Phonological development in Valley Zapotec

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  - B. May Bernhardt (UBC)

Research project

- First language acquisition in San Lucas Quiauíní Zapotec
  - Otomanguean language family
  - Oaxaca, Mexico; 2000 speakers
  - + 2000 more in California
  - a variant of Valley Zapotec
  - variants not 100% mutually intelligible
  - monolinguals; some bilingualism 4;0+
  - also monolinguals age 60+

Goal of Project

- General acquisition at several levels
  - Phonology (incl. phonetics)
  - Morphology (incl. interaction w’ phonol)
  - Syntax
- Tasks
  - Naming (object & picture)
  - Description of video clips (verbs)
  - word-less story books (e.g., Frog)
  - various other
  - limited spontaneous (below 5;0)

Participants so far

- Two-week field session each August, 5 years
  - Two “one-hour” sessions (usually), one week apart
- Age: as young as possible through 6;0
  - with a few older children for reference
- So far
  - 51 children (ca. 5-10% of target group)
  - 8 children longitudinal over 5 years
  - ~130 hours of video
- Only a few transcribed (Phon needed!)

Transcription

- Narrow phonetic transcription
  - perception-based transcription
    - guided by waveform (& spectrogram)
  - use only words with clearly identified lexical targets
This talk

- Quantitative examination of data for two monolingual Zapotec-learning children
  - one session each (1st session)
    - 1;11, male: Carlos
    - 2;11, female: Floriselda
  - selected interesting topics
    - variability in input
    - phonology-morphology interactions
    - features, clusters, feet, etc., & frequency

Preliminary

- Only two children
  - ¿age effects?
  - ¿effects of variability between children?
- Limited infrastructure on adult language
  - dictionary (9,000+ words) and grammar
    - no source for token frequency counts
  - few detailed studies of phonetics
    - Mario Chavez-Peón’s Ph.D. research
  - range of adult variation not fully known
    - so some “child errors” here ...

Why?

- Particular characteristics of the adult language
  - cross-linguistically less common phenomena
    - phonology
      - 4 voice qualities
      - stress and tone
      - consonant clusters with sonority
        - plateaus & reversals (/mn, nd wbw, .../)
    - morphology: suppletive allomorphy of inflectional aspectual prefixes
    - syntax: basic VSO word order

Why local connectionist & OT?

- Both have mechanisms that can easily derive child output pronunciations on the basis of adult perceived forms
- Both allow for detailed reasoning about causes underlying a given limitation in the output
  - OT is especially useful for identification of restrictions in output
    - due to explicitness
- All theories are useful only for reasoning, and predicting new data; all current theories are wrong in major ways (like all previous ones)

Why?

- Cross-language comparison of same or similar sound or sequence or structure
  - identify similar vs. different patterns
  - may help identify the factors responsible for particular patterns
    - by unconfounding variables
      - e.g., different adult inventories

Why? To evaluate theories.

- I use two:
  - local connectionist (interactive activation)
    - emphasizes role of processing
  - Optimal Theory (OT)
    - based on local connectionist, except
      - non-quantitative constraint interaction
      - each constraint separate (no summing of difficulty/markedness)
      - constraints explicit rather than implicit in weights between units
Another reason: Error-driven learning
- In response to error, the system is altered to make (that same) error less likely on the next trial
  - Errors reveal that something is not working properly
  - Changing the system may improve performance
- Changing the system when it’s working properly, for other reasons, can cause u-shaped learning (increased error rate)

Why not usage-based & exemplar models?
- Don’t account for basic child phonology.
- Assume: output closely based on perceived forms
  - If hear cat [kʰæt]
  - predicted output [kʰæt]
  - ACTUAL for many very young children: [QA:] (Error-driven learning not allowed)

Frequency is important
- type vs. token
- level of element:
  - word, syllable, phoneme, feature, …
  - contingent frequencies (e.g. /he/, /tu/, …)
  - neighborhood density (friends, enemies)
- role of morphologically complex words
- speech to child vs. speech by child
  - if error-driven learning
  - = exposure vs. number of learning trials

But frequency isn’t everything
- different initial states preadapt to different outputs
- complexity effects
- error-driven learning effects
- expect many differences even across adults
- look for effects that reflect frequency and for those that don’t

Subperceptual differences
- incomplete neutralization covert contrast
- Claimed to show that no deletion/substitution
  - because traces of target
- Predicted by connectionist models (processing)
  - fully gradient output
  - competing outputs never at zero amplitude
  - errors predicted to be lower amplitude than targets, so competitors have greater effect
- performance in the real world, not competence
  - Whorf: meaning of “empty”; operational def.

