

The Perception and Production of English /ɛ/ and /æ/ by Korean Children and Adults Living in North America

Kimiko Tsukada¹, David Birdsong², Ellen Bialystok³, Molly Mack⁴, Hyekyung Sung⁵ and James Flege¹

¹Division of Speech and Hearing Sciences, University of Alabama at Birmingham; ²Department of French and Italian, University of Texas; ³Department of Psychology, York University; ⁴Department of Linguistics, University of Illinois; ⁵School of Education, Stanford University

E-mail: ¹tsukada@uab.edu, ²birdsong@ccwf.cc.utexas.edu, ³ellenb@yorku.ca, ⁴m-mack1@uiuc.edu,
⁵sung@stanford.edu, ¹jeflege@uab.edu

ABSTRACT

This study assessed the production and categorial discrimination of English /ɛ/ and /æ/ by native Korean (NK) adults and children. A total of 108 participants (72 NK and 36 age-matched native English speakers) were tested twice. The NK participants were further subdivided according to length of residence (LOR) in North America. In Experiment 1, both the NK adults and NK children differed from age-matched native English (NE) participants in discriminating /ɛ/ from /æ/, but the NK children showed more accurate discrimination than the NK adults did. The participants' productions of /ɛ/ and /æ/ were examined in Experiment 2. An acoustic analysis suggested that, unlike the results obtained for vowel discrimination, the NK children's production of the two target vowels closely resembled NE children's. However, the NK adults failed to produce as large a contrast as NE adults. The differing pattern of results obtained for discrimination and production for the NK children but not the NK adults suggested that the relation between production and perception abilities in a second language (L2) might depend on the age of L2 learning.

1. INTRODUCTION

It is well known that adult L2 learners have varying degrees of difficulty in perceiving and producing phonetic contrasts that do not occur in the native language (L1). At the same time, it is widely accepted that children are more successful in learning an L2, especially pronunciation, than adults are. One possible explanation for age-related difference in L2 speech acquisition is that the L1 phonetic system exerts a stronger influence for adults than for children because adults' L1 phonetic system is more fully developed. Alternatively, children's advantage might be attributed to not having passed a critical period for speech learning. Despite the widely held belief that youth confers an advantage in L2 learning, few studies have directly compared L2 learning by adults and children [16, 17] and virtually no studies have included age-matched native speaker controls as a yardstick for assessing the L2 performance of non-native adults and children.

This study compared the perception and production of the English vowels /ɛ/ and /æ/ by NK adults and children. The performance of these participants was compared to age-matched NE speakers. Both the NK and NE participants were tested on two occasions separated by about 1.2 years. The two English vowels examined here – /ɛ/ and /æ/ – occur in a portion of vowel space occupied by a single Korean vowel, and are of known learning difficulty for Koreans [5, 10].

The questions addressed in this study were: 1) Would the NK children perceive and produce the contrasts between English /ɛ/ and /æ/ better than NK adults with the same LOR in North America? 2) Would greater differences exist between NK and NE adults than between NK and NE children? 3) Would the NK children show greater evidence of speech learning from Time 1 to Time 2 than the NK adults?

2. PROCEDURE

2.1 Participants

A total of 108 individuals living in an English-speaking community in North America (Alabama, California, Illinois, Ontario, Texas) participated. As shown in Table 1, they were assigned to six groups of 18 each.

Group	N	Age	LOR	AOA
Child-NE	7m, 11f	12.7 (2.5)	--	--
Child-5	7m, 11f	13.7 (2.0)	4.9 (0.6)	8.9 (2.1)
Child-3	6m, 12f	12.3 (2.4)	2.9 (0.4)	9.4 (2.4)
Adult-NE	7m, 11f	32.3 (4.4)	--	--
Adult-5	5m, 13f	33.1 (5.3)	4.8 (0.6)	28.3 (5.2)
Adult-3	8m, 10f	30.4 (5.1)	3.0 (0.6)	27.4 (5.0)

Table 1: Mean characteristics of the six groups of participants. NE: = Native English; Age = chronological age; LOR = length of residence; AOA = age of arrival.

