

THE EFFECT OF AGE OF ACQUISITION AND SECOND-LANGUAGE
EXPERIENCE ON SEGMENTS AND PROSODY: A CROSS-SECTIONAL STUDY OF
KOREAN BILINGUALS' ENGLISH AND KOREAN PRODUCTION

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DISSERTATION ABSTRACT

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Title: The Effect of Age of Acquisition and Second-Language Experience on Segments and Prosody: A Cross-Sectional Study of Korean Bilinguals' English and Korean Production

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The current dissertation investigated segmental and prosodic aspects of first- (L1) and second-language (L2) speech production. Forty Korean-speaking adults and children varying in L2 experience (6 months—inexperienced vs. 6 years—experienced) as well as twenty age-matched native English speaking adults and children participated. Experienced children born in the U.S. were first exposed to English much earlier than inexperienced children. Group differences were investigated for insight into the effect of differing language experience on speech production.

For segmental aspects, spectral quality and duration of English and Korean vowels (Chapter II), the effect of English coda consonant voicing on vowel and consonant closure duration (Chapter III), and language-specific voice onset time (VOT) in English and Korean stops (Chapter IV) were examined. All Korean groups except the experienced children differed from the native English speakers in vowel spectral quality and coda voicing production. The experienced children showed native-like production of both English and Korean vowels and also used VOT to distinguish Korean aspirated and

English voiceless stops. These results suggest that the experienced children have separate phonological representations for their two languages.

For prosodic aspects, stressed and unstressed vowels in English multisyllabic words (Chapter V) and Korean four-syllable phrases (Chapter VI) were elicited. The results of stressed and unstressed vowel production revealed that the Korean adults were able to acquire English prosody in a native-like manner, except for reduced vowel quality. Contrary to the little L1-L2 interaction in prosody for adults, Korean experienced children's production suggested a strong influence of English acquisition on the development of Korean prosody in terms of fundamental frequency, intensity, and duration patterns.

Different degrees of L1-L2 interaction between Korean experienced children's production of segments and prosody are discussed from the developmental standpoint of simultaneous bilingual children's language shift from the mother tongue to English. In addition to children's greater plasticity of language acquisition, external (e.g., peer pressure, language input) and internal (e.g., ethnic self-identity) factors are likely to have created a language learning environment different from that of the Korean adults. As a result, the degree and direction of L1-L2 interaction varied by linguistic domains, depending on the age of the learner and the language experience.

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CHAPTER I

INTRODUCTION

The current dissertation investigates segmental and prosodic aspects of first-(L1) and second-language (L2) speech production produced by Korean speaking adults and children varying in age and L2 experience. Two Korean pre-school child groups consisted of ten 6- to 8-year old Korean children who were born in the United States (U.S.) and ten 6- to 8-year old Korea-born children with 6 months of English exposure in the U.S. The two Korean adult groups were both exposed to English in their late adolescence but differed in the amount of English experience in the U.S. (6 months vs. 6 years). The Korean adult and child groups were compared to twenty age-matched native English-speaking child and adult groups. The primary questions of interest included whether the U.S-born Korean experienced children, who were exposed to the L1 and L2 before either of the languages was fully established, would be able to acquire the two languages in a native-like (or monolingual-like) manner. Also, different effects of L2 experience on Korean adults' and children's L1 and L2 productions were examined from both segmental and prosodic perspectives of language acquisition. Typically, in the bilingualism literature, the Korean experienced children are classified as either simultaneous or early sequential bilinguals depending on how one defines the terms "simultaneous" and "early". Therefore, we begin with examination of how these terms have been defined in previous research and what implications the categorization criteria might have toward the understanding of bilingualism.

The course of bilinguals' language acquisition and development has been the topic of much interest for many years. Several studies have striven to unfold bilinguals' unique learning mechanism and linguistic identity that is thought to differ from the monolinguals in both production (segments - Guion, 2003; Kang & Guion, 2005, 2006; Sundara, Polka, & Baum, 2006; prosody - Guion, 2006; Lee, Guion, & Harada, 2006; Trofimovich & Baker, 2007; morphosyntax - Paradis, & Genesee, 1996) and perception (Bosch & Sebastian-Galles, 2003; Sundara, Polka, & Molnar, 2008; Dupoux, Peperkamp, & Sebastian-Galles, 2010). However, there are still remaining questions as to how two (or more) languages compete and interact to create distinctive systems and what factors determine the degree of separation between the two languages.

The examination of bilinguals' production of L1 and L2 has allowed researchers to gain insight into several factors that indicate the degree and direction of L1-L2 interaction and the native-likeness of the L2. First and foremost, age at time of L2 exposure has been discussed as the strongest predictor of native-like L2 attainment among bilinguals. Studies which compared early and late bilinguals have reported a strong correlation of age and the degree of L1 interference (Guion, 2003; Aoyama, Flege, Guion, Yamada, & Akahane-Yamada, 2004; Baker & Trofimovich, 2005; Flege, Birdsong, Bialystok, Mack, Sung, & Tsukada, 2006; Baker, Trofimovich, Flege, Mack, & Halter, 2008). Although the ultimate attainment of native-like proficiency in the L2 among early bilinguals is still controversial, the notion of 'the earlier the better' has been confirmed by numerous studies showing early learners' ability to produce the L2 in a more native-like manner than late learners. Additionally, the amount of L2 exposure

(Flege, Bohn, & Jang, 1997; Jia, Strange, Wu, & Guan, 2006; Trofimovich & Baker, 2006), the amount of L1 use in relation to L2 use (Flege, Frieda, & Nozawa, 1997; Guion, Flege, & Loftin, 2000; Piske, Flege, MacKay, & Meador, 2002; Flege, Schirru, & MacKay, 2003; MacKay, Flege, Piske, & Schirru, 2001) and the similarity between the L1 and L2 systems (Flege, MacKay, & Meador, 1999; Baker et al., 2008) have been shown to affect the accuracy of L2 production.

The aforementioned studies have been successful in sorting the influential factors that might result in indelible foreign accents in L2 production. Yet, conflicting results were reported regarding early bilinguals' L2 production. Some argued that early bilinguals can produce some aspects of the L2 in a native-like manner (Flege, 1991; Flege et al., 1999; Guion, 2003; Kang & Guion, 2006; Tsukada, Birdsong, Bialystok, Mack, Sung, & Flege, 2005) while others reported notable foreign accents in their L2 production (Asher & Garcia, 1969; Baker & Trofimovich, 2005; Flege et al., 2006). The different results were generally attributed to different research methods (see Deuchar & Clark, 1996; Yeni-Komshian, Flege, & Liu, 2000) or samples (Flege & Liu, 2001; Fowler, Sramko, Ostry, Rowland, & Hallé, 2008). To my knowledge, however, few studies have pointed out that the conflicting results can be due to the fact that the criteria for defining someone a 'bilingual' vary substantially from study to study. Especially when the scope of being bilingual can extend from a person who can manage simple communication in two languages (Haugen, 1953) to a person who speaks both languages in a native-like manner (Bloomfield, 1933), referring to the participants as early or late bilinguals with no clear definition of bilingual is likely to introduce considerable

variability across bilingual speakers. Moreover, the definition of bilingual has become even broader since the term “early bilingual” was used interchangeably with “early learner” (Flege, 1991; Højen & Flege, 2006).

Only a handful of studies have followed Bloomfield’s narrow definition of bilingual (i.e., a person who speaks two languages in a native-like manner) and recruited those who qualified the criteria. The criteria often included the one-parent one-language rule, a roughly equal amount of exposure to both languages during the preverbal stage of development, and monolinguals’ assessment of native-likeness. In Bosch and Sebastian-Galles (2003)’s study on Catalan and Spanish bilingual infants’ perception of Catalan vowel contrasts, the bilinguals were determined by the language spoken by parents and relatives as well as the hours of daily exposure to the two languages, which had to be in the range from 50 to 65%. The three criteria Cutler, Mehler, Norris, and Segui (1992) used to choose French-English bilinguals were (1) native competence assessed by the monolinguals of that language, (2) early exposure to both languages (1 year of age or earlier) and (3) regular use of both languages. In Sundara and Polka (2008)’s study, the French-English simultaneous bilinguals were chosen based on four criteria: the native language of the parents, the language they were educated in, the language of the community they lived in, and self-ratings of their knowledge of both languages, which were later confirmed by a balanced bilingual speaker. Although the criteria used for choosing a balanced bilingual vary across studies, the attempts to define and restrict the linguistic background of bilingual groups are crucial. As Myers-Scotton (2006) stated, if the language background of the child is not clearly defined as to when and how long the

child was exposed to the second language, the term “child bilingual” may introduce a great deal of confusion. The inconsistency in the definition is not limited to the term “bilingual”. The age range for early bilinguals and late bilinguals also differ across studies, which may have led to the conflicting results. Consequently, an “early bilingual” in one study may be referred to as a “late learner” in a different study. The issue becomes more complicated when an early bilingual can be either an adult or a child early bilingual or either a simultaneous or an early sequential bilingual.

The following section (1.1) examines how bilinguals have been defined and categorized in previous studies and how it might have influenced interpretations about bilinguals’ language acquisition. Three pairs of bilingual classifications are reviewed: 1) early vs. late bilingual (the age of arrival to the L2 speaking country), 2) simultaneous vs. sequential bilingual (the order in which two languages are acquired), 3) child vs. adult bilingual (developmental vs. ultimate stage of language acquisition). In addition, previous studies on bilingualism not only differ in the classification of the participants’ language background but also in the language (L1 or L2) or linguistic areas (segments or prosody) of interest. Several studies have shown an effect of L1 on L2 and consequently, the developmental process of bilingual has been generally described from the perspective of L2 acquisition. Although a handful of studies compare the interaction of both L1 and L2, the research areas of such studies were likely to be limited to either segments or prosody. The section 1.2 compares previous studies that presented different aspects of bilingualism and further suggests the importance of a holistic approach to bilingualism to better understand how two languages interact to create their own linguistic signature.

1.1. Definition of “bilingual”

1.1.1. Early vs. late bilingual

In many cases, an early vs. late bilingual distinction has been largely made on the basis of two criteria: age of L2 acquisition (AOA) and length of residence (LOR) in the L2 speaking country. Participants who were exposed to the L2 before the age of adolescence and resided in the L2 speaking country for a certain period of time have been classified as early bilinguals. However, because it is difficult to decide the point at which someone becomes a bilingual, the cutoff age between early and late bilinguals may vary. For instance, in Flege (1991)'s study on the voice-onset time (VOT) production of English /t/ by Spanish-English early and late bilinguals, the AOA for the early adult bilinguals ranged from 0 to 6 years old and LOR in the U.S. ranged from 14 to 26 years. The AOA for the late bilinguals ranged from 11 to 35 years old and LOR from 7 to 25 years. Flege reported that the early bilinguals' overall VOT for English /t/ was not different from the monolingual English speakers' VOT, whereas the late bilinguals' VOT differed from monolinguals' production. However, the examination of within-group variability suggests that some early bilinguals are less native-like than others. The author pointed out the possibility of age interacting with variables such as individual speaking styles, lack of English stimuli, and quality of L2 input. However, the potential effect of variables caused by the wide range of AOA and LOR was not discussed.

Kang and Guion (2006) examined early (AOA = 1-6, Mean LOR = 9.8) and late adult bilinguals' (AOA = 15-34, Mean LOR = 18.2) production of English and Korean stops. The results showed that the early, but not late, bilinguals' production of English

and Korean stops was comparable to both English and Korean speaking monolinguals' production in terms of VOT, voice quality, and fundamental frequency (F0). Similarly, Guion, Harada and Clark (2004) investigated Spanish-English early (AOA = 2.5-6, Mean LOR = 23.4) and late adult bilinguals' (AOA = 15-33, Mean LOR = 12.9) production and perception of non-words varying in syllable structure and lexical class. In a production task, the effect of syllable structure and lexical class on mean proportion of initial stress was similar between early bilinguals and native English speakers. Late bilinguals, on the other hand, showed a weaker effect of syllable structure and lexical class and a consequently greater number of initial stress production than the other two groups due to the effect of the L1 (Spanish). Overall, early bilinguals' native-like L2 proficiency suggests that early bilinguals' L2 was not as affected by the knowledge of L1 as late bilinguals' L2. However, note that the AOA for the early bilinguals in all three studies were younger than 6 years old and their age range was considerably smaller than that of the late bilinguals.

In studies where the age range of early bilinguals is larger, differences between early bilinguals and monolingual speakers are likely to emerge. In MacKay et al. (2001)'s study on Italian (L1)-Canadian English (L2) bilinguals' production of English stops, early bilinguals (AOA = 2-13, Mean LOR = 41) and late bilinguals (AOA = 15-26, Mean LOR = 30) were further divided into low (1-15%) and high (25-80%) L1 use groups. Although the early bilinguals with low L1 use were more native-like than the late bilinguals in all experiments, the mean percentage of prevoiced English stops as well as the mean percentage of errors in the identification of English /b, d, g/ were higher for

even early-low bilinguals when compared to the monolingual English speakers. The L1 influence was stronger in late bilinguals' production, but early bilinguals also showed an effect of the L1 in the merged category for Italian-English voiced stops. Also, Flege, Schirru and MacKay (2003) recruited early Italian-English bilinguals (AOA = 2-13, LOR = 33-50) and late bilinguals (AOA = 15-26, LOR = 4-42) with varying amount of L1 use (from 1 % to 75%). The early Italian-English bilinguals' vowel production was reported to be nonnative-like in acoustic analyses and also received lower ratings than monolingual English speakers. Not only the big age range but also the bigger range of LOR can be problematic, especially if the late bilinguals were exposed to the L2 from 15 years old and lived in the U.S. for over forty years.

The importance of putting some limit to the age range is shown in Flege et al. (1999). In this study, more fine-grained distinctions were made among Italian (L1)-English (L2) bilinguals to examine the effect of AOA on the production and perception of English vowels. Early (AOA = 4-10, Mean LOR = 40) bilinguals produced more vowels in a native-like manner than the mid (13-15, 34) and late (18-20, 28) adult bilinguals who also differed from the native English speakers on their mean sensitivity scores for 11 English vowel contrasts. The results also revealed a gradient pattern in that the perception scores measuring the sensitivity between two English vowels decreased as AOA increased, especially for mid-back vowel contrasts. The implication of smaller age range is also shown in Guion (2003)'s study. Guion (2003) examined Quichua (L1) – Spanish (L2) simultaneous (AOA:0), early (5-7), mid (9-13) and late (15-25) bilinguals' production of Quichua and Spanish vowels. The results showed that the simultaneous

bilinguals were able to make finer distinctions between L1 and L2 vowel categories than the early bilinguals, especially with front vowels. The study indicated that the smaller age range is likely to show fine phonetic differences across different age that may not be detected otherwise.

Note that the cutoff age for early bilinguals was 6 years old in Flege (1991), Kang and Guion (2006) and Guion et al. (2004)'s studies and 13 years old for MacKay et al. (2001) and Flege et al. (2003)'s studies. The age range of early bilinguals in MacKay et al. (2001)'s and Flege et al. (2003)'s studies is large enough to include some of the mid bilinguals in Flege et al. (1999) and some of the late bilinguals in Flege (1991)'s study. It is possible that the nonnative-likeness in early bilinguals' production in MacKay et al. (2001)'s and Flege et al. (2003)'s studies was driven by those with relatively higher AOA. As has been considered of utmost importance in the native-like L2 attainment, the age effect on bilinguals' L2 production needs closer and more focused investigation.

The confusion is not limited to early bilinguals. As shown in the increasing age range (i.e., early (2 years), mid (4 years), late (10 years)) in Guion (2003)'s study and many others, the presupposition is that one year difference in an early learners group may represent substantially larger variability than one year difference in a late L2 learners group. Allowing a large age range for late L2 learners assumes that L2 learners who were exposed to the L2 later in their life will have a similar effect of L2 experience. This assumption, however, can yield misleading interpretations or expectations about the language development of late L2 learners. In particular, Munro (1993)'s study underlined the necessity for carefully choosing late L2 learners based on their linguistic background.

The study investigated ten English vowels produced by Arabic late learners of English. The 23 native Arabic speakers between the age of 19 and 57 years who resided in the U.S. for an average of 5.7 years participated in the study. Although their English vowel production was clearly foreign accented, some Arabic speakers' production of English vowels was rated as native-like by five native English speakers. The relationship between AOA and foreign accentedness was not further investigated, but one may expect that vowel production by Arabic speakers who were exposed to English around 13 years old are likely to be closer to the native norm than the production by those who were exposed to English around 50 years old. Therefore, grouping these late learners together can readily overlook the within-group differences which may provide insightful information about language acquisition patterns of adult L2 learners.

1.1.2. Simultaneous vs. sequential bilingual

Bilinguals can be further divided into simultaneous and sequential bilinguals. Previous studies have referred both simultaneous bilinguals (Meisel, 2001; Sundara, Polka, & Genesee, 2006; Sundara & Polka, 2008) and sequential bilinguals (Flege, 1991; Kang & Guion, 2006; MacKay et al., 2001) as "early bilinguals". Early bilinguals have been generally considered as sequential bilinguals because the criteria for selecting simultaneous bilinguals have been much stricter than those for sequential bilinguals.

However, the criteria to distinguish the two groups have not been consistent across studies either. This incongruity is problematic when one group is considered to be fundamentally different from the other in language development (see Meisel, 2001).

Previously, simultaneous bilinguals have been defined as those who were exposed to both languages from birth (Padilla & Lindholm, 1984, Fowler et al., 2008) or no later than a week after exposure to the L1 (De Houwer, 1990). Early sequential (or successive) bilinguals, on the other hand, have been defined as those who were exposed to one language during the first years of life and the other in the later time period, preferentially before the age of three (Hammer, Miccio, & Rodriguez, 2004). Moreover, it has been argued that sequential bilinguals are those whose parents are monolingual speakers of the child's dominant language yet use both languages to the child on a daily basis (Sundara & Polka, 2008), or those who acquire the L2 after the L1 is fully established (Hammer & Blanc, 2003; Lee & Iverson, manuscript). The hypothesis underlying these distinctions is that the time point of exposure to two languages may differentiate the process and ultimate acquisition of both languages. However, using different criteria across studies to define and classify simultaneous and sequential bilinguals may give rise to conflicting results.

Sundara and Polka (2008) hypothesized that adult simultaneous and sequential bilinguals differ in their ultimate attainment of the two languages. Namely, sequential adult bilinguals are more likely to show merged categories for similar L1-L2 phones, whereas simultaneous adult bilinguals are likely to create an independent category for each language. In this study, simultaneous Canadian French (CF) and Canadian English (CE) adult bilinguals were compared to the monolinguals of French and English as well as the early L2 learners of French. The research goal was to examine whether simultaneous and early L2 learners differ in their discrimination accuracy between

French dental and English alveolar stops. The results showed that the simultaneous bilinguals received significantly higher scores than the early L2 learners but significantly lower scores than the monolingual English listeners especially in the back vowel context. The authors interpreted the results to indicate that simultaneous bilinguals use perceptual strategies that are distinctive from both monolinguals and early L2 learners. The differences were attributed to quality and quantity of language input, and most importantly to the timing of language exposure during childhood.

Fowler et al. (2008) also found a difference between simultaneous and sequential bilinguals. Their results, however, showed that the sequential bilinguals were closer to the monolingual speakers than the simultaneous bilinguals in their VOT duration of English and French voiceless stops. As for French VOT, English dominant bilinguals showed the longest VOT and simultaneous bilinguals showed longer VOT than French (L1) bilinguals whose VOT was comparable to French monolinguals'. This result suggested that simultaneous bilinguals were different from both sequential bilinguals and monolinguals. The simultaneous bilinguals, however, were more similar to English (L1) than French (L1) bilinguals in their French VOT production and the same pattern was observed in their VOT production for English stops as well. More specifically, English monolinguals', English dominant bilinguals' and simultaneous bilinguals' VOT for English voiceless stops were all considerably longer than French (L1) bilinguals' VOT. Considering the late onset of English acquisition for French (L1) bilinguals (around 9-10 years old), as opposed to the onset of French acquisition for English (L1) bilinguals (around 4-5 years old), the effect of English in English (L1) bilinguals' VOT may not be

as strong as the effect of French in the French L1 bilinguals' production. Moreover, the similar VOT patterns between simultaneous and English (L1) bilinguals raise a question as to how and to what extent the two groups differed from one another in their language background. Other criteria being equal, the only different description about simultaneous bilinguals was that "they had both French and English as their native language". This information about the simultaneous bilinguals is not sufficient to support the claim that the VOT difference between two groups reflects their difference in timing of language acquisition.

Another definition for sequential bilinguals as having an established L1 system before L2 is fully acquired has also been put forth. As an example, Lee and Iverson (manuscript) referred to early Korean bilinguals as simultaneous bilinguals in their study on the development of Korean and English stop systems. The term was justified on the ground of Kim and Stoel-Gammon (2009)'s finding that native Korean children learn to fully distinguish the three Korean stops after the age of 4 or 5. The authors argued that the Korean child participants who were younger than 3 years old when they first arrived in the U.S. can be considered as simultaneous bilinguals because their Korean stops (L1) were not likely to have fully established at the time of testing. This flow of argument, however, can be followed by a question as to whether one could be considered as a simultaneous bilingual in one area and a sequential bilingual in another area of language acquisition based on the degree of establishment in the L1. That is, because it is hard to find a clear point at which the L1 system is established in the gradual language development, these Korean children can be either sequential or simultaneous bilinguals

depending on which linguistic aspects one choose to investigate. Ultimately, setting separate milestones which vary by the degree of L1 development may give rise to conflicting descriptions of simultaneous bilinguals.

1.1.3. Language dominance

Contrary to studies that argue for the difference between simultaneous and sequential bilinguals, some studies have suggested that both simultaneous and sequential bilinguals acquire two languages in a similar manner such that both can distinguish their two languages from the early age. It was suggested that the difference between two bilingual groups is likely to emerge when they differ in the degree of language dominance. Genesee, Nicoladis, and Paradis (1995) examined simultaneous bilingual children ranging from 1 year and 10 months (1:10) to 2 years and 2 months old (2:2). Even though these bilingual children were reported to have equal exposure to English and French from birth, discriminant function analyses on the mean length of utterance, multi-morphemic utterances, upper bound, and word type of their productions revealed that each child was likely to have a dominant language that affected their language choice in different situations. Although the bilingual children showed a tendency to use more English with their English-speaking mothers and more French with their French-speaking fathers, the stronger the dominant language was, the less likely the non-dominant language was used even with the parent who only used that language.

In Sebastián-Gallés, Echeverría, and Bosch (2005)'s study, eighty bilinguals were grouped into either a Catalan-Spanish early adult bilingual group or a Spanish-

Catalan early adult bilingual group based on the language they were extensively exposed to before the age of four as well as their dominant language at the time of testing. Both groups had received bilingual education and proven their proficiency through a formal test. In addition, forty simultaneous bilinguals who were exposed to both languages from birth by a Catalan-speaking mother and a Spanish-speaking father and used both languages equally were compared to the early bilinguals. In a lexical decision task on Catalan (non-) words involving a Catalan /e/-/ɛ/ vowel contrast, the Catalan-Spanish early bilinguals received the highest scores closely followed by the Catalan simultaneous bilinguals and Spanish-Catalan early bilinguals. A separate set of analysis showed that the simultaneous bilinguals whose mother's language was Catalan were more accurate than those whose mother's language was Spanish. The findings suggested that the simultaneous bilinguals had a dominant language which favorably affected the processing of Catalan lexical items and detailed phonetic contrasts. Overall, the difference between Catalan simultaneous bilinguals and early bilinguals may be explained with the different degree of language dominance rather than a fundamental difference in the language processing.

In a similar line, Cutler et al. (1992) examined French-English simultaneous bilinguals' segmentation procedures and compared them with French and English monolinguals' syllable- and stress-based segmentation strategies, respectively. The authors investigated whether early exposure to two languages with different rhythmic features would yield the ability to use the two segmentation strategies. Because CV and CVC structures as in *balance* and *balcon* are segmented differently in French (ba-lance)

and English (balance) such that the syllable boundary for *balance* is ambiguous in English, the prediction was that being able to employ the two segmentation strategies would indicate a presence of balanced bilingualism. Overall, the dominant language chosen by bilinguals (12 French, 15 English) were strongly correlated with the results. That is, English-dominant bilinguals showed a similar pattern to English monolinguals in English experiments, and French-dominant bilinguals showed a similar pattern to French monolinguals in French experiment. The authors interpreted the results as bilinguals adopting only one speech processing mechanism for the ease of cognitive load and likely becoming functionally monolinguals later in life.

Cutler et al. (1989, 1992)'s view was further supported by Dupoux et al. (2010). They investigated 23 French-Spanish simultaneous adult bilinguals who were born and raised by either a Spanish speaking mother and a French speaking father or vice versa. Since French monolinguals were expected to show more difficulties discriminating different stress patterns than Spanish monolinguals due to their syllable-timed language background, the aim of this study was to examine whether French-Spanish simultaneous bilinguals make stress distinctions as accurately as Spanish speakers would in perception tasks. The simultaneous bilinguals' performance fell somewhere in between French and Spanish monolinguals' performance. The distribution of individual scores showed that 43% of the simultaneous bilinguals were in a Spanish mode and the rest in a French mode when tested. The authors interpreted the result as "bilinguals retaining a bimodal distribution with participants in the best mode performing as monolinguals and participants in the other mode performing as L2 learners" (Dupoux et al., 2010, p. 266-

267). Furthermore, correlation analyses showed that significant factors contributing to the selection of bilinguals' dominant language were the country of residence at 0-2 and 2-4 years old and language exposure during those years. It should be noted that these factors overlap with the criteria of early bilinguals introduced in the previous section. Taken together, distinguishing simultaneous and sequential bilinguals with the onset age of L2 exposure does not capture the difference between simultaneous bilinguals with different dominant languages or their similarity to early sequential bilinguals.

1.1.4. Child (developmental stage) vs. adult (ultimate stage) bilingual

Lastly, an area that has been relatively overlooked in bilingual studies is the comparison between child and adult bilinguals. Regardless of the age at the time of testing, a bilingual would be referred to as either an early bilingual or late bilingual depending on the age of L2 acquisition. However, because different quantity and quality of language input, cognitive maturity and social awareness change with increase in age, child bilinguals' production may greatly differ from early adult bilinguals' production. Adult bilinguals are more likely to show stable language systems than child bilinguals, and thus, child bilinguals' production is likely to display a stronger L1-L2 interaction. Consequently, different patterns of language interaction may arise depending on whether the early bilingual was examined during development or at the ultimate stage of language acquisition. For example, Kang and Guion (2006) compared English stops produced by early Korean (L1)-English (L2) adult bilinguals (mean age of L2 learning = 3.8, mean age at time of testing = 20) to the stops produced by age-matched English monolinguals.

The results on the VOT, H1-H2 (i.e., voice quality of the following vowel), and F0 measures showed no significant difference between early, but not late, bilinguals and English monolinguals. Moreover, early bilinguals were able to separate English stops from Korean stops by establishing five distinct stop types, suggesting that early adult bilinguals created different stop systems for the two languages.

In Guion (2003)'s study, early Quichua (L1)-Spanish (L2) adult bilinguals (mean age of L2 learning = 5.7, mean age at time of testing = 31.2) showed the acquisition of independent Spanish vowel categories unlike late (mean age of L2 learning = 19.4, mean age at time of testing = 38.9) adult bilinguals who appeared to be using their Quichua vowels for Spanish vowel production. Similarly, Guion, Harada, and Clark (2004) compared the effects of lexical class and syllable structure on stress placement in English monolinguals' production to those in early (mean age of L2 learning = 3.7, mean age at time of testing = 25.7) and late (mean age of L2 learning = 21.5, mean age at time of testing = 33.2) adult Spanish (L1) – English (L2) bilinguals' production of non-words. In the production task, only early bilinguals shifted stress patterns in the same manner that English monolinguals did, which suggested that the transfer effect from Spanish to English was insignificant in the early bilinguals' production. The similar result was found in Huang and Jun (2009) who found that early Korean (L1) –English (L2) adult bilinguals (mean age of L2 learning = 7:6, mean age at time of testing = 20:11) did not significantly differ from English monolinguals in their production of English prosody (i.e., foreign prosody rating, speech rate, pitch accents, boundary tones).

Other studies on early child bilinguals, however, have reported different results. Asher and García (1986) examined 71 Cuban child bilinguals whose age at the time of testing ranged from 17 to 19. Children's production of English sentences were recorded and judged by monolingual English speakers. When these early child bilinguals were divided into six groups based on AOA and LOR, children who arrived in California around 1-6 years old and lived there about 5-8 years received the highest near native-like scores. Surprisingly, however, not one out of 71 early bilinguals was perceived as a native speaker of English. Similarly in Baker and Trofimovich (2005), certain English vowels such as /ɪ/, /ʊ/ and /æ/, produced by early (mean age of learning L2 = 8.8, mean age at time of testing = 16.9) Korean (L1)-English (L2) bilinguals were significantly higher in the vowel space than those produced by English monolingual children. Moreover, Kehoe (2002)'s longitudinal study on vowel acquisition of early child bilinguals (mean age of learning L2 = 0, mean age at time of the last testing = 2.3) showed that German (Father's and community's language)-Spanish (mother's language) bilingual children's production of German vowels was significantly different from German monolingual children's production. More specifically, the German vowel length contrast produced by early child bilinguals was not nearly as distinctive as that produced by German monolingual children. The acquisition of Spanish vowels was mostly native-like, although there was a tendency for the early bilinguals to perform more accurately as they gained more experience with Spanish. The author interpreted the result to indicate that early bilinguals show a delay in acquiring languages that have a more complex phonological system (i.e., larger vowel inventory). The delayed development of

language-specific discrimination abilities by early child bilinguals has also been reported in Bosch and Sebastián-Gallés (2003).

Sundara, Polka, and Genesee (2006) compared both simultaneous French-English child (mean age at time of testing = 4.10) and adult (mean age at time of testing = 24.9) bilinguals to age-matched French and English monolinguals to examine whether they could discriminate the English /d/ and /ð/ contrast. The primary research goal was to investigate the simultaneous bilinguals' developmental trajectory of phonetic discrimination abilities. The results showed that the French-English adult bilinguals were comparable to the English monolinguals, whereas the child bilinguals obtained significantly lower discrimination scores than the English monolingual children did. The difference between child and adult bilinguals were largely attributed to the different amount of language experience.

One may argue that the different results on the native-likeness of early bilinguals' production are due to the fact that Guion (2003), Kang and Guion (2006), and Guion Hirada, Clark (2004) examined early adult bilinguals who were at the ultimate stage (or end-state) of language development, whereas Asher and García (1986), Baker Trofimovich (2005) and Kehoe (2002) examined child bilinguals at a specific developmental stage where both languages were not yet fully established. Recall that Lee and Iverson (manuscript) reported nonnative-like English VOT produced by simultaneous child bilinguals, whereas Kang and Guion (2006) showed native-like English VOT produced by early sequential adult bilinguals despite the bilinguals' similar

age of L2 exposure. The different results may be better explained by the differences between adult and child bilinguals rather than simultaneous and sequential bilinguals.

Child bilinguals are expected to show more L1-L2 interaction and nonnative-like proficiency in at least one of their languages, but it doesn't mean that adult bilinguals are expected to be more native-like than child bilinguals in L2 production. Child bilinguals are likely to show a shift in language dominance (or preference) as they reach older age (Kohnert, Bates, and Hernandez, 1999) due to different environmental factors such as social-cultural context, parents' attitude toward the two languages, and the role of speech community. These environmental factors heavily affect bilingual children's language choice and developmental trajectory (Hammer, Miccio, and Rodriguez, 2004) and consequently, (non) native-like features that was not observed in child bilinguals' production may emerge later in life.

Kohnert and Bates (2002) examined the comprehension and production of five different age groups (5-7, 8-10, 11-13, 14-16, 18-22 years old) of Spanish (L1)-English (L2) child and adult bilinguals who were exposed to the L2 before the age of six. The group comparisons showed that the youngest child bilingual group received lower accuracy scores and longer response times than the older groups in both languages, suggesting that their L1 and L2 were still immature. Moreover, the two youngest groups showed no difference between the L1 and L2 scores in either accuracy or response times, whereas the older groups performed significantly better in the L2. This result was taken to indicate a shift in the dominant language as the older bilinguals gained experience with the L2. Ultimately, their L1 became weaker and thus less native-like than the L2. Their

findings suggest that it is not only important to specify bilinguals' age of acquisition but also their age at the time of testing in order to better appreciate at which developmental stage the bilinguals may be.

1.2. Major topics of research on bilingualism

1.2.1. The examination of L2 in relation to L1

When comparing different studies in the area of bilingualism, it is not only critical to understand what language background the bilinguals may bring but it is also important to be attentive to the characteristics of the languages that are examined. Especially for child bilinguals whose languages constantly compete and interact, the rate and milestones of one language can affect the other language's developmental process. Assuming that the L1 and L2 systems are compared across the same developmental stage, a delay or nonnative-likeness in the L2 may not be necessarily due to the L1 transfer but rather due to the different developmental milestones across different languages. To determine at what point the language-specific knowledge is acquired in that language, the examination of monolingual children's language development as well as a specific L1-L2 pair comparison is necessary.

Relevant to the study reported here, Kim and Stoel-Gammon (2009) and Lee and Iverson (2008) examined the developmental patterns of Korean word-initial stops produced by Korean monolingual children from the age of 2:6 to 4 and found that Korean stop contrasts were not fully established by 4 years old. Based on this rate of Korean stop development, Lee and Iverson (manuscript) predicted that Korean child

bilinguals who were exposed to English before 4 years old would show a stronger effect of English on the acquisition of Korean stops than those who were exposed to English after the age of 4. That is, the degree of L1 establishment was taken as an indicator of the degree of L2 influence on the L1. In different studies, Macken and Barton (1979, 1980) reported that English monolingual children acquired an English voicing contrast by the age of 2, whereas the Spanish lead vs. lag voicing contrast was shown to be acquired much later in life by Spanish monolingual children. The late acquisition of the Spanish lag contrast compared to the English lag contrast (Deuchar & Clark, 1996) also suggests that some phonological contrasts can be more difficult, and thus, take more time to acquire in one language than the other. In the study of the acquisition of L2 suprasegmentals features, Trofimovich and Baker (2007) pointed out the importance of taking the L1 development into consideration to predict the order in which the L2 suprasegmental features are acquired. Whether through segments or prosody, the relative difficulty of the L1 and L2 and its effect on the native-like L1 and L2 acquisition require careful examination of language-specific phonetic details in both languages.

1.2.2. Segments and prosody

Lastly, examining different areas of speech is likely to yield different results to the question of whether simultaneous or sequential bilinguals can produce the L2 in a native-like manner. That is, the direction and degree of L1-L2 interaction in segments may differ from those in prosody. Children are known to acquire prosody before segments in their L1: neonates were able to discriminate different rhythmic-class

languages (Mehler, Jusczyk, Lambertz, Halsted, Bertoni, & Amiel-Tison, 1988; Moon, Panneton-Cooper, & Fifer, 1993), whereas native-like discrimination of vowels (Polka & Werker, 1994) and consonants (Werker & Tees, 1984) was acquired later in life. Along with the early acquisition of the perceptual discrimination ability in the L1, studies on monolingual children's L1 production further suggest that L1 prosodic features (e.g., F0) are mastered before segmental features (Li & Thompson, 1976, Jun, 2007).

Whalen, Levitt, and Wang (1991) examined the F0 patterns of five French and five English monolingual infants' reduplicative babbles. As the effect of frequent rising intonation in French and falling intonation in English, it was predicted that infants who were exposed to different languages would exhibit language-specific intonation patterns in their pre-verbal stage. The two groups of infants were recorded at weekly intervals from around 7 months to 11 months of age. The low-pass filtered babbles were randomized and judged by native English speakers. Overall, French (L1) infants were judged to produce a considerably more rising tone than English (L1) infants who mostly showed a falling tone. The emergence of different F0 patterns between the two infant groups was taken as the evidence for an early sensitivity to L1 prosodic cues.

If L1 prosody is acquired earlier than L1 segments, and thus is more entrenched in a bilingual children's language system, not only late bilinguals but also early bilinguals are expected to show a strong effect of L1 prosody on the acquisition of L2 prosody. In Lee et al. (2006), multisyllabic English words produced by early (mean AOA = 3.9, mean age at time of testing = 20) and late (mean AOA = 21, mean age at time of testing = 34) Korean (L1)–English (L2) bilinguals were examined. One of the primary

research goals was to examine the effect of the Korean prosodic system on the acquisition of English stressed and unstressed vowels. The hypothesis was that if knowledge of Korean prosody interferes with the acquisition of English, not only late learners but also early bilinguals would show difficulties in attaining native-like L2 phonetic features that are used to signal English unstressed vowels. Specifically, given the existence of different F0 patterns realized in Korean prosodic units, it was predicted that Korean bilinguals would readily employ F0 to signal the difference between stressed and unstressed vowels. The study reported nonnative-like prosodic features in the early adult bilinguals' unstressed-to-stressed syllable ratio for duration, intensity as well as unstressed vowel quality. The authors attributed the nonnative-like acquisition of stressed and unstressed contrasts to the different prosodic systems between Korean and English.

Similarly, Guion (2006) examined whether early (mean AOA = 4, mean age at time of testing = 20) and late (mean AOA = 22, mean age at time of testing = 34) Korean (L1)–English (L2) bilinguals would be able to acquire L2 prosodic patterns that are different from their L1. The task was to collapse two separately presented syllables with differing syllable structures into a single word and produce it in a frame sentence, once in a noun form and once in a verb form. The study explored the effects of syllable structure, lexical class and phonological similarity on Korean bilinguals' stress placement in English. The result showed that the effects of lexical class and syllable structure were diminished in both late and early bilinguals' production compared to the English monolinguals' production.

The aforementioned studies showed that earlier acquired L1 prosody can be an obstacle in the native-like acquisition of L2 prosody. Other studies, however, argued differently. For example, Huang and Jun (2009) examined three groups of Mandarin-speaking English learners who had lived in the U.S. for more than 5 years: child (mean AOA = 8), adolescent (14), and adult arrival (23) groups. The adult Mandarin speakers were asked to read a short paragraph consisted of 4 sentences after one minute of familiarization. Unlike the adolescent and adult arrival groups, the child group was native-like in all examined aspects of English prosody (i.e., speech rate, foreign prosody rating via low-pass filtered speech, mean frequencies for intermediate and intonational phrases, pitch accents, phrase accents and boundary tones). The findings supported the significance of early exposure to the L2 for the native-like acquisition of L2 prosody.

Not only early but also late L2 learners were shown to produce L2 prosodic features in a native-like manner. Kondo (2009) examined eight Japanese adult speakers' production of English multisyllabic words. The Japanese speakers were reported to have high proficiency in English and extended experience in English-speaking environments (up to 10 years). When their vowel duration, F0, intensity and unstressed vowel spectral quality were compared to native English speakers' production, only unstressed vowel quality significantly differed across the two groups. That is, Japanese speakers were able to learn L2 prosodic features that are not used in the L1 in a native-like manner.

The degree of native-likeness in L2 prosody may also vary depending on different prosodic aspects. Trofimovich and Baker (2007) investigated five English suprasegmental features which were divided into prosody-based (i.e., stress timing, peak

alignment) and fluency-based suprasegmentals (i.e., speech rate, frequency and duration of pausing). Korean child (Mean AOA = 10.7, Mean LOR = 1) and adult (Mean AOA = 9, Mean LOR = 11) learners who differed in age and the amount of English experience participated in a delayed sentence repetition task. Overall, Korean adult learners were significantly more native-like in L2 prosody than child learners due to their longer L2 experience. However, Korean adult learners showed a significantly longer speech rate and lower accentedness ratings than the age-matched English monolinguals. The authors argued that native-like prosody-based suprasegmentals can be interpreted as the adult learners having a separate representation for L2 prosody. The nonnative-like acquisition of fluency-based suprasegmentals, on the other hand, was attributed to the adult learners' slower conversion of a speech plan into articulatory output and delayed lexical access. They further suggested that the acquisition of L2 prosody is similar to that of L2 segments in that they both show a significant effect of AOA and a gradual process of development. Without Korean adult learners' production of English segments, however, this finding does not show how L2 segments and prosody are acquired in relation to one another.

1.3. The current study

The studies presented in this dissertation are designed to further the research on the acquisition of L1 and L2 segments and prosody (i.e., lexical stress) by Korean-speaking adults and children with different language experiences in the U.S. The age-matched Korean and English (near) monolinguals' productions were provided to assess

the native-likeness of experienced adults' and children's L1 and L2 productions. Differences between simultaneous and sequential adult bilinguals have been mostly described with regard to the ultimate attainment of their two languages. However, the early stage of second generation bilinguals' language acquisition and the interaction between the two languages in development has been rarely viewed in light of both segments and prosody.

