Cross-language perspectives on the interplay between phonological development and phonological change

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Plan for this talk

**Goal:** to explore some questions about the relationship between (synchronic) phonological development and (diachronic) phonological change

- Review (some of) what’s known about development
- Review (some of) what’s known about change
- Outline the questions that we will ask about the relationship between them.
- Present two case studies, involving three sound changes, that use a subset of data from the paidologos project to explore these questions

**To begin:** introduce the paidologos project: a cross-linguistic study of phonological development
What is the paidologos project?

- Ongoing comparison of phonological development
  - began in 2003 with data collection for Cantonese, English, Greek, and Japanese
  - later added Korean, two varieties of Mandarin, Taiwanese, French, and Drehu
- Recordings of analogous consonant sounds in analogous word positions across languages
  - productions by 100+ children for each language, covering same age range (2 through 5 years)
  - elicited using same task and recording equipment
  - transcribed using comparable transcription protocol

Recordings of initial 4 languages available at http://childes.psy.cmu.edu/data/PhonBank/
The paidologos recording equipment
The paidologos elicitation task

- Target consonants in word-initial position in familiar words.
- Word productions elicited in a picture-prompted repetition task.
- Child hears and repeats female voice ...

target: [doa] ‘door’
The paidologos elicitation task

• Child hears and repeats female voice saying target word in ...

• Rewarded by duck walking up ladder.

target: [to:fu] 豆腐
The paidologos transcription protocol

Two-stage transcription protocol for: (1) correct or not and (2) ...
The paidologos transcription protocol

If at stage (1) judged not correct, then (2) perceived substitution.
Phonological development

- Includes the progressive mastery of even the most difficult sounds of the ambient language.
- Often evident in stereotypical early mispronunciations:

  Palatalization (and assibilation) of stops and fricatives

  - [kʲimono] ‘kimono’ /kʲ/ pronounced as [tɕ]
  - [semi] ‘cicada’ /s/ pronounced as [ɕ]

  Devoicing or nasalization of voiced stops

  - [doa] ‘door’ /d/ pronounced as [t]
  - [gasu] ‘gas’ /ɡ/ pronounced as [k]
  - [donguri] ‘chestnut’ /d/ pronounced as [n]
Why are [d] and [g] difficult for children?

The successful production of a stop involves release of air pressure that builds up in oral cavity after momentary seal at nasopharynx to block air passage through nose coupled with momentary seal in oral cavity to block air passage through mouth.

[Figure 1 in Vorperian, Kent, Lindstrom, Kalina, Genry, & Landell (2005): mid-sagittal MRI of 7-month old female]
Why do children substitute [t] and [k]?

Voicing happens when air flow pushes vocal folds apart. Requires air pressure in oral cavity < pressure below glottis

voiceless stop variants [t, k] happen if air pressure in oral cavity builds up to impede air flow across the glottis
Why do children substitute [n] and [ŋ]?

Voicing requires air pressure below glottis > oral cavity

nasal variants [n, ŋ] if nasopharynx partially opened to prevent air pressure build-up in oral cavity so that air can continue to force air through the glottis
Progressive mastery of Japanese [d] and [ɡ] Productions as [t, k, n, ŋ] decrease with increasing age (months).
**Similar pattern in other languages**

**French**-speaking children (Allen, 1985):
- substitute [t, k] or [n, ñ] for /d, ɡ/ when they are 2 or 3 years old

**Thai**-speaking children (Gandour, Petty, Dardarananda, Dechongkit, & Mukngoen, 1986):
- produce adult-like /t/ (and /tʰ/) at 3 years of age but
- substitute something more like [t] for /d/

**Taiwanese**-speaking children (Pan, 1993):
- produce adult-like /k/ in their first words
- do not produce adult-like /kʰ/ until after 2 years
- substitute something like [k] for /ŋɡ/ until after 3 years of age
Continuous measures possible

• When the phonetic parameters involved are well understood, phonological development can also be measured quantitatively.