Participants in the two NE groups (Child-NE, Adult-NE) differed in age, as did two groups of NK children (Child-3, Child-5) and adults (Adult-3, Adult-5). The NK groups also differed in LOR in North America (3 vs. 5 years).

2.2 Analysis design

Results obtained in the perception and production

experiments were submitted to three-way ANOVAs in which Age (child, adult) and Experience with English (NE, LOR5, LOR3) served as between-subjects factors and Time of Testing (T1, T2) was a within-subjects factor.

3. EXPERIMENT 1: DISCRIMINATION

This experiment examined the categorial discrimination of English / ϵ / and / \ae / by age-matched NK and NE participants.

3.1 Methods

3.1.1 Stimuli

The stimuli were vowels originally produced in /bVbo/ non-words by eight NE males. The non-words were digitized at 22.05 kHz. Only the /bVb/ portion of the stimuli were retained. The stimuli were normalized for peak intensity, then presented over headphones at a comfortable level.

Three stimuli were presented on each trial. The participants' sensitivity to the / ϵ / vs. / \ae / contrast was assessed by eight "change" and eight "no-change" trials. The three vowel tokens presented on all change and no-change trials were spoken by different talkers. This meant that the stimuli in each trial were always physically, if not phonetically, different. The change trials contained an odd item out, that is, one vowel that differed categorically from the other two. These trials tested participants' ability to distinguish vowels drawn from two different categories. The odd item occurred with equal frequency in the three possible serial positions. The no-change trials contained three instances of a single vowel category. These trials tested participants' ability to ignore audible but phonetically irrelevant within-category variations. The inter-stimulus interval between the members of each triadic trial was 0.8 s.

3.1.2 Procedure

The participants were told to identify the serial position of the odd item out, if one was heard, by clicking a button marked "1", "2" or "3" on the computer screen. They were told to click a fourth button marked "NO" if they heard three instances of the same vowel. The participants were required to respond to each trial, and were told to guess if uncertain. A trial could be replayed, but responses could not be changed once given. A practice session with feedback preceded the experiment.

A' values were calculated to reduce bias using the formula provided by [15]. A score of 1.0 indicated perfect sensitivity; a score of 0.5 indicated a lack of phonetic sensitivity.

3.2 Results and discussion

As seen in Figure 1, the NE adults and children obtained higher A' scores than age-matched NK participants did. There was a significant effect of Age on the discrimination scores [$F(1, 102) = 8.0, p < 0.01$] and a significant effect of

Experience [$F(2, 102) = 52.6, p < 0.001$], but not a significant main effect of Time [$F(1, 102) = 2.3, p = 0.14$]. The significant Age x Experience interaction [$F(2, 102) = 8.2, p < 0.001$] was explored through simple effects tests. These tests revealed that both NK child groups (Child-3, Child-5) obtained lower scores than the NE children did; and both NK adult groups (Adult-3, Adult-5) obtained lower scores than the NE adults. The interaction seems to have arisen from a differing pattern of adult-child differences for NE and NK participants. Significantly higher scores were obtained for NE adults than NE children whereas the opposite held true for NK participants. Korean adults with an LOR of 5 years (Adult-5) obtained lower scores than Korean children with an LOR of 5 years (Child-5). However, participants with an LOR of 3 years (Adult-3, Child-3) did not differ significantly.