With more than one million Korean U.S. immigrants and an estimated 450,000 U.S.-born ethnic Koreans (U.S. Census Bureau, 2005), there are not only abundant resources for linguistic research on bilingualism but also increasing demands to better understand the language effects and role of Korean-American speech communities in the U.S. (see Lee, 2001). One way to approach these speech communities is to explore how U.S.-born Korean children come into contact with and begin to acquire Korean under the influence of the socially dominant language, English. Examining the early form of bilingual children's speech productions of Korean and English, especially before one language wins out over the other as the dominant language, is expected to provide a better view of the development and interaction of the two phonological systems. In addition, Korean experienced adults represent the majority of Korean college students who come to the U.S. for higher education. Note that these Korean adults may have lived in the U.S. for the same length of time as the U.S.-born Korean experienced children, but the different language input and experiences that children and adults undergo are likely to influence the L1 and L2 interaction in different ways.

The U.S.-born Korean children in the age range of six to eight years old are referred to as “Korean experienced” children and the Korean adults who have been living in the U.S. for approximately six to eight years are referred to as “Korean experienced” adults. To be able to examine the native-likeness of both English and Korean, the age-matched native English-speaking children and adults as well as Korean children and adults with less than 6 months of English experience in the U.S. (“inexperienced” children and adults) are included in the study. Previous studies have referred to the Korean experience children as early bilinguals and Korean experienced adults as late bilinguals in an a priori manner and interpreted their differences based on the criteria by which they were categorized. Due to the unclear definition of “early” and “bilingual”, however, each group is referred to as either child or adult and experienced or inexperienced depending on the age of L2 exposure and L2 experience in the current dissertation.

Experiment 1 in Chapter II examines the acquisition of English segments in terms of the spectral quality and duration of English vowels produced by Korean experienced and inexperienced adults and children. The vowel production is compared to the age-matched English monolingual speakers to investigate the native-likeness as well as the degree of L1 interference. To examine whether learning English vowels had any effect on the production of the Korean vowels, Experiment 2 explores Korean vowels produced by the same Korean adults and children. In Chapter III, consonant related patterns are investigated using the same productions elicited in Experiment 1 and 2. Specifically, the effect of word-final stop consonant voicing on the preceding vowel duration and

consonant closure duration was examined. The assumption was that inexperienced Korean speakers would show difficulty acquiring vowel and consonant durational differences due to the lack of voiced and voiceless word-final stop consonant distinction in Korean. Experiment 3 in Chapter IV compares VOT duration for English voiced and voiceless onset stop consonants and Korean lenis and aspirated onset stop consonants. From Experiment 4 in Chapter V, prosodic features of English multisyllabic words are explored in terms of vowel spectral quality and duration of stressed and unstressed vowels. Stressed-to-unstressed vowel duration, F0, intensity as well as the difference between maximum and minimum F0 and intensity are also examined as indicators of native-like acquisition of English stress patterns. Experiment 5 in Chapter VI investigates the effect of English acquisition on Korean via F0 contour, intensity and syllable duration of Korean 4-syllable phrases produced by the same Korean children and adults. Chapter VI explores the effect of English acquisition on Korean prosody.

CHAPTER II

ENGLISH AND KOREAN VOWEL PRODUCTION

2.1. Introduction

Experiment 1 and 2 in Chapter II focus on Korean adults and children's acquisition of English vowels and its effect on Korean vowels. Specifically, the spectral quality and duration of English and Korean vowels were examined and compared across the Korean groups with different amount of English exposure. Korean speaking groups' English vowel production was further compared to the age-matched English monolingual groups' production to assess the degree of native-likeness. The different degree of L1 and L2 separability and interaction between the groups are discussed in terms of their different language experiences.

In Oh, Guion-Anderson, Aoyama, Flege, Akahane-Yamada, & Yamada (2011)'s longitudinal study on English vowel production by Japanese learners of English, Japanese children showed higher accuracy in learning English new vowels in a year's time compared to Japanese adults. Although adults were better at the initial stage of L2 acquisition, children outperformed adults over a year's time in that Japanese children were able to acquire all eight English vowels in a native-like manner, whereas Japanese adults showed no improvement. In addition, the changes observed in the Japanese vowels by Japanese children were interpreted to suggest a strong effect of AOA on the degree of bi-directional interaction between the L1 and L2 vowel systems.

Similarly, much research on the effect of age of L2 exposure and length of residence on L2 acquisition have found native-like L2 speech among early L2 learners (Flege et al., 1995; Guion, 2003; Kang & Guion, 2006). For example, Flege et al. (1999) found no significant difference between early Italian (L1)-English (L2) bilinguals and English monolinguals' productions of ten English vowels. They argued that early bilinguals, especially those with high exposure to the L2, can produce L2 vowels in a native-like manner. Also, Tsukada et al. (2005) compared the English /ɛ/-/æ/, /ɑ/-/ʌ/ produced by English monolingual adults and children and the age-matched native Korean adults and children with different LOR (3 vs. 5 years in the U.S.) and found no significant difference between the native English and Korean children regardless of LOR. The findings were interpreted to suggest that early learners are likely to produce L2 vowels in a native-like manner after about 3 years of residence. In Guion (2003)'s study on Quichua and Spanish vowels produced by Quichua (L1)-Spanish (L2) simultaneous (Mean AOA = 0), early (6), mid (M=11) and late bilinguals (M=19), simultaneous and early bilinguals were shown to produce Spanish vowels similar to Spanish monolinguals. The mid and late bilinguals, however, were less likely to create Spanish vowel categories that are independent from the neighboring Quichua vowels and thus, had nonnative-like Spanish vowel production.

Whereas the aforementioned studies underline the possibility of early learners producing an L2 with no L1 interference, a large body of evidence showed that not all early learners can be native-like in L2 production (Asher & Garcia, 1969; Piske, Flege, & Mackay, 1999; Guion, Flege, & Loftin, 2000; Yeni-Komshian, Flege, & Liu, 2000;

Baker & Trofimovich, 2005; Baker et al., 2008). Some findings suggest that not only late but also early bilinguals may have notable L1 influence. For instance, Asher and Garcia (1969) found that no matter how early and how long the child lived in the United States, not one of the 71 Cuban children achieved a native English pronunciation. Similarly, Baker and Trofimovich (2005) found that, regardless of their LOR (1 vs. 7 years in the U.S.), early Korean-English child bilinguals' production of English vowels, /ɪ/, /ʊ/ and /æ/, were significantly higher in the vowel space compared to English monolingual children's vowels. Furthermore, in the production and perception studies in Baker et al. (2008), English vowel pairs, /i/-/ɪ/ and /u/-/ʊ/, produced by Korean child and adult learners of English showed that even though Korean children surpassed Korean adults in acquiring two English new vowels (i.e., /ɪ/ and /ʊ/), they were not able to perform like English monolingual children. Although milder than adults, foreign accents being detected in early bilinguals' production regardless of LOR (Flege et al., 2006) suggests that no amount of early exposure to the L2 may completely override the language experience acquired from the outset.

Among many other factors, the conflicting results on early bilinguals' L2 production may be attributed to 1) the amount of L1 and L2 use and 2) the similarity between the L1 and L2 vowel systems. First, let us examine the Japanese adults case in Oh et al. (2011)'s study. Although their L2 vowel production did not change in a year's time, their production of English might have improved if they were exposed to English for more than one year. Moreover, unlike the Japanese children who attended English-speaking school for a year, at least eight out of sixteen Japanese female adults (mothers

of the children) may have had relatively little opportunity to speak in English on a daily basis¹. The Japanese adults' lower L2 use and higher L1 use were likely to have resulted in their slower acquisition of English vowels. In particular, studies have shown that there was substantial improvement in adults' L2 performance after an extended amount of L2 exposure (Flege & Liu, 2001) and decreasing foreign accents with smaller amount of L1 use (Guion, Flege & Loftin, 2000).

Piske et al. (2002) showed that the vowel production of early Italian (L1)-English (L2) bilinguals with low L1 use, but not high L1 use, was not significantly different from the vowels produced by native English monolingual children. The finding suggests that deactivating the L1 may help diminish mild foreign accents. In a similar vein, Flege et al.(2003) found that early Italian (L1)-English (L2) bilinguals with low L1 use, but not high L1 use, were able to establish a new English vowel category. In a study on L2 consonants, MacKay, Flege, Piske and Schirru (2001) investigated the production of Italian (L1)-English (L2) bilinguals for English /b/ and found that all groups showed significantly higher percentage of prevoiced /b/ than English monolinguals except for the early bilinguals with low L1 use. Considering the influence of the amount of L1 and L2 use on L2 acquisition, the current study recruited Korean adults and children who have roughly equal opportunity of being exposed to English as either college students or

¹ The Japanese adults were the parents of the Japanese children. These families moved to the U.S. to work in an overseas Japanese branch for one year. While the fathers were more likely to be situated in a work place where English is frequently used, the mothers usually stayed at home. According to a self-report on daily English use, the average time spent speaking English was 3.4 hours for the Japanese adults (fathers and mothers) and 4.7 hours for the Japanese children.

preschool children attending day-care centers. Although the amount of Korean use is less predictable, adults reported to use Korean mostly with their friends and children with their parents on a daily basis (see Appendix for language background questionnaire).

Secondly, studies have suggested that the similarity of the L1 and L2 vowel inventories heavily determines the degree of accuracy in acquiring L2 vowels. McAllister, Flege and Piske (2002) compared Spanish, English and Estonian speakers' productions of four Swedish long-short vowel pairs to Swedish monolingual speakers' production to investigate the effect of L1 on the acquisition of contrastive L2 categories. The study found that the Estonian speakers were the most successful of the three groups. The results were interpreted to indicate that the similar phonological feature of vowel length contrasts shared by the two languages, but not by English or Spanish, facilitated the acquisition of the phonetic features in Swedish.

The effect of cross-language similarity on L2 acquisition presents another reason to examine the L1 vowel system in relation to the L2 vowel system in addition to assessing the effect of different developmental milestones between two languages in child bilinguals' language acquisition (see section 1.2.1). The L1 and L2 phonetic similarity giving rise to a higher chance of acquiring more accurate L2 sounds has been shown through studies on L2 vowel acquisition. Baker et al. (2008) found that Korean adult learners of English had more difficulty learning "new" English vowels (e.g., /ɪ/ and /ʊ/) than "similar" vowels (e.g., /i/ and /u/) compared to Korean child learners. The age effect on the acquisition of new vs. similar English vowels was explained in the framework of the "interaction hypothesis" which highlights the interactive dynamics of

the L1 and L2 system (Flege, 1999, Walley & Flege, 1999). Baker et al. (2008) further note the “possible change in the nature of the L1-L2 interaction as a function of the development of the L1 phonetic system at the time of L2 learning” (p. 319). In other words, not every L2 learner with the same L1 background will show the same pattern of L1-L2 assimilation. For example, Baker and Trofimovich (2005) found that the merged L1-L2 categories produced by early Korean child bilinguals with an average of 7 years of English experience was different from those by Korean adult bilinguals with the same amount of English experience. The child bilinguals assimilated Korean /ɛ/ - English /ɪ/ and Korean /i/ - English /u/, whereas the adult bilinguals assimilated Korean /i/ - English /ɪ/ and Korean /u/ - English /u/. The different patterns of L1-L2 assimilation indicate that the degree of L1 establishment may influence the perception mapping between two languages. Namely, the more the L1 is established, the more likely it is that learners will filter L2 through the L1.

In Oh et al. (2011), changes in the L1 vowels as a result of L2 learning were investigated by comparing three Japanese vowels, /i/, /a/, /u/, across time of testing. The three Japanese vowels were chosen based on the English vowels (i.e., /i/, /ɪ/, /a/, /ʌ/ and /ʊ/) that were significantly different in a year’s time. The hypothesis was that the acquisition of new L2 vowels may subsequently influence the neighboring L1 vowels, leading to either L1-L2 vowel category assimilation or dissimilation (Flege, 1995). However, the problem with examining only the three Japanese vowels is that it presupposes that the rest of the Japanese vowels have not changed because the neighboring English vowels were not acquired. Although the plasticity of the L1 has not

been discussed as much as that of the L2, especially when no L2 learning appears to have taken place, this raises a question as to whether changes in the L1 as a function of L2 learning require native-like L2 acquisition. In other words, L1 vowels were thought to be merged to or pushed away as a consequence of the newly acquired L2 vowels, but there may be a possibility that a nearby L1 vowel shifts away to leave enough vowel space for a newly acquired L2 vowel to move in. If so, then the Japanese vowels other than /i/, /a/, /u/ may have been different after a year of L2 exposure. Accordingly, independent examination of all the L1 vowels, including those that were not directly affected by the acquired L2 vowels, may provide more integrated view of how two vowel systems compete, interact and change.

This chapter examines how Korean adults and children with different language experiences in the U.S. acquire English vowels and how it influences their Korean vowel production. Especially, the likelihood of developing new English vowel categories separate from Korean vowels is explored as a function of age of L2² exposure. Specifically, the interaction of L1 and L2 vowel system(s) was examined through the L1 and L2 vowel spectral qualities and duration produced by Korean children and adults differing in the amount of L2 exposure. Additional research questions raised from Oh et al. (2011)'s previous study were incorporated: 1) If Korean experienced adults were exposed to English more than a year, will they be able to acquire L2 vowels in a native-like manner? 2) Korean experienced children, who were born in the U.S. but raised in a

² It should be noted that the L1 and L2 distinction may not be appropriate for the U.S.-born Korean experienced children. For the sake of consistent reference, however, Korean will be referred to as the L1 and English as the L2 throughout the studies in the current dissertation.

Korean family, were reported to have more Korean and less English exposure before the age of three. Then, do these children produce both L1 and L2 vowels in a native-like manner or are there L1-L2 interactions? 3) One of the important indices used to differentiate simultaneous bilinguals from early sequential bilinguals has been the degree of L1-L2 separability (see Genesee, 1989; Flege et al., 2003; Sundara et al., 2006, Sundara & Polka, 2008). If Korean experienced children are able to separate the two vowel systems and produce both Korean and English vowels in a native-like manner unlike early child bilinguals in previous research (Kehoe, 2002; Baker & Trofimovich, 2005), can we suggest that they are simultaneous bilinguals? That is, could L1 and L2 vowel productions represent the phonological systems of simultaneous bilinguals? 4) Lastly, different language experiences that the adult and child groups undergo in the U.S. are likely to have a significant impact on their L2 productions. Thus, different effects of the similar LOR on adults' and children's English and Korean vowel productions are discussed.

2.2. Experiment 1: English vowel production

2.2.1. Participants

The data were collected from six groups varying in age, LOR and overall English use: KEA (Experienced Korean Adults), KIA (Inexperienced Korean Adults), KEC (Experienced Korean Children), KIC (Inexperienced Korean Children), NEA (Native English-speaking Adults), NEC (Native English-speaking Children). Each group

had four male and six female speakers and none of them reported being diagnosed with hearing or speech disorders.

As shown in Table 1, the age of participants in the child groups ranged approximately from six to nine and the adult groups from 20 to 26 years old. All the adult speakers, including NE adults, were undergraduate students at University of Oregon. The KE adults reported an average 11 years of learning written English through formal school education in Korea. However, none of the KE adults had attended English-speaking institutions or received intensive training on English pronunciation before coming to the U.S. KE adults came to the U.S. after the age of 18 for the purpose of college education. Both KE and KI adult groups were recruited from a Korean church, which suggests their close connection to the Korean speech community. Similar to KE adults, KI adults also learned English in Korea, but arrived in Oregon approximately 6 months before the time of testing. They were either exchange students or transfer students from Seoul or Gyunggi area and many of them were planning to go back to Korea after one year.

As for the children, four out of ten KE children were recruited from Seattle and the rest of the KE and KI children were from Oregon. KE children were all born and raised in the Northwest area of the U.S. to a Korean-speaking family. According to the language background survey, KE children were mainly exposed to Korean before the age of three and started to use English as they began to attend preschool or play with English-speaking children in their neighborhood. The parents of the KE children were all Korean immigrants who worked for American companies or colleges. However, they maintained a close contact with Korean community through church or local associations. The KE

children were raised by their mother who mainly spoke Korean to their child. The parents were both native speakers of Korean but they reported occasional code-switching to English to communicate simple vocabularies (e.g., “daddy”, “car”) and short sentences (e.g., “Let’s go”, “Where is your sister?”).

Four KE children were the younger sisters or brothers of the other four KE children who also participated in the study. Their parents reported that the younger was exposed to English as early as 18 months old through the older sibling. Most of the KE children spoke English to their peers at school and church, while limiting the use of Korean to their parents or grandparents as they grew older. They may be categorized as simultaneous (Hammer & Blanc, 2003; Sundara & Polka, 2007) or sequential bilinguals (Padilla & Lindholm, 1984, De Houwer, 1990; Fowler et al., 2008) depending on the criteria one decides to use. In this dissertation, however, they are referred to as Korean experienced children to avoid any potential confusion or bias resulting from the definition of “simultaneous” or “sequential bilingual”.

KI children had resided in the U.S. approximately 6 months at the time of testing. Two KI children had prior experience with English before the test (three to four months at English institutions in Korea), but none of them was reported to have received training on English pronunciation. Three out of the ten KI children were children of Korean visiting professors who were planning to go back to Korea after one year. The other seven KI children came to the U.S. with their parents who were either planning to pursue a graduate degree or work for American companies for a short period of time. Because of

their short stay in the U.S., the parents of KI children tended to be more eager to send their children to English-speaking activities than the KE children's parents.

For the native English-speaking groups, ten age-matched NE adults and children participated. NE adults and children were raised and have resided in Oregon. Most of the NE adults had the experience learning a second language in high school but none of them had resided in a foreign country. The NE adults were granted one credit after one hour of participation. As for the NE children, four out of ten NE children were recruited from nearby day care centers and the rest of them were the children of graduate students at University of Oregon. None of the NE children reported using any other language than English at home or school.

In addition to the information reported in Table 2.1, language background questionnaire included questions such as the external motivation for learning English, self-rated proficiency in English (speaking, reading, writing, listening), and the percentage of English use in different situations (at home, at school, language spoken to parents, siblings and friends) (see Appendix). The percentage of English use shown below is the participants' reports on their overall use of English on a daily basis.

Table 2.1. Native English-speaking adults, children and Korean experienced and inexperienced adults and children participants. Note that AOA for the KEA, KIA groups indicates the age of L2 acquisition in Korea.

Group	Age	LOR	AOA	English use
NEA (4m, 6f)	21.8(3)	-	-	100%
KEA (4m, 6f)	23.6(2.5)	6.6(1.2)	12.3(1.5)	47%(10%)
KIA (4m, 6f)	23.1(2)	0.5(0.2)	12.5(1.8)	31%(13%)
NEC (4m, 6f)	7.5(1.2)	-	-	100%
KEC (4m, 6f)	7.1(1.2)	7.1(1.2)	2.4(1.6)	62%(18%)
KIC (4m, 6f)	7.3(1.3)	0.5(0.1)	6.7(1.5)	42%(8%)

2.2.2. Speech stimuli

Thirty two frequently used English words were recorded. The same vowels examined in Oh et al. (2011) were included except for /eɪ/ and /ɔ/. Instead of the off-glided /eɪ/, /ɔ/ was included in this study to examine whether the Korean participants were influenced by regional dialect variation such as /ɑ/ in ‘jog’ and /ɔ/ ‘dog’ merging in the Northwest area of the U.S. As shown in Table 2.2, with four words exemplifying each vowel category, a total of eight vowel categories were produced by the six groups. The vowels were all stressed and embedded in monosyllabic words. The coda consonants were matched with either voiced, voiceless stops or consonant clusters to constrain the surrounding consonantal context. The monosyllabic words chosen were constrained by two main factors; they needed to be familiar to English-inexperienced learners and to be imageable for the elicitation procedure, which used pictures of the words.

Table 2.2. Thirty two target words representing eight English vowel categories.

Coda	/i/	/ɪ/	/ɛ/	/ɑ/	/ɔ/	/ʌ/	/u/	/ʊ/
Voiced	bead seed	big pig	egg bed	jog nod	dog fog	bug hug	food mood	good wood
Voiceless	feet eat	six kick	neck pet	sock box	talk chalk	cut duck	fruit boot	book foot

2.2.3. Procedure

The experiment was conducted in a quiet room in the home of the participant (children) or in the phonetics lab at the University of Oregon. Pictures representing the 32 target words were presented in a random order to the participants on the screen of a laptop computer. The Korean and English-speaking adult and child participants wore a head-mounted Shure microphone (Model SM 10A) and the speech was recorded on a flash digital recorder (Marantz PMD670) at a 22.05 kHz sampling rate with 16 bit quantization. The 32 words produced in isolation were elicited three times each in random order. At first, an English production that had been prerecorded by a female native English speaker was presented along with the corresponding picture to make sure that participants understood the words. The experimenter did not provide the auditory cue on the second and third presentations unless the participants (that is, KI children) were unable to retrieve relatively difficult words such as ‘*bead*’ and ‘*mood*’. Approximately 0.04 % of the tokens produced by KI children was not retrieved at the second or third time, and thus, was replaced by the average value of that vowel category for that speaker. Only the second and third tokens of each word, that is, the non-cued productions, were analyzed. The procedure was explained in English for the English task

and Korean for the Korean task in Experiment 2 to help them change the language mode from English to Korean (see Grosjean, 2001; Antoniou, Best, Tyler, & Kroos, 2010).

2.2.4. Measurements

2.2.4.1. Formant frequency

A total of 3840 tokens (32 words x 2 repetition x 6 groups x 10 participants) for the English vowel productions were analyzed using Praat acoustic analysis software. First and second formant frequencies of each vowel were measured at the temporal midpoint of each vowel. Because the formant frequencies showed little differences across the two repetitions, mean values were used in all formant analyses.

Considering the individual differences in the vocal tract lengths between female and male participants as well as the different physique of Americans and Koreans, F1 and F2 frequency measurements were normalized for vowel spectral quality comparisons. Because it was not our interest to directly compare adults' and children's production in this study, adult and child groups were normalized separately. All formant values of KE, KI, NE adult and child groups were normalized to one member of each group (who showed the closest mean F3 value to the mean F3 frequency of that group) with reference to the average F3 frequency of the low back English vowel /ɑ/. The mean F3 of this speaker was divided by the mean F3 for each speaker. Then, the F1 and F2 frequencies for each speaker were multiplied by the factor derived from dividing the mean F3 by their own F3 frequency. The normalized measurements were used for all within and

between-group analyses (see Lee et al., 2006; Guion, 2003; Yang, 1996 for the same normalization method).

2.2.4.2. Vowel duration

The durations of English vowels produced by the six groups were measured in milliseconds from spectrographic and time domain waveform displays. The vowels were measured from the onset of voicing in the vowel to the beginning of the consonant constriction (in words such as *'feet'*). The onset and offset of clear energy in the second formant frequency on the sound spectrogram served as a reference, along with the waveform, to determine the onset and offset of the vowel. The mean duration averaged across two repetitions was submitted to analysis.

2.2.5. Statistical analyses

2.2.5.1. English vowels: formant frequency

Three adult groups (KEA, KIA, NEA) were compared using MANOVAs. The adult and child groups were analyzed separately. The dependent variables for all comparisons were the normalized F1 and F2 frequencies and the independent variables were vowel (8), conducted with repeated measures, and group (3). If the group by vowel interaction was significant, 3-way comparisons were conducted. First of all, in order to determine whether the effect of English experience was significant, MANOVAs examined English vowels produced by the KE adult and KI adult groups as well as the KE child and KI child groups separately. Furthermore, the KE adult and KI adult groups

were separately compared to the NE adult group to assess which English vowel productions were produced in a native manner and to examine whether greater amount of experience led to more native-like vowel production. In the case of a significant interaction between group and vowel, 8 MANOVAs were conducted to test the effect of group (2) on each vowel. The alpha level was adjusted to 0.006 for 8 comparisons and also for the following statistical reports unless otherwise indicated. The univariate tests for F1 and F2 frequencies are reported for each significant MANOVA comparison.

2.2.5.2. English vowels: duration

Similarly, three adult and three child groups were separately examined using ANOVAs. In case of a significant group (3) and vowel (8) interaction, 3-way comparisons were conducted. First, to examine the effect of English experience, the mean duration of eight English vowels produced by the KE adult vs. KI adult and KE child vs. KI child groups were separately analyzed. In addition, comparisons with the NE groups were made, using the factors of group (2) and vowel (8). Significant interactions between group and vowel were explored with 8 ANOVAs testing the effect of group on each vowel duration value. The alpha level was adjusted to 0.006 for 8 comparisons.

2.2.6. Results

First, English vowel productions by the three adult groups (NEA, KEA, KIA) and the three child groups (NEC, KEC, KIC) were compared in terms of vowel spectral quality. Then, the production of vowel duration was compared across the groups.

2.2.6.1. Comparisons among the adult groups: formant frequency

The NE, KE and KI adult group analysis returned a significant group (3) effect [$F(4,52) = 5.006, p < 0.05, \eta_p^2 = 0.278$] as well as a significant group (3) and vowel (8) interaction [$F(28,28) = 11.864, p < 0.05, \eta_p^2 = 0.922$]. Accordingly, all three pairings of the adult groups were compared (i.e., KE vs. KI, NE vs. KE, NE vs. KI). First, in order to examine the effect of 6-year English experience on English vowel spectral qualities, KE adult and KI adult groups' productions were compared. A MANOVA on the normalized F1 and F2 frequencies of English vowels produced by the KE adult and KI adult groups revealed no significant effect of group [$F(2,17) = 2.222, p > 0.05, \eta_p^2 = 0.207$], nor group by vowel interaction [$F(14,5) = 1.350, p > 0.05, \eta_p^2 = 0.791$], which indicated that KE and KI adult groups' vowel productions were not distinctive despite KE adults' longer L2 exposure in the U.S. The F1 and F2 frequencies of 8 English vowels produced by the two Korean adult groups are shown in Figure 2.1. In this and the following figures, the mean is represented by the placement of the vowel symbol and the ellipses enclose +/- 2 standard deviations, rotated along the axis of the first principal component to reflect the correlation between the formants (see Guion, Post, & Payne, 2004; Oh et al., 2011 for studies using the same method). The Korean Experienced and Inexperienced adult groups' vowels that were significantly different from the NE adults' vowels are indicated with an asterisk.

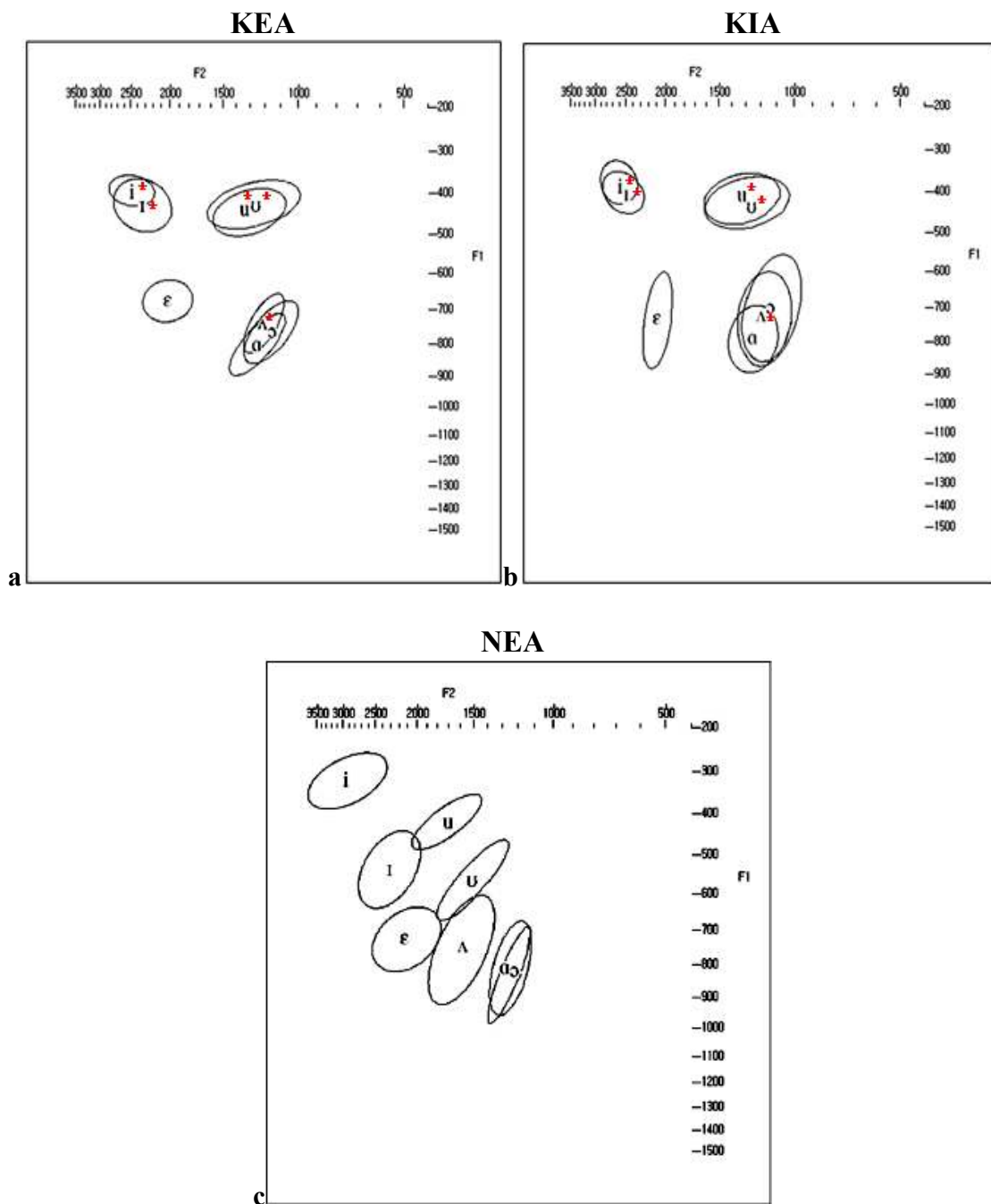


Figure 2.1. Normalized F1 and F2 frequencies of seven English vowels produced by the Korean Experienced adult group (a), Korean Inexperienced adult group (b), and Native English-speaking adult group (c) are shown. The Korean Experienced and Inexperienced adult groups' vowels that were significantly different from the NE adults' vowels are indicated with an asterisk.

Next, to examine the native-likeness of the English vowels produced by the Korean adult groups, comparisons with the NE adult group were made. Eight vowels produced by NE adults and KE adults as well as NE adults and KI adults were separately analyzed using repeated measures MANOVA. First, the NE adult and KE adult groups revealed a significant effect of group [$F(2,17) = 7.648, p < 0.05, \eta_p^2 = 0.474$], as well as an interaction of group and vowel [$F(14,5) = 18.717, p < 0.05, \eta_p^2 = 0.981$], which indicated that some vowels were significantly different across the two groups. Eight MANOVAs testing the effect of group on each vowel showed significant effects for /i/ [$F(2,17) = 31.015, p < 0.006, \eta_p^2 = 0.785$], /ɪ/ [$F(2,17) = 15.068, p < 0.006, \eta_p^2 = 0.639$], /ʊ/ [$F(2,17) = 17.624, p < 0.006, \eta_p^2 = 0.675$], /u/ [$F(2,17) = 29.753, p < 0.006, \eta_p^2 = 0.778$] and /ʌ/ [$F(2,17) = 42.700, p < 0.006, \eta_p^2 = 0.834$], but not for /ɛ/ [$F(2,17) = 3.998, p > 0.006, \eta_p^2 = 0.320$], /ɑ/ [$F(2,17) = 0.347, p > 0.006, \eta_p^2 = 0.039$] and /ɔ/ [$F(2,17) = 2.744, p > 0.006, \eta_p^2 = 0.244$]. The KE adult's vowels that are different from NE adults' vowels are indicated with an asterisk in Figure 2.1(a, c).

The univariate tests for the F1 and F2 frequencies for each significant MANOVA comparison were conducted. The F1 frequency for KE adults' /i/ [$F(1,18) = 32.118, p < 0.006, \eta_p^2 = 0.641$] was significantly higher (i.e., lower in the vowel space) but lower (i.e., higher in the vowel space) for /ɪ/ [$F(1,18) = 30.560, p < 0.006, \eta_p^2 = 0.629$] and /ʊ/ [$F(1,18) = 36.183, p < 0.006, \eta_p^2 = 0.668$] than NE adults' production. The F2 frequency was significantly lower (i.e., more back in the vowel space) for /i/ [$F(1,18) = 13.958, p < 0.006, \eta_p^2 = 0.437$], /ʌ/ [$F(1,18) = 62.421, p < 0.006, \eta_p^2 = 0.776$], /u/ [$F(1,18) = 37.201, p < 0.006, \eta_p^2 = 0.674$], and /ʊ/ [$F(1,18) = 10.902, p < 0.006, \eta_p^2 =$

0.377] in KE adults' production than NE adults' production. Summary results of the group differences are shown in Table 2.3. The nonnative-like KE adults' vowels were overall higher and more back in the vowel space than NE adults' vowels.

The overlapping English vowels produced by KE adults were also investigated in a subsequent analysis to explore whether two neighboring vowels were produced as a single category or separate categories. Based on Figure 2.1(a), five pairs were submitted to separate MANOVAs (/i/-/ɪ/, /ɑ/-/ʌ/, /ɔ/-/ʌ/, /ɑ/-/ɔ/, /u/-/ʊ/) using repeated measures.

The alpha level was adjusted to 0.01 for 5 English vowel pair comparisons. English /i/-/ɪ/ [$F(2,8) = 6.060, p > 0.01, \eta_p^2 = 0.602$], /ɑ/-/ɔ/ [$F(2,8) = 6.490, p > 0.01, \eta_p^2 = 0.619$], /u/-/ʊ/ [$F(2,8) = 0.960, p > 0.01, \eta_p^2 = 0.194$] were not different from one another, but /ɑ/-/ʌ/ [$F(2,8) = 13.798, p < 0.01, \eta_p^2 = 0.775$] and /ɔ/-/ʌ/ [$F(2,8) = 9.423, p < 0.01, \eta_p^2 = 0.702$] were differentiated in KE adults' production. The univariate test returned a significantly lower F1 for /ʌ/ [$F(1,9) = 26.659, p < 0.01, \eta_p^2 = 0.748$] than for /ɑ/, but a significantly higher F1 frequency for /ɔ/ [$F(1,9) = 11.817, p < 0.01, \eta_p^2 = 0.568$] than for /ʌ/. This result suggested that, unlike /i/-/ɪ/ and /u/-/ʊ/ contrasts, KE adults were able to produce /ɑ/ differently from /ʌ/.

Second, the KI adult group was compared to the NE adult group. Although KE adult and KI adult groups' English vowels were not significantly different, KI adults consisted of different speakers, rendering the possibility of different results and a different effect size. A MANOVA on the F1 and F2 frequencies of English vowels produced by the NE adult and KI adult groups revealed a significant effect of group [$F(2,17) = 4.711, p < 0.05, \eta_p^2 = 0.357$], and a significant interaction of group and vowel

[$F(14,5) = 32.323, p < 0.05, \eta_p^2 = 0.989$]. To investigate which vowels were significantly different across group, each vowel was submitted to MANOVAs. The effect of group on each vowel for the KI adult group showed significant effects for /i/ [$F(2,17) = 15.364, p < 0.006, \eta_p^2 = 0.644$], /ɪ/ [$F(2,17) = 33.244, p < 0.006, \eta_p^2 = 0.796$], /u/ [$F(2,17) = 20.942, p < 0.006, \eta_p^2 = 0.711$], /ʊ/ [$F(2,17) = 22.659, p < 0.006, \eta_p^2 = 0.727$], /ʌ/ [$F(2,17) = 35.960, p < 0.006, \eta_p^2 = 0.809$], but not significant for /ɛ/ [$F(2,17) = 0.259, p > 0.006, \eta_p^2 = 0.031$], /ɑ/ [$F(2,17) = 0.471, p > 0.006, \eta_p^2 = 0.052$] and /ɔ/ [$F(2,17) = 5.586, p > 0.006, \eta_p^2 = 0.397$]. KI adults' vowels that are significantly different from NE adults' vowels are indicated with an asterisk in Figure 2.1(b, c).

In the univariate tests, KI adult group's production revealed a significantly higher F1 frequency [$F(1,18) = 16.072, p < 0.006, \eta_p^2 = 0.472$] for /i/ but a lower F1 frequency for /ɪ/ [$F(1,18) = 52.744, p < 0.006, \eta_p^2 = 0.746$] and /ʊ/ [$F(1,18) = 46.603, p < 0.006, \eta_p^2 = 0.721$] compared to NE adult group's production. KI adult group's F2 frequency was significantly lower for /ʌ/ [$F(1,18) = 67.390, p < 0.006, \eta_p^2 = 0.789$], /u/ [$F(1,18) = 33.374, p < 0.006, \eta_p^2 = 0.650$] and /ʊ/ [$F(1,18) = 9.890, p = 0.006, \eta_p^2 = 0.355$] than NE adult's production. See Table 2.3 for the overall summary results. The nonnative-like KI adults' vowels were overall more back in the vowel space (lower F2) than NE adults' vowels.

Again, 5 pairs of English vowels (/i/-/ɪ/, /ɑ/-/ʌ/, /ɔ/-/ʌ/, /ɑ/-/ɔ/, /u/-/ʊ/) were submitted to MANOVAs using repeated measures. As can be seen in Figure 2.1(c), KI adults' /u/-/ʊ/ [$F(2,8) = 5.625, p > 0.01, \eta_p^2 = 0.584$] and /ɔ/-/ʌ/ [$F(2,8) = 2.228, p < 0.01, \eta_p^2 = 0.358$] were not produced significantly differently from one another. However, /i/-

/ɪ/ [$F(2,8) = 27.599, p < 0.01, \eta_p^2 = 0.873$], */ɑ/-/ʌ/* [$F(2,8) = 12.428, p < 0.01, \eta_p^2 = 0.757$] were produced differently. Unlike KE adults, KI adults distinguished */ɑ/* and */ɔ/* [$F(2,8) = 15.414, p < 0.01, \eta_p^2 = 0.794$]. KI adults' */i/* was produced with significantly lower F1 [$F(1,9) = 26.994, p < 0.01, \eta_p^2 = 0.750$] and higher and F2 [$F(1,9) = 15.788, p < 0.01, \eta_p^2 = 0.637$] than */ɪ/*, and both F1 and F2 frequencies were lower for */ʌ/* F1 [$F(1,9) = 15.700, p < 0.01, \eta_p^2 = 0.636$] F2 [$F(1,9) = 15.161, p < 0.01, \eta_p^2 = 0.627$] and */ɔ/* F1 [$F(1,9) = 24.874, p < 0.01, \eta_p^2 = 0.734$] F2 [$F(1,9) = 26.979, p < 0.01, \eta_p^2 = 0.750$] than */ɑ/*. KI adults were different from KE adults in that they discriminated */i/* from */ɪ/* and */ɑ/* from */ɔ/*. The difference between */i/* and */ɪ/* in KI adults' production is likely to be due to the small variance in F2 frequency for KI adults' */i/* (see Figure 2.1). The */ɑ/-/ɔ/* merging in KE adults' but not in KI adults' production may be due to the KE adults' long exposure to the Northwest dialect of the U.S., which does not distinguish these vowels (Labov, 2006).

Table 2.3. The Korean experienced and inexperienced adult groups' vowels that were significantly different from the NE adult group's vowels are shown. Significantly higher or lower values of F1 and F2 frequencies are marked with arrows. The overlapping and distinctive vowel pairs in the Korean adults' production are also shown.

NEA vs. KEA	/i/	F1↑, F2↓	KEA Overlapped /i/-/ɪ/ /a/-/ɔ/ /u/-/ʊ/	KEA Distinctive /a/-/ʌ/ /ɔ/-/ʌ/
	/ɪ/	F1↓		
	/ʌ/	F2↓		
	/u/	F2↓		
	/ʊ/	F1↓, F2↓		
NEA vs. KIA	/i/	F1↑	KIA Overlapped /ɔ/-/ʌ/ /u/-/ʊ/	KIA Distinctive /i/-/ɪ/ /a/-/ʌ/ /a/-/ɔ/
	/ɪ/	F1↓		
	/ʌ/	F2↓		
	/u/	F2↓		
	/ʊ/	F1↓, F2↓		

2.2.6.2. Comparisons among the child groups: formant frequency

Similarly, the NE, KE and KI child groups were compared using MANOVAs. The effect of group [$F(4,52) = 5.235, p < 0.05, \eta_p^2 = 0.287$] as well as the group by vowel interaction [$F(28,28) = 12.708, p < 0.05, \eta_p^2 = 0.927$] were significant across the three groups. First, the effect of LOR was examined for the KE and KI child groups. A MANOVA on the KE and KI child groups revealed a significant effect of group [$F(2,17) = 6.961, p < 0.05, \eta_p^2 = 0.450$] as well as a significant vowel by group interaction [$F(14,5) = 17.631, p < 0.05, \eta_p^2 = 0.980$]. In MANOVAs, six vowels returned a significant effect of group: /i/ [$F(2,17) = 17.018, p < 0.006, \eta_p^2 = 0.667$], /ɪ/ [$F(2,17) = 18.710, p < 0.006, \eta_p^2 = 0.688$], /ɛ/ [$F(2,17) = 10.933, p < 0.006, \eta_p^2 = 0.563$], /ɔ/ [$F(2,17) = 7.941, p < 0.006, \eta_p^2 = 0.483$], /ʌ/ [$F(2,17) = 20.945, p < 0.006, \eta_p^2 = 0.711$], /ʊ/ [$F(2,17) = 9.554, p < 0.006, \eta_p^2 = 0.529$]. However, /a/ [$F(2,17) = 4.669, p > 0.006,$

$\eta_p^2 = 0.355$] and /u/ [$F(2,17) = 6.865, p > 0.006, \eta_p^2 = 0.447$] were not significantly different between the Korean child groups.