Zapotec consonants
- Typical set of places of articulation & manners.
- Fortis vs. lenis distinction
  - fortis longer than lenis
  - sole difference for sonorants
  - for obstruents:
    - fortis always voiceless, stable manner
    - lenis variable voicing, “stops”~fricative

<table>
<thead>
<tr>
<th>Stems</th>
<th>Affricates</th>
<th>Fricatives</th>
<th>Nasals</th>
<th>Liquids</th>
<th>Glides</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fortis</td>
<td>p t k g s →</td>
<td>s f š f ś x</td>
<td>m n ŋ ĭ r ĭ</td>
<td>r w j</td>
<td></td>
</tr>
</tbody>
</table>
SLQZ monophthongs

- Frequency: 85% of stressed vowels
- All both stressed and unstressed
- Minimal reduction in unstressed
  - But shorter (cue to stress)
- Variation in input (stress; voice quality)
  - [i~], [e~], [u~], [a~]
  - Some adult words may be nonvariable
  - /i/ especially low-frequency
    - Except in clitics (final unstressed)

Matching variability in input

- Adult lenis “stop” varies with fricative
  - b/β, d/δ, g/ɣ/x
- Exact statistics unknown
  - Stops > 50% in word-initial
    - Fricatives > 50% in medial & final
  - All words vary
    - As far as we know
- Any variant matches adult; “correct”.
- When are all variants present?

Variability present

- Initial more stops, medial/final more fricatives
  - See figures; Y-axis = # of tokens
  - Occasional affricates: b一个职业, gɣ (non-adult)
- Variable within-word
  - For words targeted 3 or more times (# variable/total)
  - Carlos: 4/7; Floriselda: 3/6

Vowel variability

- Both “tense” and “lax” allophones present in both children
  - Esp. matching adult tendencies
  - But particular words variable to some degree
  - As in adult speech
  - Floriselda /nijs/: [i] > [l] > [g]

Diphthongization

- Adult before /nj/: /a/ > /ai/
- Both children produce both variants
  - 38% of tokens with diphthong
- But also generalize occasionally
  - Floriselda:
    - /ko ne?xwe?e/ ‘bunny’ [te’nuuk’æs]
  - Carlos:
    - /tʃango/ ‘monkey’ [dæon]
      (Unassimilated loanword)

Summary: variable input

- Often multiple variants present early
  - With some statistical matching of adult
- But need token frequency info on adults
phonology-morphology interactions

- common for e.g. English-learning children
- constraints on phonological output also on morphologically complex forms
  - no initial unstressed syllables (he went)
  - no codas (played)
- competing outputs in different forms
  - stop vs. tap (sit, sitting)
  - different vowels (fall, fell)
- overgeneralization of base elements
  - si[t]ing, falled

Zapotec rimes: V & C length

- Vowel & consonant length is predictable
  - but moraic
    - V short before (long) fortis C
    - V long before (short) lenis C
  - but in Sw, fortis C also short

<table>
<thead>
<tr>
<th>Final stressed</th>
<th>fortis</th>
<th>lenis</th>
</tr>
</thead>
<tbody>
<tr>
<td>VV:stop</td>
<td>VC</td>
<td>V:C</td>
</tr>
<tr>
<td>medial in Sw</td>
<td>VCV</td>
<td>VCV</td>
</tr>
</tbody>
</table>

