Crosslinguistic Study in Protracted Phonological Development

B. May Bernhardt, Joseph P. Stemberger
University of British Columbia

Purposes

› to compare children’s phonological patterns across languages that are both similar and different in terms of word structure, stress, segmental inventories and relative complexity
› To discover to what extent patterns observed reflect universal versus language- or child-specific constraints
› To determine what protracted development might mean to different language and cultural groups
› To develop some clinical tools for elicitation and analysis available free, PHONBANK

Outline for today’s talk

› Overview of the project
› Preliminary data from Manitoba French, Slovene, Spanish, Mandarin, German, English
› Computer programs and phonological analysis
  ◦ Speech.App (NeXt), 1994-2003 (research)
  ◦ Computerized Articulation and Phonology Evaluation System (CAPES, Masterson & Bernhardt), 2001-present, soon to be freeware (clinical purposes + research, any language)
  ◦ Phon

Criteria for language selection

› Someone in Vancouver area is a native speaker or fluent second language speaker of that language and is trained in phonetics and phonology (linguistics, speech-language pathology) and we have been able to find partners in other countries
› Variety of language families
› What else would we like? Canadian Aboriginal languages

Acknowledgments

› Yvan Rose and the whole PHON team.
› The many Partners and Families in 11+ countries
› Canadian Tri-Council Social Sciences and Humanities Research Council grant
› University of British Columbia Humanities and Social Sciences small grant

Protracted Phonological Development

› Search for a neutral term......
  ◦ people whose phonological development is ‘stretched out’ in time relative to what’s often expected
  ◦ Neutral with respect to etiology
    • not necessarily “disorder” or “delay”
  ◦ Inclusive positive focus
    • highlights strengths & needs in the system
    • acknowledges family/society’s feelings of negativity relative to words such as ‘disorder’, ‘impairment’
How many participants?

- 30 preschoolers per language with protracted phonological development
- If possible, a matched typically developing sample (only possible where within-country funds permit)
- People with protracted development allow more time to observe phenomena
- Adult speaker(s) of the dialect area

Which languages so far

- Germanic: English, German, Icelandic, (Swedish?)
- Romance: Spanish (Andalucia, Latin America), Canadian French (Manitoba), (French of northern France?)
- Semitic: Kuwaiti Arabic
- Finno-Ugric: Hungarian
- Asian: Mandarin (Shanghai, Taiwan), Japanese
- South Slavic: Slovenian, Bulgarian

Collaboration sites


Middle East: Kuwait University

Asia: Shanghai Children’s Medical Centre, National Chiao-Tung University, (Osaka University)

North America: Vancouver Coastal Health (Spanish, Mandarin, Japanese), Division Scolaire Franco-Manitobaine (DSFM): Manitoba, Canada

Testing

- Single word (primary) and connected speech data (for purposes of informal language evaluation and possible intelligibility evaluation later).
- Language comprehension test if available
- Hearing screening if available
- Brief oral mechanism examination
- Digital audio recording (some also have video) with high quality microphones in quiet environment (school, preschool, home, clinic)

Single word list elicitation

- Efficiency and content coverage
- 80-110 words which sample a variety of
  - word lengths, stress patterns, word shapes
  - and elicit segments across word positions, never less than two tokens per segment category
- Selected with the first-language partners
- Words that are imageable and at least somewhat familiar to most preschoolers
- Free stock photos, organized in themes (loose narrative)
- Repetition of 10 words with object elicitation for within-word variability measure
**Transcription**
- 1 or 2 native speakers transcribe 1-2 initial data sets.
- Use of wave/spectrum analysis program to verify voicing, frication, glottal stops, etc.
- The team works collaboratively to decide on conventions for transcription for that language, trying to maintain equivalent levels of narrowness across languages and account for what is possible to agree on, and what not, for that language.
- A transcription conventions document is then available for each transcriber outlining the key elements for transcription.
- 1 main first language transcriber, with reliability by a second (10% of sample unless more funds permit more).