In the univariate tests, the KI child group showed a significantly higher F1 frequency for /i/ [$F(1,18) = 17.237, p < 0.006, \eta_p^2 = 0.489$] and /ε/ [$F(1,18) = 7.444, p < 0.006, \eta_p^2 = 0.293$], a lower F1 frequency for /ɪ/ [$F(1,18) = 24.866, p < 0.006, \eta_p^2 = 0.580$], /ʊ/ [$F(2,17) = 20.107, p < 0.006, \eta_p^2 = 0.528$], and a higher F2 frequency for /i/ [$F(1,18) = 9.585, p = 0.006, \eta_p^2 = 0.347$] and a lower F2 frequency for /ɪ/ [$F(1,18) = 8.343, p < 0.006, \eta_p^2 = 0.317$], /ʊ/ [$F(1,18) = 10.101, p < 0.006, \eta_p^2 = 0.359$] and /ʌ/ [$F(1,18) = 29.776, p < 0.006, \eta_p^2 = 0.623$] and than the KE child group. The F1 and F2 frequencies for /ɔ/, however, were not significantly different in the univariate tests. Summary results of the differences are shown in Table 2.4. Less distinctive English vowel categories in KI children's production are more evident in Figure 2.2.

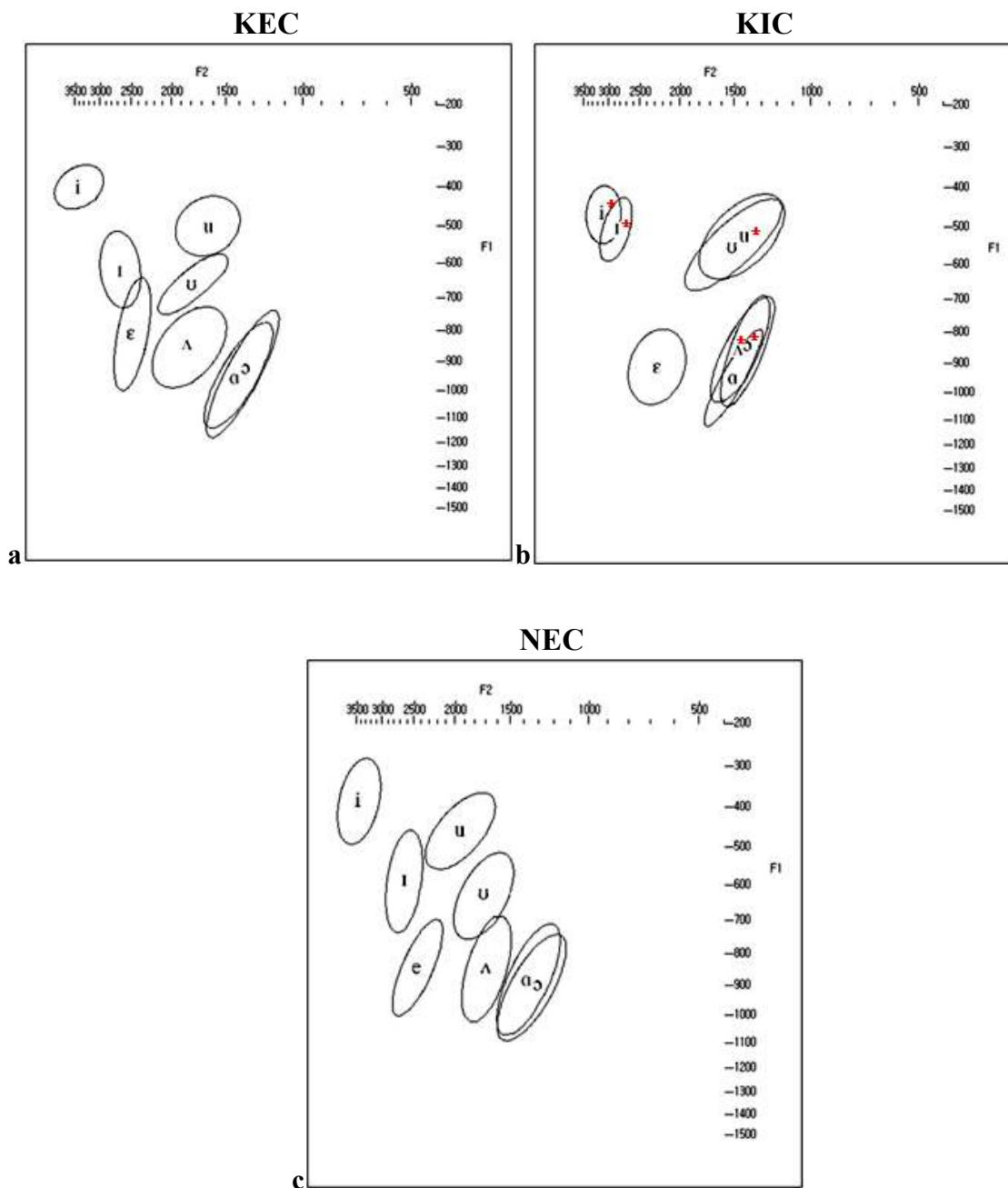


Figure 2.2. Normalized F1 and F2 frequencies of seven English vowels produced by Korean Experienced child group (a), Korean Inexperienced child group (b), and Native English-speaking child group (c) are shown. Korean Inexperienced child group's vowels that were significantly different from Native English-speaking child group's vowels are indicated with an asterisk.

In order to investigate whether KE children's production was more native-like than KI children's production, the KE and KI child groups were each compared to the NE child group. First, a separate MANOVA on the F1 and F2 frequencies of English vowels produced by the NE child and KE child groups revealed no significant effect of group [$F(2,17) = 1.110, p > 0.05, \eta_p^2 = 0.115$], nor a significant group by vowel interaction [$F(14,5) = 2.686, p > 0.05, \eta_p^2 = 0.188$], indicating that KE children's and NE children's vowels were not significantly different.

Although KE children performed like native English-speaking children, the size of each vowel ellipse was larger in KE child group's production than NE child group's production, which indicates greater variances within the KE child group. To assess whether the distance between vowels within each vowel category differ across the NE and KE child groups, the mean F1 and F2 value for each vowel category for each subject was subtracted from each datapoint. The absolute values of the difference scores were submitted to Welch *t*-test to compare the distance scores for each vowel category between the two groups. The results showed that three back vowels were not significantly different between the NE child and KE child groups: /ɔ/ $t(12) = 2.40, p > 0.006$, /u/ $t(14) = -1.857, p > 0.006$, /ʊ/ $t(15) = 2.739, p > 0.006$. Other vowels such as /i/ $t(16) = 3.193, p < 0.006$, /ɪ/ $t(16) = 8.342, p < 0.006$, /ε/ $t(14) = 3.389, p < 0.006$, /ʌ/ $t(16) = 3.530, p < 0.006$ were significant different. Larger variances within each vowel category (mostly front vowels) in the KE children's production may be interpreted as the different degree of native-likeness in their English vowel production.

The comparisons between the NE child and KI child groups with MANOVA tests returned a significant effect of group [$F(2,17) = 10.642, p < 0.05, \eta_p^2 = 0.556$], as well as a significant group by vowel interaction [$F(14,5) = 130.116, p < 0.05, \eta_p^2 = 0.997$]. A separate MANOVA showed a significant group effect for /i/ [$F(2,17) = 19.214, p < 0.006, \eta_p^2 = 0.693$], /ɪ/ [$F(2,17) = 20.655, p < 0.05, \eta_p^2 = 0.708$], /ʌ/ [$F(2,17) = 21.144, p = 0.05, \eta_p^2 = 0.713$], /ɔ/ [$F(2,17) = 5.355, p < 0.05, \eta_p^2 = 0.386$], /u/ [$F(2,17) = 46.627, p < 0.05, \eta_p^2 = 0.846$], but not for /ɛ/ [$F(2,17) = 8.090, p > 0.006, \eta_p^2 = 0.488$], /ɑ/ [$F(2,17) = 3.660, p > 0.006, \eta_p^2 = 0.284$] and /ʊ/ [$F(2,17) = 4.399, p > 0.006, \eta_p^2 = 0.341$].

The univariate test showed that KI children produced a significantly higher F1 frequency for /i/ [$F(1,18) = 14.337, p < 0.006, \eta_p^2 = 0.443$] and marginally lower for /ɪ/ [$F(1,18) = 9.287, p = 0.007, \eta_p^2 = 0.340$] than NE children. The F2 frequency was significantly lower for /i/ [$F(1,18) = 12.128, p < 0.006, \eta_p^2 = 0.403$], /u/ [$F(1,18) = 37.712, p < 0.006, \eta_p^2 = 0.677$], /ʌ/ [$F(1,18) = 22.880, p < 0.006, \eta_p^2 = 0.560$], but higher for /ɪ/ [$F(1,18) = 14.928, p < 0.006, \eta_p^2 = 0.453$] in KI children's than NE children's production. See Table 2.4 for the summarized results of the two groups' vowel differences.

The same overlapping vowel pairs compared in the adult groups were examined for the KI child group. The results returned two non-significant vowel pairs: /ɔ/-/ʌ/ [$F(2,8) = 0.378, p > 0.01, \eta_p^2 = 0.086$], /u/-/ʊ/ [$F(2,8) = 4.578, p > 0.01, \eta_p^2 = 0.534$], and three significant vowel pairs: /i/-/ɪ/ [$F(2,8) = 17.698, p < 0.01, \eta_p^2 = 0.816$], /ɑ/-/ɔ/ [$F(2,8) = 6.837, p < 0.01, \eta_p^2 = 0.631$], /ɑ/-/ʌ/ [$F(2,8) = 12.822, p < 0.01, \eta_p^2 = 0.762$]

(see Table 2.4). The univariate tests confirmed that /i/ was produced with a significantly lower F1 [$F(1,9) = 10.423, p = 0.01, \eta_p^2 = 0.537$] and higher F2 frequency [$F(1,9) = 10.251, p = 0.011, \eta_p^2 = 0.532$] than /ɪ/, and /ʌ/ [$F(1,9) = 26.478, p < 0.017, \eta_p^2 = 0.746$], /ɔ/ [$F(1,9) = 15.313, p < 0.017, \eta_p^2 = 0.630$] with a significantly lower F1 frequency than /ɑ/ in KI child group's production. That is, KI children's /ɔ/ as in 'dog' was not distinguished from either /ʌ/ as in 'duck' but was differentiated from /ɑ/ in 'sock'. KI adults and children showed the same pairs of overlapping vowels.

Table 2.4. The Korean inexperienced child group's vowels that were significantly different from the experienced child and native English-speaking child groups' vowels are shown. The inexperienced children's significantly higher or lower values of F1 and F2 frequencies are marked with arrows. The overlapping and distinctive vowel pairs in inexperienced children's production are also shown.

KEC vs. KIC	/i/	F1↑, F2↓	KIC Overlapped /ɔ/-/ʌ/ /u/-/ɔ/	KIC Distinctive /i/-/ɪ/ /ɑ/-/ʌ/ /ɑ/-/ɔ/		
	/ɪ/	F1↓, F2↑				
	/ɛ/	F1↑, F2↓				
	/ɔ/	F1↓, F2↓				
NEC vs. KIC	/i/	F1↑, F2↓				
	/ɪ/	F2↑				
	/ʌ/	F2↓				
	/u/	F2↓				

2.2.6.3. Comparisons among the adult groups: vowel duration

An ANOVA on the mean duration of English vowels produced by the NE, KE and KI adult groups revealed a significant effect of group [$F(2,27) = 5.991, p < 0.05, \eta_p^2 = 0.307$] and group by vowel interaction [$F(14,42) = 11.861, p < 0.05, \eta_p^2 = 5.463$]. First, an ANOVA on the mean duration of English vowels produced by the KE adult and KI

adult groups revealed no significant effect of group [$F(1,18) = 0.294, p > 0.05, \eta_p^2 = 0.016$], nor a significant interaction of vowel and group [$F(7,12) = 1.799, p > 0.05, \eta_p^2 = 0.512$]. The results indicated that there was no significant effect of LOR on English vowel duration.

An ANOVA on the English production by the NE adult and KE adult groups revealed a significant effect of group [$F(1,18) = 11.861, p < 0.05, \eta_p^2 = 0.397$], and a significant vowel by group interaction [$F(7,12) = 9.569, p < 0.05, \eta_p^2 = 0.848$]. Separate ANOVAs showed that the KE adults produced some vowels significantly longer than NE adults: / ϵ / [$F(1,18) = 12.868, p < 0.006, \eta_p^2 = 0.417$], / u / [$F(1,18) = 11.730, p < 0.006, \eta_p^2 = 0.395$], / o / [$F(1,18) = 19.409, p < 0.006, \eta_p^2 = 0.519$], / Λ / [$F(1,18) = 20.609, p < 0.006, \eta_p^2 = 0.534$] and marginally / $ɪ$ / [$F(1,18) = 9.210, p = 0.007, \eta_p^2 = 0.338$]. However, / i / [$F(1,18) = 5.836, p > 0.006, \eta_p^2 = 0.245$], / a / [$F(1,18) = 2.860, p > 0.006, \eta_p^2 = 0.137$], and / $ɔ$ / [$F(1,18) = 2.442, p > 0.006, \eta_p^2 = 0.119$] were not significantly different across groups. See Table 2.5 for the significantly longer vowels produced by the KE adult group. In addition, the tense-lax vowel pairs (/i/-/ɪ/, /u/-/ʊ/, /ɑ/-/ʌ/) produced by KE adults were compared, using ANOVAs. All three pairs were significantly different, indicating that lax vowels were produced with shorter duration than the corresponding tense vowels: /i/-/ɪ/ [$F(1,9) = 29.204, p < 0.017, \eta_p^2 = 0.764$], /u/-/ʊ/ [$F(1,9) = 10.754, p < 0.017, \eta_p^2 = 0.554$], /ɑ/-/ʌ/ [$F(1,9) = 36.752, p < 0.017, \eta_p^2 = 0.803$].

In the NE adult and KI adult group comparisons, an ANOVA on the mean duration of English vowels revealed a significant effect of group [$F(1,18) = 8.231, p < 0.05, \eta_p^2 = 0.314$], and a significant vowel by group interaction [$F(7,12) = 23.224, p <$

0.05, $\eta_p^2 = 0.931$]. Separate ANOVAs showed that the KI adults also produced some vowels significantly longer than NE adults: /i/ [$F(1,18) = 10.586, p < 0.006, \eta_p^2 = 0.370$], /ɛ/ [$F(1,18) = 16.280, p < 0.006, \eta_p^2 = 0.475$], /u/ [$F(1,18) = 12.949, p < 0.006, \eta_p^2 = 0.418$], /ʊ/ [$F(1,18) = 19.069, p < 0.006, \eta_p^2 = 0.514$], and /ʌ/ [$F(1,18) = 20.609, p < 0.006, \eta_p^2 = 0.534$]. However, /ɪ/ [$F(1,18) = 3.627, p > 0.006, \eta_p^2 = 0.168$], /ɑ/ [$F(1,18) = 0.016, p > 0.006, \eta_p^2 = 0.001$], and /ɔ/ [$F(1,18) = 0.004, p > 0.006, \eta_p^2 = 0.000$] were not significantly different across groups. As for the tense-lax vowel pairs, /i/ and /u/ were significantly longer than /ɪ/ [$F(1,9) = 51.109, p < 0.017, \eta_p^2 = 0.850$] and /ʊ/ [$F(1,9) = 15.118, p < 0.017, \eta_p^2 = 0.627$], respectively. However, the KI adults' /ɑ/ and /ʌ/ were not distinguished by duration [$F(1,9) = 3.843, p > 0.017, \eta_p^2 = 0.299$] (see Table 2.5).

2.2.6.4. Comparisons among the child groups: vowel duration

An ANOVA on the mean duration of English vowels produced by the NE, KE and KI child groups returned no significant effect of group [$F(2,27) = 1.457, p > 0.05, \eta_p^2 = 0.097$], but a significant group by vowel interaction [$F(14,42) = 3.658, p < 0.05, \eta_p^2 = 0.549$]. Thus, group comparisons were conducted. First, an ANOVA on the mean duration of English vowels produced by the KE child and KI child groups revealed no significant effect of group [$F(1,18) = 1.014, p > 0.05, \eta_p^2 = 0.053$], but a significant vowel by group interaction [$F(7,12) = 7.288, p < 0.05, \eta_p^2 = 0.810$]. However, separate ANOVAs revealed no significant difference for any of the 8 vowels: /i/ [$F(1,18) = 4.928, p > 0.006, \eta_p^2 = 0.215$], /ɪ/ [$F(1,18) = 0.623, p > 0.006, \eta_p^2 = 0.033$], /ɛ/ [$F(1,18) = 0.890, p > 0.006, \eta_p^2 = 0.043$], /ɔ/ [$F(1,18) = 1.902, p > 0.006, \eta_p^2 = 0.096$], /u/ [$F(1,18) = 3.164,$

$p > 0.006, \eta_p^2 = 0.150$], /ʊ/ [$F(1,18) = 0.029, p > 0.006, \eta_p^2 = 0.002$], /ɑ/ [$F(1,18) = 6.741, p < 0.006, \eta_p^2 = 0.272$], and /ʌ/ [$F(1,18) = 0.206, p > 0.006, \eta_p^2 = 0.011$].

Although not significant, KE children's /i/ and /ɑ/ were produced with longer duration than KI children's production (see Table 2.5).

A separate comparison between the KE child and NE child groups revealed no significant effect of group [$F(1,18) = 3.655, p > 0.05, \eta_p^2 = 0.169$], nor a significant vowel by group interaction [$F(7,12) = 1.461, p > 0.05, \eta_p^2 = 0.460$]. The KE child group also showed distinctive tense-lax contrasts in three vowel pairs: /i/-/ɪ/ [$F(1,9) = 31.613, p < 0.017, \eta_p^2 = 0.778$], /u/-/ʊ/ [$F(1,9) = 45.439, p < 0.017, \eta_p^2 = 0.835$], /ɑ/-/ʌ/ [$F(1,9) = 266.46, p < 0.017, \eta_p^2 = 0.967$].

The NE child and KI child groups revealed no significant effect of group [$F(1,18) = 0.300, p > 0.05, \eta_p^2 = 0.016$], but a significant vowel by group interaction [$F(7,12) = 4.038, p < 0.05, \eta_p^2 = 0.702$]. However, results from the ANOVAs on each vowel showed that none of the eight vowels produced by the KI children was significantly different from the NE children with respect to duration: /i/ [$F(1,18) = 0.531, p > 0.006, \eta_p^2 = 0.029$], /ɪ/ [$F(1,18) = 1.587, p > 0.006, \eta_p^2 = 0.081$], /ɛ/ [$F(1,18) = 5.126, p > 0.006, \eta_p^2 = 0.222$], /ɑ/ [$F(1,18) = 1.072, p > 0.006, \eta_p^2 = 0.056$], /ɔ/ [$F(1,18) = 0.668, p > 0.05, \eta_p^2 = 0.036$], /u/ [$F(1,18) = 0.482, p > 0.006, \eta_p^2 = 0.026$], /ʊ/ [$F(1,18) = 4.379, p > 0.006, \eta_p^2 = 0.196$], /ʌ/ [$F(1,18) = 4.545, p > 0.006, \eta_p^2 = 0.202$]. An ANOVA test on the tense-lax vowel pairs for the KI child group revealed significant differences for /i/-/ɪ/ [$F(1,9) = 11.316, p < 0.017, \eta_p^2 = 0.644$] and /ɑ/-/ʌ/ [$F(1,9) = 14.961, p < 0.017, \eta_p^2 =$

0.624], but for /u/-/ʊ/ [$F(1,9) = 3.577, p > 0.017, \eta_p^2 = 0.284$]. Note that KI children's production was closer to the native norm than KI adults with respect to vowel duration.

Table 2.5 Mean values of six tense-lax English vowels duration (in ms) produced by the three adult and three child groups are shown with standard deviation in parentheses. The significantly longer vowels produced by the Korean groups compared to those by the native English-speaking groups are marked in gray shades.

Group	/i/	/ɪ/	/ɛ/	/ɑ/	/ɔ/	/ʌ/	/u/	/ʊ/
NEA	170 (20)	120 (20)	140 (20)	190 (20)	190 (20)	140 (20)	170 (20)	130 (20)
KEA	200 (30)	150 (20)	200 (40)	220 (30)	200 (30)	190 (30)	210 (30)	190 (40)
KIA	200 (20)	140 (30)	200 (40)	200 (40)	180 (30)	180 (30)	210 (30)	180 (30)
NEC	190 (30)	140 (20)	180 (20)	220 (30)	210 (20)	160 (20)	210 (30)	150 (20)
KEC	220 (40)	170 (20)	190 (30)	240 (30)	220 (30)	180 (30)	230 (40)	180 (30)
KIC	180 (30)	160 (40)	210 (30)	210 (30)	200 (40)	190 (30)	220 (40)	190 (40)

2.2.7. Discussion

The results on vowel spectral quality as well as duration between the KE and KI adult groups suggested that L2 experience in the U.S. did not significantly improve the production of English vowels for Korean adults. This little effect of LOR on adults' L2 production is consistent with the findings in Munro (1993) and Fox, Flege and Munro (1995). On the one hand, the overlapping vowels within each group showed that KI adults and children, but not KE adults, were able to distinguish /ɪ/ from /i/. On the other hand, KI adults produced the assimilated /ʌ/-/ɔ/ vowel category differently from the neighboring /ɑ/, whereas KE adults distinguished /ʌ/ from the merged /ɔ/-/ɑ/. The

assimilation of /ɔ/ and /ɑ/ found in the KE adult group's production may reflect the influence of the Northwest dialect where two vowels are not distinguished.

As the Speech Learning Model (SLM) by Flege (1995, 2002) proposed, the more the Korean adults perceive the phonetic dissimilarity between an L2 and the closest L1 sound, the greater is the likelihood of Korean adults creating a separate category for that L2 sound. In other words, "new" L2 categories with no apparent L1 counterpart are more likely to be noted and acquired by L2 learners compared to the phonetically similar L1-L2 sounds. First, the establishment of "new" L2 vowels, /ʌ/, /ɔ/ and /ɪ/ distinct from the neighboring L2 vowels /ɑ/ and /i/ in the KI, but not KE, adults' production suggests that the relatively inexperienced adults were more likely to have noticed and distinguished the new L2 vowels than the experienced adults. Second, however, the results that neither the KE adult nor the KI adult group was able to accurately distinguish three English vowel contrasts, /i/-/ɪ/, /ɑ/-/ʌ/, and /u/-/ʊ/, in a native-like manner suggest the effect of cross-language similarity. Specifically, both Korean adult groups showed difficulty acquiring the new English vowels, /ɪ/, /ʌ/, and /ʊ/, that are assimilated to the phonetically similar Korean vowels, /i/, /ʌ/, and /u/, respectively. The difficulty producing a native-like contrast for these vowel pairs have also been reported in previous studies (see Baker, Trofimovich, Mack & Flege, 2001, Trofimovich, Baker & Mack, 2001, Tsukada et al., 2005).

The KE child group showed a substantial difference from the KI child group but no difference from the NE child group. In comparison to the adult groups, the differences for the child groups, suggested that Korean children were able to create more distinctive

English vowel categories with higher accuracy than the adults. Similar to KI adults, KI children were able to distinguish /ɪ/ from /i/ and /ʌ/ from /ɑ/ but not /ɔ/ from /ʌ/. /ɔ/ and /ɑ/ vowels were merged as in NE children's production.

The effect of English experience for the KE and KI adult groups was not significant on vowel duration either. The KE adult and KI adult groups showed a similar result in that they produced significantly longer vowels than the NE adult group: KEA for /ɪ/, /ɛ/, /u/, /ʊ/, /ʌ/ and KIA for /i/, /ɛ/, /u/, /ʊ/, /ʌ/. Among the tense and lax vowels, KI adults' /ɑ/ and /ʌ/ were not significantly different in terms of duration. Although both the KE and KI adult groups produced tense vowels longer than the corresponding lax vowels, the durational difference was not as large as that in the NE adult group's production, except for the /i/-/ɪ/ pair. On the other hand, none of the Korean child groups returned significantly different vowel duration in comparison to the NE child group. That is, both the KE and KI child groups produced 8 vowels' duration in a native manner, although the tense-lax vowel durational difference was still shorter in KI child group's than NE and KE child groups' productions. However, KI children were more accurate than KI adults in the acquisition of English vowel duration.

To summarize, the same results on both vowel spectral quality and duration between KE and KI adult groups' production suggested that the length of exposure to the L2 did not significantly influenced their L2 vowel production. In the child case, however, the effect of L2 experience was significant. The KE children distinguished all eight vowels in a native-like manner in terms of both spectral quality and duration. KE adults' significantly less native-like production of English vowels suggests that the ability to

create separate vowel categories decreases with increased age (Munro, Flege & Mackay, 1996; Guion, 2003; Baker & Trofimovich, 2005). However, considering the KE adults' report on English daily use (47%), which is lower than KE children's English use (62%), KE adults' slow improvements should not be fully attributed to the age of L2 acquisition. That is, different quantity and quality of L2 input Korean adults and children receive and Korean adults' high L1 daily use may have resulted in different degree of native-likeness in English vowel production (Guion, Flege & Loftin, 2000; MacKay, Flege, Piske & Schirru, 2001; Piske et al., 2002; Flege, Schirru & MacKay, 2003)

In Experiment 1, an average 6 years of L2 experience did not appear to have any effect on the Korean adults' English vowel production. However, it does not indicate that there was no interaction between the L1 and L2 vowel systems. To further investigate the effect of English learning on Korean vowel production, Experiment 2 was conducted. Based on the results in Experiment 1 in which Korean child groups showed more L2 learning than the adult groups, KE children were expected to show a stronger effect of English on Korean vowels. In addition, Korean vowel productions by the four Korean groups were compared to their English productions to illustrate the cross-language similarity and its effect on the L1-L2 interaction.

2.3. Experiment 2: Korean vowel production

In this section, the research question was whether there was any effect of English vowel acquisition on Korean vowel production. More specifically, our goal was to examine whether the acquisition of English vowels which are located near Korean

vowels triggered an assimilation of English and Korean vowels or dissimilation between English and Korean vowels. Assuming that the KI adults' Korean production is less affected by English and more likely to resemble native Korean speakers' production, the KE adults' Korean vowel production was compared to the KI adults' production. The effect of LOR on Korean vowels and the interaction between English and Korean vowels were investigated.

2.3.1. Participants

The same 20 Native Korean adults (KEA and KIA) and 20 children (KEC and KIC) who participated in Experiment 1 participated in Experiment 2.

2.3.2. Speech stimuli

Seven Korean disyllabic words were produced to elicit seven Korean vowels (see Table 2.6). Although the number of syllables differs between English monosyllabic and Korean disyllabic stimuli, the Korean vowels were carefully matched to occur after a voiceless velar stop /k/ and before a voiced velar stop /g/. The different syllable length was not shown to be a limitation in comparing vowel quality across two languages (see Yang, 1996; Baker & Trofimovich, 2005 for the similar set of stimuli for English and Korean vowel comparisons).

Table 2.6. Korean disyllabic words representing seven Korean vowel categories.

/i/	/e/	/a/	/o/	/ʌ/	/u/	/i/
/kige/	/kegan/	/kagu/	/kogi/	/kʌgi/	/kugʌl/	/kigʌt/
machine	beginning class	furniture	meat	there	begging	that

2.3.3. Procedure

The same procedure used in Experiment 1 was used in Experiment 2. The Korean stimuli were presented in a random order to the participants and each stimulus was elicited 3 times in isolation. The experimenter provided prerecorded production (by a Korean female adult who has resided in the U.S. less than 3 months at the time of testing and worked as a professional anchor woman in Seoul, Korea) of the corresponding word the first time and the participants were asked to repeat the words so that the participants were able to match the pictures with the stimuli for a picture naming task. Only the second and third productions, which were recorded without the auditory prompts, were used for the analyses.

2.3.4. Statistical analyses

Seven Korean vowels were investigated to determine whether the acquisition of English vowels would affect the Korean vowels. In order to examine whether there was any effect of English experience on Korean vowel production for the KE and KI adult and child groups, MANOVAs were conducted separately for adult and child groups. The group comparisons used the factors of group (2) and vowel (7). In the case of a significant group by vowel interaction, 7 MANOVAs were conducted to test the group

effect for each vowel. The alpha level was adjusted to 0.007 for 7 comparisons. The univariate tests for F1 and F2 are reported for each significant MANOVA comparison. All the Korean vowel productions were measured and normalized with the same method used in Experiment 1 (see 2.2.4.1).

In a subsequent analysis, the English vowels produced in Experiment 1 were also examined in relation to the Korean vowels. For each adult group, a MANOVA examining the overlapping four English-Korean vowel pairs was conducted to investigate whether they were produced as a single category or as separate categories. A separate MANOVA for the KE and KI child groups on the English-Korean vowel pairs were examined as well. The alpha level was adjusted to 0.013 for four comparisons in KE and KI adult groups' productions and 0.008, 0.017 and 0.025 for multiple comparisons in the KE and KI child groups' production.

As for the duration, the mean duration of seven Korean vowels produced by the KE, KI adult and KE, KI child groups were separately analyzed using ANOVAs. The effects of group (2) and vowel (7) were investigated. Significant interactions between group and vowel were explored with 7 ANOVAs testing the effect of group on each vowel. The alpha level was adjusted to 0.007 for 7 comparisons.

2.3.5. Results

2.3.5.1. Comparisons between the KE and KI groups: formant frequency

First, a MANOVA on the F1 and F2 frequencies of Korean vowels produced by KE adults and KI adults revealed a significant effect of group [$F(2,17) = 4.036, p < 0.05$,

$\eta_p^2 = 0.322$], as well as a significant interaction of group and vowel [$F(12,7) = 4.705, p < 0.05, \eta_p^2 = 0.890$]. The results from the MANOVA on each vowel showed that the seven vowels were not different for the two groups: /i/ [$F(2,17) = 0.426, p > 0.007, \eta_p^2 = 0.048$], /e/ [$F(2,17) = 2.990, p > 0.007, \eta_p^2 = 0.260$], /a/ [$F(2,17) = 0.560, p > 0.007, \eta_p^2 = 0.062$], /o/ [$F(2,17) = 0.461, p > 0.007, \eta_p^2 = 0.051$], /u/ [$F(2,17) = 0.564, p > 0.007, \eta_p^2 = 0.062$], /ʌ/ [$F(2,17) = 0.373, p > 0.007, \eta_p^2 = 0.042$], /ɨ/ [$F(2,17) = 5.941, p > 0.007, \eta_p^2 = 0.306$]. However, the univariate tests showed that the F2 frequency for /ɨ/ [$F(1,18) = 11.824, p < 0.007, \eta_p^2 = 0.396$] was significantly lower in the KE adult group's production. KE and KI adults' Korean vowel productions are shown in Figure 2.3.

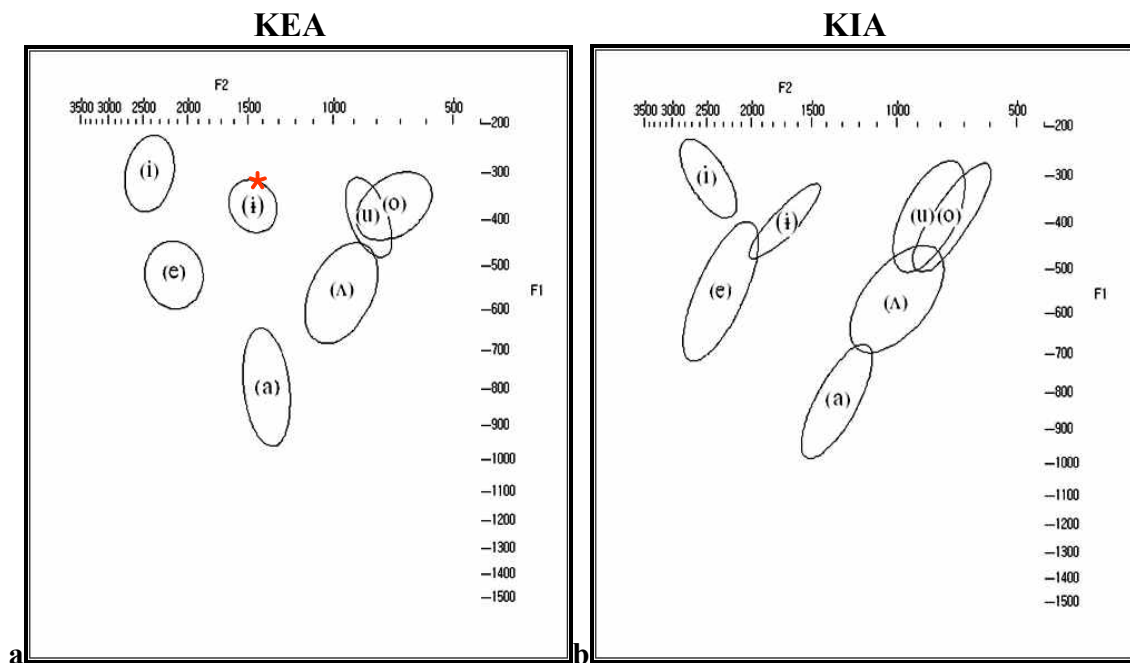


Figure 2.3. Normalized F1 and F2 frequencies of seven Korean vowels produced by Korean Experienced adult group (a) and Korean Inexperienced adult group (b) are shown. The Korean experienced adult group's vowel that was significantly different from the Korean Inexperienced adult group's vowel is indicated with an asterisk.

The KE child group did not differ from the KI child group in Korean vowel production (see Figure 2.4). A MANOVA on the F1 and F2 frequencies of Korean vowels produced by the KE child and KI child groups revealed no significant difference across groups [$F(2,17) = 3.460, p > 0.05, \eta_p^2 = 0.289$], and no significant interaction of group and vowel [$F(12,7) = 1.845, p > 0.05, \eta_p^2 = 0.651$].

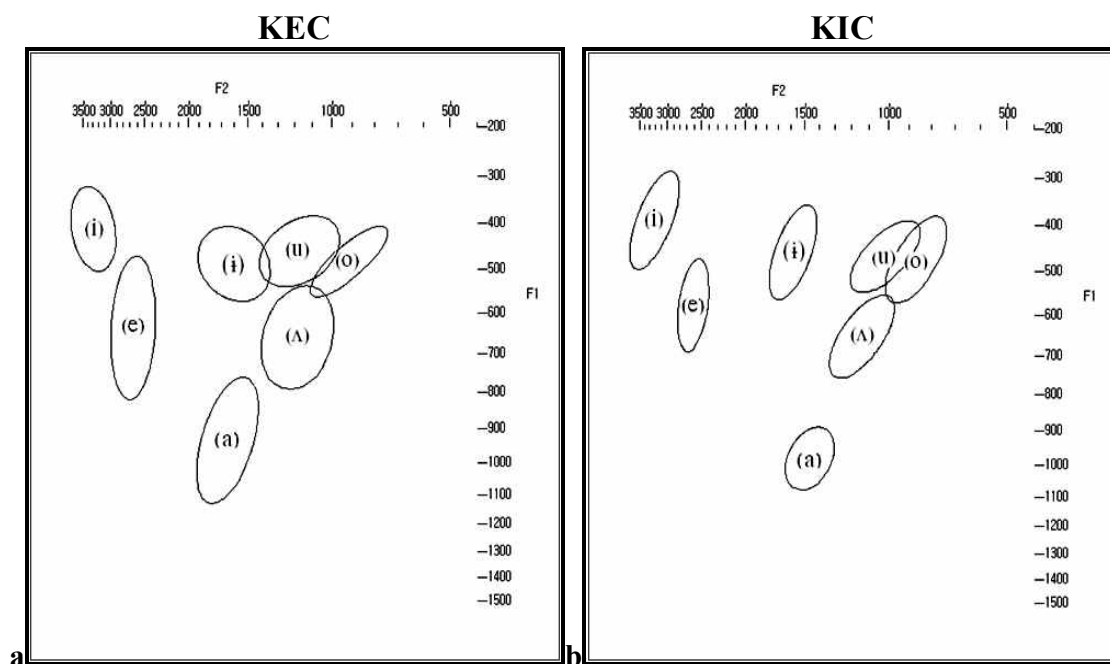


Figure 2.4. Normalized F1 and F2 frequencies of seven Korean vowels produced by Korean Experienced child group (a) and Korean Inexperienced child group (b) are shown.

2.3.5.2. Comparisons between the KE and KI groups: vowel duration

An ANOVA on the mean duration of Korean vowels produced by the KE adult and KI adult groups revealed no significant effect of group [$F(1,18) = 2.357, p > 0.05, \eta_p^2 = 0.116$], nor a significant vowel by group interaction [$F(6,13) = 1.377, p > 0.05, \eta_p^2 = 0.651$].

= 0.389]. Similarly for the child groups, the group effect [$F(1,18) = 0.211, p > 0.05, \eta_p^2 = 0.012$] and the group by vowel interaction [$F(6,13) = 0.869, p > 0.05, \eta_p^2 = 0.286$] were not significant. The result suggested that Korean vowel duration was not influenced by the amount of English experience.

2.3.5.3. Comparisons between English and Korean vowels

Next, when English vowels elicited in Experiment 1 were put together with Korean vowels (see Figure 2.5 and 2.6), overlapping vowel targets for the two languages emerged for the Korean adult and child groups. First, the relationship between Korean and English vowels was investigated for the adult groups. In the KE adult group's production, 1) English /i, ɪ/ and Korean /i, e/, 2) English /ɑ, ɔ, ʌ/ and Korean /a/ were partially overlapped. A MANOVA revealed that KE adult group's production of English /ɑ-ɔ, ʌ/ and Korean /a/ was not statistically different [$F(6,4) = 5.565, p > 0.05, \eta_p^2 = 0.893$]. However, English /i, ɪ/ and Korean /i, e/ were significantly different [$F(6,4) = 312.949, p < 0.05, \eta_p^2 = 0.998$]. Also, the pairwise comparisons for all four vowel pairs revealed significant differences: English /i/ - Korean /i/ [$F(2,8) = 20.645, p < 0.013, \eta_p^2 = 0.838$], English /i/ - Korean /e/ [$F(2,8) = 32.510, p < 0.013, \eta_p^2 = 0.890$], English /ɪ/ - Korean /i/ [$F(2,8) = 31.074, p < 0.013, \eta_p^2 = 0.886$], English /ɪ/ - Korean /e/ [$F(2,8) = 18.851, p < 0.013, \eta_p^2 = 0.825$]. The results suggested that the KE adults were able to separate the assimilated English /i-ɪ/ category from both Korean /i/ and /e/, but not English /ɑ-ɔ, ʌ/ from Korean /a/. Similarly, KI adults' English /ɑ, ɔ, ʌ/ and Korean /a/ were not significantly different [$F(6,4) = 5.485, p > 0.05, \eta_p^2 = 0.892$]. However, English

/i, ɪ/ - Korean /i, e/ were significantly different [$F(6,4) = 22.512, p < 0.05, \eta_p^2 = 0.971$] and the differences were larger than those shown in KE adults' production: English /i/ - Korean /i/ [$F(2,8) = 48.507, p < 0.013, \eta_p^2 = 0.924$], English /i/ - Korean /e/ [$F(2,8) = 42.765, p < 0.013, \eta_p^2 = 0.914$], English /ɪ/ - Korean /i/ [$F(2,8) = 35.066, p < 0.013, \eta_p^2 = 0.898$], English /ɪ/ - Korean /e/ [$F(2,8) = 25.044, p < 0.013, \eta_p^2 = 0.862$].