• Paradigm example: Phonetic parameter of voice onset time (VOT) provides a quantitative measure of:
  • “degree of voicing” for target /d, g/ in languages such as French, Thai, and Taiwanese, ...
  • “extent of aspiration” for target /tʰ, kʰ/ in languages such as Cantonese, Thai, Taiwanese, English, and Korean.

• Phonological development evident then in progressively more adult-like values for VOT that augments evidence from transcription.
Voice onset time as a measure of voicing

Duration of interval between burst & voice onset (Lisker & Abramson 1964)
VOT and acquisition of voicing contrasts

Category with short lag VOT first, because it requires the least precise articulation (Kewley-Port & Preston 1974).

short lag achieved by glottis opening at any time during the oral occlusion: easy to produce!

<table>
<thead>
<tr>
<th>Language</th>
<th>Lead</th>
<th>Short lag</th>
<th>Long lag</th>
</tr>
</thead>
<tbody>
<tr>
<td>English (Macken &amp; Barton 1980a)</td>
<td>voiced</td>
<td>voiced</td>
<td>voiceless</td>
</tr>
<tr>
<td>French (Allen 1985)</td>
<td>voiced</td>
<td>voiceless</td>
<td></td>
</tr>
<tr>
<td>Cantonese (Clumeck et al 1981)</td>
<td>unaspirated</td>
<td>unaspirated</td>
<td>aspirated</td>
</tr>
<tr>
<td>Thai (Gandour et al 1986)</td>
<td>voiced</td>
<td>unaspirated</td>
<td>aspirated</td>
</tr>
</tbody>
</table>
VOT and acquisition of voicing contrast

• English seemed to be an exception, until VOT explained transcribed [d, g] for /t, k/ substitutions in (Kewley-Port & Preston 1974, Macken & Barton 1980).

![Histograms showing VOT distribution for Cantonese- and English-speaking adults, as well as English-speaking 2-year-olds.](Image)
Phonological development, summarized

• Includes the progressive mastery of even the most difficult sounds of the ambient language.

• Often evident in stereotypical early mispronunciations, particularly of more difficult sounds such as:
  • dental fricatives and affricates
  • voiced stops, fricatives and affricates.

• Evident in the way in which early mispronunciations give way to more adult-like correct pronunciations ...
  • as the child matures (in a longitudinal study)
  • across different age groups (in a cross-sectional study)
Phonological change

- Defined as change in pronunciation norms over the history of a speech community.
- Evident in differences in pronunciation of target sounds for members of a speech community where ...
  - recordings are available at two or more different times ("real time" studies)
  - speakers of many different ages can be recorded ("apparent time" studies)
- Real-time evidence of a [ŋ] → [ɡ] change in Tokyo from comparing several apparent-time studies: Kindaichi (1967) reporting on data from 1941 versus Kato (1983) and Hibiya (1985)
Apparent-time study of Nezu speakers showed that the proportion of [g] productions for medial /g/ was smaller for older speakers.

Example: [itʃiŋo] → [itʃiɡo] ‘strawberry’
Neogrammarian distinction between ...

• **(Regular) sound change** -- diachronic change in pronunciation norms for a target sound that is:
  • transmitted in all word forms containing the target sound in the relevant phonetic context
  • associated with continuous differentiation across age groups in the speech community
• **Borrowing** -- diachronic change in pronunciation norms for a target sound that is:
  • attributed to the influence of exposure to another speech community
  • associated with a potentially abrupt differentiation between speakers with and without that exposure
Labov’s (2007) description

language internal change
• regular “transmission”
• “generated by the process of INCREMENTATION, in which successive cohorts and generations of children advance the change beyond the level of their caretakers and role models, ...”
• ... and in the same direction over many generations.”

importation of elements from other systems
• potentially irregular “diffusion”
• can show discontinuity, because it typically happens when adults come into contact with speakers from the other systems.
Denasalization of /g/ (Hibiya 1986)

Three speakers who were outliers in the relationship of proportion of [g] productions to age were the ones with most exposure to the Yamanote variety.
Phonological development amidst change

What sound patterns do children learn?
To which patterns are they exposed?
If the change is gradual, there are many possibilities ... 
  • mostly forms that are closer to the older earlier variants
  • forms that are closer to the newer “changed” variants
  • a variety of forms along a subset of the range
  • a variety of forms along the entire range
What are the possibilities if the change is abrupt?