**Analyses**
- **Quantitative: Overall plus specific topics**
  - Computerized Articulation and Phonology Evaluation System (Masterson & Bernhardt, 2001), soon to be available as FREEWARE via authors.
  - Excel analyses: Spreadsheet analyses to compare patterns across languages (e.g. confusion matrices).
- **PHON: Very Near Future**
- **Qualitative (linguistic)**

**Analyses for clinical purposes**
- Nonlinear scan analysis using form/process similar to Bernhardt & Stemberger, 2000 (Workbook in Nonlinear Phonology for Clinical Application, Pro-Ed) for English.
  - Now available free for Spanish, Mandarin, Icelandic from investigators (in the language or in English).
  - Will be available through publication for German (Angela Ullrich: NILPOD, probably 2011/2012).
  - End of 2010, for French, Japanese, Slovenian.

**Preliminary data, questions**
- Manitoba French
- Spanish (Argentina, Mexico)
- Slovene
- Mandarin
- German vs English

**Preliminary Data, Manitoba French**
- 1 child, age 4, PPD
  - **Segments**: Mismatches on sibilants, grooving, voicing of stops and fricatives (similar to English).
  - **Structure**: Word length relevant
    - Disyllabic words (iambic) 92% match (stress, length)
    - Multisyllabic words: 52% accuracy for syllable maintenance (some deletion of weak syllables) and transposition or other mismatches affecting segments.

**Segment-structure interactions**
- **Nasal vowels**: Vary with word length, stress
  - 80% match in stressed syllable position BUT 35% match in unstressed syllable position.
  - 75% match in 1-2 syllable words BUT 43% match in multisyllabic words.
- **Clusters**: Reduction reflects position
  - 72-79% match for number of Cs (CC) in syllable-initial and word-final positions BUT 10% CC use across syllable boundaries (e.g. trac.teur).
Ongoing questions......French

- Segmental matches and patterns?
- Interactions of stress and word length with segmental accuracy (both Cs and nasal Vs)?
- Multisyllabic word patterns

Similarities: Prosodic Structure Mismatches

- No word-initial CC, but a few word medially /trˈaŋgulo/ [angulo] (RP2)
- Word-initial Cs affected in initial weak syllables
  Deletion: /saˈpatos/ [e hatos] (RP2)
  Glottal use: /təˈkando/ [ʔaˈkano] (RP1)
- Harmony (redup): /saˈpatos/ [paˈpatos] (RP1)
- Reduction or alteration of VV sequences
  /ˈɡɾaɾias/ [ˈhatas] (RP2)
  /ˈueɾeʃ/ [ˈʃoːɾeʃ] (RP1)

Differences: Prosodic Mismatches

RP1
- Deletion of weak initial syllables with [eh]:
  /ˈɑkkuˈelə/ [ˈœɾkuˈelə]
- Deletion of initial stop following article ‘el’:
  /elˈbano/ [elˈano]
- Consonant epenthesis in vowel sequence:
  /ˈdʒi.aɾo/ [ˈdʒiəɾo] (dia)

RP2
- Stress shift: Sw to wS with strengthening of consonants between Vs
  /ˈuˈbas/ [ˈuˈbaɾas]
- Timing units maintained with a ‘glide-like element’ or with consonant lengthening word medially

Differences: Consonant mismatches

RP1
- /tʃ/ > /ʃ/ /notʃe/ [noʃe]
- /r, r> 1, r², ř, x /
- /ɡhˈara/ [ˈɡhaɾa]
- /ˈbasi/ [ˈbaɾi]
- /ˈkoɾtʃaɾ/ [ˈkoɾtʃaɾ]
- /ˈɾauɾiʃa/ [ˈɾauɾiʃa]
- /ˈɾaɾiʃa/ [ˈɾaɾiʃa]

RP2
- /wi ɾəs/ [wiɾəɾə]
- /ˈpeɾaʃ/ [ˈpeɾas]
- /ˈeleɾanteʃ/ [ˈelɐɾanteʃ]
- /ˈoɾəʃ/ [ˈoɾas]
- /ˈkɾaɾiʃaɾ/ [ˈkɾaɾiʃaɾ]
- /ˈɾaɾiʃaɾ/ [ˈɾaɾiʃaɾ]
- /ˈɾaɾiʃaɾ/ [ˈɾaɾiʃaɾ]

Sequences: RP1 (RP2 also)

Many sequence difficulties (place/manner)

- elefante: [elɐˈfaɾe] (harmony-redup.)*
- globo: [ˈwoɾo] (harmony-redup.)
- zapatos: [pɾaˈpatos] (harmony-redup.)
- nariz: [nɾis] (deletion, metathesis)
- blanco: [ˈbɾako] (deletion, migration)
- lámpara: [ˈmakalə] (metathesis, [k] medial)

*Where reduplication is either partial or full.
Ongoing questions: Spanish
- Mismatch patterns for (light) /l/ and trilled /r/:
  - [l] for /r/, glide-like elements, nasalized or lateralized taps
  - Similar glide-like segments in Slovene, Zapotec
- Deletion of initial stop following the masculine article ‘el’ (baño > ayo)
  - NOTE: also noted for one of our French pilot subjects - /l/ of ‘le’ took precedent over the initial stop.....
- Sequence difficulties: CC, C_C, VV?
- Initial Cs in initial weak syllables?

