Learning Second-Language Intonation: Are Children Better than Adults?

Wendy Baker, Pavel Trofimovich, Molly Mack
Brigham Young University, Concordia University, University of Illinois

1. Introduction

What factors influence how second-language learners acquire L2 phonology? Two such factors are the learner's age at the time of second-language acquisition (age) and the degree of perceptual similarity between native- (L1) and second-language (L2) segments (cross-language similarity). To date, most of the research in L2 phonology has examined the effect of these two factors upon the acquisition of individual segments (see Flege, 1995, for review). Less examined has been the influence of factors such as age and cross-language similarity on the acquisition of L2 suprasegmentals—that is, such prosodic aspects of phonology as stress, rhythm, and intonation. The purpose of this study was to examine the influence of these two factors, age and cross-language similarity, on learning L2 suprasegmentals.

The influence of age and cross-language similarity on learning L2 segments is well established. For example, exploring the age factor, one line of research has compared differences between how children and adults perceive and produce L2 segments (i.e., vowels and consonants). The findings of these studies seem to confirm that children tend to outperform adults in beginning as well as advanced stages of L2 learning (Baker, Trofimovich, Mack, & Flege, 2001). One comprehensive study (Flege, Yeni-Komshian, & Liu, 1999), for example, examined the degree of global foreign accent of 240 native Korean learners of English who differed in their age of English acquisition. The results of this study suggested a strong inverse relationship between age and the degree of global foreign accent (Flege, 1999).

Similarly, exploring the cross-language similarity factor, another line of research has examined how learners perceive and produce L2 segments that are either perceptually similar or dissimilar to segments in their L1. These studies indicate that learners are frequently more successful at acquiring those L2 segments that are perceptually dissimilar from, than those that are similar to, their L1 segments (Guion, Flege, Akahane-Yamada, & Pruitt, 2000). For example, native Korean speakers have more difficulty perceiving and producing English /ɪ/ as in *bit* than English /æ/ as in *bat*. This is because English /ɪ/ is similar perceptually to Korean /i/ but English /æ/ is not perceptually similar to any single Korean vowel (Trofimovich, Baker, &

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Mack, 2001). Native Korean children and adults are more likely to perceive and produce English /ɪ/ with a greater degree of foreign accent than English /æ/ (Baker, Trofimovich, Mack, & Flege, 2001). These results as well as those of other studies indicate that L2 learners may need to perceive some perceptual differences (however slight) between L1 and L2 segments in order to perceive and produce L2 segments accurately (Guion et al., 2000).

Do these two factors also influence how L2 suprasegmentals are learned? That is, are suprasegmentals acquired similarly to segmentals (Shen, 1990)? Very few studies have examined this question (Munro, 1995). Although at least one study addressed the effect of age on learning suprasegmental aspects of an L2, it did so in perception only—that is, by investigating younger and older L2 learners' processing of prosodic and syntactic cues to sentence interpretation (Harley, Howard, & Hart, 1995). Few other studies (if any at all) explored the learning of L2 suprasegmentals by children and adults in detail.

Similarly, few studies have examined the influence of cross-language similarity on the learning of L2 suprasegmentals. Results of one of these studies indicated that native Spanish speakers have difficulty learning English rhythm (Gutiérrez-Díez, 2001). This difficulty was attributed to cross-language differences between English and Spanish rhythmic structure: Spanish is a syllable-timed language (i.e., all syllables are of approximately equal length) while English is a stress-timed language (i.e., stressed syllables are considerably longer than unstressed syllables). Results of another study examining pitch accent (characterized by the highest value of fundamental frequency in a sentence) demonstrated that native Greek speakers were unable to learn to place pitch accents in Dutch in a native-like manner (Dutch differs from Greek in the location of pitch accent), even though they were advanced speakers of the language (Mennen, 1998).

