

Different gestures explain different acquisition patterns for Japanese and Greek voiced stops

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BACKGROUND

1. VOT distributions and mastery of voiced stops:

- Cross-language differences in the age of children's mastery of adult-like voiced stops typically are explained in terms of the relative difficulty of the gestural organization for the language-specific VOT distributions
- Early mastery of English voiced stops:
 - short-lag VOT allowed, requires little precision in the laryngeal gestures
- Late mastery of French/Spanish voiced stops:
 - lead VOT required, has the greatest motoric/aerodynamic demands

2. Puzzling mastery patterns for voiced stops in ...

- Japanese:** there is a short-lag VOT allophone (as in English)
 - but voiced stops are mastered later than voiceless stops (Yasuda, 1970).
- Greek:** lead VOT is the norm (as in French)
 - but two-year old Greek children produce them with adult-like lead VOT values (Okalidou et al., 2002)

3. Can language-specific phonetic details explain both puzzles?

- Japanese:** overlapping VOT values between voiced and voiceless stops
 - Is longer VOT lag sufficient for differentiating voiceless stops?
 - Comparison between Japanese and English
- Greek:** voiced stops are optionally prenasalized
 - Is production of lead VOT in Greek stops facilitated by prenasalization?
 - Comparison between Greek and Japanese

METHODS

I. Database*

Materials and participants:

- word-initial stops and nasals elicited in familiar words
- 50 - 93 child (aged 2 through 5 years) and 20 adult (18 - 30) speakers of Japanese, Greek, or English.
- recordings made in their home countries in the Tokyo area, Japan; Thessaloniki area, Greece; central Ohio, USA

Tasks: picture-prompted word-repetition task (Japanese and English) and picture-naming task (Greek and Japanese children)

II. Measurements and analysis

Japanese and English

- Accuracy judgment measures:** native speaker transcriptions of 'correct' or 'incorrect' for all children's stop productions (errors also transcribed phonetically)
- Acoustic measures:** VOT, /*θ*/ and H1-H2 measured in all adult productions and in all child productions that were transcribed as correct or as passive substitutions.
- Statistical analysis:** three types of mixed effects logistic regression model with target category (for adult) or transcribed category (for child productions) as dependent variable and various sets of acoustic measures as independent variables

PURPOSE: To examine what acoustic cues are used to differentiate voiced from voiceless stops.

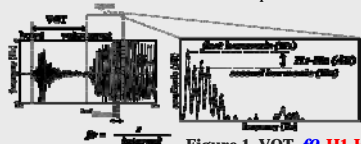


Figure 1. VOT, /*θ*/, H1-H2

Greek and Japanese

- Duration** of voicing lead (i.e., VOT) in the voiced stops and nasal murmur in nasals.
- Amplitude trajectory** during the voicing bar and nasal murmur:
 - the first peak amplitude in the FFT spectrum made from a 6 ms Hamming window centered at each glottal pulse starting at the burst,
 - normalized by the amplitude of the following vowel (Burton, Blumstein & Stevens, 1992)
- Statistical analysis:** mixed effects model with normalized amplitude as dependent variable and time as independent variable.

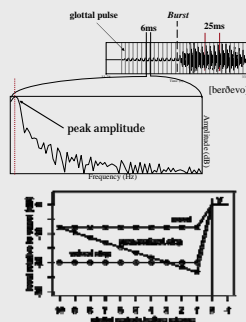


Figure 2. amplitude trajectory

PURPOSE: To examine and compare the shapes of amplitude trajectories of voicing bars and nasal murmurs

RESULTS

I. JAPANESE & ENGLISH

a. Transcription accuracy

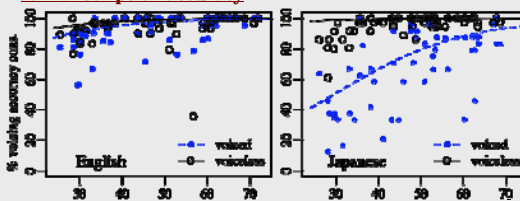


Figure 3. Transcription accuracy by age (months)

- The voicing contrast is mastered later for Japanese-speaking children, as compared to English-speaking children.
- At 42 months, Japanese-speaking children are only at 75% for /d/.

b. VOT characteristics

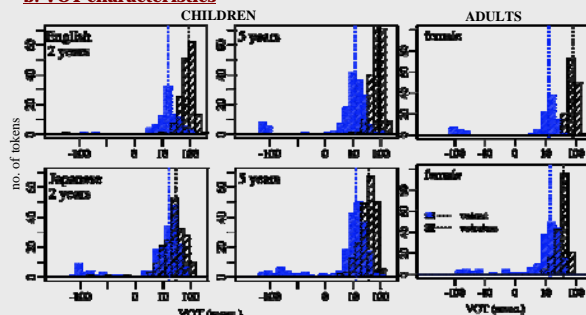


Figure 4. VOT values

- ADULTS' STOPS**
 - VOT overlap between short-lag VOT for /d/ and intermediate-lag VOTs for /t/ in Japanese

CHILDREN'S STOPS

- Japanese children produced adult-like VOT overlap.

c. Testing VOT cue sufficiency: Log-Likelihood Ratio Test

Three mixed effects logistic regression models:

- Dependent variable: odds ratio of transcribed (for children) or target (for adults) /t/.
- Predictors: (1) VOT-only model (base model), (2) VOT & /*θ*/ model, (3) VOT & H1-H2 model

Log-likelihood ratio test showed that:

- ADULTS' STOPS:**
 - Adding either /*θ*/ or H1-H2 to VOT did not improve the model fit in English
 - Adding either /*θ*/ or H1-H2 to VOT improved the model fit in Japanese
- VOT is sufficient for differentiating the target voiceless stops from voiced stops in English, but it is not sufficient in Japanese!