Slovene: Segmental Inventory

Similarities: Segmental Patterns
- Liquids
  - /l/ -- mostly matches
  - /rl/ restricted, with errors including [l]
    - (cf. Kocjančič, 2004)
    - Boy had more taps
    - Girl had more different substitutions
  - Velars almost always match target (for place)

Similarities: Segmental Patterns
- Some aspiration of voiceless stops, e.g. /k/
  - /pɑˈɡɛ.ti/ [pʰɑˌɡɛ.tʰi]
  - including word-final “b,d,g” (devoiced but unaspirated in adult speech)
    - /ɡump/ [kʰum pʰ]
- Some devoicing of /b,d,g/ (onsets)
- Some /l/-/l/, /ol/-/ol/ confusions, vowel duration issues

Preliminary data: 2 children with PPD
- Boy, age 4;7, Whole Word Match 44.6%
- Girl, age 4;9, Whole Word Match: 43.6%
- Same dialect spoken by both children, & parents
Differences: Segmental Patterns

Boy
- Alveopalatals c, z
  - /ts k/ [tsk]
  - /sa ba/ [sa ba]
- Harmony
  - ʃ sents/ [stents]

Girl
- Initial /g, z, 3, v/
  - epen. sonorant (C, V)
    - [grant/ [grant] /glavə/ [glava] /ʃaik/ [shaik] /voi/ [quoi]
  - Harmony, velar fric.
    - /ʃeʃtəp/ [shetap]
    - Affricates in clusters
      - [ʃk/ /ʃkta/ [shkta]

/ɾ/, Boy
- Usually [ɾ]
  - Word-initial in wws
    - /nu men/ [nu man] /veve rltsa/ [ve ve lit sa]
- /ɾ/: tap [ɾ]
  - Between Vs in initial Cr
    - /do ri ba/ [do ri ba] /xru ʃka/ [kru ʃka]
    - Word-final / ti ɡar/ [ti gar]
  - Deletion: /ɾ/ or C, or epenthesis V in hC/
    - /ar de ʃj/ [ar dʃ] /tʃem/ [tʃem]
  - Inconsistency in use of target alveopalatals /t, d, ɾ, s/
    - In clusters and syllable maintenance in long words (reflecting language frequency)

/ɾ/, Girl
- Substitutions of [ɾ, ʃ, ɹ]
  - /tɾe buʃ/ [tre buʃ] /tɾi ɡar/ [ti gar]
    - Incl. V epenthesis after [t, d]
    - /ar de ʃj/ [ar dʃ]
  - Tap [ɾ] uncommon (2Cr, 1VʃV)
    - /ʃk aʃ/ [ʃkaʃ] /ʃru kko/ [xru kko]

- Rarely deleted

Ongoing questions, Slovene
- Structural accuracy relatively high for codas, CC use in clusters and syllable maintenance in long words (reflecting language frequency)
  - Relative accuracy for velars, /ɾ/ segmentally?
  - Types of mismatches?
  - Interactions with adult variation
    - /lɛz/ and /oʃl-
    - /ɾ/ in intervocalic position

Similarities between the 2 children

Mismatch patterns:
- Inconsistency in use of target alveopalatals /ta/ and /a/
- Vowel mismatches: more frequent, girl
  - Some /a/ > [a]
- De-retroflexion of retroflexed sibilants
  - Possibly Shanghai Mandarin dialect

Mandarin Children with PPD

<table>
<thead>
<tr>
<th>Gender</th>
<th>Age</th>
<th>Location</th>
<th>Whole Word Match</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>4;1</td>
<td>Vancouver area</td>
<td>41/80</td>
</tr>
<tr>
<td>Male (TD cohort) S45</td>
<td>4;7</td>
<td>Shanghai</td>
<td>34/80*</td>
</tr>
</tbody>
</table>