Is children’s phonological development affected by the type of diachronic change that is going on?
Two case studies, three changes

**Study 1: Seoul Korean**, a continuous dialect-internal sound change by transmission
1) lax stops changing from mildly aspirated stops (with intermediate VOT) to breathy voiced stops with accompanying low tone

**Study 2: Dongbei Mandarin**, a phoneme split by dialect borrowing and a borrowed social marker
2) two-way contrast between [s]~[ɕ] vs [ɕ] replaced in the 1980s by standard Mandarin three-way contrast among [s] versus [ɕ] versus [ɕ].
3) more recent emergence of “feminine accent” variant of alveolopalatal [ɕ] → [ɕ]~[ɕi]
Case study 1: Korean stop phonation types

Three-way contrast among three phonation types:
• tense stops
  will be written here as [p’, t’, k’], as in:
  [t’ al.ɡi] ‘strawberry’
• lax stops
  will be written here as [p, t, k], as in:
  [ta.ɾam.dʒwi] ‘squirrel’
• aspirated stops
  will be written here as [pʰ, tʰ, kʰ], as in:
  [tʰa.ɾdʒo] ‘ostrich’
[tʰa.dʒo] ‘ostrich’
Three acoustic measures

**VOT** (measure of aspiration / voicing)

**F₀** (measure of tone)

**H₁-H₂** (measure of voice quality)

VOT (sec.)  20ms

burst  voice onset

F₀ = 1/interval

*first harmonic (H₁)*

*second harmonic (H₂)*

H₁-H₂ (dB)
Korean stop phonation types 50 years ago

Word-initial phonetic parameter values:
• tense stops with short VOT values (6 to 18 ms)
• lax stops with intermediate VOT values (~2 to 60 ms), described as “mildly aspirated” in KSL textbooks
• aspirated stops with long VOT values (~100 to 115 ms) [Kim, 1965; Weitzman & Han, 1965, 1967; Hardcastle, 1973; Kagaya, 1974]
• lax stops also differentiated by low F0 [Kagaya, 1974]

Word-medial phonetics (where no Fo difference):
• tense stops had long closure whereas lax stops had short and often voiced closures
Korean stop phonation types 20 years ago

[Mean values from tables in Mi-ran Cho Kim’s dissertation]
Korean stop phonation types today

[Fig. 1 from Silva, 2006, and apparent-time study]
VOT contrast in production

[Fig. 2 from Silva, 2006]
[from Figs. 1 and 2 in Kang & Guion, 2008]
Adult productions in the paidologos data

Data from Kong, Beckman, & Edwards, 2011

Key:
- Tense
- Lax
- Aspirated

Voice Onset Time (ms)

F0 (semit relative to 180 Hz)
Adult productions in the paidologos data

[Data from Kong, Beckman, & Edwards, 2011]
Difference measures in adults & children

[Black circles in right-hand panel indicate 2-year olds. Data from Kong, Beckman, & Edwards, 2011.]
[From Kong et al., 2011]
Study to determine perceptual weights

Seoul speakers listen to CV extracted from words and identify target by clicking on jamo for one of the three consonants:

They then rate the goodness of the production by clicking somewhere on a line from “bad” to “good” exemplar of the identified target:
Perception results analyzed

• Mixed effects logistic regression models to estimate log-likelihood that production was identified as ...
  1. tense (as opposed to lax or aspirated)
  2. lax (as opposed to aspirated)
as a function of standardized acoustics measures.

