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)*

Background (continued)

- ***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

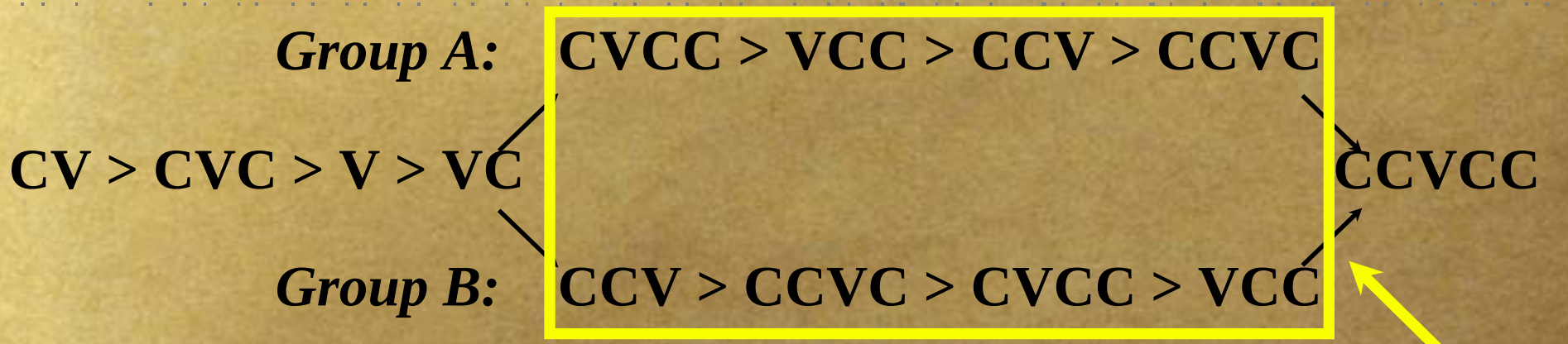
Outline of the argument

- ***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***

CV > CVC > VC > V > {CVCC ≈ CCVC ≈ CCV ≈ VCC} > CCVCC

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 <u>some but not all</u> 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***
    (e.g. Fikkert 1994, Fikkert & Freitas 1997, Jongstra 2003, Freitas 2003, Rose 2003)
- ***Emergent processes: Why do children produce patterns that have no correlates in the adult language?***
  - ***Consonant harmony (e.g. duck >*** [gʌk]***)***
  - ***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***

Perceptual effects on child's analysis

- ***Elaboration of non-adult representations because of misperceptions of the ambient signal***
  - ***Macken (1980) (data from Smith 1973)***

  - ***puzzle*** /pʌzˊɬ/ **>** [pʌdˊɬ]
  - ***puddle*** /pʌdˊɬ/ **>** [pʌgˊɬ]