Mean WWM for age 4: 66/80
Differences between the 2 children

**Vancouver girl**
- Deterioration of vowels in connected speech
- Affricates > stops

**Shanghai boy S45**
- All > [n], [(n) > [l], [f]]
- Infrequent patterns:
  - Nasal coda deletion

Infrequent patterns:
- Palatalization of coronal and dorsal Cs
- Lateralized /ɕ/, /tɕ/

Ongoing Analysis: Questions
- Tones: duration, sandhi, slope of pitch change
- To groove or not to groove? /l/, /ts/ vs /ɕ/, /tɕ/
- /l/ not > [w] but > [l] or > [z]?
- All > [w] but > [l] or [n]?
- Vowel mismatches relatively more prevalent in Mandarin speakers with PPD and have a greater effect on intelligibility than for non-tonal languages?

& Dialects of Mandarin – Beijing/Shanghai/Taiwan?

---

German vs English: Participants

<table>
<thead>
<tr>
<th>Language</th>
<th># of boys</th>
<th># of girls</th>
<th>Mean age in months</th>
</tr>
</thead>
<tbody>
<tr>
<td>German</td>
<td>12</td>
<td>4</td>
<td>50.7 (SD 10.4)</td>
</tr>
<tr>
<td>English</td>
<td>12</td>
<td>4</td>
<td>52.1 (SD 7.9)</td>
</tr>
</tbody>
</table>

*p value: t-test .8023

---

Results: Overall comparison

<table>
<thead>
<tr>
<th>Language</th>
<th>Mean Word Shape match</th>
<th>Mean Total C match</th>
<th>Mean Word-initial C match (with CC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>German</td>
<td>73.55% (SD 11.53)</td>
<td>63.89% (SD 10.59)</td>
<td>41.75% (SD 21.61)</td>
</tr>
<tr>
<td>English</td>
<td>39.2% (SD 12.7)</td>
<td>40.03% (SD 9.4)</td>
<td>47.8% (SD 11.02)</td>
</tr>
</tbody>
</table>

---

Word-initial singleton C in Sw: Mean match levels (accuracy)

<table>
<thead>
<tr>
<th>Category</th>
<th>German</th>
<th>English</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stops and nasals</td>
<td>75.6%</td>
<td>70.8%</td>
</tr>
<tr>
<td>Fricatives, affricates</td>
<td>39.2%</td>
<td>27.4%</td>
</tr>
<tr>
<td>Glides, liquids and /h/</td>
<td>74.2%</td>
<td>60.8%</td>
</tr>
<tr>
<td>All single consonants</td>
<td>63.2%</td>
<td>54.1%</td>
</tr>
<tr>
<td>Cs in common (16)</td>
<td>67.8%</td>
<td>64.4%</td>
</tr>
</tbody>
</table>

Wilcoxon’s for individual categories: Not significantly different
Student’s t-test for total set: Not significantly different
However: Liquids “l” and “r”
Match proportions

<table>
<thead>
<tr>
<th>Category</th>
<th>German</th>
<th>English</th>
</tr>
</thead>
<tbody>
<tr>
<td>“l”</td>
<td>81.3%*&lt;br&gt; (13/16 Ss)</td>
<td>22.6%&lt;br&gt; (3/16 Ss)</td>
</tr>
<tr>
<td>“r”</td>
<td>43.8%**&lt;br&gt; (13/16 Ss)</td>
<td>17.6%***&lt;br&gt; (3/16 Ss)</td>
</tr>
</tbody>
</table>

*Proportion across participants
**Both /l/ and /ɾ/ for 3 Ss
***Both /l/ and /ɹ/ for only one S

Substitutions for /l/ and ‘r’ by # of children
Some children had more than 1 substitution type

<table>
<thead>
<tr>
<th>German pattern</th>
<th># Ss</th>
<th>English pattern</th>
<th># Ss</th>
</tr>
</thead>
<tbody>
<tr>
<td>h</td>
<td>2</td>
<td>w</td>
<td>9</td>
</tr>
<tr>
<td>n</td>
<td>1</td>
<td>j</td>
<td>3</td>
</tr>
<tr>
<td>cʰ</td>
<td>1</td>
<td>v, d, n, ?</td>
<td>1 each</td>
</tr>
<tr>
<td>Uvular fricative</td>
<td>/ɾ/</td>
<td>h</td>
<td>11</td>
</tr>
<tr>
<td>/w/</td>
<td>6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>χ</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>w</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>u, x, w, h, deleted</td>
<td>1 each</td>
<td>[ʔ]/deleted</td>
<td>2</td>
</tr>
</tbody>
</table>