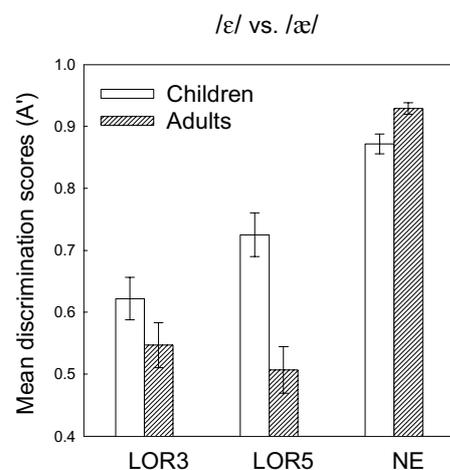


Figure 1: Mean discrimination scores obtained for six groups. The brackets enclose \pm one standard error. The scores are averaged over two times of testing.

Taken together, these findings suggest that the effect of additional L2 experience may depend on L2 learners' ages. Unlike some previous studies that failed to show an effect of LOR on vowel production [2, 3] and/or perception [3, 7] for adults, the NK children examined here seem to have benefited more from an extra two years of residence in North America than the NK adults did.

It is noteworthy that the NE children obtained significantly lower scores than the NE adults did. This suggests that the NE children had not yet reached maturity in perceiving the vowels of their L1. Alternatively, the NE adults' higher discrimination scores might have arisen from the use of stimuli that were produced by eight NE adults. Perhaps the NE adults were better attuned to vowels produced by NE adults than the NE children were. Whatever the explanation, the NE adult-child difference highlights the importance of comparing non-natives' L2 performance to that of age-matched native-speaker controls.

4. EXPERIMENT 2: PRODUCTION

4.1 Speech materials and elicitation

Pictures of each of 25 test words were shown on a computer

screen. At the same time, a native-speaker model of each word was presented via a loudspeaker. The test words of interest here contained / ϵ / (*bed, head, neck*) and / æ / (*bat, cat, hat*). The words were recorded, then digitized at 22.05 kHz. Vowels in the six words were transcribed phonetically, and measured acoustically.

4.2 Transcriptions

4.2.1 Procedure

A native English-speaking phonetician classified all 1,296 vowel tokens (108 participants \times 2 vowels \times 3 words \times 2 times of testing) as one of the 14 vowels of American English. The multiple tokens of each test word were randomly presented two times each in separate blocks. Each block contained 432 tokens (6 groups \times 18 participants \times 2 times of testing \times 2 random presentations). Vowel tokens not given the same classification both times (i.e., for both presentations) were randomly presented three times each in a subsequent session. The majority classification (2/3 or 3/3) was accepted as final.

4.2.2 Transcription results

The / æ / tokens were usually heard as intended. However, productions of / ϵ / by all groups were sometimes heard as / æ /. The NK adults' / ϵ /s were misheard as / æ / more than 50% of the time. Transcription data such as these provide useful information as to whether a vowel was produced in an identifiable way. However, vowels that were transcribed as the intended vowel might nonetheless have diverged modestly from the phonetic norms of English. It must also be remembered that participants were tested at five different locations in North America, so cross-dialect differences between the participants and the transcriber (born and raised in the Midwest of the United States) may have influenced the results. Therefore, the participants' vowel production was further assessed in a fine-grained acoustic analysis.

4.3 Acoustic measurements

4.3.1 Procedures

The frequencies of F0, F1 and F2 were measured at the midpoint of each vowel token to quantify the magnitude of / ϵ /-/ æ / contrasts. Following conversion from Hz values to bark, bark difference values for each token were derived. One indexed position in a high-low (F1-F0) dimension; the other indexed position in the front-back (F2-F1) dimension. Finally, the size of each participant's / ϵ /-/ æ / contrast was estimated by calculating the Euclidean distance between each participant's / ϵ / and / æ / in a two-dimensional (high-low vs. front-back) vowel space.

