Phonological development in Valley Zapotec

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Research project

☞ First language acquisition in San Lucas Quiaviní 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?

- 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
  - Optimality 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

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)

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* [$k^h æ:t$]
    - predicted output [$k^h æ:t$]
  - ACTUAL for many very young children: [d̥a:]
- PROBLEMS:
  - can't derive from stored or generalization over inputs
  - must assume that phonological development is outside the learning mechanisms of the system
  - error-driven learning not allowed

Frequency is important

- type vs. token
- level of element:
  - word, syllable, phoneme, feature, …
  - contingent frequencies (e.g. /te/, /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

	Stops	Affricates	Fricatives	Nasals	Liquids	Glides
Fortis	p t k	ts tʃ	s ʃ ʂ f x	mˑ nˑ ŋˑ	lˑ r	
Lenis	b d g		z ʒ ʐ	m n ŋ	l ɾ	w j

SLQZ monophthongs

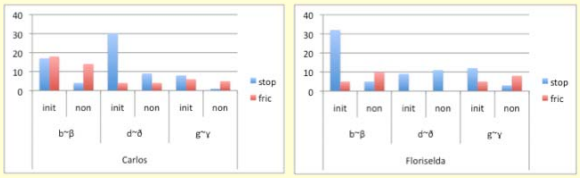
- i e a o u ɨ
  - type frequency: 85% of stressed vowels
  - all both stressed and unstressed
    - minimal reduction in unstressed
      - but shorter (cue to stress)
    - variation in input (stress; voice quality)
      - [i~ɪ], [e~ɛ̝], [u~ʊ], [ɨ~ʌ]
      - some adult words may be nonvariable
  - /ɨ/ especially low-frequency
    - except in clitics (final unstressed)

Matching variability in input

- Adult lenis "stop" varies with fricative
  - b/b̥~β, d/d̥~ð, g/g̊~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: bβ, 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 /ŋi̤s/: [i̤] > [ɪ̤] > [ɛ̤]

Diphthongization

- adult before /nj/: /a/ → /ai/
  - /maʔanj/ 'animal' [maʔainj]~[maʔanj]
- both children produce both variants
  - 38% of tokens with diphthong
- but also overgeneralize occasionally
- Floriselda:
  - /koˈnːeʔxweʔe̤/ 'bunny' [tɛˈnɛukʷe̤ç]
- Carlos:
  - /ˈtʃaŋgo/ 'monkey' [d̥æoŋ]
    (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

	fortis		lenis	
	obstruent	sonorant	obstruent	sonorant
Final stressed	VC: V?-stop	VC:	V:C	V:C
Medial in Sw	VCV opaque	VC:V	V:CV	V:CV

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%)
    - ✎ /ˈbe̯kweʔe̯/ [ˈβɛʔkwiʔi̯.] 'doggy'

- ☞ adult short V + short fortis unusual/opaque
  - ✎ 75% "regularized" to VC:V or V:CV

Diminutive suffix: -eʔẹ

- Very frequent in child speech
  - 20-30% of all word tokens
- Adult: phonologically conditioned alternations
  - /iʔi̱/ after palatal consonants
    - plus epenthetic /j/ after ending in /i/
    - assimilate [+high]
  - /ɨnj/ after other vowels (suppletive)
  - /eʔẹ/ 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 /ɨnj/: plus added -i (/ɨnj-iʔi̱/)

Variant of Diminutive suffix / Adult form	Carlos 1;11	-i	-e	-ëny	% correct
-i		28	5	---	.824
-e		3	21	---	.840
-ëny		1	---	1	.000

Diminutives: Floriselda

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

Variant of Diminutive suffix / Adult form	Floriselda 2;11	-i	-e	-ëny	% correct
-i		16	3	---	.842
-e		23	31	---	.574
-ëny		---	---	1	1.000

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 ɾ 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 ɾ r /

- medial, final: [l] usually correct
  - Carlos some medial /l:/ as [ð, ʔ], final as [n]
  - Carlos /r/ as [l], or deleted, or harmony
  - Floriselda one medial /ɾ/ as [j]
  - Floriselda final clusters /ɾj, l:j/ as [q^h, k, k^h]
- 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], [ʁ̞] if match [Dorsal]
  - but [w] would preserve uvular gesture, and child doesn't substitute
- doubtful if uvular constriction in adult [ɾ]
  - 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, ŋ /, which are less frequent
- Floriselda: some fronting
  - 22% of /g/ in stressed syllables (stop only)
  - 100% of /k/ in initial stressed syllables
    - /kaˈbaʔi/ [taˈβai] (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
  - ✎ /kaˈbaʔi/ [βaˈβai]
  - ❀ 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/ɪ] or [e/ɛ]
  - ✎ infrequently happens elsewhere: 2/21
  - ❀ /o/ 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: /peˈloʔt/ → [pot]~[ʔot]
  - ❖ 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 (/ˈbe̯kweʔe̯/)
    - ✎ if (w)S, leads to monomoraic foot [be̯]
  - ❀ 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!