BACKGROUND

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

2. Three-way laryngeal contrast in Korean stops
   - /p, t, k/ vs. tense /p, t, k/ vs. aspirated /p, t, k/
   - e.g., /tal/ mask vs. /tal/暂缓 vs. /tal/ 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 (tense, lax, 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 classifying 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 a., by exploring relationships between native speaker perception (trained transcriptions and native adults’ ratings) of children’s stop productions and the three acoustic characteristics (VOT, F0, H1-H2).

METHODS

1. Transcription Study
   - Materials: word-initial coronal and dorsal stops embedded in real words (i.e., a, u, e- context) e.g., /tan/ Gins/ /cat/ a/ strawberry/ /h4u/dog/ 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-recitation 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 phasives 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 /tI/- /t/- and /h/-/ initial words used in the transcription study: only CV portions.
     - 400 stimuli (592 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
   - Target consanant: /p, t, k/
   - Coefficients for fixed effects (β1, β2, β3, ...): 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.
       - Children’s productions were not necessarily produced with adult-like F0 or H1-H2 values.

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.
   - 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
   - Coefficients for fixed effects (β1, β2, β3, ...): the absolute value of a coefficient reflects the relative contribution of that variable in predicting the dependent variable (transcription).

4. Mixed effects logistic regression models for naïve categorizations
   - 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
     - Thus, the VOT pattern explains the early mastery of tense stops in Korean.

DISCUSSION & CONCLUSION

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4. Mixed effects logistic regression models for naïve categorizations

A. Tense vs. Non-tense (i.e., lax and asp.)
B. Lax vs. Aspirated

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