To date, no research has looked at how these factors influence the learning of L2 suprasegmentals. Hence the objective of this study was to examine whether both age and cross-language similarity influence the learning of L2 suprasegmentals. This study sought an answer to the following question: Is learning L2 phonology at the segment level similar to learning L2 phonology at the suprasegmental level? In particular, this study examined whether (1) children are better than adults at learning L2 suprasegmentals and (2) whether children and adults are better at learning those aspects of L2 suprasegmentals that are dissimilar than those that are similar in their L1. Forty native Korean speakers who differed in their age of L2 acquisition were asked to produce six English declarative sentences. To examine whether cross-language similarity influences how L2 suprasegmentals are learned, two aspects of English suprasegmentals were examined: One that differed considerably from Korean (rhythm) and one that did not (pitch accent).

2. Method

2.1 Participants

Forty native Korean learners of English as a second language participated in this study. These participants were assigned to four groups based on their age at the time of English acquisition and their length of residence in the U.S. The first group, the "Child+1" group (where "+1" indicates about 1 year of U.S. residence), had arrived in the U.S. at a mean age of 10.7 (range: 7-13 years), resided in the U.S. for about 1 year (range: 7-15 months), and were on average 11.6 years of age (range: 8-14). The second group, the "Adult+1" group, had arrived in the U.S. at a mean age of 24.5 (range: 18-26 years), resided in the U.S. for about 1 year (range: 6-14 months), and were on average 25.2 years of age (range: 19-27) at the time of testing. These two groups were considered inexperienced L2 learners.

The remaining two groups had a greater amount of experience with English in the U.S., on average about 10 years, and were recruited to determine how L2 suprasegmentals are learned following a more substantial amount of exposure to English. The Child+10 group (where "+10" indicates about 10 years of U.S. residence), had arrived in the U.S. at a mean age of 8.7 (range: 7-11 years), resided in the U.S. for about 10.1 years (range: 8-12 years), and were on average 19.7 years of age (range: 18-21 years) at the time of testing. The Adult+10 group, had arrived in the U.S. at a mean age of 21 (range: 18-26 years), resided in the U.S. for about 10.3 years (range: 8-12 years), and were on average 31.2 years of age (range: 28-36 years) at the time of testing. Ten English adult monolinguals (hereafter the "NE Adult" group) also participated for comparison purposes (Table 1).

Table 1: Participants' Demographic Characteristics

	N	CA	AOA	LOR	K. Use	Rate
Adult+1	10	25.2	24.5	0.7	51%	4.4
Child+1	10	11.6	10.7	0.9	54%	5.7
Adult+10	10	32.1	21.4	9.8	45%	7.6
Child+10	10	20.3	9.0	11.1	40%	8.5
NE Adult	10	20.7				9.4

Means for chronological age (CA), age of arrival (AOA), length of residence (LOR), amount of self-estimated Korean daily use (K. Use), and English self-rating on a 1 to 10 scale (Rate E.) with standard deviations in parentheses

Participants were recruited with the goal of having the inexperienced (Child+1, Adult+1) as well as the experienced (Child+10, Adult+10) children and adults have a comparable amount of experience with English in the U.S. (Flege & Liu, 2000). At the time of testing, all participants were attending schools in the U.S. in English. The participants provided self-ratings of their English proficiency on a 10-point scale on which 1 corresponded to 'I don't know any English,' and 10 corresponded to 'I am a native speaker of English.' The participants also estimated percent of daily use of English and Korean. Statistical comparisons of these self-ratings indicated that the Child+1 and Adult+1 groups as well as the Child+10 and Adult+10 groups did not differ in the amount of self-estimated daily use of English and Korean, English self-ratings, nor in their length of U.S. residence at both 1 and 10 years of U.S. residence, respectively.

2.2. Stimuli and Procedure

The stimuli used in this study were six English declarative sentences elicited as responses to question prompts (Table 2). The participants produced the sentences in a delayed sentence-repetition task. The speakers heard and repeated each of the six declarative sentences. The sentences were presented in three randomized blocks but only the sentences presented in the last block were used in the analyses. The analyses reported in this study are based on 300 sentences (5 groups × 10 speakers × 6 sentences). A Shure head-mounted microphone (SM10A) and Sony DAT tape recorder (TCD-D8) were used to record the participants. The sentences were excised from the speech sample, digitized, and normalized for presentation.