• Separate models for stimuli from productions by:
  1. adult women (who are leading the sound change)
  2. adult men
  3. children
so that we can use normalized ranges that are appropriate for the talker type.
Perception of adult lax (versus aspirated)
Perception of child lax (versus aspirated)

[Fig. 8 in Kong et al., 2011]
Summary, case study 1

- Change in pronunciation of Seoul Korean lax stops is a continuous (internal) change by transmission.
- Adult Seoul speakers of all ages have participated in the change production, with women leading the change, although ...
- Perceptual weights by older adults slower to change.
- Productions by children are not at leading edge, but instead are more like productions by adult men.
- Perceptual weights by adult listeners show evidence of listening with production differences in mind.
- Perception of children’s productions supports evidence from production that young children are conservative.
How can we measure fricative development?

- Both English and Japanese have a contrast between alveolar / dental [s] and postalveolar / alveolopalatal [ʃ].
- English [s] mastered earlier than [ʃ] and [s] substitutes for [ʃ] (Smit et al. 1991) -- i.e., a “fronting” stereotype.
  
  shoe

  safe

- Japanese [ʃ] mastered earlier than [s] and [ʃ] substitutes for [s] (Nakanishi et al., 1972) -- i.e., a “backing” stereotype.

  shukurimu ‘cream puff’

  semi ‘cicada’
Articulation of Japanese [s] and [ʃ]

- Whereas English [s] is alveolar and often apical, Japanese [s] is lamino-dental [panel (a) in figure].
- Whereas English [ʃ] is a rounded apical postalveolar, Japanese [ʃ] is a lip-spread alveolopalatal [panel(b)].

[Fig. 2 (Japanese sibilants) from Toda & Honda, 2003]
Acoustic measures for sibilant contrasts

spectral moments
• Choose a representative window during the fricative’s turbulent part.
• Calculate a spectrum and treat it as a pdf, by ...
• Calculating moments, such as the mean (or centroid) frequency formant transitions
• Measure $F_2$ at voice onset
Acoustic measures of sibilants

• Short front cavity of [s] in both languages: higher centroid value for [s] relative to value in [ʃ]
• Small back cavity in Japanese [ʃ]: high F2 frequency value at voice onset in following vowel.
• Phonological development examined by looking at phonetic measures:
  • undifferentiated values in the youngest children that reflects stereotypical substitution patterns
  • progressively more adult-like values in older children
Measures applied to children’s productions

Japanese- versus English-speaking

**centroid (Hz)**

**F2 onset (Hz)**

**st. dev. (Hz)**

[Fig. 6.3 from Li, 2008]
Case study 2: Sound change (2)

Involves the Mandarin sibilant fricatives ...

Lexical contrast
• PRC standard based on Beijing contrast among [ɕ], [s], [ʂ]
Articulation of Mandarin [s], [ɕ], [ʂ]

(a) dental [s] laminal, with shortest front cavity
(b) palato-alveolar [ɕ] has long constriction and hence both a large front cavity and a short back cavity (similar to Japanese [ʃ])
(c) post-alveolar [ʂ] has large front cavity (similar to English [ʃ])

[Fig. 3 in Toda & Honda, 2003]
Acoustic measures of sibilants

• Short front cavity of [s] in Mandarin:
  higher **centroid** value for dental [s] relative to values in both the palatoalveolar [ɕ] (as in similar Japanese [ʃ]) and the “retroflex” [ʂ] (as in similar English [ʃ]).

• Small back cavity in [ɕ] (as in Japanese [ʃ]):
  high **F2 frequency** value at voice onset in following vowel as compared to both [s] and [ʂ].
Dongbei (東北) Mandarin sibilants

Demographics
• Han settlement of the Dongbei in early 1900s

Lexical contrast
• Original system: two-way contrast between [ɕ] and a variable (s), as in Shandong

Social variation
• Value of (s) reflected closeness to Korean vs Manchu or Mongolian
[From Sun, Lu, & Li, 1986]
Lexical contrast for sibilants

- Beginning in the 1980s, PTH three-way system emerges, with universal education and emphasis on Putonghua pronunciation standard, reinforced by pinyin instruction in grade school.
Songyuan sibilant productions

amplitude ratio in F2 region (dB)

older males

older females

centroid frequency (Hz)