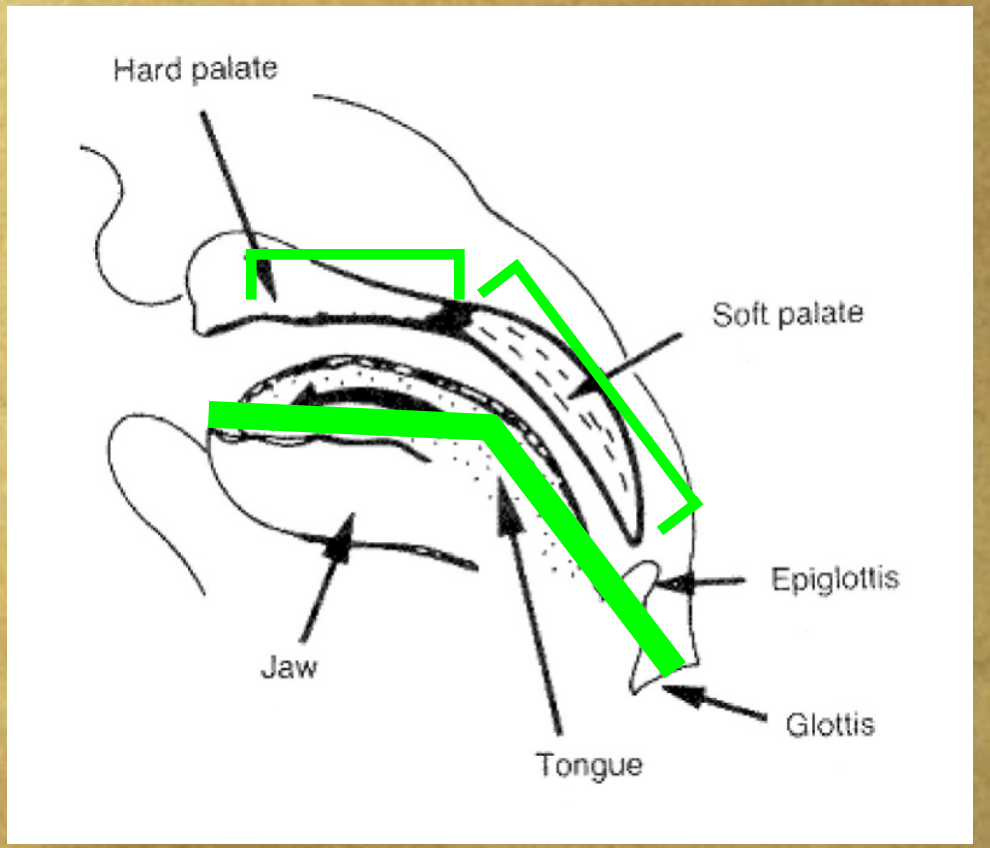
  - ***If the child can produce [d] in target puzzle, then the reason for not producing it in target puddle cannot be attributed to production or grammatical factors (see also Braine 1976)***

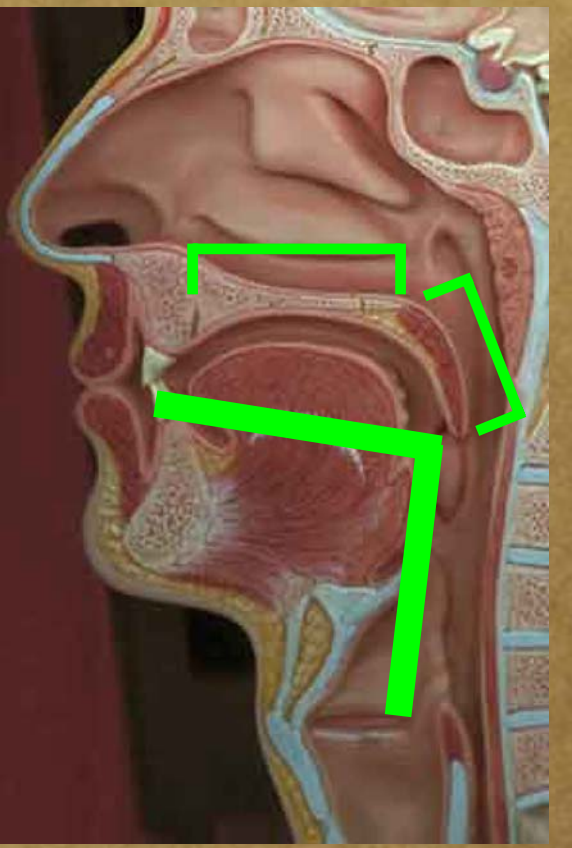
Perceptual effects (continued)

- ***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, ɬ] ***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]**

'monkey'	*[ˈmaŋ̲ki]*	*1;09.23*
'bagel'	*[ˈbejg̲u]*	*1;10.01*
'bucket'	*[ˈbʌk̲ɨt]*	*1;11.02*

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

'cup'	*[ˈt̲ʰʌp]*	*1;09.23*
'go'	*[ˈd̲o]*	*1;10.01*
'cool'	*[ˈt̲ʰuw]*	*1;11.02*

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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