PhonBank Workshop July 28, 2010

### Regular change and lexical diffusion in early phonological development

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### Developmental change and early production

How does a developmental change in phonology affect different items in production?



Data with time as a factor and words, phrases, sentences etc. as items Generalization about phonological mapping and change

### Outline of the talk

- Possible interpretations of developmental change in phonology
  - Regular change
  - Lexical diffusion
  - Item-based change
- Analyses
  - Word prosodic structures in child Japanese
  - Onset clusters in child English
- Discussion
  - Theoretical implications
  - Methodological implications for Phon(Bank)



### Regular change

- Analogy from diachronic phonology: "Sound laws admit no exceptions" (Leskien, 1876).
- Change targets phonological structures; all words that match the structural description undergo the change.
- Developmental change in phonology reflects reorganization of the underlying system (phonetic or phonological) (Smith, 1973).

<u>/pl/ &gt; [p]</u> ⇒ <u>/pl/ &gt; [pl]</u>
$ \begin{array}{l} [pi:z] \Rightarrow [pli:z] \\ [pei] \Rightarrow [plei] \\ [p \land m] \Rightarrow [pl \land m] \end{array} $
time>



### Lexical diffusion

- Analogy from diachronic phonology: Sound change "gradually worms its way through a gamut of phonetically analogous forms" (Sapir, 1921).
- Developmental change targets phonological structures, but only gradually on a word-by-word basis (cf. Gierut, 2001).
- Diffusion is systematically related to lexical frequency (a.o.t).

$$\frac{p| > p| \Rightarrow p| > p|}{p| > p|} \Rightarrow \frac{p| > p|}{p| > p|}$$

$$[pi:z] \Rightarrow [pli:z] \\ [pei] \Rightarrow [plei] \\ [p \land m] \Rightarrow [p| \land m]$$
time



### Item-based change

- Analogy from diachronic phonology: "Every word behaves independently" (Gilliéron, 1918).
- "Children never learn sounds: They only learn words, and the sounds are learned through words" (Francescato, 1968).
- > Structural generalization is epiphenomenal at least at the beginning.