[production data from Li, 2005]
Sibilant perception by younger speakers

[perception data from Li, 2005]

Mean ratings by young speakers

Centroid frequency (Hz)

△ [s]-like

△ [ʂ]-like

△ dental

△ retroflex

Older males

Older females
Sibilant perception by older speakers

- Mean ratings by older speakers
- Perception data from Li, 2005

Graphs showing mean ratings by older males and older females for sibilant sounds [s] and [ʂ]. The x-axis represents centroid frequency (Hz), and the y-axis represents mean ratings. The graph indicates differences in perception between dental and retroflex sibilants.
Summary and interpretation

• Older female speakers (like younger speakers) show clear separation, but older male speakers show substantial overlap, with many target dentals in retroflex region and vice versa.

• Older listeners use the full range of ratings for both female and male productions.

• Younger listeners use only the two end point ratings (most [s]-like versus most [ʂ]-like) in their ratings for older female productions, and use intermediate ratings only for older male productions in boundary region.

• Different between [s]~[ʂ] has changed in “meaning” from socioindexical variable indicating degree of conformity to Beijinghua norms to a lexical contrast.
Songyuan sibilants, lexical contrast today.

Paidologos data young adults from Li, 2008.
Case study 2: Sound change (3)

Involves the Mandarin alveolopalatal ...

Social variation
• Beijing vernacular “feminine accent”: [ɕ] or even [s]-like variant of (ɕ), reported in Middle School girls as early as the 1920s & 1930s by Jinxi Li, Y. R. Chao [Cao, 1986; Hu, 1991].
Individual differences in the realization of [ɕ]

[Paidologos data young adults from Li, 2008]

centroid value (3.5 to 10 kHz)
[Paidologos data for 5-year olds from Li, 2008]
Paidologos data for 4-year olds from Li, 2008

4-year-olds:

- F24: 91%
- F23: 100%
- F22: 100%
- F18: 95%
- F05: 98%
- F02: 82%

Girls

- M16: 92%
- M11: 96%
- M09: 71%
- M01: 83%

Boys

- Postalveolar
- Alveopalatal
- Dental

Centroid value over middle 40 ms (kHz)
Comparing results across languages

• The Songyuan children are learning the 3-way lexical contrast with the same pattern as Beijing children.
• The young girls seem to leading the “imported” change in the social valuation of the (ɕ) variable.
• Is this evidence of an abrupt shift in values that are transmitted in the aftermath of borrowing?
• By contrast, the Seoul child speakers are relatively conservative in the sound change that is affecting the stop phonation type system.
• Is this evidence of a slower timeline (later learning of the social valuation) in the more continuous process of “incrementation” in regular sound change?
1. Is this an artifact of differences in age of socialization?
   • The children in the Songyuan sample were all recorded at school. Women work until their mid-60s and their children are placed in government-funded nursery schools by age two.
   • By contrast, children in Seoul tend to be placed in (private) nursery schools at a later age, and to spend less time each day at school. Although many mothers work, grandmothers often tend the children when they are not in school.

2. Is this an artifact of comparing apples (sibilant place) to oranges (stop phonation type)?
• Analyze child-directed speech recordings, so that we can assess these variables in input to young children. **Compare** new phonation type pattern in Tokyo /d, ɡ/
• If this change in progress is indeed a borrowing from Tohoku dialects, we have the control condition for interpreting the Seoul sound change. **Compare** “feminine” (s) and “masculine” (ʃ) in English.
• Use gender ratings to examine social valuation.
• Look for evidence of history of this sibilant variation.
• If this change in progress is a change from below, we have the control condition for interpreting the “feminine accent” in Sonyuan girls.
Acknowledgements to

• Thanks to NCTU for inviting me to give this talk
• my collaborators, especially those listed on the title slide
• funding sources listed on the title slide
• the children who lent us their voices & their caretakers
• and you for your kind attention

Ευχαριστώ πολύ
감사합니다
ありがとうございます
Thank you