Running Head: Childhood Language Memory

Holding on to Childhood Language Memory

Janet S. Oh, Sun-Ah Jun, & Leah M. Knightly

University of California, Los Angeles

Terry Kit-fong Au

The University of Hong Kong

Abstract

While early language experience seems crucial for mastering phonology, it remains unclear whether there are lasting benefits of speaking a language regularly during childhood if the quantity and quality of speaking drop dramatically after childhood. This study explored the accessibility of early childhood language memory. Specifically, it compared perception and production of Korean speech sounds by childhood speakers who had spoken Korean regularly for a few years during childhood to those of two other groups: 1) childhood hearers who had heard Korean regularly during childhood but had spoken Korean minimally, if at all, and 2) novice learners. All three groups were enrolled in first-year, college Korean language classes. Childhood speakers were also compared to native speakers of Korean to see how native-like they were. The results revealed measurable long-term benefits of childhood speaking experience, underscoring the importance of early language experience, even if such experience diminishes dramatically beyond childhood.

Holding on to Childhood Language Memory

1. Introduction

Exposure to a language during early childhood seems crucial to mastering its phonology. Age of onset of immersion is by far the best predictor of ultimate phonological abilities; length of exposure, by contrast, seems to matter much less for late language learners (e.g., *first language*: Koluchova, 1972, 1976; Fromkin, Krashen, Curtiss, Rigler, & Rigler, 1974; Skuse, 1984a,b; *second language*: Oyama, 1976; Williams, 1980; Flege, 1987, 1991). However, it remains unclear whether continued regular exposure to a language is necessary to maintain the benefits of early exposure. In this study we examine what it may take to preserve the benefits of childhood language experience.

Childhood language memory can become seemingly inaccessible if language input is cut off early in life. Pallier and colleagues (2001) found that monolingual adult speakers of French who had been adopted as monolingual Korean-speaking children from Korea to France between ages three and eight years seemed unable to recognize Korean as adults; adoptees' event-related fMRI activation patterns did not differ while listening to Polish (an unfamiliar language) and Korean. Moreover, adoptees' activation patterns for French and Korean did not differ from those of native French speakers who had no prior exposure to Korean.

Other studies, however, suggest that childhood language memory can remain accessible in adulthood. English-speaking adults who had heard Hindi regularly during infancy could distinguish between Hindi speech sounds much better than those who had no prior exposure to Hindi (Tees & Werker, 1984). Additionally, Penfield (1959) observed anecdotally that, after having a German governess for two years during early childhood, his four children re-acquired German during adolescence and early adulthood with good accents.

Why does early language experience show lasting benefits in some cases but not others? It may have to do with the different aspects of memory involved: *storage strength* for a memory depends on how well something was learned originally, while *retrieval strength* depends on current usage (R. Bjork & E. Bjork, 1992; E. Bjork & R. Bjork, 1996). Adoptees in Pallier et al.'s study probably had strong storage strength but minimal retrieval strength for Korean because they stopped hearing Korean upon adoption. By contrast, participants in Tees and Werker's study grew up in Hindi-Canadian communities and may have maintained considerable retrieval strength for Hindi phonemes just by hearing them in accented English. Additionally, Penfield's children could have built up retrieval strength for German upon re-learning it (see Bjork & Bjork, 1996). Intriguingly, a childhood language apparently can become accessible under age-regressed hypnosis (e.g., Ås, 1962; Fromm, 1970), suggesting that storage strength could persist with minimal retrieval strength even after years of disuse.

Stopping short of hypnosis, can childhood language memory stay accessible? In this study, we explored what happens when children become virtually monolingual in a second language and then try to re-learn their first language as adults. We focused on the phonological abilities in Korean of adults who had spoken exclusively or predominantly Korean prior to starting school around age 5 and very little Korean afterward. Importantly, this sharp drop in speaking Korean occurred near the end of the critical/sensitive period for phonology acquisition (e.g., Williams, 1980; Long, 1990).

Childhood speakers were compared to three other groups: 1) novice adult learners—to assess the benefits of childhood exposure to Korean; 2) childhood *hearers* of Korean who had heard Korean regularly throughout childhood but had spoken the language minimally, if at all—to assess the benefits of childhood *speaking* per se because, like childhood hearers, childhood

speakers typically hear Korean throughout childhood; and 3) native Korean speakers—to see how native-like childhood speakers' phonology was. All participants were tested on their perception and production of Korean phonemes. Compared to novice learners, childhood speakers were expected to be more native-like in both perception and production. Compared to childhood hearers, they should be comparable for perception and more native-like for production.