Table 2: Stimuli

Question (Prompt)	Answer (Participant Response)
Did the boy get wet?	He didn't have a hood on his coat.
Why is the boy sad?	He feels bad about the news.
Did the crowd boo the team?	No, they booed the coach.
Where is my bed?	Your bed is by the window.
Can I use your bat?	No, the bat is mine.
Is he feeling ok?	No, his head hurts a lot.

The participants were tested individually in a quiet location using a personal computer and stimulus presentation software (Smith, 1997). The participants first heard a question (prompt) followed by a response to that question. The prompt was spoken in a male voice and a response to the question was spoken in a female voice. Then, the participants heard the prompt again and repeated the response they had just heard. The delay between the response and the participants' repetition of it ensured that the participants were not merely imitating the female speaker but were attempting to phonologically encode the perceived message. The use of repeated sentences—as opposed to spontaneous productions—also allowed for examining speech samples that were identical and therefore maximally comparable across all the participants.

3. Results

Two sets of analyses were carried out in the present study. The first analysis examined the role of age in the acquisition of L2 suprasegmentals. In this analysis, the recorded sentences were presented to native English speakers for foreign-accent rating. The second analysis examined the role of cross-language similarity on the acquisition of L2 suprasegmentals. In this analysis, syllable duration and the location of pitch accent were acoustically measured.

3.1. Age of L2 Acquisition

The first objective of this study was to determine whether L2 learners' age influenced the production of L2 suprasegmentals. That is, the objective was to investigate if the child L2 learners were more likely than the adult L2 learners to accurately produce L2 suprasegmentals. To attain this objective, the recorded sentences were low-pass filtered and were presented to a group of 10 native English listeners for accent judgments. Low-pass filtering removed all energy components of the speech signal above 450 Hz, thus preserving most of the suprasegmentals—that is, the acoustic correlates of stress, rhythm, and intonation—while removing most of the segmental content. Low-pass filtering ensured that the listeners based their accent judgments on the suprasegmental but not on the segmental content of the sentences. The low-pass filtered sentences sounded muffled, as if spoken in an adjacent room, just out of earshot (Munro, 1995).

The English listeners were on average 22 years of age (range: 19-25 years) and had had no experience with a foreign language outside of regular L2 classes. The low-pass filtered sentences spoken by the 50 participants were presented to the English listeners in six randomized blocks. Each block contained the participants' renditions of the same sentence. The listeners were told which sentence the participants were attempting to say so they could compare what they heard to their expectations of what the sentence should sound like. As the listeners heard each sentence played over loudspeakers positioned in front of them, they rated the degree of foreign accent in it on a 7-point scale by clicking one of seven response buttons (1="strong foreign accent," 7= "no foreign accent"). The listeners were encouraged to use the entire scale and to guess if they were unsure. They were allowed to listen to each sentence as many times as they wished but were not permitted to change their responses after they were given. The dependent variable in this analysis was the mean foreign-accent rating calculated by averaging the 10 English listeners' ratings for each participant's six sentences. On the rating scale used, higher ratings indicated a milder foreign accent while lower ratings indicated a stronger foreign accent.

The accent ratings for each participant were submitted to a two-way (age × length of residence) ANOVA comparing foreign-accent ratings among the four groups of participants. This analysis yielded a significant main effect of length of residence [$F(1,36) = 77.91$, $p < .001$] and a significant age × length of residence interaction [$F(1,36) = 11.16$, $p < .01$], but no main effect of age. Bonferroni tests (t-tests with α adjusted for number of pairwise comparisons) revealed that the child [$t(18) = 7.89$, $p < .001$] and the adult [$t(18) = 4.31$, $p < .001$] learners at 10 years of U.S. residence received higher accent scores (i.e., scores more like native English speakers) than did the Child+1 and Adult+1 groups. Bonferroni tests comparing the 4 groups and the NE Adult group (whose mean accent rating was 6.5) revealed that only the Child+10 group received foreign-accent ratings that were not statistically different from those received by the NE Adult group. The remaining three groups received significantly lower ratings than did the NE Adult group [$ts(18) > 5.93$, $p < .001$] (Figure 1).