Summary: Word-Initial Cs

**Major SIMILARITIES**
- Relative % accuracy for all but liquids
- % mismatch, place, manner equivalent

**Similar patterns: Type/freq.**
- Velar fronting %Ss
- Fricatives devoiced: %Ss

**Major DIFFERENCES**
- Accuracy for /l/ and rhotic higher in German
- However: Pattern differences
- More Ss stopping, English
- More [-voiced] > [+], English
- Place substitutions (and to a certain extent, manner) reflect language’s phonetic inventory, especially for fricatives, approximants

Ongoing Questions: German, English

- Differences in laryngeal patterns for stops are somewhat perplexing given the similar features in the two languages (although younger TD German children do have at least some de-aspiration of WI stops...Hoefflin & Stemberger, 2003). Acoustics?
- Word-medial and word-final position better in German than English for matched samples?

Questions overall so far

- What is protracted development across languages?
- Severity: Equatable across languages?
- Relative impact of segment types on inventory acquis.: Light /l/ easier/acquired earlier than English /l/; Rhotics difficult yet the German variant earlier?
- Relative impact of inventory as options for substitution?
- Palatals in German, liquid substitution types
- Relative match proportions, word structure?
- e.g., Codas in English particularly challenging?
- Structural effects: e.g. Initial Cs and iambic stress?
- Article use and effects on initial C (Spanish, French)
- Sequence constraints across languages?

Computer programs for phonological analysis

- NeXt-based Speech.app (virtually inaccessible due to dying hardware)
- ISPA-MAC (Masterson) (now out of date)
- Computerized Articulation and Phonology Evaluation System (Masterson & Bernhardt, 2001, soon to be copyright-returned)
- Uses and relative successes...
Input: Stored adult targets, full set of IPA and diacritics, organized multitranscriber options

- Word structure
  - Length, stress, word shapes
- Segments
- Features
  - Sequences within contiguous and noncontiguous contexts
  - Comparison within and across samples

Features

<table>
<thead>
<tr>
<th>Feature</th>
<th>Program</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elicitation built in (photos/pix/video)</td>
<td>CAPES (mostly English)</td>
</tr>
<tr>
<td>Add unlimited new stored adult targets</td>
<td>PHON &gt; Speech-App (CAPES)</td>
</tr>
<tr>
<td>Single word, connected speech</td>
<td>PHON, CAPES, Speech.app</td>
</tr>
<tr>
<td>Audio/video in program, segmentation</td>
<td>PHON</td>
</tr>
<tr>
<td>Inventory: match/mismatch analyses</td>
<td>CAPES, Speech-App, PHON</td>
</tr>
<tr>
<td>Word length, stress analysis</td>
<td>CAPES &gt; PHON</td>
</tr>
<tr>
<td>Word shape analysis</td>
<td>Speech-App &gt; CAPES</td>
</tr>
<tr>
<td>C, V level analysis</td>
<td>PHON &gt; Speech-App &gt; CAPES</td>
</tr>
<tr>
<td>Feature analysis (single, combo)</td>
<td>Speech-App, CAPES, PHON</td>
</tr>
<tr>
<td>Sequence analysis (CVC, CVCV)</td>
<td>CAPES &gt; PHON</td>
</tr>
<tr>
<td>Queries for analysis</td>
<td>PHON</td>
</tr>
<tr>
<td>Ongoing program revision</td>
<td>PHON ☑ (CAPES)</td>
</tr>
<tr>
<td>Available and free</td>
<td>PHON, CAPES (Speech.App)</td>
</tr>
</tbody>
</table>

Using PHON: Needs....

- Template for adult targets with easy way to link sound/video files - efficiency
- Word shape analyses: inventory, matches and mismatches
- Use of diacritics from Extended IPA
- Segment-structure interactions, sequences
- Upgraded report format

Phonbank

- Need to seek ethics approvals from all countries to share transcriptions and where possible, audio
- Find a common format to submit the information

See you in 2013 or 2014 in Vancouver for the Child Phonology Conference

And thanks, Yvan, for all this week and the excursion around the bay....