Some childhood speakers spoke Korean occasionally even after their dramatic drop in speaking Korean. To see if such minimal language use makes a difference in maintaining sufficient retrieval strength for childhood language memory, we explored whether the quantity and quality of Korean spoken beyond early childhood predicted childhood speakers' accent as adult learners.

2. Method

2.1 Participants

Thirty-one participants were recruited four months after they started first-year, college Korean language classes. Twelve native speakers of Korean were also recruited from the same university.

2.2 Materials and Procedure

Participants answered a language background questionnaire, took a language abilities test, and then had a follow-up interview. The language abilities test was run using PsyScope (Cohen, MacWhinney, Flatt, & Provost, 1993) and included a childhood slang test, a phoneme perception task, and a phoneme production task. (Test materials are available upon request.)

2.2.1 Language background assessment

Participants first answered a detailed questionnaire that included general questions about

language background (e.g., participant's first language, parents' language abilities) and specific questions about the quantity (e.g., how much they heard, were spoken to, and spoke Korean) and quality (e.g., words/short phrases/sentences; extent of mixing with English) of their experience with Korean since birth. A follow-up interview offered a chance to clarify questionnaire responses.

To corroborate their self-reports, we assessed participants' knowledge of Korean childhood slang. Fifteen English expressions (e.g., "spoiled", "a spanking") were presented on a computer screen, and participants were asked to translate them aloud using Korean expressions that are heard at home or on the playground, rather than vocabulary learned in Korean classes (*slang production test*). They also heard 15 Korean childhood slang terms over headphones and were asked to translate them into English (*slang comprehension test*). Responses were audio-taped and later evaluated against a list of acceptable responses compiled by Korean-English bilingual research assistants. Because native speakers tend to use these terms around children, the ability to produce and understand them should be a good indicator of childhood experience with Korean. We have used this task in prior research, and it agrees well with independent reports given by informants who knew the participants' childhood language experience (Au, Knightly, Jun, & Oh, 2002).

2.2.2 Phoneme perception and production

2.2.2.1 Target consonants. Target consonants were the three denti-alveolar Korean stop consonants. While English alveolar stop consonants utilize a two-way contrast (/d/ and /t/), Korean utilizes a three-way contrast: referred to here as plain, aspirated, and tense consonants (/t/, /t^h/, and /t'/ respectively). A primary distinguishing acoustical feature among stop consonants in both English and Korean is voice onset time (VOT), which refers to the time from

the stop release (when the airway is opened) to the onset of voicing of the following vowel (vocal cord vibration). VOT is an informative phonetic measure widely used in assessing phonology (e.g., Williams, 1979). While the VOT of Korean denti-alveolar stop consonants vary even among native speakers, there are clearly three distinct categories, with the longest VOT for aspirated consonants and shortest for tense (Table 1).

2.2.2.2 Phoneme perception task. Participants heard a native Korean speaker say nine words from three minimal triplets (see Appendix). Within each triplet, words varied only on the target consonant. In each trial, participants heard a word via headphones, saw the entire triplet presented in Korean orthography[1] on a computer screen, and were asked to indicate which word they heard by pressing a button. Each stimulus word was presented six times in random order, evenly divided in separate blocks of phrase-initial and phrase-medial target consonant.

2.2.2.3 Phoneme production task. The same nine stimulus words were presented three times each in random order. Participants were asked to read aloud sentences presented in Korean orthography on a computer screen. Roughly the first half of participants read "igon _____ ipnita" (English gloss: "this is a _____"); later participants read "igae _____ ipnita" (similar meaning; change was made to facilitate phonetic measurements).

2.3 Phoneme Production Assessment

2.3.1 Phonetic measurements

Utterances from the phoneme production task were digitized at a sampling rate of 12.5 kHz to measure the VOT of target consonants. Measurements were made from spectrograms of the digitized utterances by four measurers who were unaware of speakers' language experience. Inter-measurer reliability was excellent (single-measure intraclass R's = 0.96 to 0.99; all ps < 0.001).