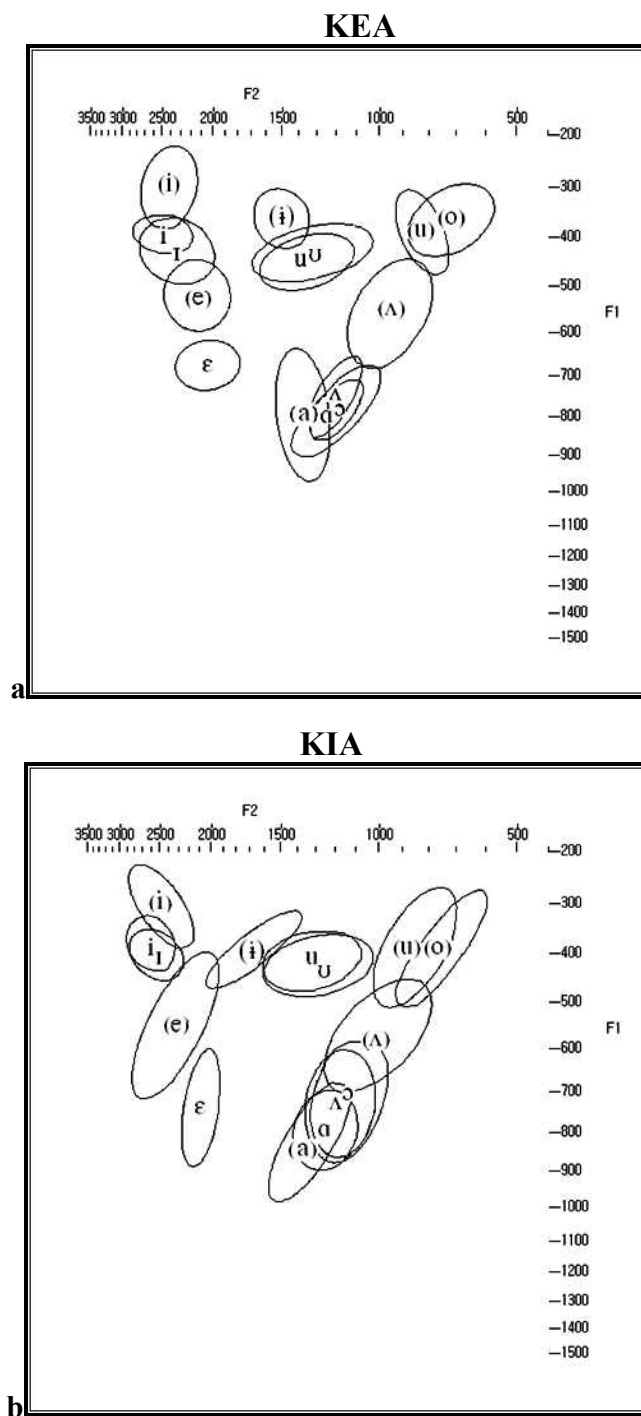


Figure 2.5. Normalized F1 and F2 frequencies of eight English vowels and seven Korean vowels produced by Korean Experienced adult group (a) and Korean Inexperienced adult group (b) are shown. Korean vowels are marked with parentheses.

As for the KE child case, there appeared to be much more overlapping English-Korean vowels than other group's production (see Figure 2.6). Three overlapping vowel pairs were examined: 1) the front vowel pairs English /i, ɪ, ε/ and Korean /i, e/, 2) the low-back vowels English /ɑ ɔ, ʌ/ and Korean /a/, 3) the high-back vowels English /u, ʊ/ and Korean /i/. A MANOVA returned significant differences for English /i, ɪ, ε/ - Korean /i, e/ pairs [$F(8,2) = 34.698, p < 0.05, \eta_p^2 = 0.993$]. In pairwise comparisons, English /i/ - Korean /i/ [$F(2,8) = 2.099, p > 0.008, \eta_p^2 = 0.344$] and English /ɪ/ - Korean /e/ [$F(2,8) = 0.429, p > 0.008, \eta_p^2 = 0.097$] were not significantly different. However, English /i/ - Korean /e/ [$F(2,8) = 67.773, p < 0.008, \eta_p^2 = 0.944$], English /ɪ/ - Korean /i/ [$F(2,8) = 45.680, p < 0.008, \eta_p^2 = 0.919$], English /ε/ - Korean /i/ [$F(2,8) = 216.677, p < 0.008, \eta_p^2 = 0.992$] and English /ε/ - Korean /e/ [$F(2,8) = 25.401, p < 0.008, \eta_p^2 = 0.864$] revealed significant differences. As shown in Figure 2.6, KE children merged English /i/ with Korean /i/ and English /ɪ/ with Korean /e/.

A MANOVA for the second low-back vowel pair, English /ɑ ɔ, ʌ/ and Korean /a/, was also significantly different [$F(6,4) = 21.348, p < 0.05, \eta_p^2 = 0.970$]. Also in pairwise comparisons, English /ɑ/ - Korean /a/ [$F(2,8) = 51.923, p < 0.017, \eta_p^2 = 0.928$], English /ɔ/ - Korean /a/ [$F(2,8) = 32.250, p < 0.017, \eta_p^2 = 0.890$], and English /ʌ/ - Korean /a/ [$F(2,8) = 8.604, p < 0.017, \eta_p^2 = 0.687$] were all significant. Third high-back vowel pairs, English /u, ʊ/ and Korean /i/, were submitted to a MANOVA and revealed a significant difference [$F(4,6) = 42.895, p < 0.05, \eta_p^2 = 0.966$]. English /u/ - Korean /i/ were not significantly different [$F(2,8) = 0.861, p > 0.025, \eta_p^2 = 0.177$]. However, English /ʊ/ - Korean /i/ was distinctively different [$F(2,8) = 102.879, p < 0.025, \eta_p^2 =$

0.963]. To summarize, English /i/ - Korean /i/, English /ɪ/ - Korean /e/ and English /u/ - Korean /i/ pairs were not differentiated in KE children's production.

The same vowel pairs were investigated for the KI child group. A MANOVA showed a significant difference for English /i, ɪ, ε/ - Korean /i, e/ pairs [$F(8,2) = 49.095$, $p < 0.05$, $\eta_p^2 = 0.995$]. In pairwise comparisons, all six comparisons were significant. A MANOVA for the second pair, English /ɑ, ɔ, ʌ/ and Korean /a/, was also significantly different [$F(6,4) = 13.107$, $p < 0.05$, $\eta_p^2 = 0.952$]. Except for the English /ɑ/ - Korean /a/ pair, the other vowel pairs, English /ɔ/ - Korean /a/ [$F(2,8) = 13.682$, $p < 0.017$, $\eta_p^2 = 0.774$] and English /ʌ/ - Korean /a/ [$F(2,8) = 19.154$, $p < 0.017$, $\eta_p^2 = 0.827$], were significantly different. Lastly, a MANOVA on English /u, ʊ/ and Korean /i/ pairs showed that three vowels were significantly different [$F(4,6) = 6.931$, $p < 0.05$, $\eta_p^2 = 0.822$]. Korean vowel /i/ was significantly different from both English /u/ [$F(2,8) = 15.078$, $p < 0.025$, $\eta_p^2 = 0.790$] and English /ʊ/ [$F(2,8) = 17.588$, $p < 0.025$, $\eta_p^2 = 0.815$]. That is, only one vowel pair, English /ɑ/ - Korean /a/, was produced as a single category in KI children's English and Korean productions. See Figure 2.6 for the different overlapping English and Korean vowels in KE and KI children's productions.

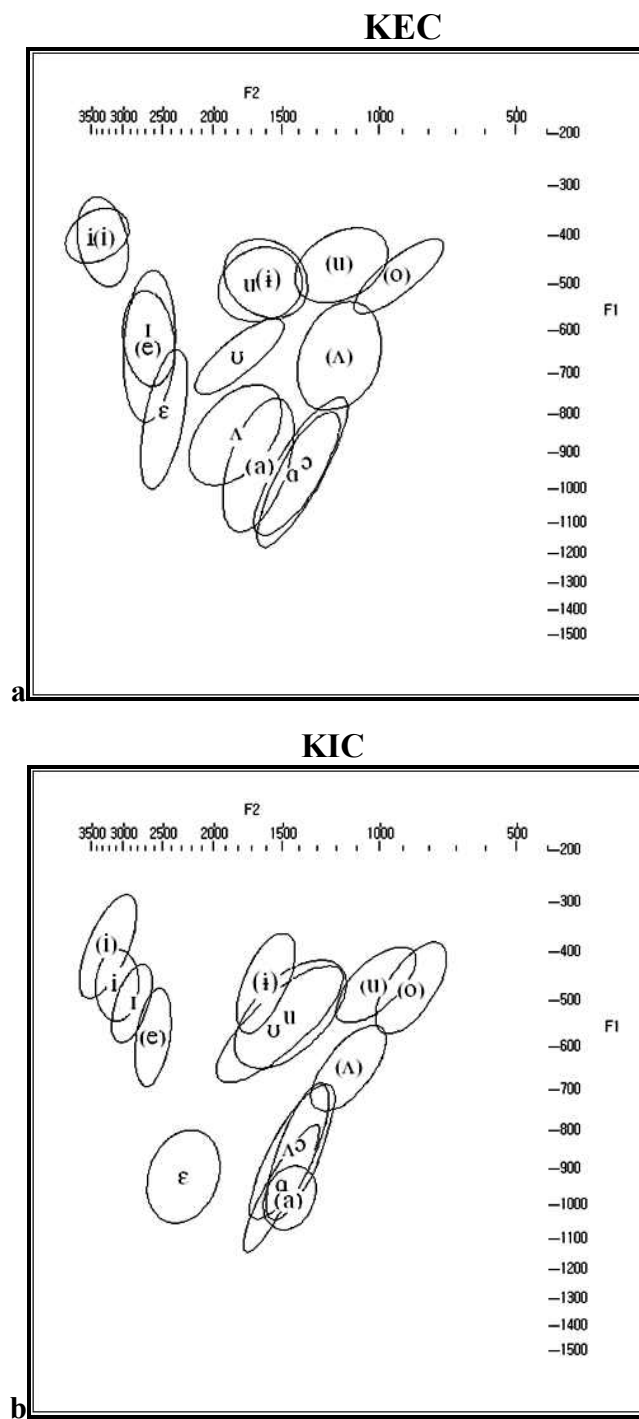


Figure 2.6. Normalized F1 and F2 frequencies of eight English vowels and seven Korean vowels produced by Korean Experienced child group (a) and Korean Inexperienced child group (b) are shown. Korean vowels are marked with parentheses.

2.3.6. Discussion

In Experiment 2, the KE and KI adult groups differed in their L1 vowel production. The difference in the F2 frequency for /i/ between the KE and KI adult groups' productions (see Figure 2.3) may be viewed as a consequence of KE adults' Korean vowel /i/ assimilating to the neighboring English vowels, /u/ and /ʊ/, as an effect of English experience (see Figure 2.5). However, when compared to the range of F1 (374-478) and F2 (1455-1737) frequencies for /i/ produced by ten female and male native speakers of Korean (Yang, 1996), both KE and KI adults' productions of Korean vowel /i/ were within the range. Thus, it seems less likely that the KE adults' Korean vowels were affected by the long exposure to the L2. Rather, it could be interpreted as the sample variability due to small sample size.

As for the children, the KE and KI child group comparisons did not show a significant LOR effect on Korean vowel production, suggesting that KE children were able to produce the seven Korean vowels in a native-like manner. When KE children's native-like Korean vowels were shown together with their native-like English vowels in the same vowel space, overlapping Korean-English vowel categories emerged. Specifically, Korean /i/, /e/, and /ɨ/ assimilated to the neighboring English /i/, /ɪ/ and /u/, respectively, and the target point in which the two vowels assimilated took place in the native space for both of the languages.

Without further information on F0, F3 frequency and spectral envelope (e.g., formant amplitudes, spectral tilt) which were shown to provide additional cues for vowel identification (Ryalls & Lieberman, 1982), it is beyond the scope of this study to

determine the full degree of acoustic similarity between the vowels that are grouped together. However, KE children's native-like production of Korean and English vowels based on the measures reported here, demonstrates that they have attained separate phonological representations for the two vowel systems. Furthermore, the grouping of the three Korean-English vowel categories suggests that making two vowels distinct between the two languages is less of a concern to KE children than to the other groups. Indeed, the other Korean groups were less likely to group the L1 and L2 vowel categories together despite the strong effect of the L1 on L2 vowel acquisition. The different patterns of L1-L2 vowel grouping between KE children and the other Korean groups may be explained by their different language processing.

Bilingual lexical processing has been a topic of much debate. On one hand, the integrated lexicon (or non-selective access) approach has argued that when bilinguals read or produce a word, both of the two languages become activated and a target language needs to be selected out of both the activated language representations (Dijkstra & van Hauven, 2002; van Hauven, Schriefers, Dijkstra, & Hagoort, 2008). The majority of the studies that argue for an integrated L1 and L2 lexicon, however, examined Dutch-English early (AOA around 10-12 years old) bilinguals using interlingual homographs (e.g., Dutch-English words that share the same orthographic symbols but different meanings). Although interlingual homographs belong to different languages and are pronounced differently, they are more likely to activate both languages than a word that is orthographically distinct in two languages. Also, note that the examined Dutch-English

bilinguals were exposed to the L2 (English) relatively later in life (see van Hauven et al., 2008).

On the other hand, different studies have shown evidence of language-specific lexical access, a mechanism that blocks the retrieval of the nontarget language and minimizes language conflict (Gerard & Scarborough, 1989; Rodriguez-Fornells, Rotte, Heinze, Nössel, & Münte, 2002). Namely, bilinguals are able to create separate lexical representations for the L1 and L2 lexicon and access the L2 lexicon independently from the L1, especially as they gain more experience in the L2 (Altarriba & Mathis, 1997; Kroll & Curely, 1998). Considering the KE children's early language exposure and native-like vowel production for both languages, one could argue that the KE children are likely to have developed separate lexical representations for Korean and English. Then, it is unlikely that KE children will retrieve both Korean and English vowel representations at the same time. For KE children, an English word '*big*', for example, will systematically retrieve the vowel representation of English /ɪ/ without evoking the neighboring Korean vowel, /e/. In other words, if the KE children's two lexicons are not activated in parallel, there is no need for the phonetically similar English and Korean vowels to compete. Thus, making effort to distinguish the two vowel systems that are not in competition would only increase extraneous cognitive load and articulatory effort in the process of bilinguals' language acquisition. The English and Korean vowel grouping further suggests evidence in favor of bilinguals' language-specific lexical access.

The other three Korean groups (KE adults, KI adults, KI children), however, made a smaller number of L1-L2 vowel grouping than the KE child group. The tendency

to separate the similar L1 and L2 categories despite their acoustic similarities (e.g., Korean /i/ and English /i/), but not the L1 vowels (e.g., English /i/ and English /ɪ/), can be attributed to their well-established L1. That is, these Korean learners are likely to retrieve L2 lexical items by translating them into the corresponding L1 lexicon (Altarriba & Mathis, 1997). Consequently, both /i/ in 'bead' and /ɪ/ in 'big' are likely to retrieve the representation of Korean vowel /i/, which operates to filter out the phonetic differences between the two L2 vowels. What these Korean learners *can* perceive and distinguish, however, may be the small phonetic differences between the L1 and L2 phones due to their developed perceptual sensitivity to the native language sounds. Consequently, L2 vowels are acquired in relation to, and not independent from, L1 vowels. This may account for the lack of L1 and L2 vowel grouping and further argues for their unitary phonological representation for the two languages.

2.3.7. General discussion

Largely, two observations can be made from KI adults' English and Korean vowel production as the effect of short exposure to English. First, KI adults, but not KE adults, were able to make distinction between the new (i.e., /ɪ/ and /ʌ/) and similar L2 vowels (i.e., /i/ and /a/) in their English production in Experiment 1. The effect of short period of L2 experience on L2 learning is consistent with Ingram and Park (1997) who found that relatively inexperienced (less than one year of English exposure) Korean learners were more accurate in discriminating English /i/-/ɪ/ than experienced Korean learners (more than five years of English exposure) and Korean speakers with no prior

English experience. The result suggests that the initial stage of L2 exposure may be the period when nonnative speakers become most attuned to new L2 sounds.

Overall, the KE child group was able to produce both English and Korean vowels like a native speaker of that language. In addition, the assimilation of Korean and English vowel categories (i.e., /i/-/(i)/, /ɪ/-/(e)/, /u/-/(ɨ/)) shows that KE children were not prone to distinguish English vowels from Korean vowels but rather enhanced distinction between vowels within each language. As an example, Korean /u/ and /o/ in KE children's production are more distinctive from each other than those in the other groups' Korean productions (see Figure 2.3 and 2.4). Based on the Korean and English vowel productions, KE children appear to have separate lexical representations for the two languages and they are systematically organized to maximize phonetic distinctions within each language. This finding is particularly relevant to the argument of simultaneous bilinguals having separate phonological systems for the two languages (Sundara et al., 2006; Sundara & Polka, 2008).

Experiment 1 and 2 showed that vowels were produced in a native-like manner in both languages by KE children. However, it does not indicate that KE children would be native-like in other areas of language development. Simultaneous bilinguals may be more likely to pay attention to the cues that are associated with the phonemic targets (e.g., vowels and consonants) than to those that are less crucial in meaning conveyance in Korean and English (e.g., prosody). If semantic weight of the phonetic cues contributes to the order in which L2 features are acquired, one might expect to find a greater degree of language interaction and less native-likeness in KE children's English prosodic

features than in English segments. In order to provide a holistic perspective of different effects of L2 experience on Korean adults' and children's language acquisition, Chapter 5 and 6 investigate prosodic features of the L1 and L2 productions. For a further examination of segmental features, Chapter 3 explores the patterns of vowel and consonant closure duration as a function of the English word-final coda voicing.

CHAPTER III

DURATIONAL PATTERNS OF WORD-FINAL STOPS

(The effect of coda voicing on vowel and consonant closure duration)

3.1. Introduction

Native speakers of English primarily distinguish voiced and voiceless coda consonants with preceding vowel duration (Chen, 1970; Mack, 1982; Flege, 1988; Crowther & Mann, 1992; Flege, 1993; Bent, Bradlow, & Smith, 2008; Hayes-Harb, Smith, Bent, & Bradlow, 2008). Despite the universal tendency for vowels to be shorter before voiceless stops than before voiced stops, producing a native-like vowel length distinction in English can be challenging, especially for L2 learners whose L1 lack the coda voicing contrast. Another major temporal acoustic property related to English coda voicing is consonant closure duration (Hayes-Harb et al. 2008; Nittrouer, 2004; Bent, Bradlow, & Smith, 2003). Consonant closure duration (i.e. from the constriction to the beginning of the release burst) is shorter for voiced than voiceless coda consonants in English (Lisker, 1986). However, voiced and voiceless coda stops are often, but not always, released in English (Byrd, 1993; Bent & Bradlow, 2003).

Previous studies have shown that the age of L2 acquisition (Flege, Munro, & MacKay, 1995) and L1 experience (Flege, 1988; Flege, Munro, & Skelton, 1992; Flege, 1993) strongly influence the degree of native-likeness in the production of voiced and voiceless contrasts. As an example, Flege et al. (1995) examined 240 native Italian speakers who emigrated to Canada between the age of 2 to 23 years old and lived in

Canada for around 14 to 44 years. 14 English words ending in /t/ or /d/ were produced by native Italian and English speakers and evaluated by a different group of native English-speaking listeners. The results showed that late Italian learners' production of /d/ tokens was frequently misidentified as /t/ tokens by the listeners. The production measures of vowel duration and consonant closure duration indicated that late Italian learners produced shorter preceding vowel duration and longer consonant closure duration for /d/ tokens than native English speakers. The early Italian learners, however, did not differ from English monolingual adults in distinguishing voiced and voiceless stops.

In a different study, Flege (1993) examined English vowel duration embedded in *bVd* and *bVt* syllable structures produced by inexperienced late (AOA = 34) Mandarin learners, late (AOA = 25.4) Taiwanese learners with varying degree of L2 experience, and early (AOA = 8.3) Taiwanese learners. The result showed that inexperienced late Mandarin learners and late Taiwanese learners produced a significantly smaller voicing effect on vowel duration than native English speakers. Even early Taiwanese adult learners' vowel duration difference was smaller than native English speakers' production. The nonnative-like vowel duration difference was attributed to the lack of voicing contrasts in the L1 as well as an insufficient L2 experience.

Some research has provided evidence that upheld the importance of the L1 over L2 experience. For instance, Crowther and Mann (1992) examined the effect of the voicing of final consonants on vowel duration produced by relatively less experienced Japanese adult learners (from 2 weeks to 5 months in the U.S.) and more experienced Mandarin adult learners (from 1 months to 60 months in the U.S.) of English. As

expected, native English speakers showed the largest difference (75.9ms) between voiced and voiceless vowel duration difference followed by Japanese (25.5ms) and Mandarin (12.8ms) learners. Considering the longer L2 experience for Mandarin learners on one hand, and Japanese, but not Mandarin, learners' native experience with phonemic vowel length contrast on the other hand, the results suggested that L2 learners with L1 experience in vowel length distinction could be more adept at learning voicing contrasts in terms of vowel duration than more experienced L2 learners with no prior exposure to vowel length distinction.

Similarly, Flege et al. (1992) reported a strong effect of the L1 on L2 acquisition of preceding vowel duration as a function of the coda voicing. Vowel duration produced by native Spanish (L1) and Mandarin (L1) learners with varying degree of English experience (4 months to 9 years in the U.S.) was compared to the production of vowel duration by native English speakers. Many of the L2 learners were found to devoice final voiced stops, and only few were able to accurately acquire vowel duration differences which are not in their L1 phonetic inventories. The results showed that L2 experience contributed little to the acquisition of voicing contrasts due to the overarching effect of the L1.

It is not only difficult to acquire new L2 features but also challenging to re-prioritize the existing L1 phonetic features for the L2. For example, Munro (1993) examined vowel duration produced in *bVd* and *bVt* structure by 23 Arabic learners of English. Despite their extensive L1 experience with a short and long vowel length distinction as well as the existence of post-vocalic voiced and voiceless consonants,

Arabic learners showed a significantly smaller effect of the coda voicing on vowel duration than the native English speakers. The nonnative-like duration differences were interpreted to indicate that vowel duration in English may have been under-attended by the Arabic speakers due to the small role of preceding vowel duration in distinguishing voiced and voiceless consonants in Arabic. Similarly, Flege et al. (1995) found that native Italian L2 learners produced smaller vowel duration differences between voiced and voiceless coda consonants native English speakers. The authors suggested that the Italian learners of English were less likely to consider preceding vowel duration as a primary cue to distinguishing final stops, because other features such as the presence or absence of closure voicing and the duration of stop closure intervals take precedence over vowel duration for word-medial stop voicing contrasts in Italian.

Different phonetic cues to coda voicing contrasts are weighted differently between the L1 and L2, and it was shown to influence L2 learners' production as well as perception. In Bent et al.(2008), the relationship between English and Chinese speakers' production and perception was examined. In the production task, native Chinese (Mandarin) speakers with high English proficiency produced English words differing in vowel length (lax vowels vs. tense vowels) and final voicing consonants. Native Chinese speakers did not differ from native English speakers in distinguishing lax and tense vowels with vowel duration and their native-like production was attributed to the allophonic vowel length variations in Mandarin. The preceding vowel duration difference between voiced and voiceless consonants, however, was significantly smaller in native

Chinese speakers' than native English speakers' production due to the lack of coda voicing contrasts in the L1.

When different groups of native English and Chinese listeners were asked to identify target words extracted from English and Chinese speakers' productions, English listeners showed higher intelligibility scores for the Chinese speaker who produced the largest duration difference than the English speaker who exhibited an average duration difference. The Chinese listeners, however, demonstrated higher intelligibility in judging the production of Chinese speakers than that of English speakers regardless of vowel duration differences. The results suggested two possibilities. First, since preceding vowel duration is thought to be the most important acoustic cue in distinguishing voiced and voiceless coda consonants for native English speakers, English listeners may have primarily relied on vowel duration differences while disregarding other foreign accented cues. Second, the study suggested that Chinese speakers may have provided additional acoustic cues, helping both English and Chinese listeners to accurately identify the target words. This argument was further supported by the additional acoustic measures such as a higher rate of release bursts, longer final consonants and longer burst duration in Chinese speaker's than English speakers' production. Overall, the different use of phonetic cues between native English speakers and Chinese speakers indicated that L2 learners are more likely to attend to important phonetic cues employed in the L1 in both production and perception.

Furthermore, Hayes-Harb et al.(2008) examined the extent of L1 influence on the relationship between production and perception of English coda voicing contrasts.

Specifically, the effect of different degrees of L2 phonological proficiency (i.e., determined by L1 accentedness) on the interlanguage speech intelligibility benefit (ISIB) was investigated. So far, studies on ISIB have shown that non-native speakers were as accurate as identifying words produced by a non-native speaker who share the same L1 language background as they are in identifying words produced by a native English speaker (Bent & Bradlow, 2003). The assumption is that non-native listeners would have an advantage over native English listeners due to the shared L1 phonological knowledge between the non-native listener and the non-native talker. Under this assumption, Hayes-Harb et al. (2008) investigated English words containing voiced and voiceless coda consonants produced by native English speakers and Mandarin speakers differing in English proficiency. Different groups of native English and Mandarin listeners were asked to identify the stimuli extracted from the English and Mandarin speakers' production. The study further divided the speakers and listeners into low and high phonological proficiency groups based on their L2 accentedness ratings. The acoustic features of speakers' production were also taken into account to better understand the relationship between the acoustic cues in L2 speech and the perceptual intelligibility.

The results showed that the ISIB only held for low proficiency Mandarin listeners who showed higher accuracy than native English listeners and high proficiency Mandarin listeners in identifying words produced by low proficiency Mandarin speakers. The acoustic features of Mandarin speakers' production significantly differed from those of native English speakers' production in terms of voicing during consonant closure, relative consonant closure (consonant closure duration divided by the sum of vowel

duration and consonant closure duration) and relative vowel duration (vowel duration divided by the sum of vowel duration and consonant closure duration). Especially, native English speakers produced relatively longer vowel duration and shorter consonant closure duration in voiced coda words than the Mandarin speakers. The low proficient Mandarin listeners' high intelligibility for low proficient Mandarin speakers' production was shown to indicate the low proficient Mandarin listeners' ability to exploit differential, yet nonnative-like, acoustic cues when listening to heavily Mandarin-accented English production.

In the case of Korean learners of English, competing predictions may be made as to whether Koreans would acquire vowel duration distinction as a function of voicing contrasts. On one hand, one might argue that because Korean does not have a voicing contrast due to a complete neutralization of final stops (Sohn, 1999; Kim & Jongman, 1996), vowel duration differences may be smaller and nonnative-like regardless of the amount of L2 experience. On the other hand, although vowel length distinction in Korean is known to be slowly disappearing in many monosyllabic words (Magen & Blumstein, 1993), short and long vowels have been traditionally described as phonologically distinctive (Sohn, 1999; Lee & Ramsey, 2000) and still are reported to be phonetically different in various word positions (Chung, Hyunsong, Kyongsok, & Huckvale, 1999). Also, Choi and Jun (1998) reported that native Korean speakers systematically shortened vowel duration before fortis and aspirated geminates. Thus, Korean speakers may be more sensitive to vowel duration differences than other L2 learners whose native languages do not distinguish vowel length. What is less clear is whether Korean learners

can employ the duration sensitivity in distinguishing English voiced and voiceless coda consonants. If native language experience with vowel length distinction is relevant to the use of vowel duration as a cue to L2 voicing contrasts in word-final position (Crowther & Mann, 1992), one might expect Korean learners to acquire vowel duration differences in a native-like manner after an extended period of L2 experience.

However, native-like acquisition of consonant closure duration, as an additional salient acoustic correlate of voicing contrasts (Nittrouer, 2004; Bent et al., 2003), is likely to be difficult for Korean learners of English. Especially, the fact that the presence or absence of a release burst does not concern any semantic alteration in either English or Korean suggests that Korean learners may have more difficulty distinguishing voiced and voiceless coda consonants with consonant closure duration than with vowel duration. The unpredictable distribution of release bursts in native English speakers' production further challenges Korean learners to distinguish consonant closure duration in a native-like manner. Because word- or coda-final voiceless Korean stops are thought to be mostly unreleased (Kim-Renaud, 1974; Lee & Ramsey, 2000), Korean learners must first learn to release coda consonants in order to acquire closure duration differences between voiced and voiceless coda consonants.

Failure to release or produce a release in a native-like manner has been shown to have a significant influence on perceptual intelligibility for native English speakers (Abramson & Tingsabadh, 1999; Lisker, 1999; Bent & Bradlow, 2003; Smith, Bent, & Bradlow, 2003; Hayes-Harb et al., 2008). For instance, Tsukada et al. (2004) examined the number of releases for the voiceless stop /t/ produced in isolation by Korean child

(AOA = 7-11 years old) and adult learners (AOA = 22-32 years old) of English varying in LOR (3 vs. 5 years) and its effect on native English speakers' intelligibility. Similar to production, the perceptual results varied with place of articulation of the word-final stops in that the native English speakers showed greater sensitivity to the absence and presence of release bursts for the /k/ tokens than the /t/ tokens. That is, the absence of a release after the final stop /k/ was more critical to the intelligibility than the absence of a release after the final stop /t/. Although the results varied with place of articulation of the final stops, both Korean child and adult learners produced significantly fewer release bursts (about 75%) than the age-matched native English speakers (> 90%) regardless of LOR. The smaller number of releases in Korean learners' production resulted in lower phonetic quality scores.

In this chapter, the effect of coda voicing on Korean speakers' production of preceding vowel duration and consonant closure duration was investigated. The same stimuli used in Experiment 1 were divided into voiced and voiceless coda words and compared across the experienced and inexperienced groups. The primary goal was to examine whether Korean learners are able to produce durational differences related to coda voicing. Specifically, the effect of L2 experience on Korean adults' and children's acquisition of voicing contrasts is investigated. First, a vowel-to-consonant closure ratio was analyzed to examine whether the compensatory balance of short vowel-long consonant closure duration in voiceless words or long vowel-short consonant closure duration in voiced words was realized in the Korean adult and child groups' productions. Moreover, voiced-to-voiceless vowel and consonant duration was separately examined in

order to investigate whether Korean groups had more difficulty distinguishing voiced and voiceless consonant duration than vowel duration.

3.2. The effect of coda voicing

3.2.1. Speech stimuli

The stimuli used in Experiment 1 were analyzed (see Table 3.1).

Table 3.1. Thirty two target words with voiced and voiceless stops in word-final position.

Coda	/i/	/ɪ/	/ɛ/	/ɑ/	/ɔ/	/ʌ/	/u/	/ʊ/
Voiced	bead	big	egg	jog	dog	bug	food	good
	seed	pig	bed	nod	fog	hug	mood	wood
Voiceless	feet	six	neck	sock	talk	cut	fruit	book
	eat	kick	pet	box	chalk	duck	boot	foot

3.2.2. Measurements

English vowel duration produced by the six groups were measured (in milliseconds) from spectrographic and time domain waveform displays. Vowel duration was measured from the onset of voicing in the vowel to constriction of final stops. The onset and offset of clear energy in the second formant frequency on the sound spectrogram served as a reference to measure vowel duration. Consonant closure duration was determined from constriction of final stops to the beginning of the release burst. Consonant closure duration for ‘six’ and ‘box’ was measured from the offset of the second formant frequency in the preceding vowel to the left edge of the fricative release burst. It should be noted that out of all the words produced in isolation over 95% of the production was released for the native English-speaking and Korean-speaking groups.

The unreleased tokens were replaced by the mean voiced or voiceless closure duration of that speaker and were submitted to analysis.

Each stimulus was analyzed for two temporal acoustic properties: preceding vowel duration and consonant closure duration. These properties were compared within a word (i.e., vowel-to-consonant closure duration) as well as between voiced and voiceless coda words (i.e., voiced-to-voiceless vowel and consonant closure duration). The ratio values also served to normalize the duration measures, which may vary by individual speech rate (Magen & Blumstein, 1993).

3.2.3. Statistical analyses

The normalized vowel-to-consonant closure duration ratio for voiced and voiceless coda words, as well as the normalized voiced-to-voiceless duration ratio for vowel and consonant closure duration produced by the three adult and the three child groups. The adult and child groups were compared separately. Each duration ratio (vowel-to-consonant closure duration ratio, voiced-to-voiceless vowel duration ratio, voiced-to-voiceless consonant closure duration ratio) was also separately analyzed using ANOVAs. For the vowel-to-consonant closure duration ratio, the effects of group (3), coda (2) and vowel (8) were investigated. Significant three-way interactions were explored with 8 ANOVAs examining the eight vowels separately for each group. The alpha level was adjusted to 0.006 for 8 comparisons.

In the subsequent analyses for the voiced-to-voiceless vowel and consonant closure duration ratios, a group (3) by vowel (8) interaction was examined. In case of a

significant interaction, the group difference was explored for each vowel. The alpha level was adjusted to 0.006 for 8 comparisons.

3.2.4. Results

An ANOVA on vowel-to-consonant closure duration ratios of the English words produced by the NE, KE, and KI adult groups revealed a significant three-way interaction [$F(14,42) = 3.337, p < 0.05, \eta_p^2 = 0.527$], as well as a significant interaction of group (3) and coda (2) [$F(2,27) = 21.938, p < 0.05, \eta_p^2 = 0.619$]. When the group difference on each coda type was examined, the NE adult group differed from the KE adult group [$F(1,18) = 7.41, p < 0.017, \eta_p^2 = 0.292$] and the KI adult group [$F(1,18) = 81.83, p < 0.017, \eta_p^2 = 0.820$] for voiced, but not for voiceless, coda words. The KE adult and the KI adult groups also differed from each other only for voiced coda words [$F(1,18) = 14.30, p < 0.017, \eta_p^2 = 0.443$].

As Figure 3.1 shows, the vowel-to-consonant closure duration ratios for voiceless coda words is smaller than 1, indicating that vowel duration was slightly shorter than consonant closure duration for all the adult groups. For the voiced coda words, however, vowel duration is approximately 3-4 times longer than consonant closure duration for voiced coda words in NE adult group's production. The duration differences between vowel and consonant closure duration are relatively smaller in Korean adult groups' productions than in NE adult groups' production. That is, the durational differences appear to decrease with a decrease in L2 experience for voiced coda words.

The effect of coda voicing on vowel-to-consonant closure duration ratios was further explored with each adult group's production for the eight vowels separately. First, the NE adult group showed a significant coda voicing effect for the eight vowels. Although smaller than NE adult group's production, the coda voicing effect on KE and KI adults' production was significant for the eight vowels (see Table 3.2).

As for the child groups, the interaction of group (3), coda (2) and vowel (8) [$F(14,42) = 2.02, p < 0.05, \eta_p^2 = 0.402$] as well as the group and coda interaction [$F(2,27) = 7.59, p < 0.05, \eta_p^2 = 0.360$] were significant. ANOVAs with group as a factor on each coda type showed a significant group difference between the NE child and the KI child groups for voiced coda [$F(1,18) = 19.31, p < 0.05, \eta_p^2 = 0.518$], but not for voiceless coda, words. The KE child group was not significantly different from either the NE child or the KI child group. As shown in Figure 3.1, the NE and KE child groups produced vowel duration approximately 3-4 times longer than consonant closure duration for voiced coda words, whereas the KI child group showed a significantly smaller durational difference. For voiceless coda words, vowel duration was slightly shorter than consonant closure duration. Overall, the different duration ratio patterns suggested that the Korean groups were more accurate in producing vowel and consonant closure duration for voiceless than voiced coda words.

When the effect of coda voicing on each vowel was explored for each child group, the NE child group showed a significant coda voicing effect on every vowel condition. Compared to the NE child group, the KE child and KI child groups made a smaller but a significant effect of coda voicing on the eight vowels. Although the

magnitude of the voicing effect on duration differed across vowels for each group, the Korean groups showed a pattern that was similar to the native English-speaking groups (see Table 3.2).

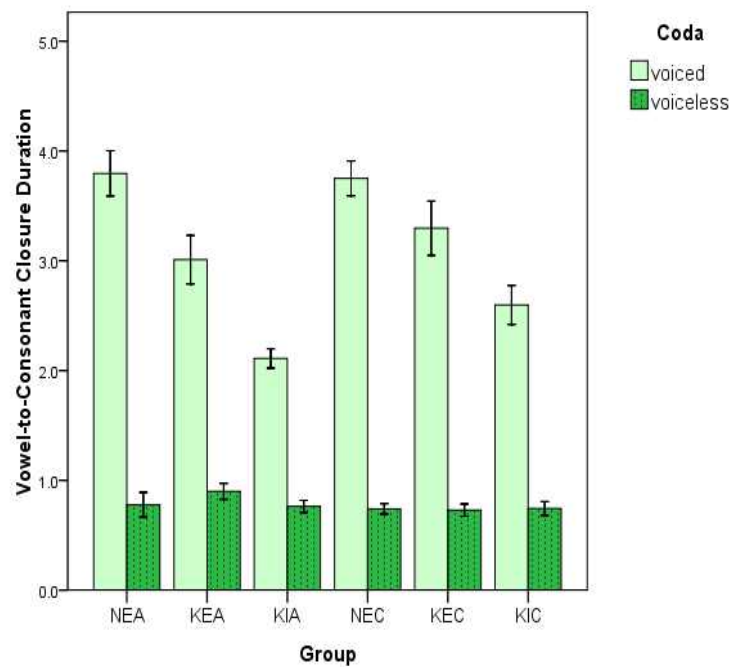


Figure 3.1. Vowel-to-consonant closure duration ratios of English voiced and voiceless coda words produced by Native English-speaking adult group, Korean Experienced adult group, Korean Inexperienced adult group and Native English-speaking child group, Korean Experienced child group, Korean Inexperienced child group are shown.

Table 3.2. The effect of coda voicing on vowel-to-consonant closure duration ratios in eight English vowel condition is shown for the native English-speaking, Korean experienced and Korean inexperienced adult and child groups.

Group		/i/	/ɪ/	/ɛ/	/ɑ/	/ɔ/	/ʌ/	/u/	/ʊ/
NEA	$F(1,9)=$ $\eta_p^2=$	132.66 0.94	110.18 0.92	265.89 0.97	562.21 0.98	116.83 0.93	82.92 0.902	259.52 0.97	82.35 0.90
KEA	$F(1,9)=$ $\eta_p^2=$	62.23 0.87	48.68 0.84	55.33 0.86	62.07 0.87	78.61 0.90	48.82 0.844	76.93 0.890	19.58 0.69
KIA	$F(1,9)=$ $\eta_p^2=$	128.62 0.94	114.92 0.93	56.13 0.86	19.05 0.68	57.78 0.87	44.63 0.832	53.06 0.86	18.93 0.68
NEC	$F(1,9)=$ $\eta_p^2=$	62.76 0.88	107.38 0.92	106.70 0.92	141.81 0.94	290.90 0.97	143.53 0.941	105.2 0.92	125.41 0.93
KEC	$F(1,9)=$ $\eta_p^2=$	33.16 0.79	98.14 0.92	72.31 0.89	121.75 0.93	89.09 0.91	70.74 0.887	37.08 0.81	36.22 0.80
KIC	$F(1,9)=$ $\eta_p^2=$	81.36 0.90	45.65 0.84	89.32 0.91	81.32 0.93	120.19 0.93	151.33 0.944	33.21 0.79	38.04 0.81

All significant ($p < .006$).

To further examine whether the significantly smaller vowel-to-consonant closure duration ratios for the KI adult and KI child groups were due to shorter vowel duration or longer consonant closure duration, voiced-to-voiceless duration ratios for preceding vowel duration and consonant closure duration were separately investigated with ANOVAs. First, the result on the voiced-to-voiceless ratios for vowel duration showed no significant effect of group [$F(2,27) = 1.06, p < 0.05, \eta_p^2 = 0.073$], but a significant interaction of group and vowel [$F(14,42) = 2.249, p < 0.05, \eta_p^2 = 0.428$]. Accordingly, a group effect on each vowel was examined. The results showed that none of the eight vowels produced by NE adults differed from the vowels produced by KE adults or KI adults (see Table 3.3). KE adults and KI adults differed for /ɪ/ [$F(1,18) = 11.19, p < 0.006, \eta_p^2 = 0.383$], but not for the other seven vowels. Figure 3.2(a) shows that preceding

vowel duration for voiced coda words was approximately twice as long as the duration for voiceless coda words for the three adult groups.

Table 3.3. The group effect on the production of voiced-to-voiceless vowel duration ratios in eight English vowel conditions is shown for the native English-speaking adult, Korean experience adult and Korean inexperienced adult groups.

Group		/i/	/ɪ/	/ɛ/	/ɑ/	/ɔ/	/ʌ/	/u/	/ʊ/
NEA vs. KEA	$F(1,18)=$ $\eta_p^2=$	0.60 0.03	4.83 0.21	0.36 0.02	5.40 0.23	0.18 0.010	0.34 0.02	5.88 0.25	0.15 0.01
NEA vs. KIA	$F(1,18)=$ $\eta_p^2=$	4.90 0.21	1.77 0.09	1.63 0.08	6.46 0.26	1.14 0.06	4.61 0.20	4.02 0.18	1.41 0.07
KEA vs. KIA	$F(1,18)=$ $\eta_p^2=$	1.10 0.06	*11.2 0.38	0.28 0.02	0.01 0.00	0.27 0.02	0.19 0.10	0.01 0.00	0.17 0.01

* $p < 0.006$

The child groups did not show a significant group effect [$F(2,27) = 1.823, p < 0.05, \eta_p^2 = 0.119$] nor a significant group by vowel interaction [$F(14,42) = 0.836, p < 0.05, \eta_p^2 = 0.218$]. Figure 3.2(a) shows that the KE child group produced a slightly larger difference between voiced and voiceless vowel duration compared to the NE child and KI child groups. However, the result indicated that the effect of coda voicing on vowel duration was not significantly different across the three child groups.