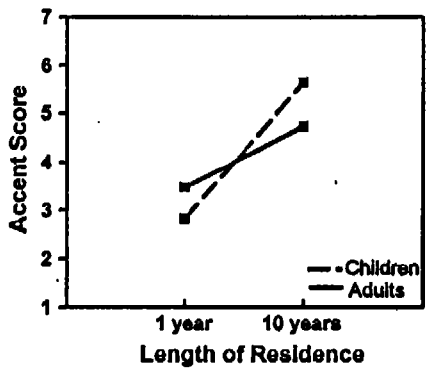

Figure 1: Mean foreign-accent ratings for the low-pass filtered sentences

These findings suggested that age does influence the degree of foreign accent at the suprasegmental level. After a relatively substantial length of residence in the U.S., the child learners were more accurate than the adult learners in producing English suprasegmentals. More importantly, however, these findings suggested that the adult L2 learners were also able to learn at least some English suprasegmentals. They were able to produce English sentences with a lesser degree of foreign accent at 10 years than at 1 year of U.S. residence. The following analysis examined in detail two specific suprasegmental aspects of English speech—rhythm and the location of pitch accent. In particular, examined in the following analysis was the effect of cross-language similarity on, a factor that may determine how well L2 learners approximate suprasegmental aspects of L2 speech.

3.2. Cross-Language Similarity

The second objective of this study was to determine whether cross-language similarity influences the production of L2 suprasegmentals. Cross-language similarity refers to the degree of perceived similarity between individual segmental or supra-segmental aspects in the L1 and in the L2. Because L2 learners are frequently more successful at acquiring those L2 segments that are perceptually dissimilar from, than those that are similar to, their L1 segments (Flege, 1995; Guion et al., 2000), it was hypothesized that the effect of cross-language similarity upon the learning of supra-segmental aspects of an L2 would be similar. More specifically, it was hypothesized that it would be easier for native Korean learners of English to produce accurately English pitch accent than English rhythm. (The location of pitch accent in English and Korean are relatively similar while English and Korean rhythmic timing are relatively dissimilar.) That is, it should be easier for L2 learners to perceive a difference between those L2 suprasegmentals that are very different from, than between those that are very similar to, L1 suprasegmentals.

3.2.1. English Rhythm

The suprasegmental aspect that is relatively dissimilar between English and Korean is rhythm. As a stress-timed language, English has a rhythm characterized by stressed syllables occurring at approximately the same time intervals. In other words, stressed syllables are usually significantly longer than unstressed syllables (Bolinger, 1965). By contrast, as a syllable-timed language, Korean has a rhythm characterized by syllables that are approximately of the same in duration (Jun, 1996). That is, in Korean all syllables (whether stressed or unstressed) are roughly the same length. Because the rhythmic patterns of English and Korean are distinct—that is, relatively dissimilar from each other, it was hypothesized that the rhythmic pattern of English should be easy to learn.

To determine if this was indeed the case, the ratio of unstressed to stressed syllables was calculated for each of the six sentences of the Korean learners of English and the NE Adult group. In particular, the duration of stressed and unstressed syllables was measured from the display of digital speech-analysis software between two cursors placed at the onset and at the offset of voicing in each syllable. For each syllable, its duration included the length of all consonants and vowels in it. The obtained stressed vs. unstressed syllable durations were averaged for each participant across all six declarative sentences and a single ratio of unstressed to stressed syllables was obtained for each participant. The ratio was the dependent variable in this analysis.

Table 3: Stressed (in bold) vs. Unstressed Syllables

He didn't have a **hood** on his **coat**.
He **feels bad** about the **news**.
No, they **booed** the **coach**.
Your **bed** is by the **window**.
No, the **bat** is **mine**.
No, his **head hurts** a lot.

If the participants used English-like rhythm, the ratio of unstressed to stressed syllables should be lower (closer to .5) because unstressed syllables are shorter than stressed ones. If the participants used Korean-like rhythm, the ratio should be higher (closer to 1) because unstressed and stressed syllables would be approximately equal in duration.