Formal analysis

- S feet must be bimoraic
  - bimoraic V or moraic C
- Sw feet
  - always same base morpheme as S
    - plus diminutive suffix or subject pronoun clitic
  - vowel has same number of moras as in S
    - but bimoraic syllable not phonologically required in Sw
    - and so short non-moraic fortis obstruent

Length in final stressed

- Carlos: all vowels short; pattern not acquired
  - 0% long before lenis
  - 8% long before fortis
  - fortis consonants also usually short
- Floriselda: partially acquired
  - 46% long before lenis
  - 8% long before fortis
  - Fortis C often long or [ʔ] before stop (40%)

Length in stressed Sw: Carlos

- Carlos: all vowels short; pattern not acquired
  - 12% long before lenis
  - 17% long before fortis
  - fortis consonants rarely long or with [ʔ] (6%)

Length in stressed Sw: Floriselda

- Floriselda: partially acquired
  - 88% long before short lenis
  - 25% short before short fortis
    - but 24% long before short fortis
  - Fortis C often long or with [ʔ] (51%)
    - /bɛkweʔe/ [bɛʔkwiʔi] ‘doggy’
  - adult short V + short fortis unusual/opaque
    - 75% “regularized” to VC:V or V:CV
Diminutive suffix: -eʔe

- Very frequent in child speech
  - 20-30% of all word tokens
- Adult: phonologically conditioned alternations
  - /iʔi/ after palatal consonants
    - plus epenthetic /j/ after ending in /i/
    - assimilate [+high]
  - /inj/ after other vowels (suppletive)
  - /eʔe/ elsewhere
    - plus epenthetic /w/ after ending in /u/
- Child must learn conditioning

Diminutives: Carlos

- Equal (highish) accuracy on /i/ & /e/
  - overgeneralizing the other
  - similar to general vowel accuracy
- One token of /inj/: plus added -i (/inj-iʔi/)

<table>
<thead>
<tr>
<th>Variant of Diminutive suffix</th>
<th>Carlos 1:11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adult form</td>
<td>-i</td>
</tr>
<tr>
<td>-i</td>
<td>28</td>
</tr>
<tr>
<td>-e</td>
<td>3</td>
</tr>
<tr>
<td>-iʔe</td>
<td>1</td>
</tr>
</tbody>
</table>

Diminutives: Floriselda

- High accuracy -i (overgeneralize -e) & -inj (n=1)
  - but lower than general V accuracy (99%)
- Lower accuracy on -e (overgeneralizing -i)
  - even though -e is adult default

Alternations: summary

- significant error rates
- predictable length
  - overgeneralization of characteristics of base form
  - overgeneralization of V:CV output pattern
  - not by 2;0
- diminutive alternations
  - ¿Floriselda doesn’t treat as assimilation?
  - overgeneralizes /i/-variant

Consonant features

- cross-linguistic comparison of some challenging sounds
  - challenging in Zapotec?
  - types of substitutions

Liquids: /l r r /

- challenging sounds cross-linguistically
- neither child had the tap or trill
  - both had [l] in medial & final only
  - initial
    - variably [j] for all 3 (never [w])
    - Floriselda also deleted some tokens (or [ʔ])
    - both showed some nasal harmony for /l/
    - both sometimes had a uvular approximant
      - not in adult Zapotec
Liquids: /l r r /
- medial, final: [l] usually correct
  - Carlos some medial /l/ as [ɬ, ?], final as [n]
  - Carlos /r/ as [l], or deleted, or harmony
  - Floriselda one medial /r/ as [j]
  - Floriselda final clusters /rj, lj/ as [q, k, kʰ]
- similar to other reports
  - tap as [l] reasonable

why uvular approximant?
- may be uvular constriction in /l, r/  
  - cross-linguistically; no data for SLQZ
  - even in light [l]
  - for /r/, possibly tongue shape to facilitate finicky airflow for trill
  - [j] if match [Coronal], [g] if match [Dorsal]
    - but [w] would preserve uvular gesture, and child doesn’t substitute
- doubtfull if uvular constriction in adult [r]
  - a puzzle

