Phonetic, phonotactic, and neighborhood effects on syllable production in child Southern Min

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Abstract

Longitudinal speech data were collected from seven children (ages 1;7 - 3;6) acquiring Southern Min (Taiwanese). Syllable production accuracy

Decreased with the phonetic complexity of targets

Showed no clear effect of phonotactic probability

Increased with higher neighborhood density

Unlike English, neighborhood density was more important than phonotactic probability, perhaps due to Southern Min's very small syllable inventory

Child speech in English

Word pronunciation accuracy is affected by

Phonetic complexity

Reduces accuracy (Gierut, 2001)

Phonotactic probability

Increases accuracy (Storkel, 2004)

Neighborhood density

Mixed effects on accuracy (Storkel, 2004)

Lexical frequency

Increases accuracy (Gierut, 2001)

Word length

Decreases accuracy (Storkel, 2004)

Age

Increases accuracy overall, and modulates the above effects (Munson et al. 2005)

Southern Min (Taiwanese)

Syllable-timed

Almost all morphemes are monosyllabic

Almost no cross-syllabic segmental phenomena

Simple syllable structure

C V V X ^{T}

C = ∅, b, p, p^{h}, t, t^{h}, g, k, k^{h}, s, z, ts (tɕ), ts^{h} (tɕ^{h}), h, m, l, n, ŋ
V = a, ă, e, ē, i, ĭ, ɔ, ɔ̆, u (ŭ), o, m̩, ŋ̍
X = ∅, m, n, ŋ, p, t, k, ʔ
T = seven tone categories (not analyzed in this study)

Very small syllable inventory

Around 800 lexical syllables (ignoring tone)

Data

Seven children from the longitudinal Taiwanese Child Language Corpus (Tsay 2007), transcribed in IPA

Child	Sex	Start	End
CEY	F	2;1.27	2;10.19
HBL	M	2;1.22	3;6.26
HYS	M	1;10.11	2;3.24
LWJ	F	2;1.8	2;8.25
LYC	F	1;6.10	2;4.1
TWX	F	1;7.13	2;3.22
WZX	M	2;1.17	3;0.2

115 hours of spontaneous interactions with adults

88,280 audible Southern Min syllable tokens with at least two target segments (for bigram calculations)

Analysis

Dependent variable

Similarity of actual pronunciation to target by segment (both transcribed allophonically)

$$1 - \frac{\text{EditDistance(Actual, Target)}}{\max(\text{length (Actual, Target)})}$$

bak → [ba]: 0.667 (= 1 – 1/3)
gua → [o]: 0.000 (= 1 – 3/3)

Independent variables

Mean number of feature differences within bigrams
[le]: 4 (Cons, Cor, Alv, Cont)
[tsu]: 10 (Cons, Lab, Cor, Alv, Cnt, Aff, Son, Vcd, Bk, Hi)

Log mean bigram probability
ia: -2.64 (= ln(121/1695))
pɔ̃: -7.44 (= ln(1/1695))

Neighborhood density (number of lexical neighbors)
ka 40 (a, ba, tsa, ke, ki, ko, kai, kak, kam, kia, ...)
kĭũ 4 (kĭ, kĭã, kĭɔ̃, tɕ^{h}ĭũ)

Log syllable frequency

Syllable length (in segments)

Age (in days)

Statistical analysis

Variables slightly confounded (max(VIF) = 4.77 < 5)

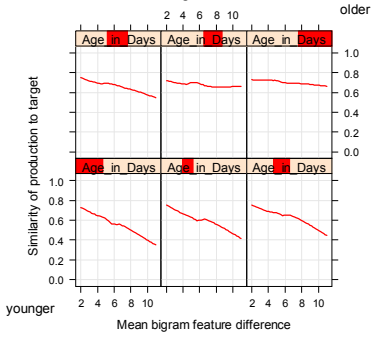
Linear mixed effects modeling

Include interactions of Age with other variables

Children treated as random variable

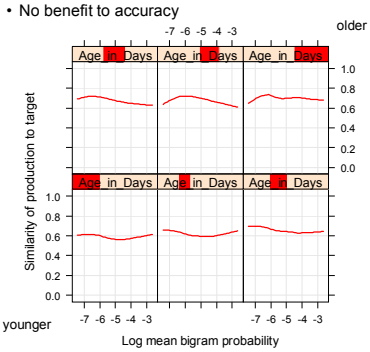
Phonetic complexity

- More difficult targets were produced less accurately
- Effect weakened with age



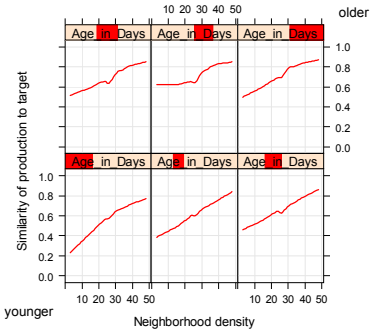
Phonotactic probability

- No benefit to accuracy



Neighborhood density

- Targets in denser neighborhoods were more accurate
- Effect weakened with age



Other effects

Log syllable frequency

Not significant

Small inventory may make all syllables relatively memorable

Syllable length

Longer syllables showed less accuracy

Age

No consistent independent benefit to accuracy

Confounded with vocabulary size (cf. Munson et al., 2005)

Caveats:

Confounding among variables is intrinsic and not negligible, especially among syllable length, phonotactic probability and neighborhood density (cf. Storkel, 2004)

Conclusions

Greater featural complexity in bigrams meant less production accuracy, independent of lexical effects

Phonotactic probability had no consistent effect

With a very small syllable inventory, decomposition may be unnecessary, since syllables can be learned as wholes

Neighborhood density improved accuracy

With a very small syllable inventory, learning syllable production may depend more on analogy than analysis

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