Conceptual and empirical challenges to statistical approaches to child language production

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Background

- **Infant speech perception:**
  Statistical and probabilistic approaches provide convincing explanations for:
  - Discrimination of sound sequences
  - Perception and development of linguistic categories
  - Development of the mental lexicon
  - (Work by, e.g. Aslin, Gerken, Jusczyk, Maye, Morgan, Newport, Saffran, Tees, Werker)
  - (Other factors such segmental, co-articulatory and supra-segmental information also play a role in language learning)
    - (Work by, e.g. Curtin, Werker)
Early word productions:
Researchers have recently proposed that patterns of early word productions can also be explained in a statistical way

Levelt, Schiller & Levelt (2000): Order of acquisition of syllable types in Dutch learners generally corresponds to frequency of syllable types in the ambient language

Demuth & Johnson (2003): Patterns of syllable truncation to CV forms in French are related to the high frequency of CV words in the language
Outline of the argument

- Statistical approaches to early word productions are conceptually and empirically problematic
- The problem is much more complex; it involves several interacting factors, for example:
  - Perceptual
  - Articulatory
  - Distributional
  - Statistical
  - Cognitive
  - ...
- Implications for research in acquisition
- Project in the works
Statistical approaches: predictions

- Acquisition order (of syllable types, word shapes, segments) match statistical prominence, such that:
  - Most frequent units acquired first
  - Less frequent units acquired last

- Variation occurs between units when the relative frequency of these units is comparable
  - Equally-frequent units are acquired in various orders, but within a relatively short period of time
Levelt et al. (2000): acq. of syll. types in Dutch

- Learning paths generally match the frequency orders observed in Dutch.
- Variation between groups A and B due to the comparable frequencies of these syll types.

Group A: \( CVCC > VCC > CCV > CCVC \)

Group B: \( CCV > CCVC > CVCC > VCC \)

Their conclusion: acquisition of syllable types in production can be predicted from input statistics.
Empirical issues

- **Levelt et al. (2000), Kehoe & Lleó (2003):** “V” syllables are acquired earlier than expected
  - Relatively infrequent in Dutch yet acquired early
  - (Potential role of interjections or child-directed speech)
- **Kehoe & Lleó (2003):** Diphthongs are acquired much earlier than expected
  - Less frequent than CVC syllables in both Spanish and German yet acquired before these syllables
- Kehoe & Lleó’s (2003) careful conclusion: “Frequency information may explain some but not all of the acquisition findings”
Frequency versus complexity

**Does a frequency-based approach make better or different predictions than a markedness/complexity-based approach?**

- ‘Simple/unmarked’ >> ‘more complex/marked’

**Dutch groups A and B focus on different positions:**
- **A: Final before initial**: CVCC > VCC > CCV > CCVC
- **B: Initial before final**: CCV > CCVC > CVCC > VCC
- **Unattested patterns**: CVCC > CCV > VCC > CCVC;
  CCV > CVCC > CCVC > VCC; …

**Markedness-based approaches allow for both paths**
- **Finnish, Klamath**: CVCC but *CCV
- **Mazateco, Sedang**: CCV but *CVCC
In the larger context...

- Statistical approaches predict similar acquisition paths within languages; variation is important
  - Acquisition of segments
    (e.g. Ferguson & Farwell 1975, Ingram 1989, Fikkert 1994, Bernhardt & Stemberger 1998)
  - Acquisition of prosodic structure
- Emergent processes: Why do children produce patterns that have no correlates in the adult language?
  - Consonant harmony (e.g. duck > [ɡʌk])
  - Positional velar fronting (e.g. kick > [tɪk])
Alternative approach

- Learning paths are driven by the child’s analysis (understanding) of the target language
- Approach explicit in, e.g. Rose (2000, 2003), Goad & Rose (2004), Fikkert & Levelt (2004), ...
- Dates back to gestalt (holistic) versus analytic acquisition styles in the acquisition literature from the 1970’s and 1980’s (e.g. Bretherton et al. 1983)
- Goad & Ingram’s (1987) sources of variation:
  - Environment-related variation (e.g. input effects)
  - Performance-related variation (e.g. rate of acquisition)
  - Linguistic variation: explicitly refers to child’s analysis
- Child’s analysis is influenced by several factors
Some factors influencing acquisition