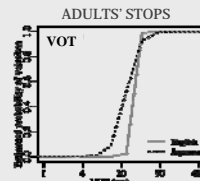


Figure 5. base model, adults

CHILDREN'S STOPS:

- Adding H1-H2 (but not /*θ*/) to VOT improved the model fit in English
- Adding either /*θ*/ or H1-H2 to VOT improved the model fit in Japanese

Parameter estimation

- In Japanese children's productions, other parameters such as /*θ*/ and H1-H2 played a relatively larger role in differentiating stops transcribed as voiceless from stops transcribed as voiced.

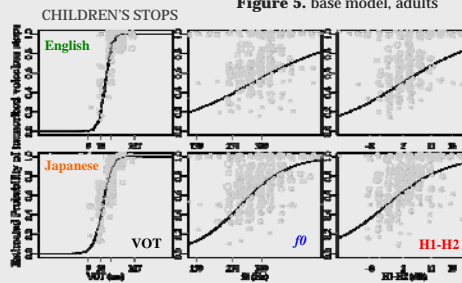


Figure 6. all three models, children

ACKNOWLEDGEMENTS

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* Paidologos Project webpage: <http://www.ling.ohio-state.edu/~edwards/>

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II. GREEK & JAPANESE

a. Duration

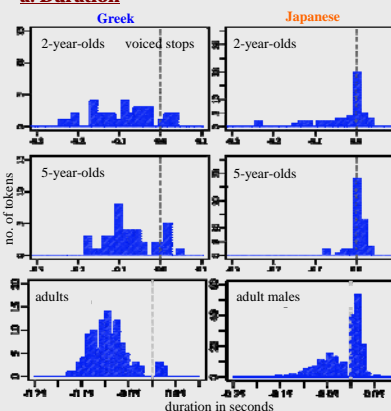


Figure 7. Histograms of VOT in voiced stops

CHILDREN'S VD. STOPS:

- The percentage of prevoiced stops was high in Greek.
 - 2 yos: 85.7%, 3 yos: 79.1%
 - 4 yos: 87.5%, 5 yos: 81.8%
- In Japanese only 29.3% (32/109) of girls' voiced stops and 24.5% (27/110) of boys' voiced stops were prevoiced.

ADULTS' VOICED STOPS:

- 94.3% (215/228) of Greek voiced stops were prevoiced.
- 10.4% (22/210) of Japanese female's voiced stops and 43.8% (92/210) male's voiced stops were prevoiced.

b & c. Amplitude trajectories

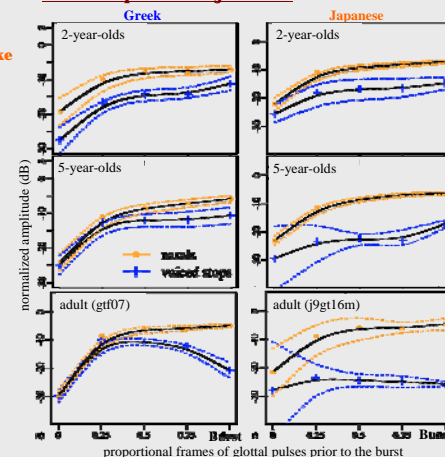


Figure 8. Medians of amplitude curves & confidence intervals

Greek

adults: prenasalization observed -- voiced stops began with energy as high as nasals followed by a gradual separation toward the burst.

2-year-olds: nasalization observed throughout voicing-- high amplitude for voiced stops throughout voicing.

5-year-olds: similar to adult pattern.

2-year-olds: nasalization observed, as in Greek 2-year-olds

5-year-olds: similar to adult pattern

2-year-olds: nasalization observed, as in Greek 2-year-olds

DISCUSSION & CONCLUSION

Japanese voiced stops ...

- can have short-lag VOT values, similar to English voiced stops. However, ...
- the voiceless stops have intermediate VOT values, so that VOT is not a sufficient acoustic cue for differentiating voiced from voiceless stops in Japanese.

Late mastery of Japanese voiced stops:

- Children need to learn to control additional acoustic parameters such as voice quality.

Greek voiced stops ...

- contrast robustly with voiceless stops in always having lead VOT values. However, ...
 - this lead can be produced with nasal venting, because voiced stops can be prenasalized
- Very early mastery of Greek voiced stops:**
- adult-like lead VOT in children's voiced stops
 - acoustic evidence of prenasalization in Greek voiced stops:
 - Children were taking advantage of nasal venting to lower the supraglottal pressure in order to maintain vocal fold vibration

• Taken together, these results suggest VOT, in and of itself, cannot explain the mastery of voicing and aspiration categories across all languages.

• If the mastery pattern in a language contradicts predictions based on VOT alone, then the language-specific phonetics of the voicing contrast may provide an explanation.