Since the Korean adult and child groups did not differ from the NE adult and child groups in distinguishing vowel duration between voiced and voiceless coda words, KI adult and child groups' significantly smaller vowel-to-consonant closure duration ratios for voiced coda words was likely due to longer consonant closure duration. When the voiced-to-voiceless duration ratios for consonant closure duration was compared

across the adult groups, the result showed a significant group effect [$F(2,27) = 35.52, p < 0.05, \eta_p^2 = 0.725$] as well as a significant group and vowel interaction [$F(14,42) = 2.53, p < 0.05, \eta_p^2 = 0.457$]. Thus, the group effect on each vowel was examined. The KE adult group was significantly different from the NE adult group for five vowels: /i/ [$F(1,18) = 13.67, p < 0.006, \eta_p^2 = 0.432$], /ɪ/ [$F(1,18) = 11.36, p < 0.006, \eta_p^2 = 0.387$], /ɑ/ [$F(1,18) = 31.96, p < 0.006, \eta_p^2 = 0.640$], /u/ [$F(1,18) = 22.85, p < 0.006, \eta_p^2 = 0.559$], /ʊ/ [$F(1,18) = 16.13, p < 0.006, \eta_p^2 = 0.473$]. The NE adult and the KI adult groups showed differences for five vowels, /ɪ/ [$F(1,18) = 14.11, p < 0.006, \eta_p^2 = 0.439$], /ɛ/ [$F(1,18) = 11.67, p < 0.006, \eta_p^2 = 0.393$], /ɑ/ [$F(1,18) = 23.95, p < 0.006, \eta_p^2 = 0.571$], /ɔ/ [$F(1,18) = 41.45, p < 0.006, \eta_p^2 = 0.697$], /ʊ/ [$F(1,18) = 26.09, p < 0.006, \eta_p^2 = 0.592$]. The KE adult and KI adult groups did not significantly differ from each other.

As shown in Figure 3.2(b), KE and KI adult groups' consonant closure duration for voiced coda words was distinctively longer than NE adult group's production. That is, NE adults' smaller voiced-to-voiceless duration ratios for consonant closure duration indicate that the NE adult group produced a greater consonant closure duration difference between voiced and voiceless coda words than the Korean adult groups did. The duration of the voiced closure was about 40% the length of the voiceless closure for the NE adult group, whereas it was roughly 60-80% of the voiceless duration for the KE and KI adult groups.

Next, the voiced-to-voiceless consonant closure duration ratio was compared across the child groups. The result showed a significant group effect [$F(2,27) = 10.55, p < 0.05, \eta_p^2 = 0.439$] and a significant group and vowel interaction [$F(14,42) = 2.04, p <$

0.05, $\eta_p^2 = 0.405$]. None of the eight vowels was significant difference between the NE child and the KE child groups nor for the KE child and the KI child groups, suggesting that the KE child group did not differ from either the NE child or the KI child group. The KI child group, however, was significantly different from the NE child group for four vowels: /a/ [$F(1,18) = 12.89, p < 0.006, \eta_p^2 = 0.417$], /ɔ/ [$F(1,18) = 13.89, p < 0.006, \eta_p^2 = 0.435$], /u/ [$F(1,18) = 19.5, p < 0.006, \eta_p^2 = 0.520$], /ʊ/ [$F(1,18) = 10.03, p < 0.006, \eta_p^2 = 0.358$]. As can be seen in Figure 3.2(b), the duration of the voiced closure was about 40% the length of the voiceless closure for the NE child group, but it was roughly 50-60% of the voiceless duration for the KE and KI child groups.

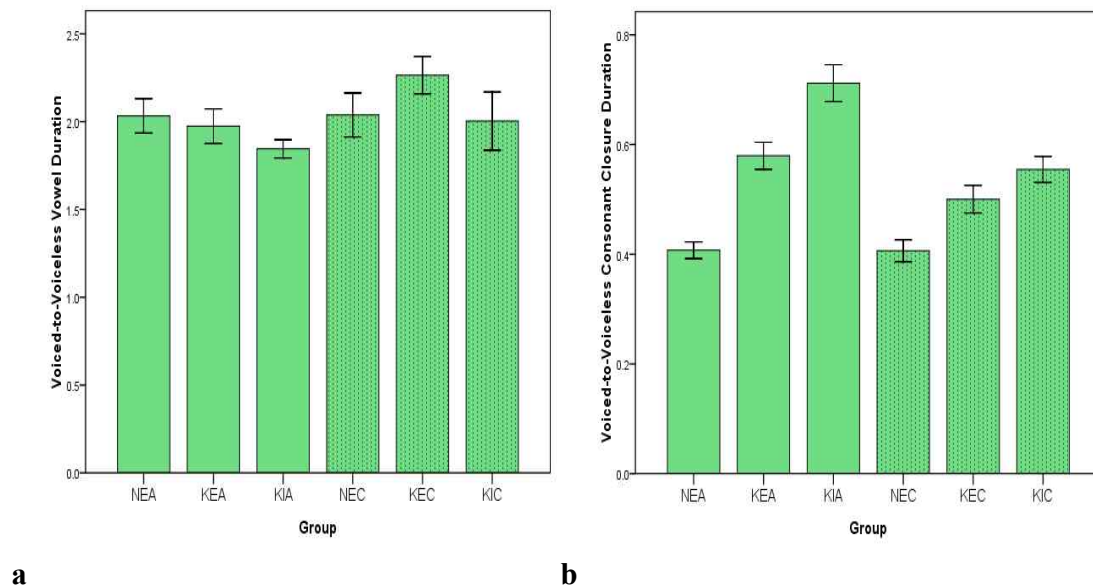


Figure 3.2. Voiced-to-voiceless vowel duration ratios (a) and voiced-to-voiceless consonant closure duration ratios (b) of English voiced and voiceless coda stops produced by Native English-speaking adult group, Korean Experienced adult group, Korean Inexperienced adult group and Native English-speaking child group, Korean Experienced child group, Korean Inexperienced child group are shown.

3.2.5. Discussion

Overall, native-like vowel-to-consonant closure duration ratios (Figure 3.1) and voiced-to-voiceless vowel duration ratios (Figure 3.2(a)) in Korean adult and child groups' production showed that the Korean groups were able to accurately distinguish vowel duration as a function of voicing contrasts in English. However, significantly smaller vowel-to-consonant closure duration ratios for voiced coda words were produced by the KE adult, KI adult and KI child groups than by the NE adult and child groups. When vowel and consonant closure durations were separately examined, Korean groups' smaller ratios for vowel-to-consonant closure duration were shown to be driven by significantly longer consonant closure duration for voiced coda words. Specifically, voiced closure duration was relatively longer than the voiceless closure duration for the KE adult and KI adult and the KI child groups. Although not significantly different from NE child group, the KE child group showed a tendency towards smaller vowel-to-consonant closure duration ratios for voiced coda words and greater voiced-to-voiceless closure duration ratios than the NE child group.

The native-like voicing distinction for vowel duration by Korean adults and children regardless of LOR suggests Korean learners' sensitivity to vowel length due to the effect of the L1. That is, prior experience with the vowel length distinction in Korean may have facilitated the acquisition of vowel duration differences before voiced and voiceless coda consonants in English. The significantly smaller voiced-to-voiceless consonant closure duration differences by the KE adults, the KI adults and children, on the other hand, suggest that Korean learners of English had more difficulty acquiring

accurate consonant closure duration than vowel duration as a function of voicing contrasts.

The nonnative-like closure duration differences, however, do not necessarily indicate the Korean speakers have not acquired distinctive phonetic representations for voiced and voiceless consonant closure duration. The results showing that Korean adults and children produced considerably shorter consonant closure duration for voiced than voiceless coda words suggest that they were able to distinguish the differences. Rather, the longer voiced closure duration in Korean groups' production should be explained by the lack of final voiced stop release in Korean. As a result of complete neutralization of a coda voicing contrast in Korean (Kim & Jongman, 1996), distinguishing language-specific voiced and voiceless coda consonants appeared to require more L2 experience than distinguishing voiced and voiceless vowel duration. As illustrated in Figure 3.2(b), the accuracy of closure duration differences increased with the amount of English experience for the Korean adult and child groups. This trend suggests that the KE adult group might be able to acquire language-specific patterns of consonant closure duration as they gain more experience with instances of voicing contrasts in English. The KE child group's native-like acquisition of relative consonant closure duration, on the other hand, shows a strong effect of age of L2 exposure on the acquisition of new L2 features that are not used in the L1.

CHAPTER IV

DURATIONAL PATTERNS OF VOICE-ONSET TIME

4.1. Introduction

One of the most cross-linguistically salient acoustic correlates of the voicing contrast in utterance- or word-initial position is the duration difference in voice-onset time (VOT) (Lisker & Abramson, 1964; Keating, 1984). However, the phonetic realization of VOT as a function of voicing contrasts is different across languages. In English, for example, VOT has been noted as the single most reliable phonological cue for distinguishing English word-initial voiced and voiceless stops: VOT is significantly shorter in voiced (short-lag VOT) than voiceless stops (long-lag VOT) in English (Lisker & Abramson, 1964). Voiced stops in Spanish are produced with VOT that leads a following consonant release (vocal cords vibrating before the release) whereas VOT for Spanish voiceless stops is as short as it is for English voiced stops (Deucher & Clark, 1996). Voiced stops in Turkish are produced with voicing lead that is shorter than Spanish voicing lead and VOT for Turkish voiceless stops were longer than Spanish VOT and shorter than English VOT for voiceless stops (Öğüt, Kiliç, Engin, & Midilli, 2006). Because VOT values distinguishing voiced and voiceless stops vary across languages, L2 learners whose L1 differ from the L2 in VOT distinctions may have difficulty separating the language-specific phonetic categories.

VOT for word-initial stops can differentiate three-way contrasts. Korean word-initial stops have three types of stop categories (i.e., fortis, lenis and aspirated voiceless

stops) which are primarily characterized by VOT, fundamental frequency (F0), and voice quality indexed by differences in amplitude between the first and second harmonics (H1-H2). Each stop type is produced with its own phonological cue that uniquely distinguishes one from the other two stops. F0 is high for aspirated and fortis stops and much lower for lenis stops. Fortis stops are generally associated with creaky voice (negative H1-H2). VOT is shortest for fortis, longer for lenis, and longest for aspirated stops (Kim, 1994; Cho et al., 2002; Kang & Guion, 2006). Recent studies, however, have suggested that the VOT difference between lenis and aspirated stops is disappearing (Silva, Choi, & Kim, 2004) and young speakers are more likely to distinguish the two stops with a greater F0 difference than VOT especially in clear speech (Kang & Guion, 2008).

Native languages exhibiting different phonetic realization in VOT for word-initial stops than a L2 can create difficulties in acquiring native-like VOT in that L2. The degree of native-likeness in L2 stop production has been shown to vary with several factors such as the effect of L1, the age of L2 acquisition as well as the amount of L2 experience (Thornburgh & Ryalls, 1998; MacKay et al., 2001; Wang & Behne, 2007). As an example, MacKay et al. (2001) examined the VOT duration of word-initial voiced stops produced by Italian monolingual adults who differed in the age of L2 exposure and the amount of self-reported L1 use. The results showed that late Italian bilinguals produced a significantly larger number of pre-voiced English /b/s than early Italian bilinguals as an effect of frequently pre-voiced Italian /b/. When the percentage of fully pre-voiced stops was examined as a function of AOA, early (mean AOA = 8 years old)

Italian bilinguals did not differ from the native English speakers, whereas late (mean AOA = 20 years old) Italian bilinguals produced pre-voiced stops much more often than the native English speakers. Similarly in a perception task, the absence of pre-voicing cues in the speech input was shown to affect late Italian bilinguals' identification judgments. That is, English voiced stops were misidentified as voiceless stops more often by late Italian bilinguals compared to native English speakers.

In Flege and Eefting (1988)'s study, Spanish (L1)-English (L2) bilingual children (mean AOA = 3.6, mean age at time of testing = 8-9) and early (AOA = 0) and late (mean AOA = 5-6, age at time of testing = 19-20) adult bilinguals imitated the synthesized production of /ta/ and /da/ with VOT ranging from [-60 ms] to [+90 ms]. In Spanish monolingual adults' and children's productions, the stimuli with VOT from [-60 ms] to [+10 ms] were mainly produced with lead, whereas English monolingual adults and children imitated [-60 ms] to [+20 ms] stimuli with short lag VOT. When the bilingual groups were compared, early adult bilinguals produced significantly longer VOT than the bilingual children or late adult bilinguals to the extent that they did not differ from native English adults or children. The results showed that a language-specific categorization of VOT for voiced and voiceless stops in the L1 can affect the way L2 learners perceive the VOT continuum. Both age of L2 acquisition and amount of English experience played important roles in creating distinctive phonetic categories for the L1 and L2 in terms of VOT.

With the same stimuli used in Flege and Eefting (1988)'s study, Flege and Eefting (1987a) examined fifty Dutch speakers between the age of 20 to 35 who differed

in L2 proficiency (indexed by a self-evaluation) as well as the amount of L2 experience (English majors vs. Engineering majors). In the first experiment, Dutch speakers were asked to circle either /ta/ or /da/ after listening to the synthesized stimuli varying in VOT. In the second experiment, the mean VOT values of /t/ produced in a frame sentence by Dutch speakers were examined to evaluate VOT measures as a function of L2 proficiency. The mean of /d-/t/ boundaries was significantly higher for native English speakers (around 47 ms) than Dutch speakers (around 35 ms) regardless of their L2 proficiency. In other words, Dutch speakers were much more likely to circle /ta/ as opposed to /da/ than the native English speakers when VOT was longer than 35 ms as the effect of shorter VOT for voiceless stops in Dutch. Moreover, the Dutch speakers with high L2 proficiency produced significantly longer VOT for English /t/ and shorter VOT for Dutch /t/ than native Dutch speakers. Enhancing the VOT differences between English and Dutch stops suggested that the Dutch speakers were likely to have created a new category for the L2 as they gained L2 experience. The result was consistent with Flege and Eefting (1987b) who also found Spanish speakers of English producing shorter VOT in Spanish voiceless stops than Spanish monolinguals.

More recently, the effects of language mode on the production of VOT were put forth to examine the bilinguals' ability to separate VOT differences for the L1 and L2. Antoniou et al. (2010) investigated Greek (L1)-English (L2) early bilinguals (mean AOA = 3.5, mean age at time of testing = 28) who were first exposed to Greek but used English as a dominant language at the time of testing. These early bilinguals with similar language background were further divided into two groups of language mode (i.e.,

English and Greek). All procedures (e.g., carrier phrases, instruction, feedback) were performed in either English or Greek depending on the language mode in order to deactivate the bilingual's other language. The bilinguals' production of bilabial and coronal stops in word-initial and word-medial position was compared to native speakers of both languages. The prediction was that the bilinguals in English mode would show short-lag and long-lag VOT distinctions for voiced and voiceless stops, whereas the bilinguals in Greek mode will show voicing lead and short-lag for voiced and voiceless stops. The results showed that both groups of bilinguals produced native-like VOT differences for word-initial stops. That is, the bilinguals in English mode and the bilinguals in Greek mode did not differ from English and Greek monolingual speakers, respectively. The results showed that the bilinguals were able to establish separate phonetic categories for the L1 and L2. Small influence of the L1 was shown in bilinguals' production of English voiced stops in word-medial position. Creating a language setting for the bilinguals to be in one language mode may have helped minimize the L1-L2 interaction.

On the other hand, some studies found L1 and L2 assimilation in bilinguals' production. For instance, Flege (1987) compared VOT for /t/ produced by French (L1) learners of English (L2) and English (L1) learners of French (L2) with varying amount of L2 experience (from less than one year to more than ten years). English and French /t/ are different in that French /t/ is produced with a short-lag VOT with dental place of articulation, whereas English /t/ is produced with a long-lag VOT with alveolar place of articulation. However, the two phones are similar in that /t/ in French can be easily

identified as the same category as /t/ in English due to the lack of distinctive auditory difference. Flege (1987) argued that adults who acquired the L2 after adolescence would show difficulty establishing separate categories for the similar L1 and L2 sounds. It was also proposed that gaining more experience with the similar L2 sound may influence its L1 counterpart, leading to a merger between the L1 and L2. The study found that the English speakers with the least French experience produced both English and French /t/ with the longest VOT. As they gained more experience with French, however, VOT for English /t/ became shorter than that produced by English monolinguals. Similarly, French speakers with extensive English experience produced longer VOT for French /t/ than French monolinguals did, showing similar VOT values for English and French /t/. The results suggested that the L2 learners have assimilated similar L1 and L2 sounds into a single category by tuning both sounds in a way that is not native-like in either language.

In addition, Kang and Guion (2006) examined early ($M=3.8$ years old at time of arrival in the U.S.) and late ($M=21.4$ years old at time of arrival in the U.S.) Korean-English adult bilinguals' VOT, F0, and H1-H2 for their English and Korean stop productions. The goal was to investigate the effect of age of L2 learning on the degree of separability between the L1 and L2 phonological systems. The results showed that early bilinguals were able to establish five independent stop categories for English and Korean, whereas late bilinguals were not able to distinguish Korean aspirated stops and English voiceless stops in any of the three variables. English voiced stops were also similar to Korean fortis stops in VOT and H1-H2. The overlapping of acoustic correlates across the L1 and L2 stops was interpreted to indicate that late bilinguals were not able to create the

two English stop categories separately from the three Korean stops. Previous research on L2 learners' VOT production (Flege & Eefting, 1987a, 1987b; Kang & Guion, 2006) have used mean VOT duration for analysis. However, it may be worth noting that comparing mean VOT may be misleading because VOT may vary with speech rate (Volaitis & Miller, 1992; Kessinger & Blumstein, 1997). For this reason, the current study provides normalized VOT along with mean VOT for group comparisons.

The difficulty of separating three word-initial stop categories is not limited to L2 learners. Developmental studies have shown that children acquire some phonetic contrasts later than others in their first language. As for the VOT patterns, studies have found that children acquire short-lag stops before long-lag stops (Macken & Barton, 1980; Westbury & Keating, 1986; Davis, 1995). Moreover, different milestones were shown for the acquisition of language-specific contrasts across languages. In a longitudinal study, Deucher and Clark (1996) examined the VOT production of utterance-initial stops in English and Spanish by a bilingual child who was exposed to both languages by her Spanish-speaking father and English-speaking mother. The same data elicited from a picture naming task were collected at age 1;7, 1;11 and 2;3. At the age of 1;7, a strong initial preference for short-lag VOT was shown regardless of voicing or language. At the age of 2;3, however, VOT values for English voiced and voiceless stops were distinguished in a near adult-like manner. The bilingual child's Spanish production also showed longer VOT for voiceless stops than voiced stops but lead voicing for voiced stops was not produced. The delayed acquisition of VOT distinction between voiced and voiceless stops in Spanish may be partly related to the heavier

influence of mother's than father's native language (see Kehoe, 2000). Furthermore, the authors argued that the distinction between voicing lead and short-lag VOT is acoustically less salient than the distinction between short- and long-lag VOT.

Different milestones for linguistic development can also be observed within a language. Kim and Stoel-Gammon (2009) examined Korean monolingual children's production of Korean stops. Four different age groups (2;6, 3, 3;6, 4) of children were compared to investigate the developmental pattern of a three-way contrast. The VOT, F0, and H1-H2 values of monosyllabic triplets for lenis, fortis and aspirated stops across the groups showed that the youngest children were not able to distinguish long-lag aspirated stops from short-lag lenis stops in any of the three variables. At the age of 3, however, children began to form a bimodal contrast between fortis and aspirated stops or fortis and lenis stops, suggesting children's sensitivity to VOT distinctions between the stops. The F0 contrast between lenis and aspirated stops or lenis and fortis stops did not emerge until the later stages of development. The earlier acquisition of VOT followed by F0 and H1-H2 suggested that children attend to VOT differences first and use it as a primary cue to distinguish Korean stops before attending to other phonetic cues. Although the use of F0 gradually developed with increase in age, the F0 distinctions across the three stops were not adult-like even in the production of 4 years old children. Considering this developmental pattern, early Korean bilinguals' mastery of three-way contrasts in VOT as well as F0 and H1-H2 in Kang and Guion (2006) not only indicates their early exposure to the Korean stop categories but also suggests an effect of constant experience with the native language thereafter.

The primary goal of this chapter is to examine the developmental patterns of language-specific VOT in Korean-English bilingual children's stop production. If native Korean children learn to fully distinguish three Korean stop categories after the age of four (Kim & Stoel-Gammon, 2009), Korean experienced children who were exposed to English before the Korean stop system was fully developed may show delayed onset of VOT acquisition for Korean stops than Korean monolingual children do. As another primary acoustic cue to distinguish Korean stop categories, the three-way F0 contrast is separately examined in Chapter 6 to explore the effect of English acquisition on Korean prosodic features. This chapter focuses on the VOT differences in Korean adults' and children's production of English voiced and voiceless stops and Korean lenis and aspirated stops. English voiced and voiceless stops produced by the Korean adult and child groups were compared to those produced by the native English adult and child groups. Furthermore, Korean stops produced by the same groups were compared to English productions in order to examine the degree of interaction between the L1 and L2 stop systems as a function of L2 experience. Voice quality (H1-H2) was not examined due to its relatively smaller role in distinguishing Korean lenis and aspirated stops (see Kong, Beckman, & Edwards, 2011).

4.2. Experiment 3: voice-onset time for English stops

4.2.1. Participants

The same 40 Korean experienced and inexperienced adults and children recruited for Experiment 1 participated in this production task.

4.2.2. Speech stimuli

The stimuli produced in Experiment 1 were chosen based on the following criteria. Three monosyllabic words with word-initial voiced stops, '*bed, dog, good*', were matched to words with word-initial voiceless stops, '*pet, talk, cut*'. The effects of vowel quality (Lisker & Abramson, 1967; Klatt, 1975) and place of articulation (Thornburgh & Ryalls, 1998, Broersma, 2010) on VOT were taken into account and were closely matched between the voiced and voiceless word-initial stops to minimize the effect of surrounding consonantal contexts on VOT.

4.2.3. Measurements

Using Praat VOT was measured as the time duration from the beginning of the stop burst release to the onset of the first full pitch pulse of the initial vowel. English voiced stops were pre-voiced by the NE adult 5 %, child group 2 %, KE adult 0.8 %, KE child 1.3 % and KI adult and KI child group 0 % of the time. Pre-voiced stops were taken out and replaced by the mean voiced VOT value of that subject's production. The voiced-to-voiceless VOT ratios were submitted to analysis for normalization.

4.2.4. Statistical analyses

The voiced-to-voiceless VOT ratios for the NE, KE, KI adult groups and NE, KE, KI child groups were separately analyzed using ANOVA repeated measures. Because VOT values varied with place of articulation, VOT ratios for bilabial, alveolar, and velar stops were examined separately. First, the effects of group (3) and POA (place of

articulation) (3) were investigated. In case of a significant group and POA interaction, 3 ANOVAs assessing the effect of group on each POA were conducted. Tukey's HSD tests were reported for post- hoc comparisons.

4.2.5. Results

An ANOVA on voiced-to-voiceless VOT ratios for the NE, KE, and KI adult groups revealed no significant main effect of group [$F(2,27) = 2.327, p > 0.05, \eta_p^2 = 0.147$], nor a significant interaction of group and POA [$F(4,54) = 0.609, p > 0.05, \eta_p^2 = 0.043$]. The child groups, however, returned a significant effect of group [$F(2,27) = 3.662, p < 0.05, \eta_p^2 = 0.213$], as well as a significant group and POA interaction [$F(4,54) = 3.282, p < 0.05, \eta_p^2 = 0.196$]. When the group effect on each POA was examined, VOT ratios for bilabial [$F(2,27) = 2.258, p > 0.05, \eta_p^2 = 0.143$] and labial stops [$F(2,27) = 1.880, p > 0.05, \eta_p^2 = 0.122$] were not significantly different across the child groups. However, VOT ratios for velar stops [$F(2,27) = 6.001, p < 0.05, \eta_p^2 = 0.308$] were significantly larger in the KE child group than in the NE child group (Tukey's HSD tests, $p < 0.05$). The differences between the NE and KI child groups were marginally significant ($p = 0.05$). Figure 4.1(a) shows larger VOT ratios for velar stops in the KE and KI child groups than the NE child group. Alveolar stops were produced with slightly smaller VOT ratios by the KE child group than the NE child group. Regardless of POA, however, all four Korean adult and child groups conformed to the pattern of the NE groups, producing significantly longer VOT for voiceless than voiced stops. Adults produced their voiced stops with roughly 20-40% of the duration of the voiceless stops'

VOT. As for the children, NE children produced the voiced stops with 15-30% and KE, KI with 20-40% of the duration of the voiceless stops' VOT. The velar stops showed the largest difference from the other stops, especially in KE children's production. The result suggested that the relative duration of VOT for voiced stops was longer for velar stops than bilabial or alveolar stops.

When the mean VOT values were averaged across POA for the voiced and voiceless stops and separately submitted to an ANOVA, voiced stops' VOT returned a significant group effect for adults [$F(2,27) = 3.444, p < 0.05, \eta_p^2 = 0.203$] as well as children [$F(2,27) = 6.191, p < 0.05, \eta_p^2 = 0.314$]. Tukey's HSD tests ($p < 0.05$) returned a marginal difference between the NE and KI adult groups ($p = 0.058$), as well as a significant difference between the NE, KE child groups and the KI child group. For the voiceless stops' VOT, the ANOVA reached a significant group effect on child groups only [$F(2,27) = 3.539, p < 0.05, \eta_p^2 = 0.208$]. The KE child group's shorter VOT for voiceless stops and the KI child group's longer VOT for voiced stops are illustrated in Figure 4.1(b).

Overall, Korean adults' production of English stops showed a trend towards more native-like VOT distinction between voiced and voiceless stops as they gained English experience. The KE child group produced relatively shorter VOT for voiceless stops, whereas the KI child group produced significantly longer VOT for voiced stops compared to the other groups. In the following section, Korean stops were examined to assess whether the nonnative-like production of English stops' VOT can be explained by the effect of Korean stop categories.

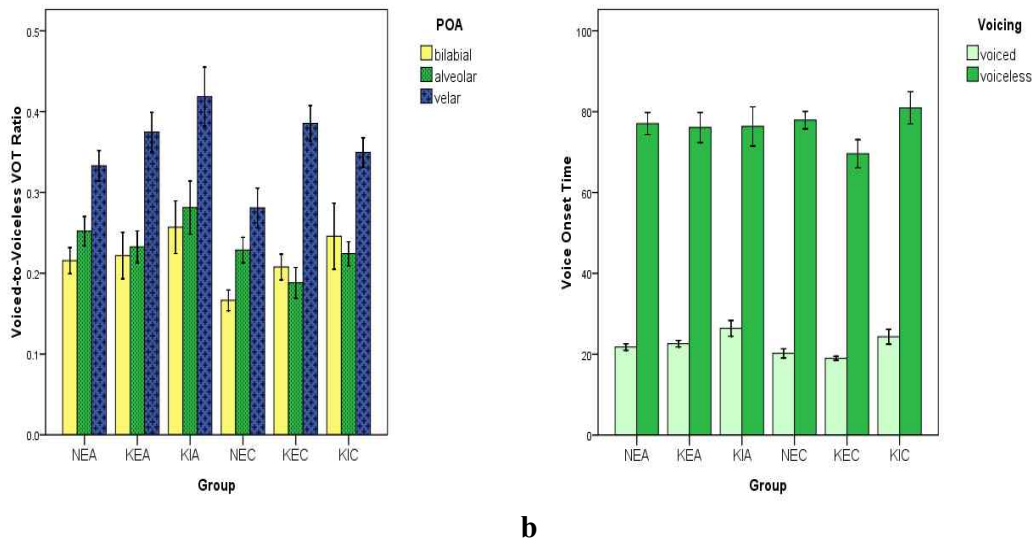


Figure 4.1. Voiced-to-voiceless voice-onset time ratios (a) and mean voice-onset time (b) for English voiced and voiceless stops in word-initial position produced by Native English-speaking adult group, Korean Experienced adult group, Korean Inexperienced adult group and Native English-speaking child group, Korean Experienced child group, Korean Inexperienced child group are shown.

4.3. Voice-onset time for Korean stops

In Experiment 3, Korean speakers' productions of Korean stops and affricates are compared in terms of VOT. Affricates are included because they have a three-way contrast as stops in Korean. Different VOT patterns between the experienced and inexperienced groups are examined as a means to assess whether acquiring L2 phonetic categories have affected the VOT production of Korean stops. In particular, VOT differences between lenis and aspirated stops were investigated in view of the effect of L2 acquisition on the L1 as well as the current sound change in the L1. The primary acoustic correlate that distinguished lenis and aspirated stops has been shown to change from VOT to F0 among younger (younger than 40 years old) Korean speakers (Kang &

Guion, 2008). Older Korean speakers were shown to retain VOT differences between lenis and aspirated stops. U.S.-born children mostly receive Korean input from their parents who are likely to produce longer VOT for aspirated than lenis stops. Thus, one might expect that KE children would learn to distinguish the two stops primarily with VOT. In addition, acquiring English voiced and voiceless stops may have directed the children's attention to VOT differences for stop contrasts. In this section, the Korean VOT production of lenis and aspirated stops are further compared to the English VOT production of voiced and voiceless stops to examine the degree and direction of interaction between the L1 and L2 stop system(s).

4.3.1. Speech stimuli

The phrase-initial syllables produced in four-syllable Korean phrases were prepared to elicit three pairs of Korean lenis and aspirated obstruents differing in places of articulation (i.e., alveolar, post-alveolar, velar). Korean lenis and aspirated obstruents are referred to as lenis and aspirated stops for the sake of brevity when comparing Korean lenis and aspirated obstruents to English voiced and voiceless stops. Three pairs of POA-matched target words were embedded in the first CVC syllable except for the alveolar lenis stop, which was produced in a CV syllable, /ta/. Vowel quality of the first syllable was matched with either the low vowel /a/ or /ʌ/. The target phrases are as follows.

<u>Lenis</u>	vs.	<u>Aspirated</u>
/ta.ɾim.ni.da/ ((It's) different)		/tʰat.sim.ni.da/ ((It's) burned)
/teat.sim.ni.da/ ((I) slept)		/teʰat.sim.ni.da/ ((I'm) searching)
/kʌt.sim.ni.da/ ((I'm) walking)		/kʰʌt.sim.ni.da/ ((I've) grown)

4.3.2. Measurements

VOT (in milliseconds) of stops and affricates was measured as the time from the onset of the noise burst to the onset of the first clear periodic cycle of the waveform for the initial vowel of the target words. None of the Korean stops were pre-voiced.

4.3.3. Statistical analyses

VOT normalization was conducted in order to control for potential VOT differences driven by different speech rates (Kessinger & Blumstein, 1998). Normalized lenis-to-aspirated VOT ratios for the KE, KI adult and the KE, KI child groups were separately analyzed using ANOVA repeated measures. The group (2) and POA (3) interaction was further examined by 3 ANOVAs assessing the effect of group on each POA.

4.3.4. Results

An ANOVA on lenis-to-aspirated VOT ratios for the KE and KI adult groups revealed no significant effect of group [$F(1,18) = 0.213, p > 0.05, \eta_p^2 = 0.012$], nor a significant interaction of group and POA [$F(2,36) = 0.585, p > 0.05, \eta_p^2 = 0.031$]. The

child groups returned a significant effect of group [$F(1,18) = 6.095, p < 0.05, \eta_p^2 = 0.253$], but no significant group and POA interaction [$F(2,36) = 1.267, p > 0.05, \eta_p^2 = 0.066$]. The ANOVAs on each POA showed a significant group effect on VOT ratios for alveolar stops [$F(1,18) = 4.737, p < 0.05, \eta_p^2 = 0.208$] and post-alveolar affricates [$F(1,18) = 4.647, p < 0.05, \eta_p^2 = 0.205$]. As shown in Figure 4.2(a), VOT ratios for alveolar stops and post-alveolar affricates appeared to be greater in KI children's than KE children's production. Also, the KE, KI adults' and KI children's VOT ratios approximates 1, except for velar stops, indicating that lenis and aspirated stops were produced with similar VOT. Overall, KE children made a relatively greater VOT distinction between lenis and aspirated stops. To further investigate whether KE children's smaller ratios were due to longer VOT for aspirated stops or shorter VOT for lenis stops, the mean VOT values were compared across the groups.

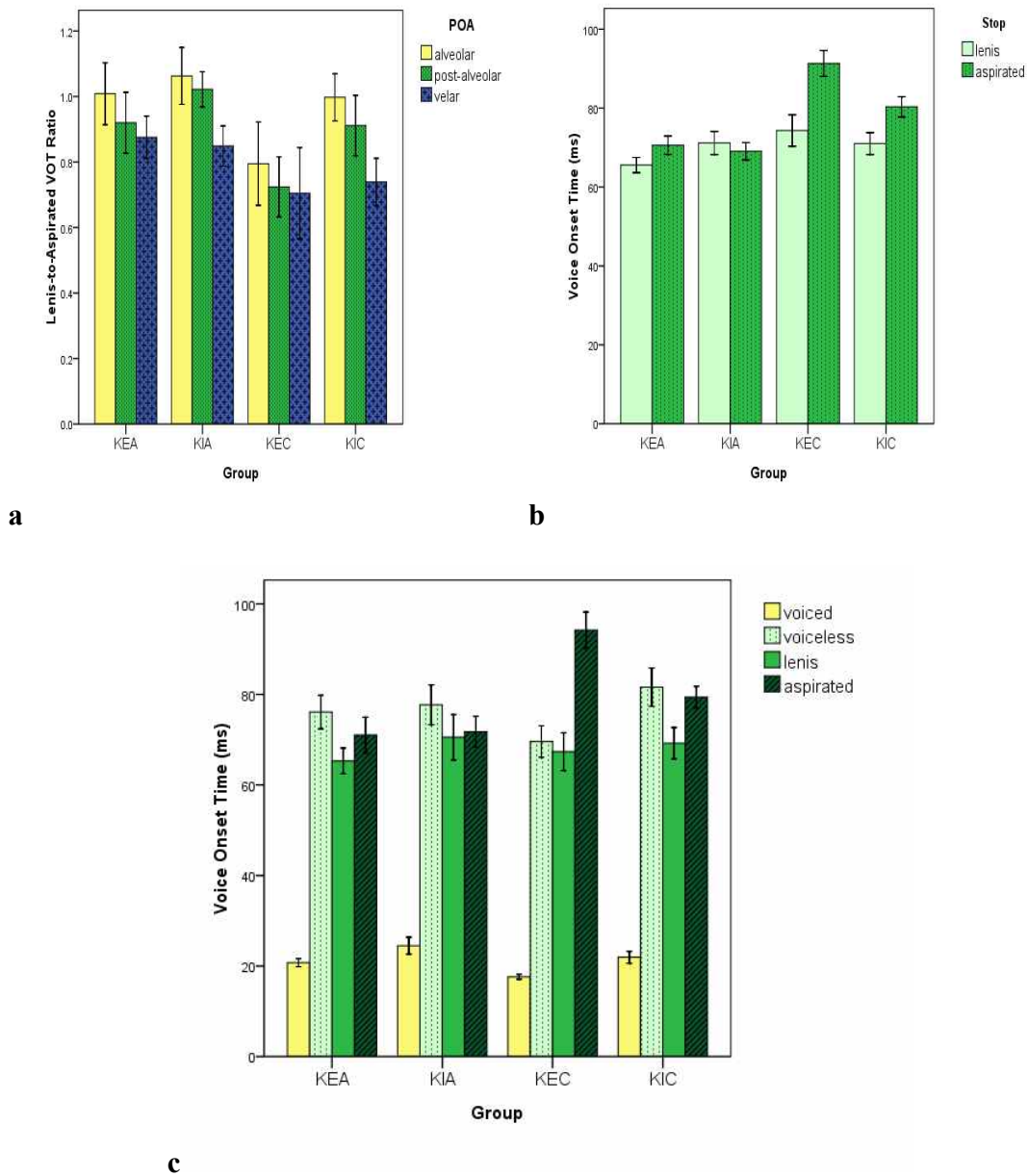


Figure 4.2. Lenis-to-aspirated voice-onset time ratios for Korean lenis and aspirated stops and affricates in bilabial, post-alveolar, velar position (a), and mean voice-onset time (ms) for Korean lenis and aspirated stops (b) produced by Korean Experienced adult, Korean Inexperienced adult groups and Korean Experienced child, Korean Inexperienced child groups are shown. The mean voice-onset time for English voiced and voiceless stops produced by the same four groups is compared to the mean voice-onset time for Korean lenis and aspirated stops (c).

When the mean VOT values were compared across the four groups (adult and child groups), a significant effect of group for aspirated [$F(3,36) = 6.940, p < 0.05, \eta_p^2 = 0.366$] but not lenis, stops was shown. Tukey's HSD tests ($p < 0.05$) revealed a significant difference between the KE child group and the other three groups. KE children's distinctively large VOT for aspirated stops is illustrated in Figure 4.2(b).

Next, mean VOT values for Korean lenis and aspirated stops were compared to the corresponding English voiced and voiceless stops in order to examine whether the Korean adults and children were able to create separate phonological categories for Korean and English stops in terms of VOT. Because VOT for English voiced stops was notably short, the remaining three types of Korean and English stops (i.e., Korean lenis, aspirated and English voiceless stops) were compared. 3 ANOVAs using repeated measures investigated the effect of stop (3) on each adult and child group. The alpha level was adjusted to 0.017 for the pairwise comparisons. The results showed no significant stop difference for the KE adult [$F(2,18) = 4.810, p > 0.013, \eta_p^2 = 0.348$] or the KI adult [$F(2,18) = 2.066, p > 0.013, \eta_p^2 = 0.187$] group, suggesting that the Korean adults produced all three stops with the same VOT. As expected in younger (< 40) Korean speakers' production, Korean lenis and aspirated stops were not distinguished by VOT due to the sound change.

On the other hand, VOT for the three stops was significantly different for the KE child [$F(2,18) = 19.853, p < 0.013, \eta_p^2 = 0.688$] as well as the KI child [$F(2,18) = 10.174, p < 0.013, \eta_p^2 = 0.718$] groups. In the pairwise comparisons, the KE child group showed a significant VOT difference between Korean aspirated and Korean lenis stops as well as

Korean aspirated and English voiceless stops. Figure 4.2(c) shows KE children's substantially longer VOT for Korean aspirated stops. KI children's lenis stops were distinguished from Korean aspirated stops but not from English voiceless stops.

4.3.5. Discussion

The voiced-to-voiceless VOT ratios showed that all four of the Korean adult and child groups produced significantly longer VOT for voiceless than voiced English stops similar to native English speakers. For the Korean adult groups, VOT for bilabial and alveolar voiced stops was around 20-25% and velar voiced stops around 30-40% of the voiceless counterparts. The effect of voicing on VOT was not significantly different between KE and KI adults' production. The child groups showed a similar pattern to the adult groups in that velar voiced and voiceless stops were produced with a smaller durational difference in relation to bilabial and alveolar stops. Regardless of the POA, however, NE adults and children made an overall greater VOT distinction between voiced and voiceless stops than Korean adults and children. In the analysis of mean VOT values, KE children produced significantly shorter VOT for voiceless stops than NE and KI children. At first blush, the factor influencing KE children's nonnative-like English VOT for voiceless stops is unclear. However, when taken together with their Korean production, a possible explanation emerges.

The results of Korean stop production showed that KE adults did not differ from KI adults in either lenis-to-aspirated ratios or mean VOT values. In addition, the VOT merging of lenis and aspirated stops in adults' production is consistent with the sound

change documented in previous research (Silva, 2006; Kang and Guion, 2006, 2008). The KE child group, on the other hand, showed significantly lower VOT ratios across different places of articulation, indicating that they produced a greater VOT difference between lenis and aspirated stops than the other three groups. Specifically, KE children produced distinctively longer VOT for aspirated than lenis stops (26 ms). KI children also produced longer VOT for aspirated stops than lenis stops but to a much lesser extent (10 ms). This distinction made by KI children may be due to the input from their parents who are still likely to preserve the VOT difference between the two Korean stops (Silva, 2006; Kang & Guion, 2008).

When the mean VOT values for the three different stops (Korean lenis, aspirated and English voiceless stops) were compared, English voiceless stops, Korean lenis and aspirated stops showed the same range of VOT values for the KE and KI adult groups (see Figure 4.2(c)). On the other hand, KE children's shorter VOT for English voiceless stops and longer VOT for aspirated stops may be interpreted as a form of dissimilation between Korean aspirated and English voiceless stop for a greater L1-L2 contrast (Flege & Eefting, 1987b; Flege, 1995). According to the Speech Learning Model proposed by Flege (1995, 2002, 2003), category dissimilation is likely to occur when a new category has been established for an L2 speech sound. The nearest L1 stop category shifts away from the newly established L2 stop category to maintain phonetic contrasts between the two sounds. In the process of developing stop contrasts in the two languages, KE children might have noted the presence of cross-linguistically similar acoustic features of Korean aspirated and English voiceless stops that are both produced with long-lag VOT

(see Schmidt, 1996). It is likely that KE children employed VOT to separate the similar L1 and L2 stop categories. This pattern of category dissimilation between the English and Korean stop categories further suggests that KE children have developed separate phonological representations for their two languages (see Flege et al., 2003).