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[pi:z] \Rightarrow [pli:z][pei] \Rightarrow [plei][p \land m] \Rightarrow [pl \land m]time
```



### Regular change: Predictions

- Timing of acquisition: Timing of convergence on target systematically differs across structures but not between lexical items with the same structure.
- Variability: Within-structures (between-items) variability is noise.
- Frequency: Timing of acquisition may be related to input frequencies of structures (type or token).



### Excursus on input frequency (I)

#### Input frequency

- Structural: Frequency of words with a particular structure
  - Type: Number of different types of words with the structure
  - Token: Total instances of the structure in running speech
- Lexical: Frequency of a particular word



Type frequency of /pl-/: 3 Token frequency of /pl-/: 10 Lexical frequency of 'play': 5

- Source of estimation
  - Typically maternal speech in spontaneous speech data

### Excursus on input frequency (II)

Two views on the role of structural input frequency

- Phonological acquisition = Tracking distributional probabilities of sound structures in the input (Beckman & Edwards, 2001; Zamuner, Gerken, & Hammond, 2004, 2005)
- Phonological acquisition = (Universal) markedness + Structural input distribution as data for grammatical reorganization (Levelt & Van de Vijver, 1998; Hayes & Boersma, 2001; Hayes & Wildon, 2008)

"Every time different rerankings of the grammar are theoretically possible, the learner opts for the reranking that leads to the possibility of producing the most frequent syllable type of the surrounding language, which the previous grammar did not allow for." — Levelt, Schiller, & Levelt (1999/2000)



### Lexical diffusion: Predictions

- Timing of acquisition: Timing of convergence on target systematically differs across structures and also between lexical items with the same structure.
- Variability: Between-structure and within-structure variability is systematic.
- Frequency: Timing of acquisition within each structure is related to input frequencies of *lexical items*.



### Item-based change: Predictions

- Timing of acquisition: Timing of convergence differs systematically between *items*, but *not necessarily across structures*.
- Variability: Between-item variability is systematic.
- Frequency: Timing of acquisition is related to input frequencies of *lexical* items regardless of structures.



### The state of the art

#### Previous research

- Within-structure variability in phonological targets (Ferguson & Farwell, 1975; Taelman & Gillis, 2002)
- Effects of structural frequency (Zamuner et al., 2005, Levelt et al., 1999/2000, Beckman & Edwards, 2000, Munson, 2001)
- Effects of lexical frequency (Gierut, Morrisette, & Champion, 1999; Gierut & Storkel, 2002, Gierut & Dale, 2007)

Limitations

- Structural and lexical frequency effects often confounded.
- Experimental data largely limited to older children.
- Timing of acquisition analysis with naturalistic data not controlled for lexical sampling effects (the 'Gwen problem').



# Study 1: Word production in child Japanese (Ota, 2006)

#### Data

- Longitudinal spontaneous speech data from 3 children (1;5-2;1) Aki, Ryo and Tai in Miyata (1992, 1995, 2000; CHILDES)
- Transcribed in JCHAT (phonemic) and UNIBET (broad phonetic)
- Focus of analysis
  - Targetlike 'word production' = Production of target word without syllable omission
  - Input frequency estimates based on maternal speech
  - Structural description of target word prosodic structure
    - Macro-analysis: Number of syllables
    - Micro-analysis: I) Number of syllables, 2) syllable weight, and 3) location of pitch accent
    - Examples: /untén∫u/ 'driver' HHL2, /budoo/ 'grape' LH0

### Macro-analysis: Number of syllables

• Longer words are 'acquired' (produced without truncation) late.



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### Macro-analysis: Number of syllables

• This pattern correlates with the frequency distribution of words in the maternal input. It might be a structural or lexical frequency effect.



# Micro-analysis: Number of syllables, weight and pitch accent

 Micro-level structures within disyllabic or trisyllabic targets vary in production accuracy.

	Aki			Ryo			Tai			
	Truncation	Input		Truncation Input		<u>iput</u>	Truncation		Input	
	_	type	token	_	type	token	1;5-1;7	1;8-1;10	type	token
LL0	2.2	1.6	5.5	0.4	2.1	7.1	4.8	0.3	2.3	5.2
LL1	2.7	5.1	5.6	0.0	5.9	12.1	0.2	0.7	4.5	5.0
LL2	7.3	5.1	6.0	0.0	3.7	4.1	0.0	0.0	3.0	4.5
LH0				0.0	1.6	1.3	100.0	0.0	1.0	0.5
LH2	0.0	3.1	2.4	13.6	3.2	1.9	7.1	0.0	3.0	2.1
HL1	1.2	5.1	3.9	9.0	6.7	4.0	1.0	0.2	4.7	5.7
HH1	5.3	1.8	1.5	0.3	2.0	5.7	0.7	0.0	1.7	3.8
LLL1				30.0	2.5	1.0	52.1	6.7	6.0	1.9
LLL2				0.0	3.7	2.1	40.0	0.0	2.7	0.7
LHL0				38.9	0.1	0.2		0.0	0.5	0.1
HLH2	100.0	0.4	0.2	6.7	0.4	0.3	100.0		0.3	0.1
HHL2				12.0	0.3	0.5		12.5	0.5	0.1
HHH1	55.6	0.3	0.2				14.3	1.4	0.2	0.8
HHH2	5.3	0.3	1.0	0.0	0.3	0.6	83.3	0.0	0.2	0.2

# Micro-analysis: Number of syllables, weight and pitch accent

Truncation of LH2 in Ryo's data

/omói/ > [moi]	'heavy'	(2;0.15)
/kajúi/ > [jɯi]	'itchy'	(2;0.4)
/sugói/ > [ŋoi]	'great'	(2;0.8)

- Truncation of LH0 in Tai's data
   /budoo/ > [buː] 'grape' (1;5.20)
   /tokee/ > [keː] 'clock' (1;6.11)
- Non-truncation of HHH2 in Aki's and Ryo's data
   /ſiŋkansen/ > [ſiŋdʒoːsoː] 'bullet train' (Aki, I;II.2)

/hambaagaa/ > [hammaːgaː] 'hamburger' (Ryo, 2;0.4)

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# Micro-analysis: Number of syllables, weight and pitch accent

• This *may* be related to structural input frequency.



Accuracy of disyllabic structures by type or token structural frequency