The ratios for each participant were first submitted to a two-way (age × length of residence) ANOVA comparing syllable-duration ratios. This analysis yielded a significant main effect of age [$F(1,36) = 11.73$, $p < .01$] and a significant main effect of length of residence [$F(1,36) = 31.33$, $p < .001$], but no significant age × length of residence interaction. Bonferroni tests revealed that both the child [$t(18) = 10.09$, $p < .001$] and the adult learners [$t(18) = 5.10$, $p < .001$] had significantly lower (and therefore more English-like) unstressed-to-stressed syllable duration ratios at 10 years than at 1 year of U.S. residence. Bonferroni tests comparing syllable-duration ratios between each of the four groups and the NE Adult group (whose mean ratio was .47) further revealed that both groups of the L2 learners at 1 year of U.S. residence (Child+1, Adult+1) had a significantly higher syllable-duration ratios than did the group of the NE Adult group [$ts(18) > 3.51$, $p < .01$]. By contrast, both groups of the L2 learners at 10 years of U.S. residence (Child+10, Adult+10) had syllable-duration ratios that did not differ from the NE Adult group's syllable-duration ratio (Figure 2).

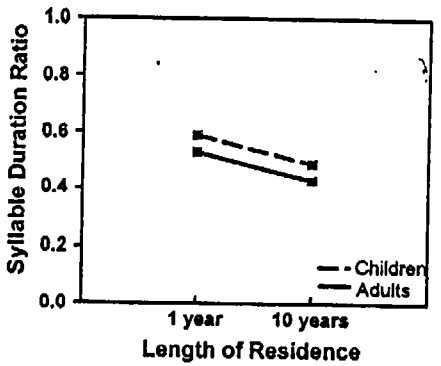

Figure 2: Duration ratio between unstressed and stressed English syllables

These findings suggested that the experienced child and adult L2 learners learned to produce English rhythm in a native-like manner. They were able to do so most likely because English and Korean rhythmic patterns are different from each other. These findings suggested that the learners' age did not seem to affect their ability to produce English rhythm. That is, both the child and the adult L2 learners did not differ significantly from each other in their ability to learn this aspect of L2 suprasegmentals.

3.2.2. English Pitch Accent

The suprasegmental aspect that is relatively similar between English and Korean is the location of pitch accent—that is, the location of the highest value of fundamental frequency in an utterance. In English, pitch accent is aligned with the onset of the stressed syllable in the most prominent (stressed) word (Ladd, Mennen, & Schepman, 2000). In Korean, pitch accent is aligned with the offset of the stressed syllable of the most prominent word (Kim & Kim, 2001). In other words, in both English and Korean, pitch peak occurs in the most prominent word in the sentence; however, it is aligned with the onset of the word in English and with the offset of the word in Korean. It was hypothesized that the placement of pitch accent in English would be harder to learn than English rhythm. This is because the difference in the alignment of pitch accent in English and Korean is relatively minor—both are high and both occur in the most prominent word in the sentence. Moreover, this difference may be considered as being relatively slight perceptually because it would not affect comprehensibility or intelligibility (Munro & Derwing, 1995).

To determine if it would be harder for L2 learners to place pitch accent appropriately in English than to produce native-like English rhythm, the location of the pitch accent in the six English sentences was measured for each participant. The measurements were done from the display of digital speech-analysis software and involved an examination of the fundamental-frequency (F0) contour at different locations in the sentence. The location of pitch accent in the stressed syllable (hereafter, peak alignment) was defined as the distance (in milliseconds) between the onset of the vowel in that syllable and the point in F0 contour with the highest F0 value (Ladd et al., 2000, and Mennen, 1998). The obtained peak-alignment values were averaged for each participant across the six declarative sentences. The mean peak-alignment value was the dependent variable in this analysis. If the L2 learners used English-like placement of pitch accent, then pitch accent should be aligned with the onset of the stressed syllable (i.e., the peak-alignment value should be close to 0). If the L2 learners used Korean-like placement, then pitch accent should be aligned with the offset of the stressed syllable (i.e., the peak-alignment value should be larger than 0).