As an alternative explanation, being exposed to the short- and long-lag VOT distinction in English before the adult-like acquisition of Korean three-way stop contrasts may have attracted KE children's attention to the VOT differences among different stop categories in the L1. That is, KE children may have produced Korean aspirated stops with distinctively long VOT as a way to create a greater difference between Korean aspirated and lenis stops. Korean lenis and aspirated stops are primarily distinguished by F0 (i.e., low F0 for lenis and high F0 for aspirated stops). However, if KE children have not yet acquired the F0 distinction between the two stops, it is likely that VOT was exaggerated to compensate for the smaller F0 difference. Especially considering that KE children have received Korean input mainly from their parents who maintain a VOT difference between the two stops, KE children's longer VOT for aspirated stops may be interpreted as their attempt to separate Korean stop categories with VOT. The heavy use of VOT may be attributed to the acquisition of English stops. This assumption, however, begs the question of whether KE children were able to acquire the F0 contrast for Korean stops. We will be revisiting this research question in Chapter VI.

Furthermore, the low frequency and perceptual saliency of aspirated stops in KE children's language input may have contributed to the large VOT difference between lenis and aspirated stops. In Jun (2007), the percentage of fortis (8.7%) and aspirated

stops (11.5%) were shown to be considerably lower than the percentage of lenis stops (28%) in child-directed parents' speech during a child's first year. Jun (2007) investigated a Korean child's developmental pattern of L1 production from 2 months to 22 months. The results showed that fortis stops were acquired earlier than lenis and aspirated stops in terms of F0 and VOT. The author suggested that the early mastery of fortis stop sound may be explained by its salient acoustic cues such as strong amplitude, high F0 of the following vowel, and long stop closure. Along the same line, considering the limited Korean input these bilingual children receive on a daily basis, the effect of low lexical frequency and salient acoustic cues (i.e., long VOT, high F0) of aspirated stops may account for the KE children's exaggerated VOT production.

CHAPTER V

ENGLISH PROSODY

(Stressed and unstressed vowel duration, F0, Intensity, Unstressed vowel spectral quality)

5.1. Introduction

Previous studies on nonnative speakers' acquisition of L2 segments have provided some evidence that the L2 segmental features may be acquired in a native-like manner depending on the learners' AOA and LOR (Tsukada et al., 2005; Kang & Guion, 2006; Oh et al., 2011). The native-like acquisition of segments, however, does not complete the process of phonetic encoding in speech production: the acquired segmental properties must also be realized within the L2 prosodic structure (see Keating & Shattuck-Hufnagel, 2002). Segments manifested in a nonnative-like prosody may be perceived as foreign accented and nonnative-like L2 prosody is likely to interfere with listeners' comprehensibility (Munro & Derwing, 1999; Trofimovich & Baker, 2007). Because segments and prosody have independent representations (Lehiste, 1970; Levelt, Roelofs, & Meyer, 1999) and at the same time interact with one another in close relationships (Keating & Shattuck-Hufnagel, 2002; Keating, 2003), L2 prosody produced by nonnative speakers could be an important means to assess the acquisition of L2 from a perspective that is fundamentally different from segments.

Despite this important aspect of prosody, studies on the acquisition of bilinguals' prosody have been comparatively sparse hitherto. Among the few, Huang and Jun (2009)

examined an English four-sentence paragraph produced by Mandarin-speaking learners of English with different AOA (mean early AOA =7, mid = 13, late = 23). The speech rate, foreign accentedness ratings by native English speakers, and intonation patterns of English production were investigated using ToBI (Tones and Break Indices) (Silverman, Beckman, Pitrelli, Ostendorf, Wightman, Price, Pierrehumbert, & Hirschberg, 1992). The results showed that the earlier the L2 exposure was, the more likely the prosody was to resemble the native norm. The early Mandarin-speaking adults were native-like in all the examined aspects of prosody whereas the late learners were shown to produce English sentences with significantly more phrasal breaks, more high tone pitch accents for each sentence and slower speech rate than the native English speakers. The native-like acquisition of L2 prosody by early L2 learners and different degree of native-likeness in mid and late learners' production across different prosodic aspects were interpreted to support the strong effect of AOA on the acquisition of L2 prosody.

Similarly, the effect of AOA on L2 prosody has been reported in Lee et al. (2006)'s study. The study also proposed that having the same phonetic features that are used to signal phonological differences in both L1 and L2 would likely facilitate the acquisition of L2 prosodic features. English, as a stress-timed language, has rhythmic features that the L2 learners from mora-timed or syllable-timed language background may be unfamiliar with. As is well known, English stressed syllables are produced with longer duration, higher pitch and greater amplitude than unstressed syllables (Lieberman, 1960; Lehiste, 1970). Unstressed vowels are also distinguished from stressed vowels in vowel spectral quality (Gay, 1978). However, these prosodic features can be under-

attended by L2 speakers when they are not phonologically meaningful in their native languages. The research hypothesis was that if knowledge of L1 interferes with L2 learning, not only late learners but also early bilinguals would show difficulties in attaining a native-like L2 prosodic system. More specifically, Korean and Japanese learners were predicted to be good at using F0 as a means to mark English stress, while only Japanese learners were predicted to be better at using duration for distinguishing stressed and unstressed vowels due to the phonemic length distinctions in Japanese.

In Lee et al. (2006), Korean early (Mean AOA = 3.9), late (21.4) and Japanese early (3.7), late (21) adult learners of English produced two- or three-syllable words containing 21 unstressed vowels. The unstressed-to-stressed vowel duration, F0 and intensity ratios were assessed along with the F1 and F2 frequencies of the unstressed vowels. The results showed that both Korean early and late and Japanese early and late learners were able to accurately differentiate stressed and unstressed vowels in terms of F0. However, Japanese early and late learners showed higher accuracy in duration and intensity ratios than Korean early and late learners. Although significantly influenced by AOA, the vowel spectral qualities of unstressed vowels were not native-like in either the Korean or the Japanese group. Specifically, Korean early group's unstressed vowels merged around the center of the vowel space, whereas Korean and Japanese late learners' vowels were more dispersed as an effect of English orthographic representations. Furthermore, the acoustic distance between unstressed vowels was found to be the smallest for Korean early learners and this vowel concentration was attributed to the substitution of Korean vowel /i/ for English reduced vowels. Overall, the accurate

acquisition of L2 prosodic features such as duration and F0 by early and late Japanese learners indicated the positive influence of the L1 on L2 prosody. The intensity difference was also produced in a native-like manner by the Japanese learners despite its lack of distinction in their L1 phonology (though see Neustupny, 1966; Homma, 1971 for the discussion on the role of intensity in Japanese pitch accent).

Similar results were reported in Tomita, Yamada and Takatsuka (2010)'s study in which Japanese learners' production of unstressed vowels in English disyllabic words (e.g., *chicken*, *spoonful*, *Tarzan*) encompassed greater schwa-space and longer distance between unstressed vowels than native English speakers' production. The authors suggested that Japanese learners were unable to reduce the spectral quality of unstressed vowels as native English speakers due to the different rhythmic patterns between Japanese and English (mora-timed vs. stress-timed).

Other studies have paid more attention to the effect of L2 experience on the acquisition of L2 prosody (Trofimovich and Baker, 2006, 2007). Trofimovich and Baker (2007) examined English prosody produced by 20 native English speakers and 20 Korean children and adults with the similar AOA (child mean = 10.7, adult mean = 9.0) but different LOR (child mean = 1, adult mean = 11) in the U.S. The main research question was whether Korean adults who have been exposed to English at an early age would be able to acquire English prosody in a native-like manner after extensive L2 experience. A delayed repeated task was conducted to elicit Korean speakers' English sentences which were later analyzed for indication of stress timing (unstressed-to-stressed syllable duration) and F0 peak alignment (from the stressed vowel onset to the highest F0 in the

pitch contour) for prosody-based suprasegmentals and speech rate (dividing the number of uttered syllables by their total duration), pause length, and pause frequency for fluency-based suprasegmentals. In addition, Korean speakers' productions were low-pass filtered and rated by ten native English speakers to determine the degree of foreign accentedness. The results showed that the ratings for Korean children were significantly lower, and thus less native-like than the ratings for Korean adults. The absence of significant perceived foreign accents for Korean adults suggested that 10 years of English experience may have overridden the effect of L1 on English prosody. The Korean adults' acoustic features of suprasegmentals were native-like except for the speech rate, whereas Korean children showed nonnative-like prosody in all five aspects. The authors argued that the early L2 acquisition and 10 years of experience in the L2-speaking country made it possible for Korean adults to execute the complex layers of rhythmic control in L2 production.

Although Trofimovich and Baker (2006, 2007)'s studies showed the importance of L2 experience in learning native-like L2 prosody, it may be too hasty to conclude that Korean adults were able to acquire native-like L2 prosody. Considering the rhythmic differences between Korean (syllable-timed) and English (stress-timed) prosodic systems, stress timing alone may not be a sufficient measure to uphold the claim that Korean learners were able to master new prosodic features over the course of 10 years of experience. Along with F0 peak alignment, speech rate, pause frequency, English-specific stress correlates such as F0 and intensity (Lieberman, 1960) would further

provide evidence in support of a significance of L2 experience on the acquisition of L2 prosody.

In Chapter 5, Korean adults' acquisition of L2 prosodic features, as well as bilingual children's developmental pattern of L2 prosody is examined as a function of L2 experience. It should be clearly noted that the term prosody in this chapter specifically refers to the prosodic features associated with stress at the word level. To examine the effect of L1 on the realization of English stress pattern, the ratios of unstressed-to-stressed vowel duration, F0, and intensity were compared across Korean and English-speaking groups. In addition, the maximum and minimum F0 and intensity produced within the stressed and unstressed syllables were investigated to explore the F0 and intensity range across stressed and unstressed syllables. Lastly, the spectral quality of unstressed vowels is examined in order to determine whether Korean groups with more L2 experience have learned to spectrally reduce unstressed vowels in a native-like manner.

5.2. Experiment 4: stressed and unstressed vowels

5.2.1. Participants

The same 20 KE and KI adults, 20 KE and KI children and age-matched 20 NE adults and children who participated in Experiment 1 also participated in this production task.

5.2.2. Speech stimuli

A total of seven frequently used three-syllable English words, representing four vowel categories (i.e., two words for /ɛ/, /æ/, /ɑ/, and one word for /u/) were presented to the six groups of Korean speakers differing in the amount of English experience. The word-initial stress pattern and the vowel qualities of stressed and unstressed vowels in the first and second syllables were matched between the words in each vowel category. The stimuli were as follows: /ɛ/- ***e**lephant, **te**lephone*, /æ/ - ***a**nimal, **f**amily*, /ɑ/ – ***c**rocodile, **o**ctopus*, /u/ – ***c**ucumber*. The stressed vowels in the first syllable and the unstressed vowels in the second syllable are marked in bold.

5.2.3. Procedure

The same procedure used for Experiment 1 (see section 2.2.3) was used in this experiment. The multisyllabic words were presented in a random order with corresponding pictures on the screen of a laptop computer. This experiment was conducted after Experiment 1. English production prerecorded by a female native English speaker was provided for the first presentation. The words were elicited three times and only the second and third tokens of each word were used for analysis. Words that KI children were unable to retrieve by themselves at the second or third attempt were replace by the average value of that vowel category of that speaker. This was done in approximately 0.09 percent of the cases.

5.2.4. Measurements

The vowel duration of 840 English three-syllable English words was measured (in milliseconds) using Praat. The onset and offset of clear energy in the second formant frequency on the sound spectrogram served as a reference, along with the waveform, to determine the onset and offset of the vowel. The stressed vowels were taken from the onset of voicing (e.g., *animal*, *elephant*) or the steady-state formant frequencies (F1, F2, F3) to the beginning of the consonant constriction, frication noise, or nasal murmur (e.g., *crocodile*, *elephant*, *family*). The unstressed vowels were measured in a similar fashion. The mean vowel duration averaged across two repetitions of stressed and unstressed vowels was submitted to analysis. The unstressed vowel duration was divided by the stressed vowel duration (i.e., unstressed-to-stressed vowel duration ratio) to obtain normalized values. Duration was normalized to control for differences in speech rate across speakers. The smaller the ratio value was, the longer the stressed vowel was relative to the unstressed vowel. Two more acoustic measures, F0 (in hertz) and intensity (in decibels), were taken at the temporal midpoint of the stressed and unstressed vowels. Similar to the vowel duration, the averaged F0 and intensity midpoint values of unstressed vowels were divided by the F0 and intensity averaged midpoint values of stressed vowels.

5.2.5. Statistical analyses

The ratios for unstressed-to-stressed vowel duration, F0 and intensity produced by the NE, KE, KI adult groups and the NE, KE, KI child groups were separately

analyzed. First, ANOVAs assessing the effect of group (3) on vowel duration ratios, F0 ratios, and intensity ratios were separately reported. In case of a significant group difference, separate ANOVAs were conducted to examine whether the effects of stress on vowel duration, F0 and intensity were manifested in a similar manner across the groups. For each analysis, the dependent variable was the mean vowel duration (or mean F0 values or mean intensity values) and the independent variables were group (3) and stress (stressed vs. unstressed) as repeated measures. In the case of a significant group and stress interaction, the effect of group on each stressed and unstressed vowel measures was tested. Partial eta squared (η_p^2) values are provided for all analyses to provide information on the effect size.

5.2.6. Results: unstressed-to-stressed vowel duration ratios

The results returned no significant group effect for either adults [$F(2,27) = 1.679$, $p > 0.05$, $\eta_p^2 = 0.111$] or children [$F(2,27) = 2.847$, $p > 0.05$, $\eta_p^2 = 0.174$] on unstressed-to-stressed vowel duration ratios. Although there was a marginal difference between the NE child and KI child groups ($p = 0.06$) in post-hoc comparisons, it was not statistically meaningful. See Figure 5.1(a) for the similar ratios for the adult and child groups. The six groups produced unstressed vowel duration roughly half the duration of stressed vowels ($<.58$). However, there was a trend for both inexperienced adult and child groups to show a higher ratio than the native and Korean experienced groups, suggesting that their duration difference between stressed and unstressed vowels was relatively smaller.

As shown in Figure 5.1(b), when the mean stressed and unstressed vowel duration was examined separately, KE children appeared to produce longer stressed and unstressed vowels than NE and KI children, which may be due to their slower speech rate. Overall, stressed and unstressed vowel duration was produced in a near native-like manner by the Korean adult and child groups.

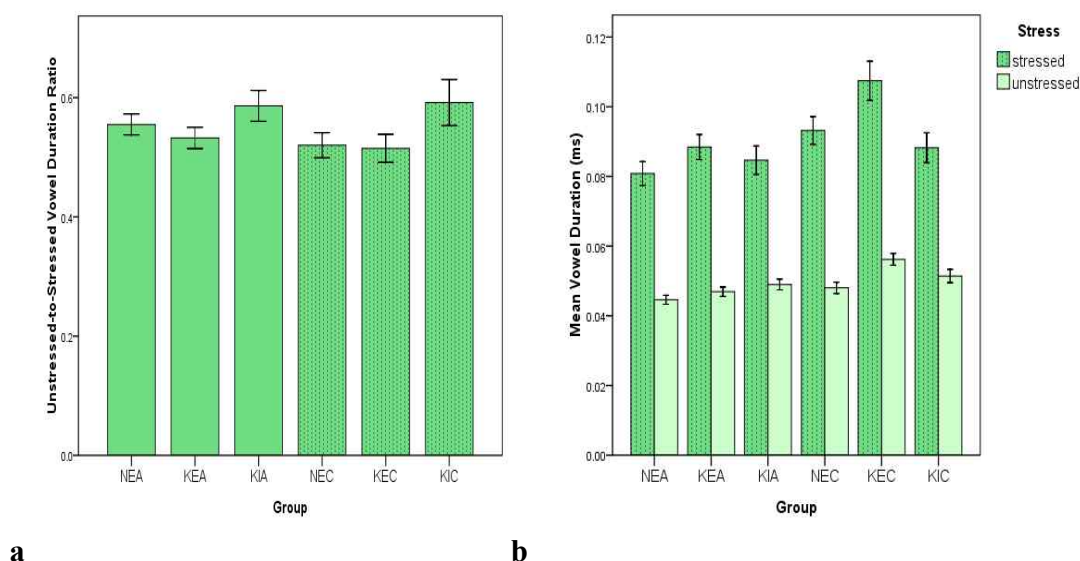
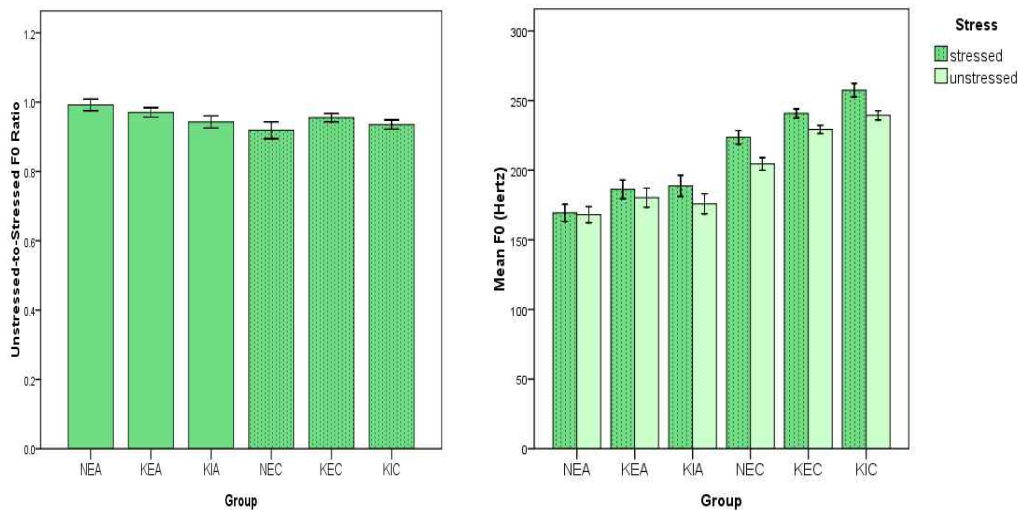


Figure 5.1. Unstressed-to-stressed vowel duration ratios (a) and mean duration (in ms) of stressed and unstressed vowels (b) produced by Native English-speaking adult group, Korean Experienced adult group, Korean Inexperienced adult group and Native English-speaking child group, Korean Experienced child group, Korean Inexperienced child group are shown.

5.2.7. Results: unstressed-to-stressed F0 and intensity ratios

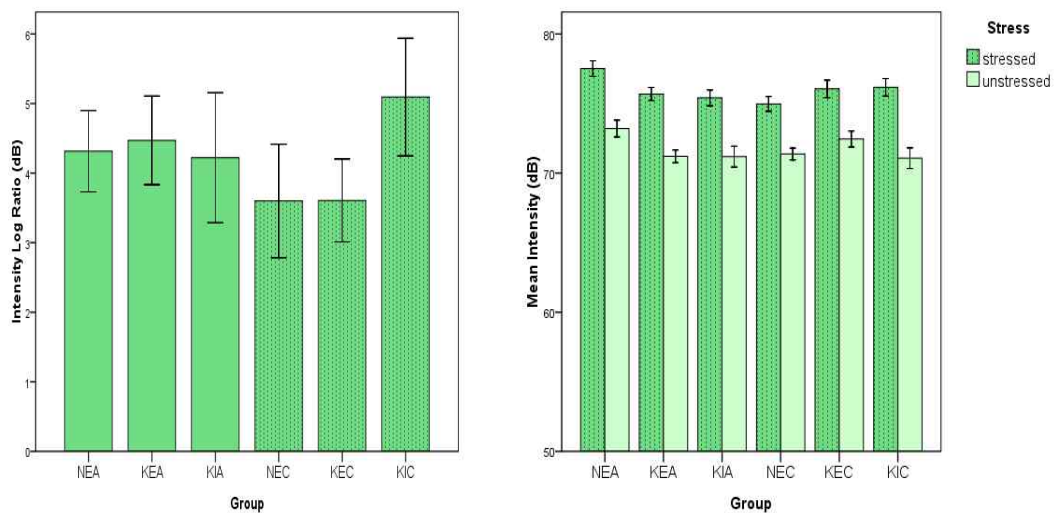
The effect of group on F0 ratios was not significant for either the adult [$F(2,27) = 2.352, p > 0.05, \eta_p^2 = 0.148$] or the child groups [$F(2,27) = 1.088, p < 0.05, \eta_p^2 = 0.202$]. Figure 5.2(a) shows that the groups' F0 ratios were mostly around or slightly

smaller than 1, indicating their similar F0 difference between stressed and unstressed vowels. As illustrated in Figure 5.2(b), unstressed vowels were produced with roughly the same or smaller F0 values than stressed vowels across the groups. There was a trend for the less experienced child groups to produce higher F0 for both stressed and unstressed vowels than the NE child group. When the stressed and unstressed vowels were separately compared across the child groups, the pairwise comparisons showed that the NE child group produced significantly lower F0 for unstressed, but not stressed, vowels compared to the KE and KI child groups ($p < 0.05$). Differences in physique (i.e., the size of vocal cords) between typical American and Korean adults and children may be attributed to the Korean groups' higher F0.



a **b**
 Figure 5.2. Unstressed-to-stressed F0 ratios (a) and mean F0 (in hertz) of stressed and unstressed vowels (b) produced by Native English-speaking adult group, Korean Experienced adult group, Korean Inexperienced adult group and Native English-speaking child group, Korean Experienced child group, Korean Inexperienced child group are shown.

Following the method used in Lee, Guion, & Harada (2006), the mean intensity values were transformed to log values, which was calculated by subtracting the intensity (in decibels) of the unstressed vowel from the intensity of the stressed vowel. Higher log values indicate bigger intensity differences between unstressed and stressed vowels. The results showed that the intensity ratios were not significantly different across the adult groups [$F(2,27) = 0.030, p > 0.05, \eta_p^2 = 0.002$] or child groups [$F(2,27) = 1.278, p > 0.05, \eta_p^2 = 0.086$]. Although statistically not significant, Figure 5.3(a) shows that KI children made relatively greater intensity differences between stressed and unstressed vowels than NE and KE children. As shown in Figure 5.3(b), stressed vowels were produced with greater intensity than unstressed vowels and the differences are similar across the six groups.



a **b**
 Figure 5.3. Intensity log ratios (a) and mean intensity (in decibels) of stressed and unstressed vowels (b) produced by Native English-speaking adult group, Korean Experienced adult group, Korean Inexperienced adult group and Native English-speaking child group, Korean Experienced child group, Korean Inexperienced child group are shown.

5.3. Maximum and minimum F0 and intensity range

The F0 and intensity values taken at the temporal midpoint of stressed and unstressed vowels provide a reference point that compares a difference between the productions of Korean groups and those of native English speakers. However, comparing a static point in speech production presents limited information about the dynamic aspects of a prosodic system. Figure 5.2(b) and 5.3(b) show that stressed vowels are produced with slightly higher F0 and stronger intensity than unstressed vowels. What is still unknown is how higher and stronger the F0 and intensity are for stressed syllables compared to unstressed syllables. The goal of this section is to better understand to what extent the Korean groups differ from the NE groups in setting the scope of maximum (max) and minimum (min) F0 and intensity for stressed and unstressed syllables within a word.

5.3.1. Measurements

Max F0 and intensity were taken in the first syllable and min F0 and intensity in the second syllable. Max and min values were always located in the first and second syllables, respectively. The first two syllables were taken to avoid measuring the word-final F0 fall as min F0. The first syllable was measured from the onset of the first clearly periodic pattern in the acoustic signal. The periodic portion of /r/ for [*cro.co*]dile was included. The end of the second syllable was determined by the beginning of nasal murmur (ex. [*a.ni*]mal) or the beginning of an increasing F3 and an abrupt change in energy with reference to spectrogram (ex. [*fa.mi*]ly). It should also be noted that there

was an intensity fall between the first and second syllables for [*oc.to*]pus, [*cu.cum*]ber, and [*cro.co*]dile due to the stop closure. For these words, the first syllables were measured until the end of the periodic, voiced patterns and the second syllables were measured from the onset of voicing to the stop closure. The max and min F0 and intensity values were automatically obtained by using ‘pitch’ function in Praat. None of the tokens was produced with stress on the second syllable. However, approximately 12% of the NE adult and 8 % of the NE child groups produced a word with a rising intonation, which placed the max F0 at the very end of the word. These tokens were replaced with the average max or min value of that word produced by that speaker. The intensity contour, however, was not affected by the rising tone. The independent patterns of F0 and intensity in English stressed words have been noted in Lehiste (1970).

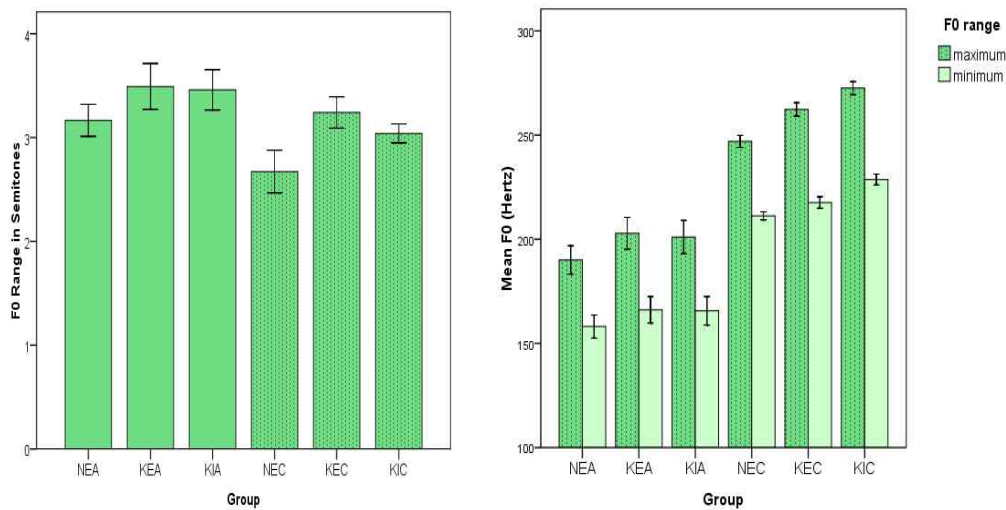
5.3.2. Statistical analyses

The difference between max and min F0 values (in Hertz) was semitone transformed (ST) for normality and more comparable pitch ranges for male and female participants. The formula used was as follows: $[12 \times \log(f0_{\max}/f0_{\min})] / \log(2)$. A higher value indicates a larger difference between max and min F0.

The F0 range (ST) and intensity range were separately submitted to ANOVAs for group (3) comparisons. In case of a significant group effect on range (max-min), the effect of group was independently investigated for the max and min F0 (or intensity) in order to explore the source of the range difference. Pairwise comparisons (Tukey’s HSD tests, $p < .05$) were reported for a significant difference across groups.

5.3.3. Results: maximum/minimum F0 range

An ANOVA on the F0 difference (ST) was not significant across adult groups [$F(2,27) = 0.875, p > 0.05, \eta_p^2 = 0.061$], but the child groups showed a significant difference [$F(2,27) = 3.408, p < 0.05, \eta_p^2 = 0.202$]. Specifically, Tukey's HSD tests returned a significant difference between the NE child and KE child groups as well as the NE child and KI child groups. As shown in Figure 5.4(a), NE children's F0 difference was less than 3 semitones, whereas KE and KI children produced a larger F0 range within the stressed and unstressed syllables. When the effect of group was assessed for max and min F0 separately, a significant group effect on children's max, but not min, F0 was shown [$F(2,27) = 3.303, p = 0.05, \eta_p^2 = 0.197$]. As can be seen in Figure 5.4(b), the max F0 is especially higher for the KI child group compared to the NE child group ($p = 0.05$). The increasing pattern of max F0 across the child groups displays similar trend as the pattern shown in Figure 5.2(b) for the midpoint F0 values.



a b

Figure 5.4 Maximum and minimum F0 range (in semitones) (a) and mean maximum and minimum F0 (in Hertz) in the first and second syllables of the seven multisyllabic words (b) produced by Native English-speaking adult group, Korean Experienced adult group, Korean Inexperienced adult group and Native English-speaking child group, Korean Experienced child group, Korean Inexperienced child group are shown.

5.3.4. Results: maximum/minimum intensity range

An ANOVA on the intensity difference (in decibels) was not significant across the adult groups [$F(2,27) = 2.229, p > 0.05, \eta_p^2 = 0.142$], but KE and KI adults showed a tendency to make larger max/min intensity differences between stressed and unstressed syllables than NE adults (see Figure 5.5(a)). Children showed a significant group difference [$F(2,27) = 4.349, p < 0.05, \eta_p^2 = 0.244$]. Tukey's HSD tests returned a significant difference between the NE child and KI child groups, but not between the NE child and KE child or the KE child and KI child groups. The trends in Figure 5.5(a) show that the least experienced child group made the largest intensity difference between stressed and unstressed syllables. When the effect of group on max and min intensity was separately submitted to ANOVAs, however, neither the max [$F(2,27) = 0.355, p > 0.05$,

$\eta_p^2 = 0.026$] or min intensity [$F(2,27) = 0.472, p > 0.05, \eta_p^2 = 0.034$] was significantly different across the child groups (see Figure 5.5(b)). In general, the Korean child groups appeared to make a greater intensity distinction between stressed and unstressed syllables compared the NE groups.

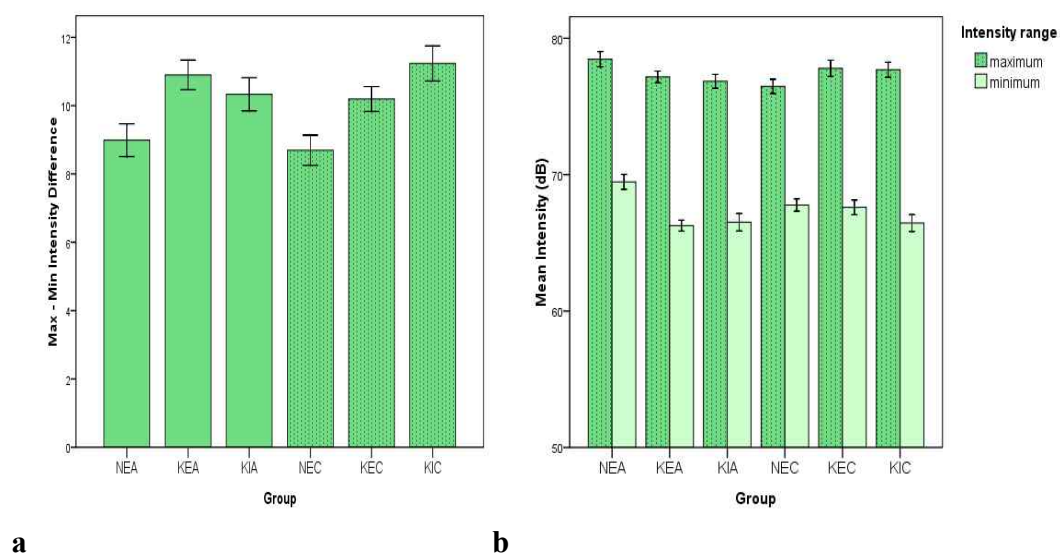


Figure 5.5. Maximum and minimum intensity range (in decibels) (a) and mean max and minimum intensity values within the first and second syllables of the seven multisyllabic words (b) produced by Native English-speaking adult group, Korean Experienced adult group, Korean Inexperienced adult group and Native English-speaking child group, Korean Experienced child group, Korean Inexperienced child group are shown.

5.3.5. Discussion

The unstressed-to-stressed ratios of vowel duration, and the midpoint values of F0 and intensity were not significantly different across the adult or child groups. In addition, the KE and KI adult groups did not differ from the NE adult group in the production of max and min F0 and intensity differences. The KE and KI child groups, however, showed a significantly larger F0 range for stressed and unstressed syllables

than the NE child group. The intensity range was also significantly larger in KI children's than in NE children's production. First of all, the results suggest that the max and min differences show additional information which temporal midpoint comparisons were not able to provide. Especially, the max and min values captured the different ranges of F0 contour that varied with stress across the groups. The larger F0 and intensity differences in KI children's production suggest that F0 and intensity were used to a greater extent in distinguishing stressed and unstressed syllables than the native norm.

Secondly, both KI children and KE children showed a larger F0 range than NE children. The greater use of F0 can be viewed as an effect of Korean in which F0 plays a primary role of marking prosodic units in both perception and production (Jeon & Nolan, 2010). Because of the heavy role of F0 in Korean prosody, KE and KI children may have overshoot the maximum F0 for stressed syllables (see Figure 5.4(b)). KE and KI adults, however, showed native-like F0 and intensity patterns both in the measures of temporal midpoints and the max and min differences. Although KI adults produced a slightly smaller durational difference between stressed and unstressed vowels than KE adults did, the overall results for the adult groups suggest that the effect of L2 experience on the acquisition of L2 prosodic features was insignificant.

The native-like acquisition of stress patterns in terms of duration, F0 and intensity by KI adults, but not KI children, may be explained by their prior English experience in Korea. Although both KI adults and children had arrived in the U.S. about six months before the time of testing, KI adults have been learning English since middle school in Korea. Considering the easiness and higher frequency of the English stimuli,

KI adults are likely to have over-learned the prosodic features of the words in Korea. Thus, in addition to LOR in the L2 speaking country, L2 learners' LOR in the L1-speaking country should be taken into account to appreciate the effect of L2 experience to a greater extent.

5.4. Unstressed vowel spectral quality

In addition to the prosodic correlates of stress, unstressed vowel spectral quality is another important segmental cue to the presence or absence of stress. In this section, unstressed vowel productions were compared across the adult and child groups to further investigate whether the Korean groups were able to acquire reduced vowels in a native-like manner. The degree of reduction for unstressed vowels was explored as a function of L2 experience.

5.4.1. Speech stimuli

The same seven three-syllable English words were used. The reduced vowel in each word is represented with the orthographic symbol of the unstressed vowel as follows: /i¹/ - *animal*, /i²/ - *family*, /e¹/ - *elephant*, /e²/ - *telephone*, /o¹/ - *crocodile*, /o²/ - *octopus*, /u/ - *cucumber*. The multisyllabic words needed to be easy and familiar to English inexperienced children and to be imageable for the picture naming task. Except for *cucumber*, each unstressed vowel category consisted of two words which were matched on a word-initial stress pattern. The consonantal contexts, however, were not controlled across the vowel categories, which would be desirable.

5.4.2. Measurements

A total of 840 tokens (7 words x 2 repetition x 6 groups x 10 participants each) for the English unstressed vowel productions were analyzed using Praat. Similar to the measurements for monosyllabic words in Experiment 1, first and second formant frequencies were measured at the temporal midpoint of each unstressed vowel. Due to the different length of the vocal tract across female and male participants, F1 and F2 frequency measurements were normalized with reference to the average F3 frequency of the low back English vowel /ɑ/ (see 2.2.4.1 in Chapter 2 for details). The adult and child groups were normalized separately. The normalized measurements were used for the within and between-group spectral analyses.

5.4.3. Statistical analyses

Three adult (or child) groups were compared using MANOVAs. If the group (3) and word (7) interaction was significant, 3-way comparisons were conducted. First, to investigate the effect of LOR, a MANOVA examining the difference between experienced and inexperienced groups' unstressed vowels was conducted. In addition, KE and KI groups were separately compared to the NE group to assess whether the unstressed vowels were produced in a native-like manner. The dependent variables for all comparisons were F1 and F2 frequencies and the independent variables were word (7), submitted as repeated measures, and group (2). In the case of a significant interaction between group and word, 7 MANOVAs were conducted to test the effect of group on each word. The alpha level was adjusted to 0.007 for 7 comparisons. The univariate tests

for F1 and F2 frequencies of unstressed vowels are reported for each significant MANOVA comparison.

5.4.4. Results: unstressed vowel spectral quality

5.4.4.1. Comparisons among the adult groups

The spectral quality of unstressed vowels were examined and compared across the adult groups. The NE, KE and KI adult group analysis revealed a significant group effect [$F(4,54) = 6.296, p < 0.05, \eta_p^2 = 0.318$] as well as a significant group and word interaction [$F(24,34) = 11.645, p < 0.05, \eta_p^2 = 0.892$]. When KE and KI adult groups were submitted to a MANOVA, the results returned a significant effect of group [$F(2,517) = 11.280, p < 0.05, \eta_p^2 = 0.570$] as well as a significant group and word interaction [$F(12,7) = 14.299, p < 0.05, \eta_p^2 = 0.961$]. Seven MANOVAs investigating the effect of group on each unstressed vowel showed that five out of seven vowels were not different between the KE and KI adult groups: *el*[e¹]*phant* [$F(2,17) = 0.635, p > 0.007, \eta_p^2 = 0.070$], *an*[i¹]*mal* [$F(2,17) = 3.186, p > 0.007, \eta_p^2 = 0.273$], *croc*[o¹]*dile* [$F(2,17) = 1.435, p > 0.007, \eta_p^2 = 0.144$], *oct*[o²]*pus* [$F(2,17) = 3.781, p > 0.007, \eta_p^2 = 0.308$], *cuc*[u]*mber* [$F(2,17) = 2.262, p > 0.007, \eta_p^2 = 0.210$]. However, *tel*[e²]*phone* [$F(2,17) = 8.583, p < 0.007, \eta_p^2 = 0.502$] and *fam*[i²]*ly* [$F(2,17) = 50.495, p < 0.007, \eta_p^2 = 0.856$] were significantly different across the two groups. In the univariate tests, F2 frequencies for *tel*[e²]*phone* [$F(1,18) = 18.173, p < 0.007, \eta_p^2 = 0.502$] and *fam*[i²]*ly* [$F(1,18) = 98.027, p < 0.007, \eta_p^2 = 0.845$] were significantly higher in KI adult group's than in KE adult group's production. The results are summarized in Table 5.1.

As can be seen in Figure 5.6(a) and (b), KE adults' unstressed vowels are more concentrated around the central area of the vowel space than KI adults' vowels, possibly suggesting a smaller effect of orthographic spellings due to longer L2 experience. Thus, the KE and KI adult groups were separately compared to the NE adult group to examine whether KE adults were more native-like than KI adults in producing the unstressed vowels. The KE and NE adult groups showed no significant effect of group [$F(2,17) = 0.872, p > 0.05, \eta_p^2 = 0.093$], but a significant group and word interaction [$F(12,7) = 26.241, p < 0.05, \eta_p^2 = 0.978$]. The words that were significantly different between the two groups were *an*[i¹]*mal* [$F(2,17) = 56.585, p < 0.007, \eta_p^2 = 0.869$], *el*[e¹]*phant* [$F(2,17) = 27.958, p < 0.007, \eta_p^2 = 0.767$], *tel*[e²]*phone* [$F(2,17) = 16.805, p < 0.007, \eta_p^2 = 0.664$], *croc*[o¹]*dile* [$F(2,17) = 39.764, p < 0.007, \eta_p^2 = 0.824$], *oct*[o²]*pus* [$F(2,17) = 36.536, p < 0.007, \eta_p^2 = 0.811$], *cuc*[u]*mber* [$F(2,17) = 8.567, p < 0.007, \eta_p^2 = 0.502$]. However, *fam*[i²]*ly* [$F(2,17) = 3.052, p > 0.007, \eta_p^2 = 0.26$] was produced in a native-like manner.

The univariate tests returned a significantly lower F1 frequency for *an*[i¹]*mal* [$F(1,18) = 38.952, p < 0.007, \eta_p^2 = 0.684$] and higher F1 for *el*[e¹]*phant* [$F(1,18) = 13.106, p < 0.007, \eta_p^2 = 0.421$], *tel*[e²]*phone* [$F(1,18) = 16.158, p < 0.007, \eta_p^2 = 0.473$] and *oct*[o²]*pus* [$F(1,18) = 23.894, p < 0.007, \eta_p^2 = 0.570$] in KE adults' than NE adults' production. KE adults' F2 frequency was significantly lower for *croc*[o¹]*dile* [$F(1,18) = 83.709, p < 0.007, \eta_p^2 = 0.823$], *oct*[o²]*pus* [$F(1,18) = 30.074, p < 0.007, \eta_p^2 = 0.626$], *cuc*[u]*mber* [$F(1,18) = 17.364, p < 0.007, \eta_p^2 = 0.491$] and higher for *an*[i¹]*mal* [$F(1,18) = 62.251, p < 0.007, \eta_p^2 = 0.776$], *el*[e¹]*phant* [$F(1,18) = 48.476, p < 0.007, \eta_p^2 = 0.729$]

and *tel[e²]phone* [$F(1,18) = 31.106, p < 0.007, \eta_p^2 = 0.633$] than NE adults' unstressed vowels. The overall results are shown in Table 5.1.