2.3.2 Accent ratings

Eight additional native Korean speakers were recruited to rate the accents of participants' utterances from the phoneme production task, using a five-point scale ranging from 1 (pronunciation with a very strong foreign accent: definitely non-native) to 5 (pronunciation with no foreign accent: definitely native). Inter-rater reliability was excellent (intraclass R's = 0.93 to 0.95; all ps < 0.01). An accent rating score was computed for each speaker-participant by averaging across raters.

3. Results

3.1 Language Background Assessment

Two coders, using questionnaire and interview responses, independently categorized the participants as: native speaker, childhood speaker, childhood hearer, and novice learner (*Cohen's kappa* = 0.78; discrepancies between coders resolved through discussion). Groups consisted of:

12 **native speakers** (7 female, 5 male) who were born in Korea, immigrated to the U.S. after age 12 (M = 17.2, SE = 1.2), and regularly spoke Korean throughout their lives.

15 **childhood speakers** (12 female, 3 male) who had spoken Korean regularly for at least three years during early childhood and experienced a sharp drop in speaking Korean by age 7 (M = 5.3, SE = 0.3). Most were born in the U.S; four were born in Korea and immigrated to the U.S. between birth and age 5. Prior to the drop in speaking Korean, Korean was their dominant language; on average, they spoke in Korean sentences and phrases for 28.6 hours/week (SE = 2.4). After the drop, if they spoke Korean at all, it became mostly isolated words and short phrases (M = 3.9 hours/week, SE = 1.2). Although childhood speakers estimated that they spent nearly 4 hours/week around people with whom they spoke Korean, ethnographies of immigrant

families in the U.S. suggest that once children become virtually monolingual in English, they rarely talk to their relatives who speak little or no English even when they are together (e.g., Fillmore, 1991; Kouritzin,1999).

6 **childhood hearers** (3 female, 3 male) who had regularly heard Korean during childhood but had rarely spoken it, if at all. Four were born in the U.S.; two were born in Korea and immigrated to the U.S. before they were a year-old. Before age 5, they had, on average, heard Korean 40.3 hours/week (*SE* = 6.8). After this, they heard Korean for about 4.6 hours/week (*SE* = 2.1). Ethnographies also reveal that childhood hearers in the U.S. rarely interact with their relatives who speak little or no English (e.g., Kouritzin, 1999).

10 **novice learners** (6 female, 4 male) who had no experience with Korean until college Korean classes.

Childhood slang knowledge corroborated participants' self-reports: novice learners had the lowest scores, followed by childhood hearers, then childhood speakers, and native speakers had the highest scores (Table 2).

3.2 Phoneme Perception

A one-way *ANOVA* comparing the four groups on phoneme perception scores revealed reliable group differences (F (3,39) = 20.28, MSE = 0.01) and a reliable linear trend (F (1,39) = 45.08; ps < 0.001). Childhood speakers did not reliably differ from native speakers or childhood hearers, but that they reliably outperformed novice learners (p < 0.001 by HSD test; Table 3).

3.3 Phoneme Production

3.3.1 Phonetic measurements.

As mentioned earlier, aspirated consonants have the longest VOT and tense consonants have the shortest. This pattern held for every participant group (Table 4; data for 2 novice

learners, 2 childhood speakers, and 1 native speaker missing due to equipment failure). To see if each group reliably contrasted these three consonants, we compared the VOT measurements for each consonant pair (i.e., aspirated-plain, plain-tense, aspirated-tense) separately for each of the four participant groups, resulting in twelve planned, paired *t*-tests (Table 5). Childhood speakers and native speakers reliably contrasted all three consonants (*p*s < 0.01), whereas novice learners and childhood hearers did not for any pair (*p*s > 0.10).

3.3.2 Accent rating.

A one-way *ANOVA* comparing the four groups on accent rating scores revealed reliable group differences (F (3,34) = 41.35, MSE = 0.30) and a reliable linear trend (F (1,34) = 121.38; *p*s < 0.001; Table 6). While outperformed by native speakers, childhood speakers outperformed childhood hearers and novice learners (*p*s < 0.05, by HSD test).