The peak-alignment values for each participant were submitted to a two-way (age × length of residence) ANOVA. This analysis yielded a significant main effect of length of residence [$F(1,36) = 6.16$, $p < .025$] but no significant main effect of age or a significant age × length of residence interaction. Bonferroni tests revealed that only the child L2 learners [$t(18) = 2.46$, $p < .025$] had significantly smaller peak-alignment values at 10 than at 1 year of U.S. residence. Bonferroni tests comparing peak-alignment values between each of the four groups of the child and the adult learners and the NE Adult group (whose mean peak-alignment value was .03 ms) further revealed that only the group of child L2 learners at 10 years of U.S. residence (Child+10) had peak-alignment values that were not different from NE Adults'. The remaining three groups of L2 learners (Child+1, Adult+1, Adult+10) all had peak-alignment values that were significantly lower than those of the NE Adult group [$ts(18) > 2.63$, $p < .025$] (Figure 3).

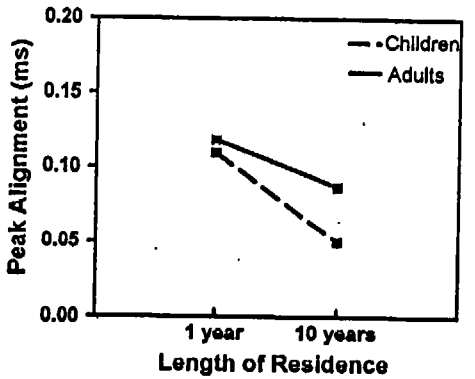

Figure 3: Peak alignment in English

These findings suggested that only the experienced child L2 learners aligned the pitch accent the way native English speakers do. One of the reasons why adult L2 learners were not able to do so may reflect the fact that the placement of pitch accent in English and Korean represents a relatively subtle cross-language difference. This explanation is in fact consistent with reports of segmental learning by children and adults (i.e., Baker et al., 2001) and suggests that children may be sensitive to slight cross-language differences whereas adults may "overlook" them. These findings also suggested that learning to realize native-like pitch peak alignment in production may be more difficult than learning to produce the alternating stressed-unstressed English rhythmic pattern. As this analysis indicated, within 10 years of U.S. residence, the adult L2 learners learned to produce English rhythm in a native-like manner but were not able to place pitch accent the way native English speakers do.

4. Discussion and Conclusion

What are the implications of these findings? One implication is that models and theories of L2 speech processing and learning may be extended to account for both segmental and suprasegmental aspects of an L2. That is, the learning of phonological segments may be similar to the learning of the prosodic patterns of rhythmic timing and location of pitch accent. Thus, speech learning theories need to and can account for the processing and learning of both segmental and suprasegmental aspects of an L2.

The results of this study also demonstrated that age is an important factor determining how both segmental (Baker et al., 2001) and supra-segmental aspects of an L2 are acquired. In order to further explore the effect of age on L2 suprasegmental learning, it will be important to examine what experiential, social, and neurobiological factors play to children's advantage at learning virtually all aspects of L2 phonology. Moreover, future research should also examine several aspects of L2 suprasegmentals to determine whether different types of suprasegmentals (i.e., stress, intonation, rhythm, pitch, etc.) are more susceptible to the effects of age and why this may be so.

The results of this study demonstrated that cross-language similarity may also affect how L2 suprasegmentals are produced. In particular, at least for the adult L2 learners, English rhythm, an aspect of English that is relatively different from Korean, was easier to learn than English pitch accent, an aspect of English that is relatively similar to Korean. By contrast, the child L2 learners, unlike the adult L2 learners, produced both English rhythm and English pitch accent like native English speakers. This finding indicated that cross-language similarity may play a lesser role in child versus adult L2 learning, a finding that is also obtained in learning L2 segments (Baker et al., 2001).

In order to further explore the effect of cross-language similarity on the learning of L2 suprasegmentals, it will be important to develop techniques to estimate, in processing terms, the degree of cross-language similarity of both segmentals and suprasegmentals. In addition, other factors besides fine-grained perceptual/acoustic differences most likely distinguish various suprasegmental aspects of an L2 (e.g., the amount of meaning pitch accent or rhythm convey) and should be accounted for as well. Thus, being able to know how to estimate the degree of cross-language similarity between suprasegmental aspects of an L1 and an L2 may help explain and predict what aspects of L2 phonology will need to be addressed in training.

The findings of this study overall provided evidence for striking similarities in the learning of L2 segmentals and suprasegmentals and invited further investigation into the factors that influence child and adult learning of L2 phonology.

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