4.3.2 Results and discussion

Figure 2 shows the mean bark difference scores obtained for the six groups. The NK children produced much larger contrasts than the NK adults, but there was little difference between NE adults and children. An ANOVA examining the bark difference scores yielded significant main effects

of Age [$F(1, 102) = 39.7, p < 0.01$] and Experience [$F(2, 102) = 13.1, p < 0.01$], but not Time [$F(1, 102) = 1.7, p = 0.19$]. Simple effects tests carried out to explore the Age \times Experience interaction [$F(2, 102) = 9.56, p < 0.001$] revealed that the effect of Age was significant only for the NK participants (i.e., larger contrasts for Child-3 than Adult-3, and larger for Child-5 than Adult-5). There was no difference between the three child groups (Child-3, Child-5, Child-NE), whereas Adult-NE produced a larger contrast than Adult-3 and Adult-5. A similar pattern of findings was obtained for vowel discrimination in Experiment 1.

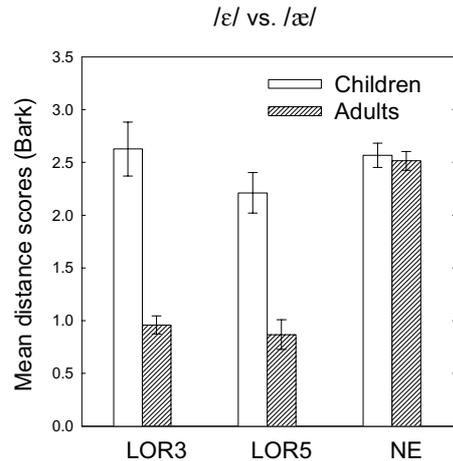


Figure 2: Mean acoustic distance between / ϵ / and / æ / by the six group of participants (in Bark). The brackets enclose \pm one standard error. The scores are averaged over two times of testing.

These results suggest that NK children have learned to produce and, to a lesser extent, perceive the distinction between English / ϵ / and / æ / in a native-like fashion following 3 years of residence in North America. The Child-5 group's discrimination resembled that of Child-NE to a somewhat greater extent than Child-3, but both groups of Korean children differed significantly from the NE children. This suggests the possibility that, at least for the NK children, development of native-like production occurred before native-like perception.

5. RELATIONSHIP BETWEEN L2 PRODUCTION AND PERCEPTION

The relationship between the production and perception of L2 sounds has been investigated in previous research [1, 3, 4, 6, 11, 12, 13, 14]. Some studies suggested that native-like perception may precede native-like production [1, 3] but others suggested the opposite [14]. It is generally agreed, however, that the relationship between the production and perception is complex, and is affected by factors such as amount of L2 experience [11].

The NK adults examined here differed from NE adults both in perceiving and producing English / ϵ / and / æ / whereas the NK children differed from the NE children only in perception. This pattern might be taken to mean that L2 learners will come to produce L2 vowels accurately before

developing the ability to perceive L2 vowels in a native-like fashion. However, there are reasons for caution with respect to such a conclusion.

First, there are difficulties inherent to comparing production and perception data [4, 8]. Level of difficulty of the tasks used in Experiments 1 and 2 may not have been equivalent. (Perhaps the discrimination test was cognitively more demanding than the picture-naming task.) Secondly, the results obtained here for /ɛ/ and /æ/ might not generalize to other vowel contrasts, and might not be replicated if the vowels were examined in greater detail. Finally, previous research suggests that the social consequences of non-native production and perception differ [12, 13]. Social factors might interact with age, and might exert a stronger effect on children than adults. For example, children might feel less pressure to demonstrate “language loyalty” by speaking with a foreign accent than adults do. The present study suggests that chronological age should be added to the list of factors that influence the relationship between segmental L2 perception and production.

6. CONCLUSION

The present study demonstrated that the NK children more closely resembled NE children than NK adults resembled NE adults in producing and perceiving English /ɛ/ and /æ/. It would be a mistake, however, to interpret this as evidence for a critical period in language learning. All we can infer from this pattern is that the adults are relatively disadvantaged compared to the children, but we have no evidence regarding the trajectory of that disadvantage. Joining two disparate points (young children, middle aged-adults) tells us nothing about the path between those points. As shown in [9], the pattern of acquiring second language proficiency across the lifespan, measured from 0 to 80 years old, reveals a straight and gradually decreasing curve and not a critical period. Many factors are responsible for the slope of the curve, including cognitive changes, education level, and social and motivational factors.