A MANOVA on the KI and NE adult groups also showed a significant group [$F(2,17) = 11.299, p < 0.05, \eta_p^2 = 0.569$] as well as a significant group and word interaction [$F(12,7) = 100.169, p < 0.05, \eta_p^2 = 0.994$]. The group effect was significant for all seven vowels: *an[i¹]mal* [$F(2,17) = 59.339, p < 0.007, \eta_p^2 = 0.875$], *fam[i²]ly* [$F(2,17) = 72.990, p < 0.007, \eta_p^2 = 0.896$], *el[e¹]phant* [$F(2,17) = 30.751, p < 0.007, \eta_p^2 = 0.783$], *tel[e²]phone* [$F(2,17) = 51.722, p < 0.007, \eta_p^2 = 0.859$], *croc[o¹]dile* [$F(2,17) = 42.559, p < 0.007, \eta_p^2 = 0.834$], *oct[o²]pus* [$F(2,17) = 58.889, p < 0.007, \eta_p^2 = 0.874$], *cuc[u]mber* [$F(2,17) = 6.635, p = 0.007, \eta_p^2 = 0.438$].

According to the univariate tests, the KI adult group showed a lower F1 frequency for *an[i¹]mal* [$F(1,18) = 51.259, p < 0.007, \eta_p^2 = 0.740$], *fam[i²]ly* [$F(1,18) = 10.232, p < 0.007, \eta_p^2 = 0.362$], higher F1 for *el[e¹]phant* [$F(1,18) = 19.564, p < 0.007, \eta_p^2 = 0.521$], *tel[e²]phone* [$F(1,18) = 29.298, p < 0.007, \eta_p^2 = 0.619$], lower F2 for *croc[o¹]dile* [$F(2,17) = 88.359, p < 0.007, \eta_p^2 = 0.831$], *oct[o²]pus* [$F(1,18) = 59.602, p < 0.007, \eta_p^2 = 0.768$], *cuc[u]mber* [$F(1,18) = 13.096, p = 0.007, \eta_p^2 = 0.421$], and higher F2 for *an[i¹]mal* [$F(1,18) = 68.782, p < 0.007, \eta_p^2 = 0.793$], *fam[i²]ly* [$F(1,18) = 112.582, p < 0.007, \eta_p^2 = 0.862$], *el[e¹]phant* [$F(1,18) = 55.571, p < 0.007, \eta_p^2 = 0.755$], and *tel[e²]phone* [$F(1,18) = 107.034, p < 0.007, \eta_p^2 = 0.856$] than the NE adult group (See Table 5.1.).

Table 5.1. Significantly different unstressed vowels between the adult groups are shown. The results of a less native-like group (marked in bold) are given in comparison to a corresponding group. The significant differences are marked with an arrow indicating significantly high or low F1 and F2 frequencies.

Group	Significantly different unstressed vowels
KEA- KIA	<i>fam</i> [i ²] <i>ly</i> (F2↑), <i>tel</i> [e ²] <i>phone</i> (F2↑)
NEA- KEA	<i>an</i> [i ¹] <i>mal</i> (F1↓,F2↑), <i>el</i> [e ¹] <i>phant</i> (F1↑, F2↑), <i>tel</i> [e ²] <i>phone</i> (F1↑,F2↑), <i>croc</i> [o ¹] <i>dile</i> (F2↓), <i>oct</i> [o ²] <i>pus</i> (F1↓,F2↓), <i>cuc</i> [u] <i>mber</i> (F2↓)
NEA- KIA	<i>an</i> [i ¹] <i>mal</i> (F1↓,F2↑), <i>fam</i> [i ²] <i>ly</i> (F1↓,F2↑), <i>el</i> [e ¹] <i>phant</i> (F1↑, F2↑), <i>tel</i> [e ²] <i>phone</i> (F1↑,F2↑), <i>croc</i> [o ¹] <i>dile</i> (F2↓), <i>oct</i> [o ²] <i>pus</i> (F1↓,F2↓), <i>cuc</i> [u] <i>mber</i> (F2↓)

Largely two observations can be made from the results in Table 5.1. First, the effect of L2 experience for the adult groups was shown in only one word, *family*. Figure 5.6 shows that KE adults' F2 frequency for 'i' in *family* was significantly lower (more back in the vowel space) than KI adults' production. Second, the KE and KI adult groups produced unstressed vowels with orthographic symbols used for front vowels with higher F2 and back vowels with lower F2 with than the NE adult group. Overall, there was a small effect of L2 experience and Korean adults' unstressed vowel production showed a strong influence of the orthographic spellings. This pattern is more evident in Figure 5.6.

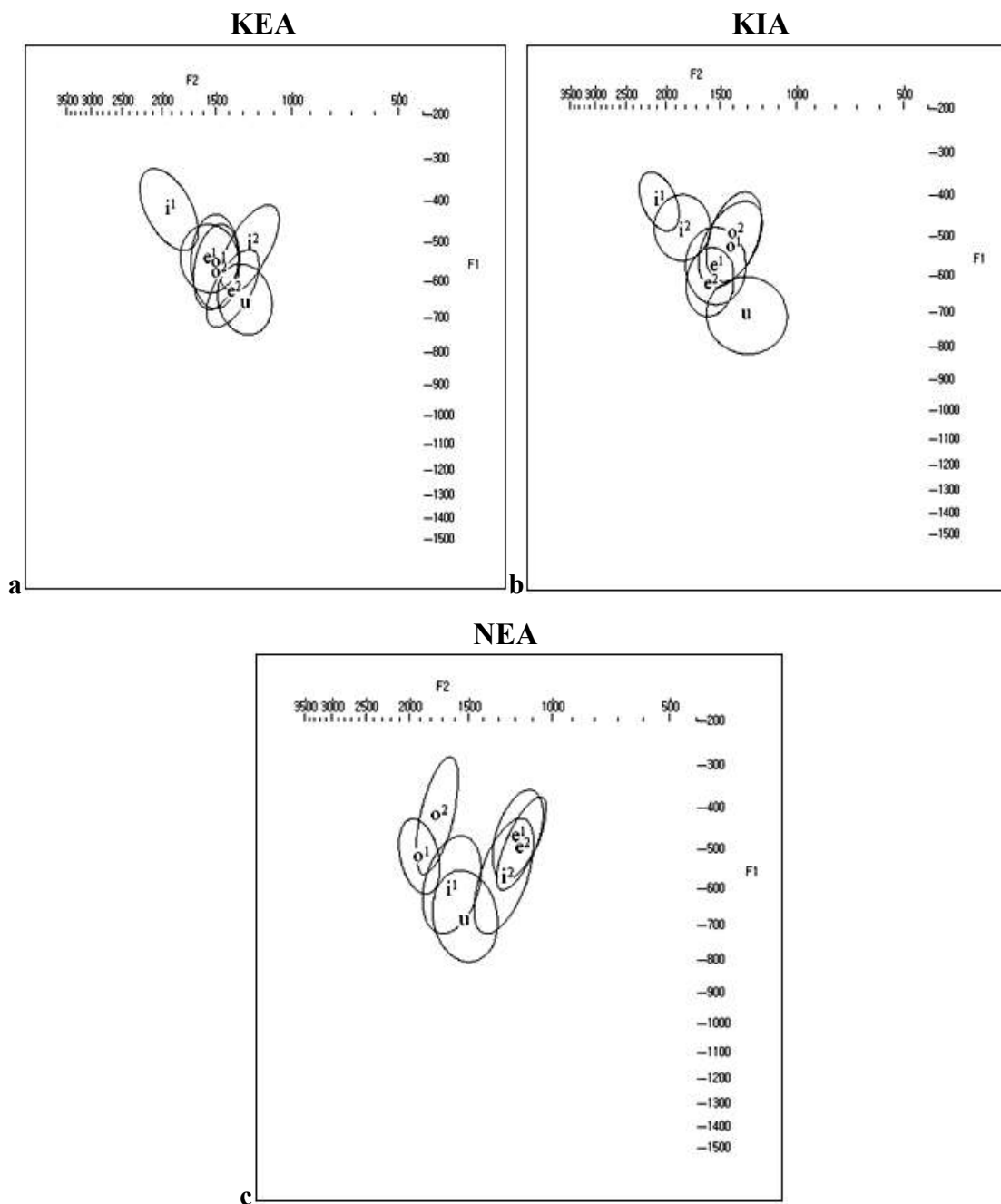


Figure 5.6. Normalized F1 and F2 frequencies of seven English unstressed vowels produced by Korean Experienced adult group (a), Korean Inexperienced adult group (b), and Native English-speaking adult group (c) are shown. Each vowel in a circle is marked with an orthographic representation of the unstressed vowel (i^1 - *animal*, i^2 - *family*, e^1 - *elephant*, e^2 - *telephone*, o^1 - *crocodile*, o^2 - *octopus*, u - *cucumber*).

As illustrated in Figure 5.6, the unstressed vowels produced by the NE adult group showed more dispersion than those produced by KE and KI adults due to the strong coarticulatory effect. KI adults' unstressed vowels are also widely dispersed, but they were produced with the formant frequencies similar to full vowels with the same orthographic spelling: the unstressed vowels with orthographic symbols used for front vowels (i.e., 'i' and 'e') were more fronted in the vowel space than the unstressed vowels with orthographic symbols used for back vowels (i.e., 'o' and 'u').

5.4.4.2. Comparisons among the child groups

The KE, KI and NE child groups were compared using MANOVAs. The results returned a significant group effect [$F(4,54) = 3.401, p < 0.05, \eta_p^2 = 0.201$] as well as a significant group and word interaction [$F(24,34) = 5.551, p < 0.05, \eta_p^2 = 0.797$]. Separate MANOVAs on the KE and KI child groups showed a significant effect of group [$F(2,17) = 5.416, p < 0.05, \eta_p^2 = 0.389$] and a group and word interaction [$F(12,7) = 18.627, p < 0.05, \eta_p^2 = 0.970$]. The group effect was shown for *an*[i¹]*mal* [$F(2,17) = 42.123, p < 0.007, \eta_p^2 = 0.832$], *fam*[i²]*ly* [$F(2,17) = 16.450, p < 0.007, \eta_p^2 = 0.659$], *el*[e¹]*phant* [$F(2,17) = 7.937, p < 0.007, \eta_p^2 = 0.483$] and *cuc*[u]*mber* [$F(2,17) = 14.931, p < 0.007, \eta_p^2 = 0.637$]. However, *tel*[e²]*phone* [$F(2,17) = 0.108, p > 0.007, \eta_p^2 = 0.013$], *croc*[o¹]*dile* [$F(2,17) = 3.982, p > 0.007, \eta_p^2 = 0.319$] and *oct*[o²]*pus* [$F(2,17) = 0.781, p > 0.007, \eta_p^2 = 0.084$] were not significantly different across the two groups. In the univariate tests, KI children showed a lower F1 frequency for *an*[i¹]*mal* [$F(1,18) = 57.444, p < 0.007, \eta_p^2 = 0.761$], higher F2 for *an*[i¹]*mal* [$F(1,18) = 28.347, p < 0.007, \eta_p^2 =$

0.612], *el[e¹]phant* [$F(1,18) = 16.792, p < 0.007, \eta_p^2 = 0.483$], *fam[i²]ly* [$F(1,18) = 30.175, p < 0.007, \eta_p^2 = 0.626$] and lower F2 for *cuc[u]mber* [$F(1,18) = 12.859, p < 0.007, \eta_p^2 = 0.417$]. Table 5.2 summarizes the results. The differences between KE and KI children's productions are illustrated in Figure 5.7(a) and (b).

To examine whether the differences shown in KE and KI child groups' unstressed vowel productions are more native-like, the KE child group was compared to the NE child group in a MANOVA. The results revealed no significant effect of group [$F(2,17) = 1.053, p > 0.05, \eta_p^2 = 0.110$] or group and word interaction [$F(2,17) = 2.270, p > 0.05, \eta_p^2 = 0.796$], suggesting KE children's production of unstressed vowels was overall native-like (see Figure 5.7(a), (c)).

The KI and NE child groups, on the other hand, showed a significant group effect [$F(2,17) = 6.145, p < 0.05, \eta_p^2 = 0.420$] and a significant group and word interaction [$F(12,7) = 10.636, p < 0.05, \eta_p^2 = 0.948$]. The separate MANOVAs returned a significant effect of group for *an[i¹]mal* [$F(2,17) = 61.943, p < 0.007, \eta_p^2 = 0.879$], *el[e¹]phant* [$F(2,17) = 14.339, p < 0.007, \eta_p^2 = 0.628$], *croc[o¹]dile* [$F(2,17) = 10.928, p < 0.007, \eta_p^2 = 0.562$], and *oct[o²]pus* [$F(2,17) = 7.783, p < 0.007, \eta_p^2 = 0.478$]. The rest of the three vowels were not significantly different: *fam[i²]ly* [$F(2,17) = 3.199, p > 0.007, \eta_p^2 = 0.273$], *tel[e²]phone* [$F(2,17) = 0.942, p > 0.007, \eta_p^2 = 0.100$], *cuc[u]mber* [$F(2,17) = 2.010, p > 0.007, \eta_p^2 = 0.191$].

In addition, the univariate tests showed that KI children produced a significantly lower F1 frequency for *an[i¹]mal* [$F(1,18) = 112.471, p < 0.007, \eta_p^2 = 0.862$], lower F2 for *croc[o¹]dile* [$F(1,18) = 21.149, p < 0.007, \eta_p^2 = 0.540$], and higher F2 for *an[i¹]mal*

[$F(1,18) = 38.435, p < 0.007, \eta_p^2 = 0.681$] and *el*[**e**¹]*phant* [$F(,18) = 29.946, p < 0.007, \eta_p^2 = 0.625$] than NE children. The F1 and F2 frequencies for *oct*[**o**²]*pus* were not significant in the univariate test. Table 5.2 summarizes the results from the child group comparisons.

Table 5.2. Significantly different unstressed vowels between the child groups are shown. The results of a less native-like group (marked in bold) are given in comparison to a corresponding group. The significant differences are marked with an arrow indicating significantly high or low F1 and F2 frequencies.

Group	Significantly different unstressed vowels
KEC-KIC	<i>an</i> [i ¹] <i>mal</i> (F1↓,F2↑), <i>fam</i> [i ²] <i>ly</i> (F2↑), <i>el</i> [e ¹] <i>phant</i> (F2↑), <i>cuc</i> [u] <i>mber</i> (F2↓)
NEC-KEC	
NEC-KIC	<i>an</i> [i ¹] <i>mal</i> (F1↓,F2↑), <i>el</i> [e ¹] <i>phant</i> (F2↑), <i>croc</i> [o ¹] <i>dile</i> (F2↓), <i>oct</i> [o ²] <i>pus</i>

The results were similar to the adult group comparisons in that the KI children's production was most influenced by the orthographic representation of the unstressed vowels. However, KI children produced more native-like unstressed vowels than KE adults and KI adults. Figure 5.7 illustrates the group difference enumerated in Table 5.2.

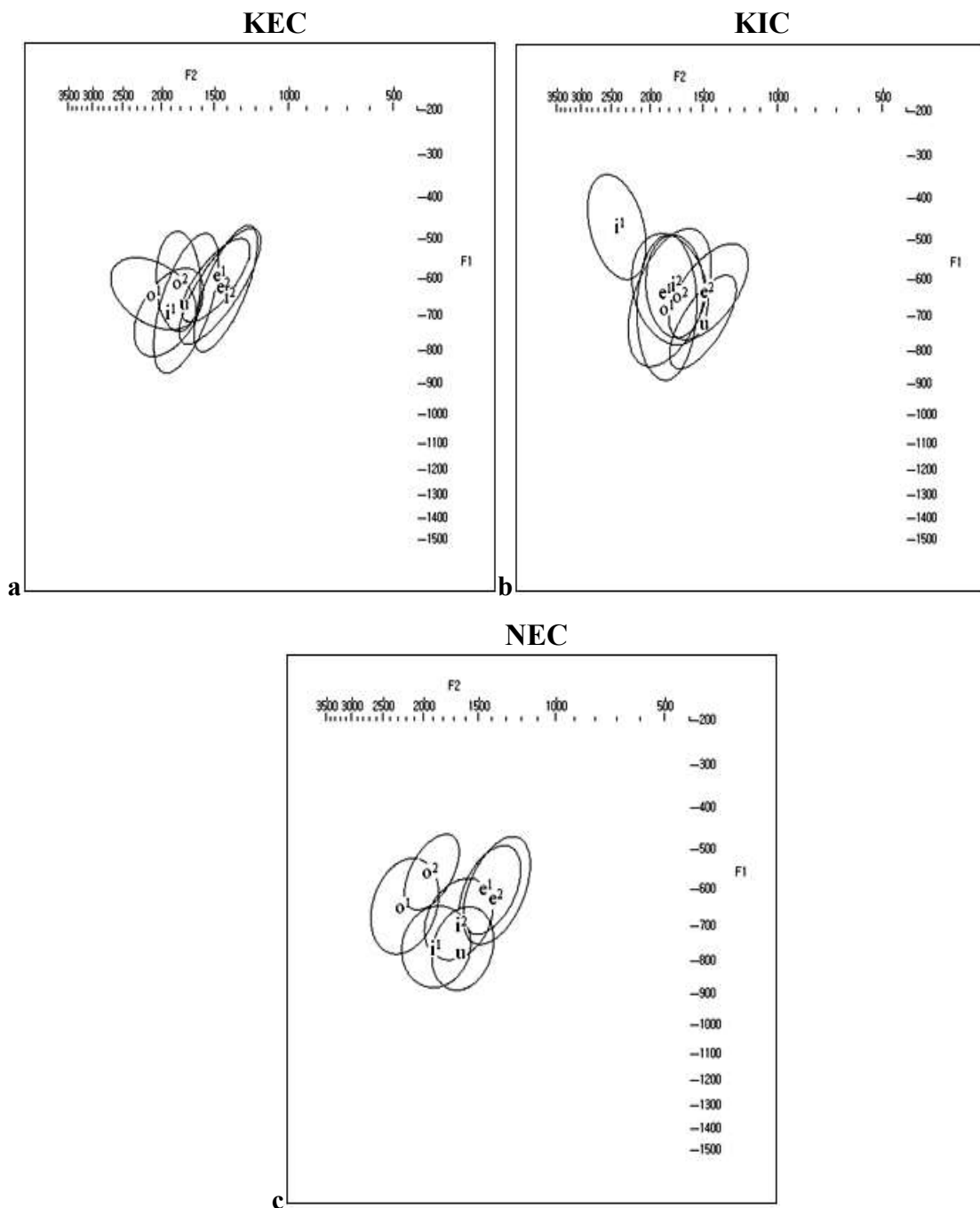


Figure 5.7. Normalized F1 and F2 frequencies of seven English unstressed vowels produced by Korean Experienced child group (a), Korean Inexperienced child group (b), and Native English-speaking child group (c) are shown. Each vowel in a circle is marked with an orthographic representation of the unstressed vowel (i¹ - *animal*, i² - *family*, e¹ - *elephant*, e² - *telephone*, o¹ - *crocodile*, o² - *octopus*, u - *cucumber*).

5.4.5. Discussion

The effect of LOR on the acquisition of unstressed vowel quality was small, but KE adults produced the unstressed vowel ‘i’ in *family*³ more accurately than KI adults did. The word *family* may be less influenced by the orthographic representation in KE adults’ production due to its high word frequency in English. As shown in Table 5.3., when each English word was entered in Google and COCA (The Corpus of American Contemporary English), *family* returned the highest word frequency among the seven words in both corpora: *family* was at least four times more frequent than the second most commonly used word, *animal*. Given the high word frequency, KE adults may have been more likely to learn the native-like vowel spectral quality for *family* than the other six words after 6 years of English exposure. On the other hand, the lack of L2 experience and the quality of L2 input KI adults received in Korea may have resulted in nonnative-like production for all seven unstressed vowels.

The effect of word frequency was also shown in KI children’s production. Despite the short L2 experience, KI children outperformed KE adults and KI adults, showing native-like production of unstressed vowels for *telephone* and *cucumber* and *family*. One of the factors contributing to the early acquisition of at least the two of the words with unstressed vowels, *telephone* and *family*, may be their relatively high word frequency in English (see Table 5.3.). The result showing that KI children were able to

³ The word *family* frequently occurs in Korean fixed phrases borrowed from English such as *family restaurant* and *family card*. Korean dramas and shows also borrow the English word directly into the titles. However, *family* is different from other English loanwords such as *banana* and *kangaroo* in that its usage is limited to certain contexts and there is a corresponding Korean word ‘가족’ /kaʒok/ which is used much more often than *family*.

acquire greater production accuracy than KI adults suggests children's greater ability to acquire new L2 sounds than adults. The lack of experience with Korean-colored English words in Korea also may account for KI children's better performance.

KI children, however, also showed a strong influence of orthographic symbols (e.g., 'i' in *animal* with significantly lower F1 and higher F2 frequencies). Note that KE adults' and KI children's higher F2 frequency for 'e' in *elephant* than 'e' in *telephone* may be due to their different orthographic representations in a Roman transliteration system for Korean: 'e' in *elephant* is spelled and produced with a Korean character 'i' (i.e., /ɛl.li.pʰʌn.tʰi/ and 'e' in *telephone* with a Korean character 'e' (i.e., /tɛl.lɛ.pʰon/). Acquiring L2 words that are borrowed into the L1 can affect the phonetic representations of the L2 sounds, resulting in a stronger effect of L1 on L2. The importance of AOA in the L2 speaking country has been overemphasized as an index to L2 learners' first exposure to the native-like L2 input, but the quality and length of L2 input they received in the L1- speaking country should also be taken into account to better understand the influence of the L1 on the L2.

Table 5.3. The word frequencies of seven English words which were extracted from Google and COCA were combined and listed from the highest to the lowest frequent words. The order of frequency matched between the two corpora.

Word	Word Frequency
Family	2,380,208,789
Animal	551,026,227
telephone	425,020,414
elephant	97,603,944
crocodile	31,301,061
cucumber	23,501,470
octopus	28,100,662

Overall, KE adults, KI adults and KI children showed a strong tendency to produce unstressed vowels with spectral characteristics that are similar to the full vowels typically represented by the orthographic symbols coding the unstressed vowel (e.g. the /u/ vowel for the ‘u’ symbol in an unstressed syllable). Unlike the characteristics of English unstressed vowels that float in the trajectory of one stressed vowel to another (Fowler, 1981), each vowel in Korean is produced with an articulatory plan that is designed to execute a specific acoustic target. Due to this language-specific difference, acquiring reduced vowel quality is challenging for Korean learners of English. Also, the absence of an acoustic target for unstressed vowels may induce Korean learners to resort to the orthographic symbols. Unlike NE adults who showed strong coarticulatory effects on the unstressed vowels (Browman & Goldstein, 1992), KE adults’ unstressed vowels which were less influenced by the spellings were concentrated around the center of the vowel space. The resistance to the coarticulatory effect and the convergence of the unstressed vowels may suggest that KE adults have created an acoustic target for English unstressed vowels in the vicinity of schwa /ə/. Lee et al. (2006) suggested that Korean learners may use Korean high-central vowel /i/ as a replaced target for unstressed vowels. However, this assumption was not upheld in the current findings.

Note that although the KE adult, KI adult and KI child groups’ productions were under the influence of the orthographic symbols, the effect was not as strong as that reported in Lee et al. (2006). The different results may be explained with the different stimuli. Specifically, the use of English loanwords (e.g., *banana*, *calendar*, *medium*, *origin*, *kangaroo*, *spaghetti*) in Lee et al. may have lead to greater dispersion between

unstressed vowels. English loan words such as *medium* and *spaghetti* are phonetically realized as /*mi.di.um*/ and /*si.pa.ge.ti*/ in Korean. The effect of spelling can be more salient when a vowel category is represented by a single loan word (e.g., *medium* for [u]). Also, grouping the unstressed vowels based on spelling can be problematic when the unstressed vowels have different phonetic representations. For instance, Korean speakers are much more likely to produce [a] in *banana* or *spaghetti* as /a/ than [a] in *manage*⁴, which is rather closer to /i/. Different degrees of variance across the unstressed vowels in the same category may account for the different results.

When syllable duration, F0 and intensity values of stressed and unstressed vowels are taken together with the quality of unstressed vowels, different acquisition patterns emerge between the KE adult and KE child groups. KE adults' production was more native-like in English prosodic features (i.e., duration, F0 and intensity) than vowel spectral quality, whereas KE children showed more native-like accuracy in vowel quality than prosodic features. The results of KE adults' production are in accord with Kondo (2009) who showed that late Japanese learners of English were native-like in producing duration, F0 and intensity of stressed and unstressed English vowels but not vowel spectral quality. The native-like acquisition of vowel spectral quality has been shown to be challenging even for early L2 learners (Trofimovich & Baker, 2005 for stressed vowels; Lee et al., 2006 for unstressed vowels). Thus, the fact that none of the seven unstressed vowels produced by U.S-born KE children, but not adults, differed from the vowels produced by NE children suggests that the age of the learner is a greater

⁴ *manager* is an English loanword in Korean.

contributor to the native-like acquisition of L2 unstressed vowel quality than L2 experience. Taking KE children's native-like English stressed vowel and Korean vowel productions (in Chapter II) into consideration, these children appeared to have developed distinctive phonemic categories for English and Korean. Namely, the ability to separate the two vowel systems can be an indicator of complete L1-L2 separability and a possible attribute of simultaneous bilinguals.

Overall, a stronger effect of Korean was exerted on KI than KE groups' production and on adults' than children's production. Also, KE children showed little effect of Korean on English prosody. However, the lack of Korean interference raises questions as to whether the effect was small because KE children were able to establish separate prosodic systems for the two languages or because their Korean prosody is not developed enough to interfere with English production. In Chapter VI, Korean prosodic features produced by the four Korean groups are examined to further explore the effect of English acquisition on Korean and the degrees of L1-L2 interaction on prosody as a function of L2 experience.

CHAPTER VI

KOREAN PROSODY

(F0, Intensity, Syllable duration)

6.1. Introduction

Previous studies have shown different effects of L1 on L2 production depending on the degree of cross-language differences between the L1 and L2 (McAllister et al., 2002; Baker et al., 2008). For L2 adult learners, similar L2 sounds are likely to be perceived and produced as instances of L1 sounds due to the fully established L1 sound system. A child's L1, however, is less developed compared to an adult's L1 and thus, L1 interference may be weaker in child than in adult L2 production. This prediction has been supported by previous research which showed that children were better able to create new L2 sound categories that were independent from the neighboring L1 categories than adults (Guion, 2003; Baker & Trofimovich, 2005). However, what has been relatively less studied is the effect of L2 acquisition on the L1 for children whose L1 has not yet fully developed. Especially when the target L2 phone requires relatively less complicated articulatory skills than the corresponding L1 phone, L2 acquisition may cause a delay in L1 language development.

Studies on the development of L1 segments have proposed that children are likely to acquire language-universal features that are relatively easy to articulate and salient to perceive before acquiring language-specific features. As an example, Buder and Stoel-Gammon (2002) examined 24 and 30 month-old English and Swedish

monolingual children's productions to explore the order in which phonetic features are acquired in the L1. It was shown that Swedish monolingual children shortened vowel duration before voiced coda obstruents in Swedish despite the absence of a postvocalic voicing contrast in Swedish (see Stoel-Gammon, Buder, & Kehoe, 1995), indicating children's early development of phonetic features that are not specific to the native language. The study predicted that the universal pattern such as shorter vowel duration before voiced coda obstruents may be acquired earlier than the language-specific phonetic distinctions such as vowel quality differences between English tense-lax vowels or Swedish short-long vowels. The results were consistent with the prediction in that the effect of final-consonant voicing on vowel duration significantly decreased from 24 month- to 30 month-old Swedish children's production. The vowel duration correlating the voicing of a following voiced or voiceless obstruent, however, increased in English monolingual children's production. As children gained more experience with their L1, /i/ and /ɪ/ were duly differentiated by duration in Swedish monolingual children's production, whereas English monolingual children primarily distinguished the two vowels with the first and second formant frequencies. The shortening of vowel duration differences for voicing contrasts and lengthening of duration differences for vowel contrasts in Swedish monolingual children's production were presented as the evidence for the developmental transition from language-universal to language-specific patterns over the course of native language experience.

Different development milestones at which children master language-specific elements in the L1 found in monolingual children's production (Kehoe & Stoel-Gammon,

1997; Buder & Stoel-Gammon, 2002; Ramus, 2002; Jun, 2007; Kong et al., 2011) were also shown in bilingual children's production (Johnson & Wilson, 2002; Lee et al., manuscript). According to these studies, the benefit of an early exposure to the L1 does not guarantee the earlier acquisition of L1 phonetic features than the corresponding L2 features. For instance, Johnson and Wilson (2002) examined two Japanese (L1)-English (L2) bilingual children's (aged 2:10 and 4:8) VOT production of Japanese and English. Although both English and Japanese have a two-way voicing contrast, Japanese has a pre-voicing and short-lag VOT distinction that is thought to be acquired later than the short-lag and long-lag VOT distinction in English (Macken & Barton, 1980). Following the universal pattern, the younger Japanese bilingual child produced short- and long-lag VOT for Japanese stops as in English. In lieu of showing a prevoicing pattern, the older bilingual child made a greater difference between the Japanese and English by producing longer VOT for English voiceless stops. Even though the VOT contrast in the bilingual children's L1 was not adult-like until the age of 4:8, they were able to make a significant distinction between Japanese and English in terms of VOT. The emergence of the two separate VOT systems indicated that bilingual children are likely to develop separate representations for the two languages. The adult-like realization of the language-specific details of the L1 and L2 may simply take time, especially for young children with immature articulatory skills.

Similarly, Lee and Iverson (manuscript) argued that acquiring L2 categories before the full establishment of L1 categories could affect the developmental pattern and native-likeness in the L1. The study examined the VOT and voice-onset F0 of Korean

and English stops produced by thirty simultaneous Korean (L1) –English (L2) bilingual children aged 5 and 10 years old. The 5 year-old children had resided in the U.S. for approximately 2 years and 10 year-old children around 5 years. The bilingual children were referred to as simultaneous bilinguals because they were first exposed to English before the age of 5 – the age that the Korean monolingual children begin to distinguish Korean stops (Lee & Iverson, 2008). The results showed that the 10 year-old children were able to separate all five English and Korean stop categories whereas the 5 year-old children produced a binary two-way VOT distinction. The 5 year-old children also produced a merged F0 for voiced-fortis, voiceless-lenis, voiceless-aspirated stops. The VOT and F0 assimilation of Korean stops into English voiced and voiceless stops in younger bilingual children’s production was interpreted as an effect of English acquisition on Korean development. The finding that L1 categories can assimilate into later-acquired L2 categories suggests that early exposure to the L1 may not fully override bilingual children’s preference for more distinctive, universal and easily articulated features in the L2. Whether segmental or prosodic features, the amount of time that is needed for a bilingual child to completely separate the two languages varies depending on the L1 and L2.

The age of L2 exposure is important in that it not only predicts the degree of sensitivity to new L2 sounds but also provides a yardstick to determine whether the child’s L1 at the time of testing is likely to represent the native-like norm of the L1. Examining how established the L1 is in relation to the L2 allows some estimation of the degree of L1 interference on L2 acquisition. The majority of studies on bilingual

children's L1-L2 interaction and the degree of native-likeness in L1 and L2 production have been described at the level of segments. Particularly, the effect of the L2 on L1 production has hitherto compared the production of L1 and L2 segmental features (Flege, 1987; Flege & Eefting, 1988; Guion, 2003; Harada, 2003) and global foreign accents (Yeni-Komshian, Flege, & Liu, 2000; de Leeuw, Schmid, & Mennen, 2010). Reports on the changes in L1 prosodic features as a result of L2 acquisition, however, have been relatively scarce.

This chapter investigates Korean prosodic features produced by Korean adults and children with different LOR (6 months vs. 6 years). The primary goal was to examine the effect of age of English exposure on Korean prosodic features such as F0, intensity and syllable duration. In particular, U.S.-born Korean bilingual children who were exposed to both Korean and English at an early stage of language development were expected to show a stronger effect of an English stress system on Korean prosody than Korea-born children with 6 months of English exposure. As a follow-up to the study on the production of VOT distinction for English and Korean stops in Chapter 4, F0 was explored as a measure to assess whether US-born Korean children were able to create the three Korean stop categories with F0 in a native (or adult)-like way.

The tone pattern of the Accentual Phrase in Seoul dialect varies depending on the laryngeal feature of phrase-initial segments (Jun, 1998). Aspirated and fortis phrase-initial obstruents start with high tone and lenis obstruents with low tone, which are respectively realized as High (aspirated/fortis)-High-Low-High and Low (lenis)-High-Low-High in four-syllable phrases. Some studies have reported higher F0 for aspirated

stops than fortis stops (Kang & Guion, 2006; Broersma, 2010 for alveolar stops) while others (Cho, Jun, & Ladefoged, 2002; Kong et al., 2011) have found no F0 difference between the two stops. Lenis stops, however, are realized with distinctively lower F0 than aspirated and fortis stops. Because of their salient prosodic cue, low F0 for lenis stops are acquired fairly early by Korean children. Jun (2007) reported that the F0 contrast between lenis and aspirated stops was found in a U.S.-born Korean child's speech by the age of 18 months. This study, however, did not further discuss how native-like the child's Korean production was in comparison to native Korean speaking children of the same age. In the current study, KE children may be able to distinguish the H-H pattern for aspirated and fortis initial phrases from the L-H pattern for lenis initial phrases. However, recall that KE children's aspirated stops were distinguished from lenis stops with substantially lengthened VOT, which may be attributed to its status as the primary cue of VOT in the English stop distinction. Because the F0 difference in English voiced and voiceless stops is not as prominent as that in Korean stops, it is expected that the high F0 target for aspirated stops and low F0 target for lenis stops will be underachieved by KE children.

The intensity and syllable duration in Korean production are likely to show an effect of the stress-timed rhythm of English. In English, intensity and duration are used as correlates of stress to signal lexical contrasts. Korean, however, does not have lexical stress. The smallest prosodic domain in Korean is the Accentual Phrase which is primarily realized by different F0 patterns. As a syllable-timed language, successive syllables in Korean phrases are thought to be produced with near-equal duration, whereas

time intervals between stresses are likely to be near-equal in English (Pike, 1945; Abercrombie, 1965). Therefore, as a result of an early acquisition of the English stress system, KE children might use intensity and duration to mark prosodic prominence in their Korean production.

Furthermore, the effect of English experience on KE adults' Korean production was investigated. Trofimovich and Baker (2006) showed that more experienced Korean adults were not only perceived as a native speaker of English in the accentedness rating but also attained more native-like prosody than less experienced adults. The results suggest that Korean adults may have become better at attending to critical L2 prosodic features that are distinctive from the L1. Then, the question is whether the redirected sensitivity to L2 prosodic cues would have any effect on how L1 prosody is realized. F0, intensity and syllable duration were examined to determine the effect of English experience on KE adults' Korean prosody.

6.2. Experiment 5: F0 contour

6.2.1. Participants

The same 20 KE and KI adults and 20 KE and KI children who participated in Experiment 1 participated in this production task.

6.2.2. Speech stimuli

Korean lenis, fortis, and aspirated stops were each produced in six frequently used Korean phrases. Each phrase was presented in Korean characters with a

corresponding picture on a computer screen. The four-syllable phrases ended in either /rim.ni.da/ or /sim.ni.da/ (present indicative ending in a polite form). The first syllables representing the three Korean stop types were matched for their place of articulation (i.e. alveolar and velar). Except for the lenis and fortis alveolar phrase-initial stops, /ta, t^{*}a/, the first words were CVC syllables (/t^hat/, /kʌt/, /k^{*}ʌt/, and /k^hʌt/). The first words started with either /a/ or /ʌ/ (low back vowels). The randomized phrases were spoken in isolation at a normal speech rate. The target phrases are shown below.

Lenis

Fortis

Aspirated

/ta.rim.ni.da/(It's) different. /t^{*}a.rim.ni.da/(I'm) following. /t^hat.sim.ni.da/(I) rode.
 /kʌt.sim.ni.da/(I'm) walking. /k^{*}ʌt.sim.ni.da/(I) turned off. /k^hʌt.sim.ni.da/(I've) grown.

6.2.3. Procedure

Six Korean phrases were presented with corresponding pictures in a random order to the participants on the screen of a laptop computer. The six phrases were elicited three times each in random order from each participant. At first, Korean production prerecorded by a female native Korean speaker from Seoul (LOR in the U.S. less than 6 months) was presented with pictures to make sure that participants understood the words. The experimenter did not provide the auditory cue on the second and third presentations. All the children were able to read Korean characters. Only the second and third tokens of each word, that is, the non-cued productions, were analyzed.

6.2.4. Measurements

The four-syllable phrases produced by Korean adults and children were displayed in Praat as oscillograms and spectrograms. F0 was measured at the temporal midpoint of each vowel in four syllables. Vowel onset was determined from the onset of the periodic waveform to the stop or nasal coda with reference to spectrograms. The first vowel duration measured the time from the onset of periodic phonation to the stop closure or to the lowering of the third formant frequency in the case where /r/ followed. The vowel of the second syllable starting with /r/ was identified by abrupt changes in the third formant frequency.

6.2.5. Statistical analyses

In order to determine whether three stop types were distinguished by F0, F0 values for the three stop types were compared for each group. The independent variable was stop type (3), as a repeated measure, and the dependent variable was F0 values averaged across the two repetitions for each speaker.

In case of a significant effect of stop type on F0, 3 ANOVAs were conducted to examine the group effect on the F0 differences among the three types. The F0 differences among the three stops were the dependent variable and group (2) was the independent variable. The F0 differences were obtained by subtracting fortis stops' F0 from aspirated stops' F0 (aspirated-fortis), lenis stops' F0 from aspirated stops' F0 (aspirated-lenis), and lenis stops' F0 from fortis stops' F0 (fortis-lenis). Group comparisons were made to investigate the extent to which group produced more F0 differences among the three stop

types as a function of English experience. As in the previous experiment, the analyses were done separately for adult and child groups.

Furthermore, in order to investigate whether a H-H pattern for aspirated and fortis stops and a L-H pattern for lenis stops were manifested, the F0 differences between the first and second syllable were compared across the groups with 2 ANOVAs. For this analysis, the group (2) effect on the F0 difference between the first and second syllables was conducted for each stop type.

6.2.6. Results: F0 contour

First, both KE adult [$F(2,18) = 96.980, p < 0.05, \eta_p^2 = 0.915$] and KI adult groups [$F(2,18) = 55.289, p < 0.05, \eta_p^2 = 0.860$] returned a significant effect of stop type on F0. The pairwise comparisons showed significant F0 differences among the three types for both adult groups ($p < 0.01$). Figure 6.1 illustrates that the three stops were distinguished by F0 in Korean adults' productions regardless of the amount of English experience. Aspirated stops were produced with the highest F0 followed by fortis stops, which were distinctive from lenis stops' low F0. The F0 difference between aspirated and fortis stops is consistent with Kang & Guion (2006)'s study.

The KE child group also differentiated the three stops with F0 [$F(2,18) = 289.375, p < 0.05, \eta_p^2 = 0.970$] similar to the KI child group [$F(2,18) = 185.134, p < 0.05, \eta_p^2 = 0.954$]. As shown in Figure 6.1, however, aspirated and fortis stops showed a smaller F0 difference (12.1 Hz) in KE children's production than in KI children's (24.5 Hz) production ($p > 0.01$).

Next, the degree of F0 differences between the stop types was compared across the adult groups. 3 ANOVAs separately examined the group effect on aspirated-fortis, aspirated-lenis, and fortis-lenis F0 differences. The results showed that none of the three F0 differences was significantly different between the adult groups: aspirated-fortis [$F(1,18) = 0.051, p > 0.05, \eta_p^2 = 0.003$], aspirated-lenis [$F(1,18) = 0.025, p > 0.05, \eta_p^2 = 0.001$], and fortis-lenis [$F(1,18) = 0.007, p > 0.05, \eta_p^2 = 0.000$]. In other words, the degree of the F0 differences among the three stops was similar between the KE and KI adult groups.

The KE and KI child groups, on the other hand, showed significant F0 differences in all three pairs: aspirated-fortis [$F(1,18) = 4.828, p < 0.05, \eta_p^2 = 0.212$], aspirated-lenis [$F(1,18) = 11.271, p < 0.05, \eta_p^2 = 0.385$], fortis-lenis [$F(1,18) = 6.774, p < 0.05, \eta_p^2 = 0.273$]. In particular, the group effect was the strongest on the differences between aspirated and lenis stops. As shown in Figure 6.1, the KI child group made significantly greater F0 differences among the three stops than the KE child group did. Although KE child group's aspirated stops and fortis stops were produced with significantly higher F0 and lenis stops with lower F0, the differences were not as distinctive as those in KI child group's production.