- **Perceptual effects**
  - May result in non-adult representations

- **Articulatory effects**
  - May result in non-adult productions

- **Distributional / contextual facts**
  - May influence acquisition across positions within the syllable or within the word

- **Statistical pressure from the ambient language**
  - May affect acquisition of rare versus frequent structures
  - May explain some cross-linguistic variation
Some factors influencing acquisition

- **Statistical pressure from the productive lexicon**
  - May influence the overall shape of linguistic productions
  - May provide explanation for the emergence or resolution of processes attested in child language

- **Cognitive factors**
  - Children’s analyses generally match those of existing grammars
  - Universal Grammar can be seen here as a cognitive frame that constrains the representation and processing of linguistic units in the human brain
Elaboration of non-adult representations because of misperceptions of the ambient signal

Macken (1980) (data from Smith 1973)

- **puzzle** /pʌzˈl/ > [pʌdˈl]
- **puddle** /pʌdˈl/ > [pʌdˈl]

- If the child can produce [d] in target puzzle, then the reason for not producing it in target puddle cannot be attributed to production or grammatical factors (see also Braine 1976)
Perceptual effects (continued)

- **Merging of perceptually-similar segments**
  - Acquisition of /θ/ ~ /f/ contrast in English:
    - /f/ > [f]
    - /θ/ > [f] (e.g. Bernhardt & Stemberger 1998)
  - /θ, f/ are acoustically very similar (e.g. Levitt et al. 1987; Borden et al. 2004)

- **Analysis of allophones as different phonemes**
  - Acquisition of /l/ in English (e.g. Bernhardt & Stemberger 1998, Inkelas & Rose 2005):
    - Onset: /l/ > [j]
    - Coda: /l/ > [w]
  - Pattern matches [l, l] allophonic distribution in English
Articulatory effects on child’s analysis

- Child versus adult vocal tract (e.g. Crelin 1987)

(Adult shape gradually attained by approximately age 6)
Motor control influences (e.g. Studdert-Kennedy & Goodell 1992)
Articulatory effects on child’s analysis

- **Velar fronting:** data from child code-named ‘E’

**Prosodically weak positions:** /k, g/ -> [k, g]

<table>
<thead>
<tr>
<th>Word</th>
<th>Pronunciation</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>monkey</td>
<td>['maŋki]</td>
<td>1:09.23</td>
</tr>
<tr>
<td>bagel</td>
<td>['bejgu]</td>
<td>1:10.01</td>
</tr>
<tr>
<td>bucket</td>
<td>['bʌkit]</td>
<td>1:11.02</td>
</tr>
</tbody>
</table>

**Prosodically strong positions:** /k, g/ -> [t, d]

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>cup</td>
<td>['tʌp]</td>
<td>1:09.23</td>
</tr>
<tr>
<td>go</td>
<td>['do]</td>
<td>1:10.01</td>
</tr>
<tr>
<td>cool</td>
<td>['tuw]</td>
<td>1:11.02</td>
</tr>
</tbody>
</table>

Inkelas & Rose (2003)
Articulatory effects on child’s analysis

- Inkelas & Rose (2003) on positional velar fronting
  - Child perceives an allophonic contrast between stops in strong versus weak prosodic positions
  - Immature shape of vocal tract and imprecise articulatory control prevent a reproduction of the contrast for velars
    - Requires expanded, more forward contact of tongue body on hard palate, which induces coronal release
  - The child produces [t,d] versus [k,g] surface variants that correspond to velars in strong versus weak positions, even if these variants are phonetically inaccurate
- Conclusion: the process of positional velar fronting reveals child’s analysis of the target language
Explaining chain shifts

- Chain shifts are problematic for grammatical-only approaches to language production (Hale & Reiss 1998; see also Bernhardt & Stemberger 1998)

- An example of chain shift:
  - /θ/ > [f] (thick /θɪk/ > [fɪk])
  - /s/ > [θ] (sick /sɪk/ > [θɪk])

- Why not /θ/ > [θ] since [θ] production is attested?