The critical period hypothesis predicts native-like performance by the NK children, but this was not the case in this study. The NK children did not differ from the NE children in producing a distinction between English /ɛ/ and /æ/, but they failed to discriminate these as accurately as NE children did. This suggests a mismatch in the rate at which the NK children learned to produce and perceive the English vowels.

7. ACKNOWLEDGEMENTS

This research was supported by NIH grant DC02892. The authors thank Lance Gunnin for help collecting data.

REFERENCES

- [1] Borden, G., Gerber, A. and Milsark, G., “Production and perception of the /r/-/l/ contrast in Korean adults

- learning English”, *Language Learning*, **33**(4), pp. 499-526, 1983.
- [2] Flege, J. E., “Factors affecting degree of perceived foreign accent in English sentences”, *JASA*, **84**(1), pp. 70-79, 1988.
- [3] Flege, J. E., “Production and perception of a novel, second-language phonetic contrast”, *JASA*, **93**(3), pp. 1589-1608, 1993.
- [4] Flege, J. E., “The relation between L2 production and perception”, *Proceedings of the XIVth ICPHS*, pp. 1273-1276, 1999.
- [5] Flege, J. E., Bohn, O.-S. and Jang, Y., “Effects of experience on non-native speakers’ production and perception of English vowels”, *J. of Phonetics*, **25**(4), pp. 437-470, 1997.
- [6] Flege, J. E., MacKay, I. R. and Meador, D., “Native Italian speakers’ perception and production of English vowels”, *JASA*, **106**(5), pp. 2973-2987, 1999.
- [7] Flege, J. E., Munro, M. J. and Fox, R. A., “Auditory and categorical effects on cross-language vowel perception”, *JASA*, **95**(6), pp. 3623-3641, 1994.
- [8] Gass, S., “Development of speech perception and speech production abilities in adult second language learners”, *Applied Psycholinguistics*, **5**(1), pp. 51-74, 1984.
- [9] Hakuta, K., Bialystok, E. and Wiley, E. “Critical evidence: A test of the critical period hypothesis for second language acquisition”, *Psychological Science*, **14**(1), pp. 31-38, 2003.
- [10] Ingram, J. C. and Park, S-G., “Cross-language vowel perception and production by Korean and Japanese listeners”, *J. of Phonetics*, **25**(3), pp. 343-370, 1997.
- [11] Listerri, J., “Relationships between speech production and speech perception in a second language”, *Proceedings of the ICPHS 95*, **4**, pp. 92-99, 1995.
- [12] Mack, M., “Consonant and vowel perception and production: Early English-French bilinguals and English monolinguals”, *Perception and Psychophysics*, **46**(2), pp. 187-200, 1989.
- [13] Sheldon, A., “The relationship between production and perception of the /r/-/l/ contrast in Korean adults learning English: A reply to Borden, Gerber, and Milsark”, *Language Learning*, **35**(1), pp. 107-113, 1985.
- [14] Sheldon, A. and Strange, W., “The acquisition of /r/ and /l/ by Japanese learners of English: Evidence that speech production can precede speech perception”, *Applied Psycholinguistics*, **3**(3), pp. 243-261, 1982.
- [15] Snodgrass, J., Levy-Berger, G. and Haydon, M., “Human Experimental Psychology”, Oxford U. P., Oxford, 1985.
- [16] Snow, C. E. and Hoefnagel-Höhle, M., “Age differences in the pronunciation of foreign sounds”, *Language and Speech*, **20**(4), pp. 357-365, 1977.
- [17] Snow, C. E. and Hoefnagel-Höhle, M. “The critical period for language acquisition: Evidence from second language learning”, *Child Development*, **49**(4), pp. 1114-1128, 1978.