical analyses in which the mapping patterns were compared in each of the five phonetic contexts between the participant groups. In particular, one-way ANOVAs were conducted to determine if, for each English vowel, there were group-based differences in the mapping patterns. Results revealed that there was a significant difference, by group, for seven of the eight English vowels when these vowels occurred in three of the five phonetic contexts (/l_C/, /b_d/, and /n_C/). (In each analysis, the obtained p-value was less than .05). Thus, the L2 learners with more English-language experience, regardless of age at the onset of their exposure to English, were more likely than those

with less English-language experience to map the English vowels onto their Korean modal response alternatives. That is, the more experienced L2 learners perceived the English vowels, at least when they occurred in certain phonetic contexts, as being more similar to the corresponding Korean vowels than did the less experienced L2 learners.

2.5 Discussion

Experiment 2 was designed to test the hypothesis that experienced L2 learners would perceive selected L2 allophones as L1 phonemes. Specifically, it was predicted that the perceived relationship between L1 and L2 sounds, among experienced L2 learners, would not be influenced by the phonetic context in which the L2 sounds occurred.

Results of this experiment largely supported this hypothesis. (As in Experiment 1, these results obtained in the analysis of cross-language mapping, but not in the analysis of similarity ratings, suggesting that similarity ratings may not always reveal context-based differences in L2 learners' perception of the relationship between L1 and L2 sounds.) That is, the more experienced L2 learners tended to map the English vowels /i/, /ɪ/, /u/, /ʊ/, /ɑ/, and /ʌ/ onto their Korean modal response alternatives equally often in all five phonetic contexts. It is important to note that this result obtained for those vowels which the Korean monolinguals in Experiment 1 had perceived as being the most similar to their Korean modal response alternatives. (For example, the Korean monolinguals perceived the English vowel /i/ as being that vowel most similar to the Korean vowel /i/.) Such a finding suggests that a 'perceptual overlap' between L1 and L2 sounds may help L2 learners to ignore non-meaningful context-dependent phonetic variants in L2 sounds and the extent to which such variants can be ignored appears to be, at least in part, a function of amount of experience with the L2.

One exception to the above pattern of results was, however, exemplified by the L2 learners' perception of the English vowels /æ/ and /ɛ/. That is, regardless of their amount of English-language experience, the more experienced L2 learners still mapped the English vowels /æ/ and /ɛ/ onto the Korean vowels in a way that depended upon the phonetic context in which these English vowels occurred (Table 5). Again, it is important to note that this result was observed in those vowels which the Korean monolinguals in Experiment 1 had perceived as being the most dissimilar from Korean vowels. (For example, the Korean monolinguals perceived the English vowels /æ/ and /ɛ/ as being dissimilar from the Korean vowels /ɛ/ and /e/.) Thus, a relatively poor perceptual overlap between L1 and L2 sounds apparently renders more salient the idiosyncrasies of L2 sounds, causing L2 learners to be particularly sensitive to non-meaningful context-dependent phonetic variants in L2 sounds.

Finally, the more experienced L2 learners who were exposed to their L2 as children (i.e., those in the Early+10 group) mapped all English vowels onto their Korean modal response alternatives equally often, regardless of the phonetic context in which they occurred. Thus, the more experienced L2 learners who were

first exposed to their L2 as children perceived the L2 vowels as native speakers do by ignoring non-meaningful context-dependent (allophonic) effects.

3. General discussion

As will be recalled, the present study tested two related hypotheses. The first hypothesis was that, in their perception of L2 vowels, inexperienced L2 learners would be influenced by context-based effects, as reflected in their tendency to map L2 allophones onto L1 phonemes, rather than treating L2 allophones as (mere) non-meaningful phonetic variants. (Another way of stating this is to say that inexperienced L2 learners would be so sensitive to small acoustic differences in the phonetic instantiations of certain L2 sounds that they treat them as members of different sound categories in their L1.) The second hypothesis was that, by contrast, experienced L2 learners would not be strongly influenced by context-based effects in vowel perception, as reflected in their tendency *not* to map L2 allophones onto distinct L1 phonemes (and in this regard, would perform much as do native monolingual speakers who learn to ignore non-meaningful allophonic variants in their formation of native-language sound categories).