3.4 Korean Spoken Beyond Early Childhood

To explore the role of retrieval strength for childhood language memory in childhood speakers' abilities, we examined correlations between accent rating scores and both the quantity (how many hours/week) and quality (nature of utterance: Korean words, short phrases, or sentences; mostly English, mostly Korean, or half and half) of Korean spoken during three periods after their sharp drop in speaking Korean: elementary, middle, and high school. Accent rating scores were not reliably correlated with *quantity* of post-drop spoken Korean, but they were reliably correlated with *quality* of spoken Korean during elementary school (r = .59) and high school (r = .63; *p*s < 0.05; Figure 1). Analogous analyses with VOT data revealed no reliable correlations.

Because quality of Korean spoken beyond early childhood was reliably related to childhood speakers' accents, we wondered what childhood speakers who spoke no Korean or

virtually no Korean beyond early childhood sound like. We therefore re-ran all of our production analyses on six such childhood speakers in our sample; three who spoke no Korean after early childhood, and three others who spoke no more than short Korean phrases or isolated Korean words within mostly English or half English-half Korean utterances. This sub-sample of six childhood speakers knew fewer Korean childhood slang terms than the remaining nine (*production*: 33.8%, t (12) = 2.01, $p < 0.10$, data missing for 1 sub-sample participant; *comprehension*: 24.8%, t (13) = 3.00, $p < 0.05$). Importantly, the sub-sample reliably contrasted aspirated and tense consonants (t (3) = 3.35, $p < 0.05$; data missing for 2 participants), almost reliably contrasted aspirated and plain consonants (t (3) = 3.14, $p = 0.052$), but not plain and tense consonants (t (3) = 1.32, *n.s.*). Mean accent rating for the sub-sample was 2.68 (SE = 0.2). Like the full sample of childhood speakers, this was reliably better than the novice learners but worse than native speakers (ps < 0.05). Unlike the full sample, they were not reliably better than the childhood hearers.

4. Discussion

Childhood speakers were as good as native speakers at hearing the phonemic contrasts of their childhood language, outperforming the novice learners. Their phoneme production was quite native-like and outperformed novice learners and childhood hearers, highlighting the benefits of childhood speaking experience. Furthermore, their accent rating scores suggest that this advantage in phonology goes beyond just individual phonemes. Together, these findings not only underscore the importance of early language experience, but also suggest that the benefits of early language experience are long lasting even with little or no subsequent experience with the language.

The nature of early language experience seems to be important: childhood hearers

outperformed novice learners in the perception but not production of Korean phonemes, whereas childhood speakers outperformed childhood hearers and novice learners in both phoneme production and whole-sentence accent. Thus, early hearing experience helped later perception and early speaking experience helped later production. As logical as it sounds, this is probably not the whole story. We have found that childhood overhearing experience can have lasting benefits for phonology production in Spanish (Au et al., 2002). One possible explanation for these seemingly discrepant findings is the duration of re-learning. The childhood overhearers of Spanish had four to five years of Spanish classes, while the childhood hearers in this study had only four months of Korean instruction. Perhaps it takes several years of re-learning to reveal the benefits of childhood hearing on phonology production. Another possible explanation is the relative difficulty of the phonemic contrasts. While Spanish, like English, utilizes a two-way contrast in stop consonants (although with different VOT boundaries), Korean utilizes a three-way contrast. Mastery of this three-way contrast may require childhood speaking experience. Whatever the true reason, these findings highlight how the nature of language experience can affect language acquisition.

We also found that while the quantity of Korean spoken after early childhood did not predict childhood speakers' accents as adults, quality did. Our analyses on the sub-sample of childhood speakers who spoke virtually no Korean beyond early childhood suggested that speaking Korean for several years during early childhood by itself suffices to help adult learners speak with a good accent. Perhaps re-learning a childhood language helps adult learners build up sufficient retrieval strength to capitalize on the considerable storage strength of their childhood language memory. This means not only savings in learning efforts for re-learners (e.g., Luh, 1922; Kruger, 1929; Ebbinghaus, 1964), but perhaps more importantly for language

development, it means saving childhood learning that cannot be easily accomplished by adult learners due to a sensitive/critical period of acquisition. Meanwhile, continued—even only occasional—use beyond early childhood probably serves to maintain sufficient retrieval strength, resulting in additional measurable benefits for adult re-learners. Given the potential of re-learning to tap childhood language memory, it would be interesting to see whether adoptees such as those in Pallier et al.'s (2001) study would see lasting benefits of childhood speaking experience upon re-learning their childhood language.

This study constitutes a first step in exploring the accessibility of childhood language memory in adulthood. It remains to be seen whether such early language experience has lasting benefits for adult re-learners beyond phonology.