- Hypothesis: conspiracy of perceptual and articulatory effects
  - /θ/ > [f]: perceptual source
  - /s/ > [θ]: articulatory source
Distributional effects on child’s analysis

- **Acquisition of word-medial codas versus word-final consonants across languages**
  - Dutch, French, German: word-final consonants acquired clearly before word-medial codas (e.g. Levelt et al. 2000, Rose 2000, Kehoe & Lleó 2003)
  - Japanese, Spanish: variable patterns (e.g. Ota 1999, Kehoe & Lleó 2003)

- **Phonological analysis of word-final consonants**
  - Dutch, French, German: Onsets of Empty-Headed syllables (unrestricted distribution)
  - Japanese, Spanish: true codas (restricted distribution)
Statistics of ambient language

- Within languages: exceptional phonological behaviours are often found in high-frequency words (e.g. Menn & Matthei 1992; Kern, this workshop)
- Across languages: acquisition of complex/marked structures is favoured by high frequency
  - Segments (e.g. Pye, Ingram & List 1987, Zamuner 2003)
  - Prosodic structure (e.g. Demuth & Johnson 2003)
- Challenge: high frequency often correlates with unmarkedness within and across languages
- Need: cross-linguistic approaches to the acquisition of complex segments and sequences
Cognitive influences on child’s analysis

- Despite the various influences covered:
  - Variation relatively constrained within and across language learners (e.g. Jongstra 2003, Goad & Rose 2004)
  - Emergent properties of child language are similar to those of adult languages
  - Child language can be analysed using the theoretical constructs required in the analysis of adult languages

- Compatible with Continuity Hypothesis (Pinker 1984)

- Supports some degree of abstraction, constrained by theories of linguistics and cognition, in the analysis of child language
Overall implications

- **Statistical approaches to children’s productions:**
  - Cannot explain much of the evidence
  - Prevent explanations of some of the phenomena observed

- **An understanding of children’s productions requires analysis covering several factors such as:**
  - Perceptual influences
  - Articulatory pressures
  - Properties of target language (e.g. inventories, distributions and statistics)
  - Nature of children’s attempted and produced words

- **Ultimately, all single-factor approaches are doomed**

- **What’s needed: broad, cross-linguistic investigations**
However

- No cross-linguistic database currently exists
  - Except for Dutch (the Levelt-Fikkert corpus), the data available cover only a few children
  - The few existing corpora are based on various methodologies and transcription conventions

- No computerized tool currently exists to make the elaboration of the ‘dream’ database possible
  - No data encoding standard
  - No data sharing system
Proposed solution

- **Phon** (Rose et al. 2005):
  Software program for transcription, compilation and analysis of phonological data
  - Provides specialized functionality for acquisition studies
  - Offers a standard for data sharing among researchers

- **PhonBank** (MacWhinney, Rose & Davis):
  Proposal for a publicly-available database for the study of phonological development
Phon software project

- Programmed in Java with Unicode support
  - Works on Macintosh, Windows, Linux, UNIX
- Data storage in CHILDES TalkBank format
- Main functions:
  - User management
  - Segmentation of multimedia datafiles
  - Functionality for multiple-blind IPA transcriptions
  - Segmentation of transcribed utterances
  - Automatic syllabification of the transcribed forms
  - Automatic alignment of target and actual segments and syllables
  - Query language
PhonBank database project

- **Project leaders**
  - Brian MacWhinney (Carnegie Mellon University)
  - Yvan Rose (Memorial University of Newfoundland)
  - Barbara Davis (University of Texas-Austin)

- **Collaborators**
  - Barbara Davis (University of Texas-Austin)
  - Rodrigue Byrne (Memorial University of Newfoundland)

- **Research consortium**
  - 26 collaborators
  - 16 languages
  - Monolingual, bilingual, clinical, include babbling

- **Pending funding...**
Immediate potential

- Scientific exchanges between researchers working in related areas made easier
- Research based on:
  - Much stronger empirical base
  - Combination of various experimental methods
- Systematic comparisons of various corpora:
  - Within and across languages
  - Within and across populations
  - Within and across age groups
  - ...
Longer-term potential

- Better understanding of:
  - Language acquisition process
  - Developmental and acquired language disorders
- Contribution to development of more adequate theoretical models
- Establishment of more accurate baselines for early detection of language delays/disorders
- More rapid and efficient educational and therapeutic interventions
Thanks for your attention!
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