Why are Korean tense stops mastered early? evidence from production and perception.

Eun Jong Kong[1], Mary E. Beckman[2], Jan Edwards[1]
[1] University of Wisconsin-Madison, [2] The Ohio State University

BACKGROUND

1. Cross-linguistic generalization
- Stops with "unmarked" short-lag VOT values are usually mastered first in languages with a 2-way laryngeal contrast: /b, d, g/ in English, /p, t, k/ in French, Japanese, etc.

2. Three-way laryngeal contrast in Korean stops

lax /p, t, k/ vs. **tense** /p', t', k'/ vs. **aspirated** /p^h, t^h, k^h/
e.g., /tal/ *moon* vs. /t'al/ *daughter* vs. /t^{h}al/ *mask*

tense stops are "marked" by multiple acoustic cues
- **Voice Onset Time (VOT):** the tense stop is the short lag VOT category, but ..
- **F0:** the tense stop has higher F0, suggesting tensing to actively prevent voicing
- **H1-H2**: the tense stop has negative values, reflecting its pressed voiced quality.

3. Mastery pattern of Korean stops

Transcription-based studies (Kim, Y, 1996; Kim & Pae, 2005; Kim, M, 2008) describe:
- All 3 types (lax, tense, and aspirated) mastered by three years.
- **Tense stops** appear first in youngest children's productions (before 2;6)

4. Research question
- **Does the VOT pattern explain the early mastery of tense stops?** Given the multiplicity of acoustic cues, we need to show that native speakers weigh VOT more than other features in assimilating children's stop productions to the adult norms.

5. Goals
- Reproduce the results of earlier transcription studies in a large cross-sectional study.
- Answer question in 4. by exploring relationships between **native speaker percept** (trained transcriptions and naïve adults' ratings) of children's stop productions and the **three acoustic characteristics (VOT, F0, H1-H2).**

METHODS

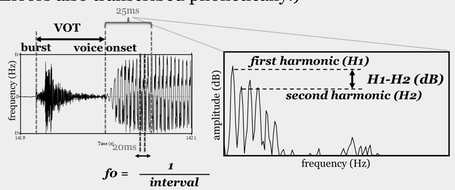
I. Transcription Study

Materials: word-initial coronal and dorsal stops embedded in real words (/i, a, u/ context)
e.g., /taŋ.gɨn/ carrot, /t'al.gi/ strawberry, /t^{h}a.dʒo/ ostrich

Participants:
- 70 Korean-speaking children (24 mo. ~ 72 mo.) and 20 adults (10 males and 10 females: 18-30 years) were tested in Seoul, Korea.

Task: A picture-prompted auditory word-repetition task.

Analysis:
- **Accuracy judgment measures:** native speaker **transcriptions** of 'correct' or 'incorrect' in children's stop productions. (Errors also transcribed phonetically.)
- **Acoustic measures:** All productions identified as correct or transcribed as plosives if incorrect acoustically analyzed as shown in figure to right in order to measure **VOT**, **F0** and **H1-H2.**



- **Statistical analysis:** Mixed effects logistic regression models:
  a. **Transcribed accuracy** as a function of **age**
  b. **Transcribed category** as a function of **acoustic parameters.**

II. Perception Study

Materials:
- a subset of adults and children's tokens of /t/- /t^h/- and /t'/-initial words used in the transcription study: only CV portion.
- 400 stimuli (350 from children's productions and 50 from adults' productions) chosen based on the stop VOT values to reflect the whole range of the natural data from the production experiment.

Participants: 20 Korean-speaking adult listeners

Task: After each stimulus item was played, listeners were asked to select one stop category as their choice by clicking on the Hangul character on the screen.

RESULTS

1. Transcription Accuracy/Error Analysis

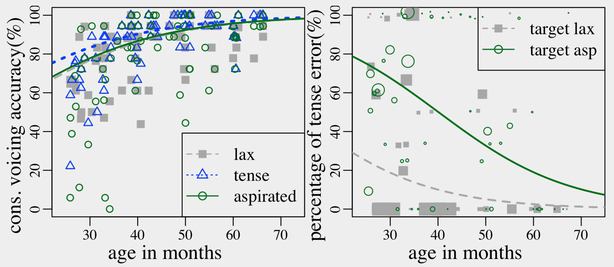
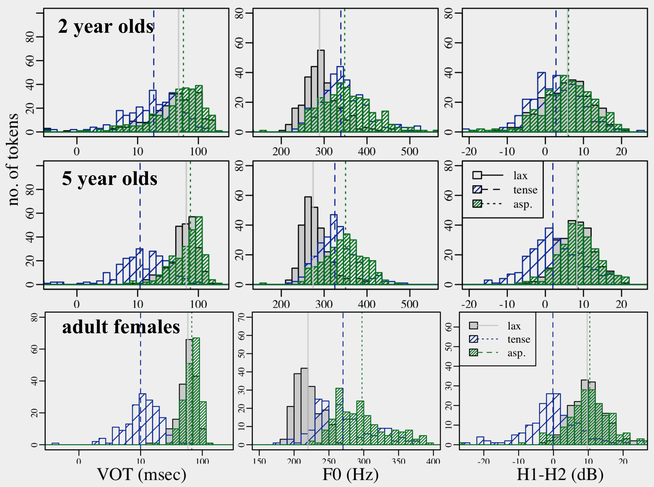


Figure on left shows that:
- the stop targets with highest transcribed accuracy rates for youngest children were tense.

Figure on right shows:
- a tendency for the younger children to substitute tense stops for non-tense stops.