Author Note

Janet S. Oh, Department of Psychology, University of California, Los Angeles (UCLA). Sun-Ah Jun, Department of Linguistics, UCLA. Leah M. Knightly, Department of Psychology, UCLA. Terry Kit-fong Au, Department of Psychology, the University of Hong Kong.

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Correspondence concerning this article should be addressed to Janet S. Oh, UCLA Psychology Department, Box 951563, Los Angeles, CA 90095-1563, U.S.A. Email: janetoh@ucla.edu.

Appendix

Stimuli Used in Phoneme Perception and

Production Tasks (and English Translations)

[taN][a] (a crowd)	[tal] (the moon)	[t@k][b] (virtue)
[t'aN] (the earth)	[t'al] (daughter)	[t'@k] (cake)
[t^haN] (hot water)	[t^hal] (mask)	[t^h@k] (chin)

a: [N] represents the velar nasal sound (as in the last sound of 'sing').

b: [@] represents the mid-central vowel (as in the middle sound of 'sun').

References

Ås, A. (1962). The recovery of forgotten language knowledge through hypnotic age regression: A case report. *American Journal of Clinical Hypnosis, 5,* 24-29.

Au, T. K., Knightly, L. M., Jun, S.-A., & Oh, J. S. (2002). Overhearing a Language During Childhood. *Psychological Science, 13,* 238-243.

Bjork, E. L. & Bjork, R. A. (1996). Continuing influences of to-be-forgotten information. *Consciousness and Cognition: An International Journal, 5,* 176-196.

Bjork, R. A. & Bjork, E. L. (1992). A new theory of disuse and an old theory of stimulus fluctuation. In A. Healy, S. Kosslyn, & R. Shiffrin (Eds.), *From learning processes to cognitive processes: Essays in honor of William K. Estes* (Vol. 2, pp. 35-67). Hillsdale, N. J.: Erlbaum.

Cohen, J. D., MacWhinney, B., Flatt, M., & Provost, J. (1993). PsyScope: A new graphic interactive environment for designing psychology experiments. *Behavioral Research Methods, Instruments, and Computers, 25(2),* 257-271.

Ebbinghaus, H. (1964). *Memory: A contribution to experimental psychology* (H. A. Ruger & C. E. Bussenius, translators; original work published 1885). New York: Dover.

Fillmore, L. W. (1991). When learning a second language means losing the first. *Early Childhood Research Quarterly, 6,* 323-346.

Flege, J. (1987). A critical period for learning to pronounce foreign languages? *Applied Linguistics, 8,* 162-177.

Flege, J. (1991). Age of learning affects the authenticity of voice-onset time (VOT) in stop consonants produced in a second language. *Journal of the Acoustical Society of America, 89(1),* 395-411.

Fromkin, V. A., Krashen, S., Curtiss, S., Rigler, D., & Rigler, M. (1974). The development of language in Genie: A case of language acquisition beyond the "critical period." *Brain and Language, 1,* 81-107.

Fromm, E. (1970). Age regression with unexpected reappearance of a repressed childhood language. *International Journal of Clinical and Experimental Hypnosis, 18,* 79-88.

Han, M. S. & Weitzman, R. S. (1970). Acoustic features of Korean /P,T,K/, /p,t,k/, and /p^h,t^h,k^h/. *Phonetica, 22,* 112-128.

Koluchova, J. (1972). Severe deprivation in twins: A case study. *Journal of Child Psychology and Psychiatry, 13,* 107-114.

Koluchova, J. (1976). The further development of twins after severe and prolonged deprivation: A second report. *Journal of Child Psychology and Psychiatry, 17,* 181-188.

Kruger, W. C. F. (1929). The effects of the degree of overlearning on retention. *Journal of Experimental Psychology, 12,* 71-78.

Kouritzin, S. G. (1999). *Face(t)s of First Language Loss.* Mahwah, NJ: Erlbaum.

Lisker, L. & Abramson, A. S. (1964). Cross-language study of voicing in initial stops: Acoustical measurements. *Word, 20,* 384-422.

Long, M. H. (1990). Maturational constraints on language development. *Studies in Second Language Acquisition, 12(3),* 251-285.

Luh, C. W. (1922). The conditions of retention. *Psychological Monographs, 142.*

Oyama, S. (1976). A sensitive period for the acquisition of a nonnative phonological system. *Journal of Psycholinguistic Research, 5(3),* 261-283.