Results of Experiments of 1 and 2 provided support for these hypotheses and thus suggest that the perceived relationship between the sounds of the L1 and L2 evolves over time as L2 learning progresses. More specifically, the present study suggests that the L2 learners may reorganize their L1 and L2 phonetic system(s) as L2 speech learning progresses (Best & Strange 1992; Flege 1995) and that those learners who are exposed to their L2 as children rather than as adults may be more successful in carrying out such phonetic reorganization (Mack & Trofimovich 2001). That is, in the present study the more experienced L2 learners, unlike the less experienced L2 learners, and the early L2 learners, unlike the late L2 learners, were less influenced by phonetic context in their perception of L2 sounds and also were more likely to map L2 sounds onto corresponding L1 sounds. This evidence for a reorganization of the L2 learners' L1 and L2 phonetic system(s) obtained for those L2 sounds which were acoustically most unlike the L1 sounds or for those L2 sounds which occurred in the phonetic contexts that violated L1 phonotactic constraints. The perceptual differences between such L2 sounds and the sounds in the L1 apparently have caused the L2 learners to reorganize their L1 and L2 phonetic system(s) (Best & Strange 1992; Flege 1995). Further research could provide important information about the acoustic and articulatory correlates of cross-language differences. It could also determine which perceptual training procedures would be useful in rendering previously imperceptible L2 sound contrasts (such as the oft-cited problems with the /s/-/ʃ/ distinction among Japanese learners of English) more salient to adult L2 learners (McClelland 2001).

Finally, the finding that L2 learners may reorganize their L1 and L2 phonetic systems as their L2 speech learning progresses leads to an important question regarding the nature of such reorganization. For example, L2 learners may establish new categories for L2 sounds (Best & Strange 1992; Flege 1995) or may adjust existing L1 categories to accommodate perceptually similar L2 sounds (MacKay, Flege, Piske, & Schirru 2001). For example, to accurately perceive and produce

the English vowel /i/, which is nonoccurrent in Korean, more experienced native Korean learners of English probably need to establish a new vowel category. By contrast, to accurately perceive and produce the English vowel /i/, such learners may simply need to modify the category for their Korean vowel /i/ since that phoneme is so acoustically similar to the English vowel /i/. The results of the present study favor the latter alternative. That is, because the more experienced L2 learners, in contrast to the less experienced L2 learners, were more likely to map L2 sounds onto corresponding L1 vowels, they may have been modifying existing L1 sound categories to process perceptually similar L2 sounds (Flege 1995; MacKay, Flege, Piske, & Schirru 2001). Overall, therefore, this study suggests that L2 learners likely exploit the perceived similarity between L1 and L2 sounds to accommodate existing L1 categories to process L2 sounds.

In conclusion, the present study examined how inexperienced L2 learners perceive L2 vowels in different phonetic contexts and how L2 experience influences this ability. In particular, the extent to which inexperienced and experienced L2 learners recognize that L2 allophones are (merely) context-dependent variants — as reflected in the way in which they were mapped onto L1 phonemes — was investigated.

Results revealed that L2 learners may indeed process L2 allophones as if they are members of particular L1 phonemic categories as they become increasingly familiar with the sounds of the L2. In so doing, L2 learners appear to exploit cross-language perceptual similarities as they gain familiarity with the L2. This finding underscores the importance of continuing the study of cross-language relationships, just as Uriel Weinreich did so many years ago, and it reveals the continued need for careful cross-language analyses in the development of theories regarding second-language acquisition and the functional organization of two languages in various types of bilinguals.

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NOTES

¹ Overall low cross-language identification frequencies (i.e., the presence of a 'floor' effect) may have concealed how phonetic context influenced the perceived relationship between the English /æ/ and /ɛ/ and the Korean /ɛ/ and /e/. The loss of a phonemic distinction between Korean /ɛ/ and /e/, both of which are frequently perceived and produced as allophones /e/ in many dialects of Korean (Lee & Ramsey 2000; Sohn 1999), may have also obscured how phonetic context influenced the perceived relationship between these English and Korean vowels.

² Demographic data for the group of Korean monolinguals from Experiment 1 have been included in this table for purposes of comparison.

³ Data for the group of Korean monolinguals from Experiment 1 have been included in this and the following table for purposes of comparison.

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