2. Acoustic characteristics



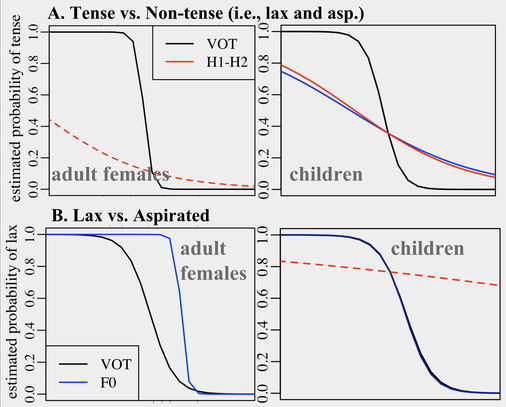
CHILDREN'S STOPS
- **VOT**: overlap in the short lag VOT range for 2-year-olds.
- **F0:** relatively lower **F0** in lax stops for all children.
- **H1-H2:** lower **H1-H2** in tense stops for 5-year-olds.

ADULT STOPS
- **VOT**: short lag VOT only in tense stops
- **F0:** lower F0 for lax stops
- **H1-H2:** lower H1-H2 for tense stops

3. Mixed effects logistic regression models for transcriptions

$$\log\left(\frac{\text{target consonant}}{1-\text{target consonant}}\right) = \beta_0 + \beta_1 VOT + \beta_2 F0 + \beta_3 H1H2 + \ldots$$

- **Coefficients for fixed effects** (β_1, β_2, β_3...): the absolute value of a coefficient reflects the relative contribution of that variable in predicting the dependent variable (transcription).

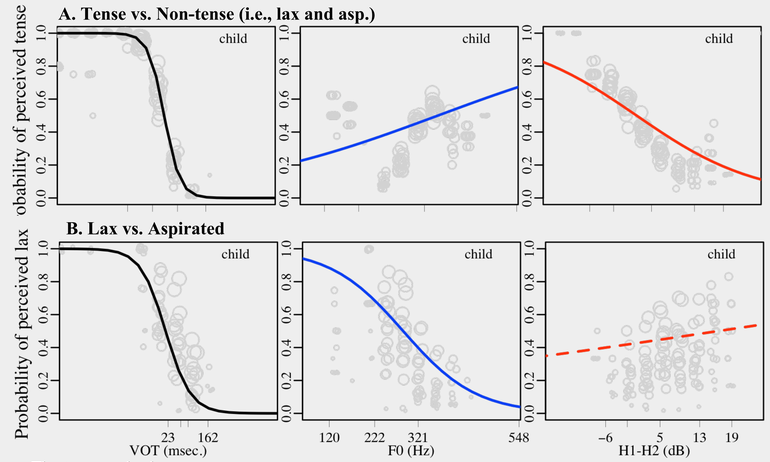


Figures on left show that:
- **VOT** dominated in differentiating tense stops in adult productions.

Figures on right show that:
- The transcriber identified the children's productions as tense primarily based on the **VOT** values of the productions.
- The transcription of tense stops was less influenced by F0 and H1-H2.

	A. Tense vs. Non-tense		B. Lax vs. Aspirated	
	coefficeicnt		coefficeicnt	
	adult	child	adult	child
VOT	-8.1	-3.6	-2.7	-2.5
F0	(n.s.)	0.5	-10.2	-2.6
H1-H2	(n.s.)	-0.5	(n.s.)	(n.s.)

4. Mixed effects logistic regression models for naïve categorizations



The top panels show:
- In the perception of tense stops vs. non-tense stops, the coefficient for VOT values had the greatest absolute value and hence the steepest slope (-4.29 for **VOT** vs. 0.30 for **F0** vs . -0.55 for **H1-H2**).

The bottom panels show:
- Even in the perception of lax stops (as opposed to aspirated stops), the coefficient for the VOT values was greater (-2.69 for **VOT** vs. 0.92 for **F0** vs. 0.12 for **H1-H2**).

DISCUSSION & CONCLUSION

- As in earlier transcription studies, tense stops were the first stop phonation category to be mastered by Korean children.
- A potential explanation is available from the distributions of acoustic cue values, namely ...
  - Although the tense stops are differentiated from lax and aspirated stops in adult productions by their high F0 values and negative H1-H2 values as well as by their uniquely short lag VOT values, younger children's stops in all three categories are realized with short lag VOT values.
- Regression models relating perceived categories to acoustic parameters showed that ...
  - The transcriber identified the children's productions as tense primarily based on the VOT values of the productions, and was less influenced by F0 and H1-H2.
  - The naïve Korean adult listeners' responses in the perception task showed the same patterns.
- The early mastery of tense stops in Korean-speaking children's productions was, in fact, related to two factors:
  - Children's earliest productions are have short lag VOT values
  - These short lag VOT tokens are perceived as tense by Korean adults, even though these productions were not necessarily produced with adult-like F0 or H1-H2 values.
- Thus, the VOT pattern explains the early mastery of tense stops in Korean.
  - The early mastery of tense stops in Korean is not an exception cross-linguistically when we consider how children's productions are understood by adult listeners of the native language.

ACKNOWLEDGEMENTS

We thank the children who participated in the study, the parents who gave their consent, and the child-care centers at which the data were collected. This research was supported by: an Ohio State University, Dept. of Linguistics Targeted Investment in Excellence award to Eun Jong Kong, NIDCD Grant 02932 to Jan Edwards, and NSF Grant BCS0739206 to Mary E. Beckman.

The Acoustical Society of America Meeting at Baltimore Maryland, 2010 Spring (April 19-23)