Pallier, C., Dehaene, S., Poline, J.-B., LeBihan, D., Argenti, A.-M., Dupoux, E., & Mehler, J. (2001). *Brain imaging of language plasticity in adopted adults: Can a second language*

replace the first? Manuscript submitted for publication.

Penfield, W. (1959). The learning of languages. In W. Penfield & L. Roberts (Eds.), *Speech and Brain Mechanisms.* Princeton, NJ: Princeton University Press.

Skuse, D. H. (1984a). Extreme deprivation in early childhood-I: Diverse outcomes for 3 siblings from an extraordinary family. *Journal of Child Psychology and Psychiatry, 25,* 523-541.

Skuse, D. H. (1984b). Extreme deprivation in early childhood-II: Theoretical issues and a comparative review. *Journal of Child Psychology and Psychiatry, 25,* 543-572.

Tees, R. C. & Werker, J. F. (1984). Perceptual flexibility: Maintenance or recovery of the ability to discriminate non-native speech sounds. *Canadian Journal of Psychology, 38(4),* 579-590.

Williams, L. (1979). The modification of speech perception and production in second-language learning. *Perception & Psychophysics, 26,* 95-104.

Williams, L. (1980). Phonetic variation as a function of second-language learning. In G. H. Yeni-Komshian, J. F. Kavanagh, & C. A. Ferguson (Eds.), *Child Phonology* (pp. 185-215). New York: Academic Press.

Footnotes

1. Our assessment required participants to read Korean orthography. Our participants' Korean language professor assured us that Korean orthography is fairly easy to master; students can generally read it by the fourth week of classes and should be very familiar with it by the fifth month of classes, when we assessed them. Nonetheless, to minimize the impact of variability in reading skills in Korean among participants, one option for future research is to use pseudowords as stimuli.

Figure Caption

Figure 1. Relation between childhood speakers' accent rating scores and quality of Korean spoken during elementary school and high school. "Quality of spoken Korean" was calculated as a score from 0 to 6 based on the participants' report of whether they spoke: 1) Korean words, short phrases, or sentences and 2) utterances composed of mostly English, half English-half Korean, or mostly Korean. If the participant spoke no Korean, they were assigned a score of 0. Participants who did speak Korean were assigned a score from 1 (Korean words within mostly English utterances) to 6 (Korean sentences within mostly Korean utterances).

Figure 1

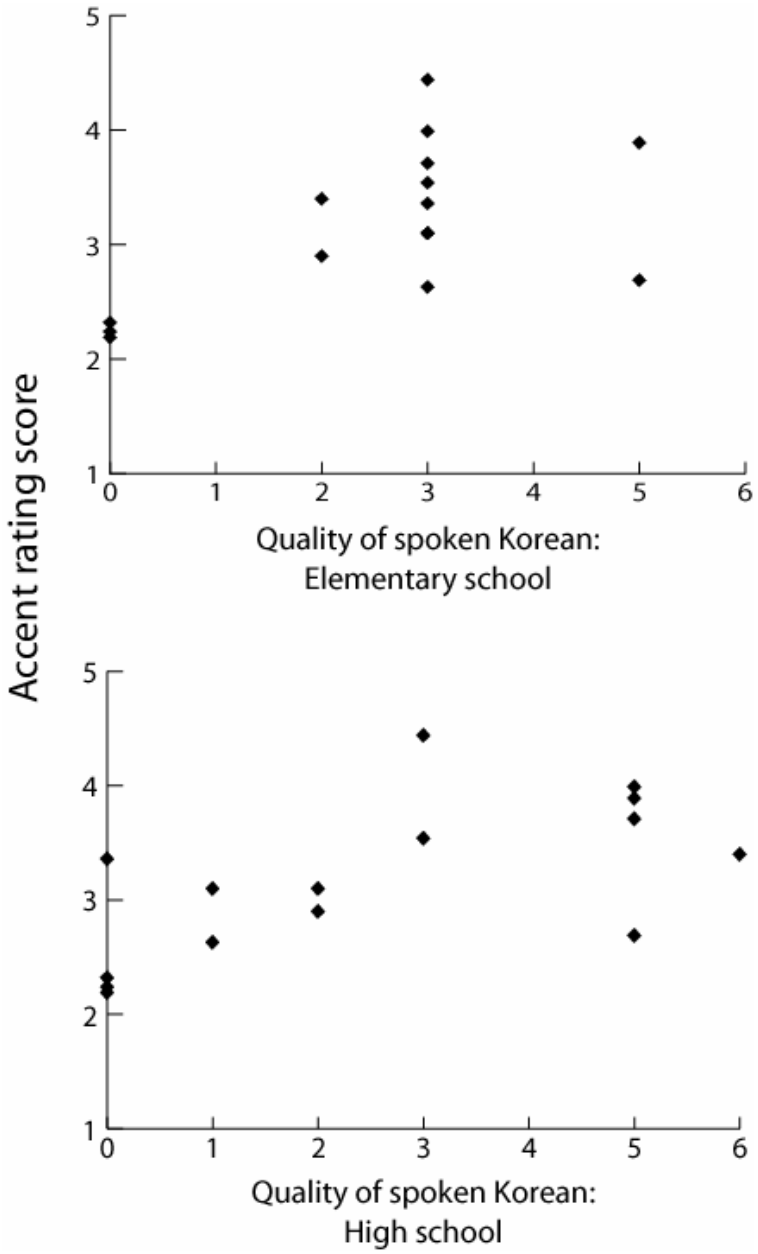
Accent rating score
Quality of spoken Korean:
Elementary school
Quality of spoken Korean:
High school