Lastly, the F0 differences between the first and second syllable were compared across the groups to assess whether the Low-High pattern for lenis stops and the High-High pattern for aspirated and fortis stops were realized. 3 ANOVAs examining the group effect on F0 differences for each stop type showed that the KE and KI adult groups did not significantly differ in producing syllable 1 – syllable 2 F0 (H-H pattern) for

aspirated [$F(1,18) = 2.381, p > 0.05, \eta_p^2 = 0.117$] and fortis [$F(1,18) = 0.372, p > 0.05, \eta_p^2 = 0.020$] and syllable 1-syllable 2 F0 (L-H pattern) for lenis stops [$F(1,18) = 0.168, p > 0.05, \eta_p^2 = 0.009$]. This result suggested that the adult groups produced the first two syllables in a similar F0 pattern for all three stops. However, the child groups showed a group difference for lenis [$F(1,18) = 4.231, p = 0.05, \eta_p^2 = 0.190$], but not for aspirated [$F(1,18) = 0.902, p > 0.05, \eta_p^2 = 0.048$] and fortis stops [$F(1,18) = 0.140, p > 0.05, \eta_p^2 = 0.008$]. As shown in Figure 6.1, KE children's F0 for lenis stops in the first syllable is relatively higher compared to KI children's F0. In sum, KE children's high F0 target for aspirated stops and low F0 target for lenis stops were undershot, resulting in a smaller F0 distinction among the three stop types.

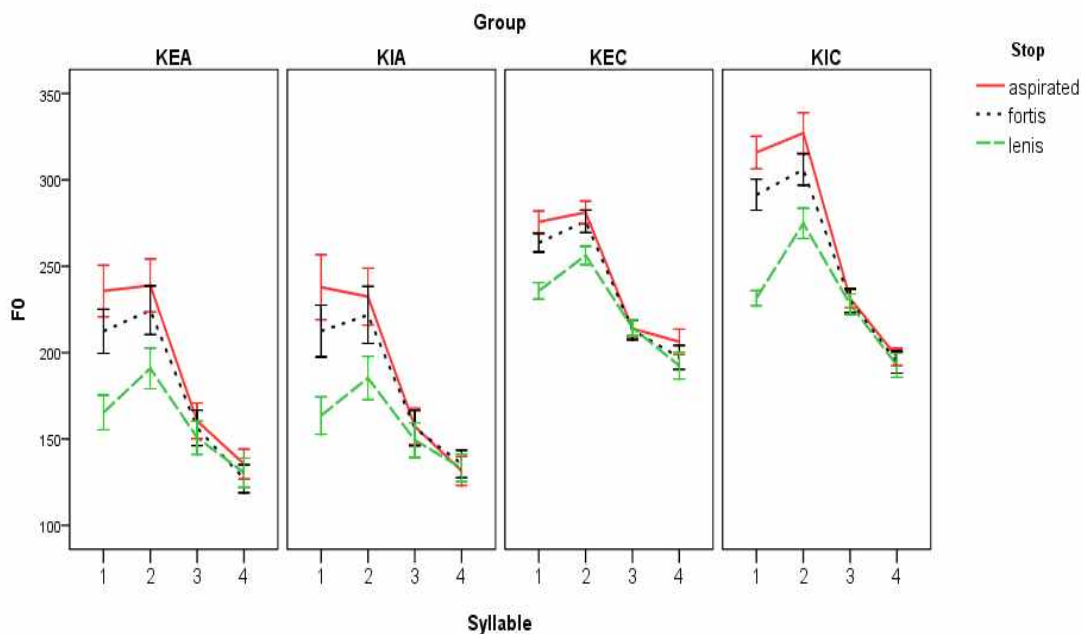


Figure 6.1. Fundamental frequency values (in hertz) of Korean four-syllable phrases beginning with aspirated (upper solid line), fortis (middle dotted line), lenis stops (lower dashed line) produced by Korean Experienced adult group, Korean Inexperienced adult group and Korean Experienced child group, Korean Inexperienced child group are shown.

6.3. Intensity

In this section, four-syllable Korean phrases produced by the same Korean adult and child groups were examined to assess the effect of English acquisition on Korean prosody. More specifically, the patterns of intensity across the Korean four syllables were compared across the groups to determine whether knowledge of English stress influenced the rhythmic features in Korean production.

6.3.1. Speech stimuli

A total of five pairs of lenis and aspirated words with the same vowels and the same syllable structure (i.e. CVC.CVC.CV.CV) were presented to the participants. The fortis-initial phrases that were used for the F0 comparisons were excluded because there were not enough fortis-initial phrases that matched the syllable structure and vowel quality of aspirated- and lenis-initial phrases and were easy for US-born KE children to comprehend. Also, the aim of this section is to examine how the groups differ in their prosodic patterns across the four syllables, and therefore, distinguishing the three stop types is not the main topic of interest. Thus, aspirated and lenis initial phrases were collapsed for intensity and syllable duration measures. As shown below, only two pairs of lenis and aspirated stimuli differed in place of articulation for their initial and coda obstruents (i.e., /tɕap/-/tʰat/, /dʌp/- /pʰʌt/), but vowel quality and the second, third, fourth syllables were matched across the stimuli.

Lenis

/tɛat.sɪm.ni.da/ ‘(I) slept’

/kʌt.sɪm.ni.da/ ‘(I’m) walking’

/tɛʊp.sɪm.ni.da/ ‘(I’m) picking X up’

/tɛap.sɪm.ni.da/ ‘(I) am catch’

/tʌp.sɪm.ni.da/ ‘(It’s) hot’

Aspirated

/tɛ^hat.sɪm.ni.da/ ‘(I’m) finding’

/k^hʌt.sɪm.ni.da/ ‘(I’ve) grown’

/tɛ^hʊp.sɪm.ni.da/ ‘(I’m) cold’

/t^hat.sɪm.ni.da/ ‘(It) burned’

/p^hʌt.sɪm.ni.da/ ‘(I) scooped’

6.3.2. Measurements

Intensity (in decibels) was measured at the temporal midpoint of each vowel in the four syllables using PRAAT. The onset of each vowel was determined from the onset of the periodic waveform to the stop or nasal coda with reference to spectrogram. The vowel of the third syllable starting with a nasal consonant was identified by abrupt changes in the second formant frequency. The last syllable /da/ was measured until the end of the offset of the periodic waveform.

6.3.3. Statistical analyses

Each syllable’s intensity values for aspirated and lenis stops were collapsed and averaged across the two repetitions for each speaker. Then, the raw intensity values for the four syllables were each divided by the mean intensity for that speaker. The mean intensity for each speaker was obtained by averaging the intensity values across the four syllables. The ratio value was greater than 1 if the raw intensity of a given syllable was greater than the mean intensity, and smaller than 1 if the raw intensity of a given syllable

was smaller than the mean intensity. This normalized intensity was submitted to ANOVAs using repeated measures. As in other studies, adult and child groups were compared separately. To examine the intensity pattern across the four syllables, the normalized intensity for each syllable was compared across the groups. If the group (2) and syllable (4: first, second third, fourth) interaction was significant, the effect of group (2) on each syllable was examined. The alpha level was adjusted to 0.013 for both adult and child groups.

6.3.4. Results: intensity

As for the adult groups, an ANOVA returned a significant effect of syllable [$F(3,196) = 83.466, p < 0.05, \eta_p^2 = 0.561$] and a significant interaction of syllable and group [$F(3,196) = 8.30, p < 0.05, \eta_p^2 = 0.113$]. Thus, the effect of group on each syllable was examined. The first [$F(1,198) = 0.088, p > 0.013, \eta_p^2 = 0.00$] and third syllables [$F(1,198) = 1.955, p > 0.013, \eta_p^2 = 0.010$] were not significantly different across adult groups. However, the second [$F(1,198) = 22.212, p < 0.013, \eta_p^2 = 0.101$] and fourth syllables [$F(1,198) = 13.269, p < 0.013, \eta_p^2 = 0.063$] were significantly different between the KE and KI adult group. As shown in Figure 6.2, KE adults' second syllable was produced with a relatively weaker intensity, leading to a greater intensity difference between the first and second syllable than the difference in KI adults' production. The intensity for the fourth syllable appeared to be lower in KI adults' than KE adults' production. However, the gradual decrease in the intensity pattern was similar between the KE and KI adult groups.

The child groups showed a significant effect of syllable [$F(3,196) = 152.446, p < 0.05, \eta_p^2 = 0.700$] as well as a significant syllable and group interaction [$F(3,196) = 3.608, p < 0.05, \eta_p^2 = 0.052$]. The first [$F(1,198) = 2.812, p > 0.013, \eta_p^2 = 0.014$], second [$F(1,198) = 0.457, p > 0.013, \eta_p^2 = 0.002$] and fourth [$F(1,198) = 0.088, p > 0.013, \eta_p^2 = 0.000$] syllables were not significantly different between the KE and KI child groups. However, the third syllable showed a significant group effect [$F(1,198) = 10.456, p < 0.013, \eta_p^2 = 0.050$]. Figure 6.2 illustrates that the KE child group's intensity for the third syllables was distinctively lower than KI child group's production. The lowering of the third syllable's intensity resulted in a relatively higher intensity for the last syllable, which differs from the other three groups' patterns.

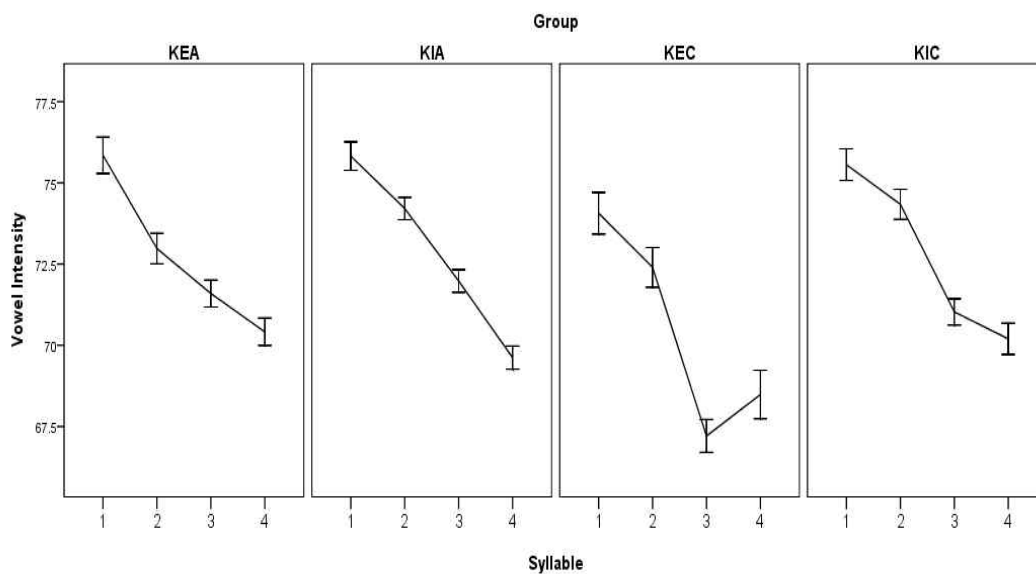


Figure 6.2. The mean intensity values (in decibels) of each vowel in Korean four-syllable phrases produced by Korean Experienced adult group, Korean Inexperienced adult group and Korean Experienced child group, Korean Inexperienced child group are shown.

6.4. Syllable duration

The durational patterns realized across the four-syllable Korean phrases were compared across the same groups. In particular, the effect of English stress acquisition on temporal features of Korean prosody is investigated as a function of English experience.

6.4.1. Speech stimuli

The same Korean phrases used in the previous section were analyzed.

6.4.2. Measurements

Each syllable duration (in milliseconds) was measured using Praat. The first syllables were measured from the release of the initial stop to the end of the stop closure of the syllable-final coda (e.g., /kʌt|sim|ni|da/). The boundary between the second and third syllable, where /m/ and /n/ adjoined, was determined by abrupt changes in periodic energy and the second formant transition (i.e., often higher F2 frequency for /n/ than /m/). The second syllable consisted of inherently long segment materials such as /s/ and /m/, and thus, was much longer than the first syllable.

6.4.3. Statistical analyses

Similar to the method used for intensity, the mean duration of each of the four syllables was divided by the mean syllable duration for that phrase for that speaker. If the duration for the syllable of interest was greater than the mean duration, the value was greater than 1, and smaller than 1 if the syllable duration was smaller than the mean

duration. The normalized duration was submitted to ANOVAs using repeated measures and the adult and child groups were analyzed separately. If the syllable (4) and group (2) interaction was significant, the effect of group (2) on each syllable was examined. The alpha level was adjusted to 0.013 for both adult and child groups.

6.4.4. Results: syllable duration

As shown in Figure 6.3, the KE and KI adult groups did not differ from each other in producing syllable duration. The KE and KI adult groups showed a significant main effect of syllable [$F(3,196) = 471.164, p < 0.05, \eta_p^2 = 0.878$], but no significant interaction between the syllable and group [$F(3,196) = 2.012, p > 0.05, \eta_p^2 = 0.030$]. The results suggested that the syllable duration across syllables did not differ between the adult groups.

The KE child group, however, disproportionately lengthened the second syllable and shortened the third syllable compared to the KI children's production. The KE and KI child groups returned a significant effect of syllable [$F(3,196) = 289.283, p < 0.05, \eta_p^2 = 0.816$] and a significant syllable and group interaction [$F(3,196) = 13.311, p < 0.05, \eta_p^2 = 0.169$]. The KE child group's second [$F(1,198) = 13.097, p < 0.013, \eta_p^2 = 0.062$] was considerably longer and the third syllables [$F(1,198) = 28.139, p < 0.013, \eta_p^2 = 0.124$] was significantly shorter than the KI child group's production. The first [$F(1,198) = 0.192, p > 0.013, \eta_p^2 = 0.001$] and fourth syllables [$F(1,198) = 2.871, p > 0.013, \eta_p^2 = 0.014$] were not statistically different between the child groups.

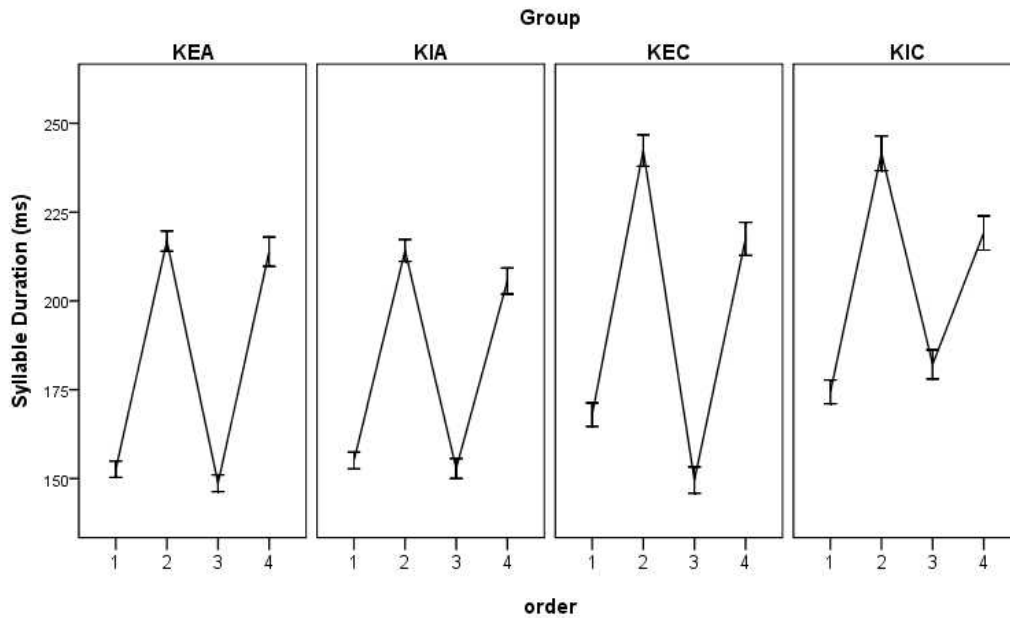


Figure 6.3. The mean syllable durations (in ms) of Korean four-syllable phrases produced by Korean Experience adult group, Korea Inexperienced adult group and Korean Experienced child group, Korean Inexperienced child group are shown.

6.4.5. Discussion

Overall, KE and KI adults' productions showed no significant effect of English experience (6 years) on Korean prosody. Both KE and KI adults produced aspirated stops with the highest F0 and lenis stops with distinctively low F0. The phonological contrast among the three stops was clearly manifested in F0 for the adult groups. The KE child group, on the other hand, significantly differed from the KI child group in the F0 distinction as well as in the patterns of intensity and syllable duration.

First, the F0 differences between aspirated and fortis, aspirated and lenis, and fortis and lenis stops in KE children's production were not as distinctive as those observed in KI children's production. Figure 6.1 shows that the F0 for both aspirated and

lenis stops was less distinctive from the F0 for fortis stops in KE than KI child groups' production. This finding indicates that KE children were not able to fully separate the three phrase-initial stops with F0 as KI children would. On a separate note, the mean F0 values for lenis, fortis, and aspirated stops were all significantly different, indicating that the three stops were produced as independent categories, only to a lesser extent. Furthermore, KE children's High-High pattern for fortis stop-initial phrases was closer to KI children's production compared to the other two patterns (High-High for aspirated stops and Low-High for lenis stops). This result is similar to Jun (2007)'s finding that showed the earliest acquisition of fortis stop-initial words among the three stops by a Korean child. In addition to the ease of articulation (see Kim & Stoel-Gammon, 2011), strong amplitude, high pitch, and low frequency of fortis stop-initial words in child-directed speech have been noted to enhance the perceptual saliency of the stop sound and facilitate the acquisition (Jun, 2007).

Moreover, Kong et al. (2011) explained Korean children's early mastery of fortis stops by children having only one acoustic parameter (i.e., short-lag VOT) to attend to in order to differentiate fortis stops from the others, whereas lenis and aspirated stops require an additional cue (i.e., F0) to be distinguished. Figure 6.1 shows that the F0 values for fortis stops are located in between the F0 for lenis and aspirated stops. The F0 development pattern shown in KE and KI children's production may suggest that lenis and aspirated stops' F0 diverges from the fortis stop's F0 which appear to behave as reference (or default) point. Although KE children showed a similar developmental pattern to KI children, KE children may need a longer time to fully establish the three

stop categories due to the quality of Korean input from their peers and lack of opportunity to produce Korean on a daily basis.

Furthermore, KE children's underdeveloped Korean stop system can be viewed as an effect of English stop system. Recall that aspirated stops were produced with a substantially greater VOT difference between lenis and aspirated stops by KE children than KI children (see Figure 4.2 (b) in Chapter 4). The longer VOT difference and the undershoot of the F0 targets for lenis and aspirated stops can be interpreted as an effect of the English stop system. That is, English voiced and voiceless stops are primarily distinguished by VOT, and F0 is employed as a secondary cue in case of VOT ambiguity (Whalen, Abramson, Lisker, & Mody, 1993). Thus, the relatively greater role of VOT in distinguishing English stop categories may have influenced the way KE children acquired Korean stops. As a result, the most distinctive suprasegmental property of aspirated stops (i.e., F0) seemed to be replaced by the segmental property (VOT) of English voiceless stops in KE children's production.

Similar to the F0 results, the pattern of intensity was not significantly different between KE and KI adults' productions. Although KE adults' first and second syllables showed a greater intensity difference and the third and fourth syllable showed a smaller intensity difference than KI adults' production, the magnitude of intensity gradually decreased from the phrase-initial to the phrase-final syllable. The difference between KE and KI adult groups can be due to the difference in their speech style rather than the effect of L2 learning on the L1. That is, some of the KE adults may have tried to emphasize or articulate the first syllable with intensity because the following three

syllables mostly repeated themselves. The decreasing pattern, however, was not realized in KE children's production. The intensity in the third syllable was significantly decreased, yielding an intensity difference of more than 5 decibel between the second and third syllables. Intensity is thought to be a relatively less important phonetic cue in Korean, whereas native English adults as well as children as young as three years old were shown to employ intensity to signal stress in English (Pollock et al., 1993; Lee, Guion, & Harada, 2006). Considering the small weight of intensity in Korean word-level prosody, the sudden drop in intensity in KE children's Korean production may be attributed to the effect of the English stress pattern. Then, the question arises as to why the weakest intensity was given to the third syllable among the four syllables. This should be considered together with KE children's production of syllable duration, which also showed a sudden duration drop in the third syllable.

Duration has been described to be one of the most reliable acoustic correlates to signal stress across languages (Campbell & Beckman, 1997 for English; Sluijter & van Heuven, 1996 for Dutch, Ortega-Llebaria & Prieto, 2005 for Spanish). Especially when comparing two languages that belong to different rhythmic classes (stress vs. syllable-timed), syllable duration can capture crucial cues to different rhythmic types between the two languages. The results of syllable duration showed that KE and KI adults did not differ in either the mean duration of each syllable or the syllable duration intervals. Syllable duration and duration intervals in KE and KI children's productions, however, were less consistent than those in KE and KI adults' productions.

On the one hand, the less evenly distributed syllable duration in KI children's production may be explained by their shorter final lengthening. As can be seen in Figure 6.3, KI children's final syllable was significantly shorter than the adults' syllable. In line with Snow (1994)'s finding that showed native English children acquire intonation (i.e., F0 contour) earlier than syllable final lengthening, shorter duration of KI children's final syllable may be considered as a feature that is not yet fully developed and refined in an adult-like manner. As Lindblom (1978) and Snow (1994) argued, final lengthening as a syntactic boundary marker is a learned, grammar-based effect which improves as children acquire more complex syntactic strategies for chunking meaningful units.

KE children, on the other hand, produced significantly longer second and shorter third syllables than KI children. Figure 6.3 shows that the third syllable was shorter than 150 ms., resulting in more than 100 ms. difference between the second and third syllables. Particularly, KE children's third syllable was substantially shorter than KI children's third syllable. This result is consistent with the pattern of intensity, which was the lowest on the third syllable. Taken together, the intensity and syllable duration patterns in KE children's production of the first two syllables and the last two syllables resemble the iambic foot structure (i.e., an unstressed syllable followed by a stressed syllable) that can be observed in a stress-timed language.

According to Hall (2007), 76% of the four-syllable words in native English-speaking children's vocabulary have stress on either 1st or 2nd syllable and only 23% received stress on the 3rd syllable. Among the overall high-familiarity four-syllable English words, the 2nd syllable was most likely to receive main stress in adults' speech

(43%). The low percentage of four-syllable words with main stress on the 3rd syllable in both native English-speaking children's and adults' lexicon suggested that the 3rd syllable in four-syllable words is likely to be perceived as an unstressed syllable in English. In addition, because English stress is highly susceptible to syllabic weight, the location of stress is determined by whether the 3rd syllable is heavy or light. If it is heavy, main stress is assigned. Otherwise, the 2nd syllable attracts main stress.

In the case of the Korean four-syllable phrases, the 1st and 2nd syllables were heavy (CVC) and the 3rd and 4th syllables were light (CV). The 2nd syllable was particularly long because of the fricative onset and nasal coda consonants. Accordingly, KE children appeared to have assigned main stress to the 2nd syllable and produced the 3rd syllable as an unstressed syllable. The 4th syllable was long due to the phrase-final lengthening. Consequently, the iambic foot structure, 1st (weak)-2nd (strong) syllables and 3rd (weak)-4th (strong) syllables, emerge. The results suggest that KE children's early exposure to the rhythmic features of a stress-timed language (i.e., English) appeared to have influenced the prosody of a syllable-time language (i.e., Korean), which is thought to be realized with roughly equal duration between successive syllables (Abercrombie, 1965). Despite the different rhythmic features between the L1 and L2, KE children were not able to completely separate the two prosodic systems due to the early acquisition and continuous exposure to English.

CHAPTER VII

DISCUSSION AND CONCLUSION

The studies presented in the current dissertation examined the segmental and prosodic characteristics of Korean (L1) and English (L2) productions by Korean adults and children with varying amount of English experience. The primary research goal was to explore the effect of age of L2 learning on the developmental pattern and the degree of native-like acquisition of the L2. In addition, the interactions of the L1 and L2 on segments and prosody were investigated as a function of L2 experience. Overall, the effect of English experience exhibited a stronger influence on Korean children's than adults' Korean and English productions. The interaction between Korean and English was differently manifested depending on the linguistic domain. Specifically, the U.S.-born Korean children showed a significant effect of English on Korean prosodic features, whereas Korean exerted a strong influence on the acquisition of English segments for the Korean experienced adults. In this chapter, the different direction and degree of Korean-English interaction are discussed in an attempt to provide more integrated perspectives on language acquisition and bilingualism.

7.1 The factor of age on the acquisition of L2

The overall results of English productions by the four Korean groups are summarized in Table 7.1. Native-like and nonnative-like acquisition of the target L2

sounds (marked with O and X, respectively) was determined with reference to the age-matched native English speakers.

Table 7.1. The overall results of the segmental and prosodic features of English productions by Korean Experienced adults, children and Korean Inexperienced adults, children are shown. Native-like productions are marked with O and nonnative-like productions are marked with X. Features that are nonnative-like but showed a closer pattern toward the native English speakers' production than the same features produced by the other age-matched group are marked with Δ.

	Examined features	Section	KE adult	KI adult	KE child	KI child
English segments						
Full Vowel	Spectral quality	2.2.6.1(2)	X	X	O	X
	Duration	2.2.6.3(4)	X	X	O	O
Coda Consonant Voicing	Vowel to coda consonant duration ratio	3.2.4	Δ	X	O	X
	Coda C duration	3.2.4	X	X	O	X
	Vowel duration	3.2.4	O	O	O	O
Onset Consonant Voicing	VOT	4.2.5	O	O	X	X
English prosody						
Reduced Vowel	Spectral quality	5.6.4(5)	X	X	O	X
	Unstressed to stressed vowel duration ratio	5.2.6	O	O	O	O
Intensity	Unstressed to stressed vowel intensity ratio	5.2.7	O	O	O	O
	Max/min intensity range	5.3.4	O	O	O	X
F0	Unstressed to stressed vowel F0 ratio	5.2.7	O	O	O	O
	Max/min F0 range	5.3.3	O	O	X	X

One of the most notable differences was found between the English productions of Korean experienced adults and children. Except for the VOT ratio and F0 range, KE

children were clearly more native-like than KE adults in most of the examined English features. Although both groups were exposed to English for 6 years in the U.S. and KE adults have been learning English since middle school in Korea, the differences in KE adults' and KE children's English production indicate that the age of L2 acquisition has overridden the amount of L2 experience. Note, however, that the same LOR does not imply that KE adults and KE children have received the same language experience and opportunity to be in an environment that facilitates L2 learning. Different age of English exposure in the U.S. provides different L2 immersion settings that differ in the quality of L1 and L2 input, social pressure and motivation. The effects of LOR on L2 learning adults and children are further discussed in view of social influences later in this chapter.

As for the inexperienced groups, KI adults outperformed KI children, producing more native-like voiced-to-voiceless VOT ratio, max/min F0 and intensity range. KI adults' better performance at the initial stage of L2 exposure is likely due to their prior L2 experience in Korea, contributing as a favorable factor. Contrary to the assumption that early-acquired and thus more entrenched L1 prosody would create a greater L1-L2 interaction in prosody than in segments, KI adults showed more L1-L2 separability in the prosodic than segmental domain. In addition, a stronger influence of short L2 exposure (i.e., 6 months) on KI adults' than KI children's production may be suggestive evidence for adults' initial benefit of L2 learning within 4-5 months of immersion exposure (Snow & Hoefnagel-Höhle, 1978; Garcia-Mayo & Garcia-Lecumberri, 2003). In the current studies, however, note that Korean adults' production of L2 prosody is investigated in terms of the acquisition of lexical stress pattern in English. Korean adults may have

acquired some knowledge of the statistical distribution of stress placement in English as a result of L2 experience in Korea and U.S. (see Guion et al., 2004). Also, it could also be that KE and KI adults had memorized the word-sounds due to the high lexical frequency of the stimuli. Thus, Korean prosody having little influence on Korean adults' acquisition of English prosody may be limited to the lexical stress level.

When the same age groups with different amount of English exposure in the U.S. were compared (experienced vs. inexperienced), KE adults' production was not different from KI adults' production except for the preceding vowel-to-consonant duration ratios for voiced and voiceless coda words. KE children, however, differed from KI children in vowel quality, duration as well as in several other prosodic features. Overall, the extent to which 6 years of L2 experience influence the degree native-likeness in the L2 is heavily determined by the age of L2 acquisition. However, KE children's native-like production shown at a specific developmental state does not necessarily suggest that they would maintain the native-likeness at the ultimate state. Especially, given the influence of the socially dominant language (Culter et al., 1992; Genesee et al., 1995; Sebastián-Galés et al., 2005), it is difficult to predict whether KE children will maintain the accuracy of their English productions.

The differences between KE adults' and KE children' English production should not be solely attributed to the degree of articulatory maturation or plasticity of language acquisition. In addition to the different quality of language input that Korean adult and children receive in the U.S., sociolinguistic factors such as language attitude created by different prestige of the L1 and L2, and ethnic-identity come into play in shaping the way

two languages develop and interact. As it is for KE children, most bilingual children become sensitive to power relations between the two languages from a very early age and their language choice often depends on the social context they find themselves in. Being aware that English is a socially dominant language and having to get along with other English-speaking peers at school in the U.S. are only a few reasons that motivate KE children to choose English and keep the use of Korean to a minimum. These bilingual children gather and develop their own speech community where a gradual change from frequent code-switching to a complete language shift to English occurs as they age. English-accented Korean is a shared attribute among Korean bilingual speakers and rather viewed as normal, whereas Korean-accented English is an index of the characteristics which do not belong to their speech community.

Consequently, KI children who want to be involved in this community will have to either get rid of their Korean accents in English or create their own circle in which one will continue to speak Korean. Thus, the quality of Korean input the KE children are exposed to is less likely to be native-like due to the socially structured linguistic norms. On the other hand, KE adults who have a stable sense of self- and ethnic-identity as a Korean tend to show less motivation to speak English with no accents, especially around their friends who are mostly Koreans. As different social environments impose different expectations of the language use, it is important to acknowledge that the quantity and quality of English and Korean that KE adults and children experience can substantially vary even with the same LOR in the U.S.

7.2. L1 and L2 interactions in segmental and prosodic domains

In the current studies, the development and acquisition of the L2 have been discussed in relation to the L1. Table 7.2 summarizes the native-likeness of KE adults' and children's Korean productions which was determined in comparison to KI adults' and children's productions.

Table 7.2. The overall results of the segmental and prosodic features of Korean productions by KE adults and children as compared to the KI adults, children are shown. Similar to Table 7.1, native-like production of the KE group is marked with O and nonnative-like production with X. KE adults' and children's productions are compared to the KI adults' and children's productions, respectively. KI groups were used as a reference point of (near) native Korean production.

	Examined features	Section	KE adult	KE child
Korean segments				
Full Vowel	Spectral quality	2.3.5.1	X	O
	Duration	2.3.5.3	O	O
Onset Consonant Contrast	Lenis to aspirated VOT	4.3.4	O	X
Korean prosody				
F0	3-way distinction & F0 contour of 4-syllable phrases	6.2.6	O	X
Intensity	Intensity pattern of 4-syllable phrases	6.3.4	X	X
Syllable Duration	Duration pattern of 4-syllable phrases	6.4.4	O	X

As has been briefly mentioned in Chapter II, the problem with assuming that KI adults' production is closer to the L1 native norm has its risks of disregarding the effect a short period of L2 exposure on the L1. As shown in Table 7.2, however, the KI adults' and KI children's English productions merely suggest the possibility of a stronger

effect of English on the KI groups' Korean than KE groups' Korean production. In other words, KI adults and children showed less native-likeness in English production and it was assumed that their Korean was closer to native Korean speakers' in Korea. It should be noted, however, that is difficult to find young Korean adults who have no knowledge of English even in Korea.

As expected, KE adults were more native-like than KE children in producing Korean phrases. KE adults' production showed some differences from KI adults' production. However, if one can agree that the nonnative-likeness in KE adults' productions of Korean vowel quality, specifically the F2 frequency for /i/, and intensity can be interpreted as an effect of speaker variability and speech style between the adult groups, rather than a group effect (see the discussion in Chapter II and VI), there was no major difference between the adult KE and KI groups. KE children, on the other hand, were clearly different from KI children in many aspects of Korean production. Especially, delay in the native-like acquisition of F0 contrasts for the three Korean stops and uneven distribution of intensity and duration across syllables in KE children's Korean production was found. These patterns were attributed to the effects of two-way VOT contrasts between voiced and voiceless stops and lexical stress in English on Korean prosody.

One explanation for KE children's nonnative-like acquisition of Korean prosody (i.e., F0, intensity, syllable duration) may be inferred from KE children showing more difficulty creating distinct categories for Korean stops than KI children who have established Korean's three-way stop contrast before learning the two-way contrast for English stops. In other words, the relative difficulty of the L1 and L2 can affect the order

in which the target features in the L1 and L2 are acquired. Culter et al. (1989) suggested that speakers from stress-timed language background would have more difficulty acquiring prosodic features of syllable-timed language than the other way around. It may be that reducing prosodic features (i.e., stress-timed) requires less articulatory effort than learning to put equal emphasis on each syllable (i.e., syllable-timed). As an example, the absence of reduced vowels in Korean means greater use of vowel space and articulatory movements. Thus, KE children's nonnative-like Korean, but not English, stop contrasts and prosodic features may be reflecting the relative difficulty between the Korean and English prosodic features.

Table 7.1 and 7.2 together show how the degree of the L1-L2 separability and the direction of L1-L2 influences differ across the groups, depending on linguistic domains. The direction of L1-L2 influences was different between KE adults and children in that KE adults had a stronger effect of Korean on English, whereas KE children showed more effect of English on Korean. When examined more closely, KE adults' production showed the effect of Korean mainly on the production of English segments. KE children, on the other hand, mainly showed the effect of English on Korean prosodic features. That is, the separation between English and Korean was less likely for segments for KE adults, suggesting that the new English categories were not independently established from Korean. For KE children, knowledge of English appeared to interfere with Korean prosodic features.

The nonnative-likeness in KE adults' English production is observed in the new L2 features which are not phonologically meaningful in the L1. Note that KE and KI

adults were less likely to be native-like in English-specific features that are not used in Korean segments or prosody. Specifically, KE adults revealed extensive overlap between neighboring English vowels and assimilated them into a single category (i.e., /i/-/ɪ/, /ɑ/-/ɔ/, /u/-/ʊ/). KE adults also produced significantly smaller voiced-to-voiceless consonant duration than NE adults due to the lack of coda voicing contrasts in Korean. Moreover, the nonnative-like vowel reduction for unstressed vowels reflects their difficulty acquiring vowel spectral quality as a cue to English stress. The nonnative formation of new vowel categories and length contrasts as the effect of L1 suggests that KE adults had more challenges in creating new L2 categories and prosodically conditioned vowel variants.

KE children, on the other hand, were found to have created separate categories for the English and Korean features that are cross-linguistically different. Although KE children produced some of the English and Korean features differently from NE and KI children, their English production was not negatively influenced by the lack of tense and lax vowel distinction in spectral quality and duration, coda voicing, or vowel reduction in Korean. Rather the nonnative-likeness in KE children's productions for the two languages was shown in the significantly lengthened VOT for Korean aspirated stops and raised maximum F0 for English stressed vowels. Considering that both languages make use of VOT for stop contrasts and F0 to signal prosodic contrasts, KE children's nonnative-like English production may suggest that they have not yet fully demarcated cross-linguistically similar features between English and Korean. As a way to separate the two languages, category dissimilation occurred. In particular, the VOT dissimilation

between Korean aspirated stops and English voiceless stops suggests that they enhanced the phonetic cues to maintain L1-L2 contrasts, suggesting KE children's separate representations for the L1 and L2 (Flege, 1995, 1999).

Lastly, the acquisition patterns concern the ambiguous distinction between the segments and prosody. That is, the unstressed vowel quality was categorized as a prosodic feature in order to differentiate it from vowel quality produced in monosyllabic words. However, a similar acquisition pattern between monosyllabic stressed and multisyllabic unstressed vowel quality is shown across the four groups. As shown in Table 7.1, if monosyllabic stressed vowels were not produced in a native-like manner, then neither were the unstressed vowels. The KE child group was the only Korean group to accurately produce both Korean and English vowel spectral quality and this suggests that the acquisition of vowel spectral quality may be more subject to age of L2 exposure compared to other phonetic features. The result is consistent with Kondo (2009) who found that Japanese late learners of English were able to master prosodic features such as F0, intensity and duration of stressed and unstressed vowels but not vowel spectral quality. The different outcomes were interpreted to indicate the difference in articulatory controllability. That is, the likelihood of acquiring L2 phonemic categories in a native-like manner is low when the articulatory configuration is already adjusted to execute L1 vowels.

In the current findings, KE children's native-like production of Korean and English vowels may be explained with their exposure to both languages in the early stage of motor development. In addition to the articulatory flexibility, accurate spectral quality

for Korean and English vowels in KE children's productions could be related to its heavy contribution to the conveyance of meaning. Unlike intensity or F0 range, for example, small differences in spectral quality between /ɪ/ and /i/ could change the meaning of a word. Also from a cognitive aspect, the KE children's early mastery of vowel quality and delayed acquisition of Korean prosodic features may reflect the order in which they prioritize linguistic elements to minimize the cognitive load brought on by processing two languages. The order of native-likeness appears to be Korean/English vowel quality, followed by English prosody and then Korean prosody. This order is determined by both linguistic and social factors described above.

7.3. Characteristics of simultaneous bilinguals

As has been pointed out in Chapter I, the inconsistent definition of simultaneous bilinguals have caused some confusion as to whether simultaneous bilinguals fundamentally differ from early (sequential) bilinguals and what linguistic traits might distinguish the two bilingual groups. The issue is not only that the given period of time for a child to be classified as a simultaneous bilingual varies from birth (Padilla & Lindholm, 1984, Fowler et al., 2008) to three years old (Hammer et al., 2004), but also that researchers have tried to explain their differences based on partial aspects of language development. Consequently, different results have led to different interpretations. Some have suggested that simultaneous bilinguals hold a unique linguistic status, and thus, are distinctive from monolinguals and early sequential bilinguals (Sundara et al., 2006; Sundara et al., 2008). Others have argued that

simultaneous and sequential bilinguals go through fundamentally the same language processing and a distinction emerges depending on how socially dominant one language is over the other (Cutler et al., 1992; Genesee et al., 1995, Jia & Aaronson 2003; Sebastián-Gallés et al., 2005).

From the patterns observed in the current findings, the speech production of U.S.-born KE children provides empirical evidence for the development of separate L1 and L2 representations. In particular, the native-like acquisition of Korean and English vowel categories suggests that KE children were able to attain language-specific phonemic representations for both languages unlike many early sequential bilinguals who were shown to produce nonnative-like L2 vowels despite the early onset of L2 exposure (Baker & Trofimovich, 2005; Lee et al., 2006; Baker et al., 2008). Moreover, category dissimilation between Korean and English shown in KE children's VOT productions is consistent with Sundara and Polka (2008)'s description of simultaneous adult bilinguals whose L1 and L2 categories are likely to dissimilate in both production and perception.

Although KE children showed trends toward simultaneous bilinguals, KE children's productions examined in a particular developmental stage may look very different from their productions in the ultimate stage. After all, as Genesee et al. (1995) and Sebastián-Gallés et al. (2005) would argue, the distinction between simultaneous and sequential bilinguals is not categorical because the degree of language dominance is a relative concept and it constantly changes over time. With KE children's higher English use (62%) and bilingual children's quick shift in language dominance from the L1 to L2 in an L2-speaking environment (Jia & Aaronson, 2003), it seems as though KE children

had already chosen English as their dominant language and this language choice will eventually result in greater Korean attrition. The future avenues of research include exploring KE children's productions of the two languages when they become adults and compare them to the current findings. Revisiting the same questions at their ultimate stage of language acquisition will provide better understanding of how two languages develop in relation to one another and what social and linguistic factors partake in shaping bilinguals' language system(s).

APPENDIX

LANGAUGE BACKGROUND QUESTIONNAIRE

	KEA	KIA	KEC	KIC
How did you begin learning English (number)				
1. at school in home country	1.(9)	1.(10)	1.(0)	1.(1)
2. school in the US	2.(0)	2.(0)	2.(5)	2.(7)
3. at home	3.(1)	3.(0)	3.(4)	3.(1)
4. with English-speaking friends	4.(0)	4.(0)	4.(0)	4.(1)
Self-rated proficiency (1=very poor, 9=native-like)				
1. speaking	1.(5.5)	1.(4.1)		
2. reading	2.(5.7)	2.(4.2)		
3. writing	3.(5.0)	3.(3.8)		
4. listening	4.(6.1)	4.(5.0)		
English use in different situations (%)				
1. (grand)parents	1.(0)	1.(0)	1.(38)	1.(12)
2. siblings	2.(0)	2.(0)	2.(85)	2.(10)
3. with friends	3.(46)	3.(25)	3.(73)	3.(21)
4. at home	4.(14)	4.(10)	4.(42)	4.(10)
5. at school	5.(73)	5.(44)	5.(100)	5.(76)

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