Velar Fronting
- Common in English & German
  - perhaps less common in Slavic languages
  - Beckman & Edwards argued shouldn’t happen in Japanese, where /k/ is more frequent than /t/
    - but has been reported for very young Japanese children
  - Zapotec: /k, g/ more frequent than /t, d/
    - labial stops /p b/ are intermediate
    - especially in initial unstressed syllables

Velar Fronting
- Carlos: no fronting of /k, g/
  - but some of /x, η/, which are less frequent
  - Floriselda: some fronting
  - 22% of /g/ in stressed syllables (stop only)
  - 100% of /k/ in initial stressed syllables
    - /kaˈbaʔi/ [kaˈʔai] (not assimilation)
  - 100% Labial Backing of /p, b/ to [t, d] in initial unstressed syllables

Effects of morphology
- Freq. of velars even greater proportion in initial weak
  - esp. if count in progressive ca-
- ¿should frequency of prefixes affect acquisition in single-morpheme wS?
  - Characteristics of single-morpheme forms affects morphology often.
  - Does the opposite happen? Have we observed this? Have we looked for it?

How to measure frequency
- Anterior coronals are the most frequent place of articulation: high feature type frequency
  - measured across all 11 phonemes
    - 44% of C’s in onset of stressed syllables
    - velars only 24%
  - but phoneme frequency of stops lower
- Maybe: effect of feature frequency
  - not contingent on co-occurring features, CV sequences, or position in word
Weak position

- illustrates weak positions
  - weak in cognitive processing
  - though “word onset” (Shattuck-Hufnagel)
    - fewer adult speech errors
  - ¿ weak perceptually?
- For other Zapotec children, observe partial reduplication in initial wS
  - /kâ’ba?î/ [βa’i]îai
  - Similar to Spanish

Vowel accuracy in initial unstressed

- Floriselda
  - resemblance to adult diminutive allomorphy
  - /a/ assimilates to following palatal consonant or front vowel: 14/19
    - becoming [i/i] or [e/e]
  - infrequently happens elsewhere: 2/21
  - /oi/ is absent (before palatal, front V)
    - always realized as [e] or [ɛ]

Weak position

- Fronting and raising of /o a/ seems to be assimilation to [-back] or [Coronal,-ant]
  - ¿ error on relatively low-frequency targets?
    - [+low] .384, [+Labial] .082
  - ¿ higher-freq default [+back] (.575) assimilates to lower-freq [-back]?

Developmental progression

- Vowel accuracy
  - deletion of syllable
    - Carlos: /pe’lo?î/ → [pot]-[?ot]
  - lower accuracy of vowel features
  - monophthongization of diphthongs
  - S > Sw > wS
    - note: wS = 44% of adult word types
  - not counting inflected verbs
    - adds many wS, no Sw
  - Sw only diminutives, subject pronoun clitics

Trochaic vs. iambic

- Adult phonology is equivocal
  - wS in all single-morpheme disyllables suggests iambic
  - Chávez-Peón: Sw works better
    - short-V short-fortis pattern (/bêkwe?ê/)  
    - if (w)S, leads to monomoraic foot [bg]
  - alternative in OT: coercible Sw

explanations

- high token frequency of Sw
  - but maybe only 50% more frequent
  - high type frequency only if count verb +subject-pronoun-clitic as a “unit”
  - earlier mastery of Sw
- trochaic bias
  - innate, or
  - deriving from innate biases in perceptual processing
### Conclusions about Zapotec

- **variable input**: children show multiple variants early
- **phonology-morphology interactions**
  - predictable V-C length acquired later
  - overgeneralize final-C characteristics to Sw
  - overgeneralize long V before short C
  - diminutive allomorphy errors
  - cluster reduction & weak syllable deletion
  - eliminate overt aspectual prefix marking

### Conclusions about Zapotec

- Frequency effects all over
  - but lots of things counter to what expect by frequency
  - modal voice quality
  - V differences between children
  - feature frequency vs. phoneme frequency
  - velar fronting
- cross-linguistic similarities (liquids)
- and differences (¿initial cluster reduction?)

X:tyoozënn yùad!