Table 1

Mean Voice Onset Time of Korean Denti-Alveolar Stop Consonants in msec

	aspirated /t^h/	plain /t/	tense /t'/
Lisker & Abramson (1964)	100 (75-130)[a]	30 (15-40)	11 (0-20)
Han & Weitzman (1970)[b]	104 (45-190)	26 (10-80)	8 (2.5-25)

a: The range of VOT values are given in parentheses.

b: Average values were computed from the individual informant values reported by these authors.

Table 2

Childhood Slang Test: Mean Percent Correct (with standard errors) by Group

	Production	Comprehension
Novice Learner	0.7(0.7)[a]	0(0)[a]
Childhood Hearer	32.1(7.3)[b]	25.8(9.5)[a,b]
Childhood Speaker	48.7(6.1)[b,c]	43.1(6.2)[b,c]
Native Speaker[1]	68.2(8.8)[c]	64.7(7.8)[c]

Within each column, means with different superscripts differed reliably ($p < 0.05$ by HSD post-hoc test), means with the same superscript did not differ reliably.

1: The native Korean speakers' somewhat limited English proficiency may have accounted for their less than perfect scores on this test. While they might know the Korean slang terms, they sometimes did not know how to translate them into English (slang comprehension) or did not understand the stimulus expressions in English (slang production).

Table 3

Phoneme Perception Task: Percent Correct Responses (with standard errors) by Group

Novice Learner	61.3(3.4)[a]
Childhood Hearer	88.3(4.4)[b]
Childhood Speaker	89.4(2.9)[b]
Native Speaker	98.6(3.1)[b]

Means with different superscripts differed reliably ($p < 0.01$ by HSD post-hoc test), means with the same superscript did not differ reliably.

Table 4

Phoneme Production Task: Mean VOT (with standard errors) in msec by Group

	Aspirated	Plain	Tense
Novice Learner	68(8)	57(9)	47(9)
Childhood Hearer	64(17)	36(9)	33(19)
Childhood Speaker	109(5)	75(9)	29(8)
Native Speaker	97(5)	78(5)	11(1)

Table 5

Phoneme Production Task: Pair-wise t-statistics for VOT Contrasts by Group

Consonant Pair:	Aspirated-Plain	Aspirated-Tense	Plain-Tense	*d.f.*
Novice Learner	0.90	1.77	1.76	7
Childhood Hearer	1.96	1.68	0.14	5
Childhood Speaker	5.33*	10.18*	4.14*	12
Native Speaker	4.73*	17.72*	12.01*	10

*: $p < 0.01$

Table 6

Phoneme Production Task: Mean Accent Ratings (with standard errors) by Group

Novice Learner	1.90 (.16)[a]
Childhood Hearer	2.56(.28)[a]
Childhood Speaker	3.30(.17)[b]
Native Speaker	4.59(.13)[c]

Means with different superscripts differed reliably ($p < 0.05$ by HSD post-hoc test), means with the same superscript did not differ reliably.