### Lexical frequency effects (I)

Effects of lexical frequency are not detected when all cases are analyzed.
 Many low-frequency items are produced without syllable omission.



### Lexical frequency effects (II)

• But lexical frequency effects emerge when we analyze only words that undergo some syllable omission (i.e., words not completely acquired).



# Summary: Word production in child Japanese

Consistent with...

- Disyllabic targets are 'acquired' before longer words; correlated with structural input frequency.
- Accuracy of micro prosodic structures varies; possibly correlated with structural input frequency.
- Lexical input frequency not correlated with overall accuracy of production.
- Lexical input frequency correlated with accuracy of words in the process of acquisition.





# Discussion: Word production in child Japanese

Best interpretation: Lexical diffusion

- Development of word production is conditioned by the prosodic structure of the target word.
- Items on their way to be acquired show lexical input effects.
- Issues
  - No clear frequency effects in micro analysis of prosodic structure. Analysis may be based on wrong classification of prosodic structure types or simply lacking in power.
  - Only accuracy analysis. No timing-of-acquisition analysis.
  - Poor time resolution in analysis.



### Study 2: Onset cluster production in child English

#### Data

- Longitudinal spontaneous speech data from Naima (1;0-3;4) in the Providence corpus (Demuth, Culbertson, & Alter, 2006; CHILDES)
- Transcribed in SAMPA > UNICODE (phonetic)
- Focus of analysis
  - Targetlike 'cluster production' = Production of target word-initial consonant clusters without segmental deletion, insertion or substitution (ignoring voicing)
  - Input frequency estimates based on maternal speech

### Accuracy analysis by cluster type

• There are some systematic differences across cluster types in the level of accuracy and the timing of change.



### Accuracy analysis by cluster type

Naima cannot produce clusters including /r/.

[t^k] 'truck, ' [pɪrɪ] 'pretty' (1;6)
[kwim] 'cream,' [tweɪn] 'train' (3;0)
[twi] 'tree,' [pwɪtɛnd] 'pretend,' [fwɛn] 'friend' (3;10)

- But Naima cannot produce singleton /r/s either.
   [wʌbɪŋ] 'rubbing, ' [weɪnɪn] 'raining' (2;0)
   [wid] 'read,' [wæn] 'ran' (3;0)
   [wuf] 'roof,' [waks] 'rocks,' [wikʊd] 'record,' [waɪ] 'right' (3;10)
- Remove C(C)r clusters from the analysis.



### Accuracy analysis by cluster type

There are still differences: /bl/, /kl/, /pl/, /sk/, /st/ > /tw/ > /sl/, /fl/ > /sw/ > /mj/



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### Accuracy and frequency of cluster type

• These differences are related to the type frequencies of cluster types, at least in the early months.



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# Timing-of-acquisition analysis: Dealing with the 'Gwen problem'

 Criteria used to establish the timing when the cluster is acquired in each lexical item: Accuracy > 0.9 + attempts in immediately preceding age bins.



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# Timing-of-acquisition analysis by cluster type and words

The timing of acquisition (Accuracy > 90%) is not always close for words with the same cluster type.



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# Timing-of-acquisition analysis by cluster type and words

• Acquisition timing within some clusters is related to lexical input frequency.



Accuracy analysis by words and lexical input frequency (the '7' pattern)

Is this part of a general lexical frequency effect?



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# Accuracy analysis by words and lexical input frequency

A lexical input frequency effect emerges when we remove already-acquired items.
1 2 3 4 5 6



### Summary: Onset cluster production in child English

Consistent with...

- Systematic difference in accuracy and acquisition timing across cluster types; correlated with structural input frequency
- Large lexical variability of acquisition timing within each cluster type; correlated with lexical frequency.
- Lexical input frequency not correlated with overall production accuracy.
- Lexical input frequency correlated with production accuracy of words that are not completely acquired.



### General implications

- Convergence on targetlike production occurs
  - at systematically different rates across phonological structures; structures that are more frequent in the input are acquired first.
  - at systematically different rates across lexical items that include a structure in the process of being acquired; the target structure is acquired sooner when it is contained in words that are more frequent in the input.
- In other words...
  - Developmental change in production does target phonological forms.
  - Change is not uniform but spreads across lexical items.

### General implications

#### Unresolved issues

- Markedness effects independent of input frequency effects?
  - $\bullet \ \sigma \ \sigma > \sigma \ \sigma \ \sigma$
  - CC > CCC
- Frequency
  - Token or type?
  - Input (exposure) or output (trials)?
- Lexical neighborhood
- Any phonological structure?
- Why lexical diffusion?



### (Content) conclusion

• Are we justified in doing this?



### Methodological implications for PhonBank

- Desirable features for (further) investigation: Corpora
  - Input data (at least orthographic transcription of caretaker speech).
  - Density; density-resolution tradeoff in binned regular sampling can be reduced by focused sampling.



### Methodological implications for Phon

- Desirable features for (further) investigation: Analysis program
  - Reporting outputs in dataframes.

