Locality and Cumulative Complexity Effects in Child Phonology

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1. Introduction

The big question: When, if ever, can sources of complexity interact cumulatively in child phonology?

• Does accuracy of a given marked structure decrease when additional sources of complexity are present in the word?

This type of effect has been described in a variety of sources:

• Ferguson & Farwell (1975: 423) report that some of their data can be attributed to “backgrounding” – such that “the word-initial consonant is deleted or drastically reduced when the child is ‘working on’ another part of the word”

\[ \text{milk} \rightarrow \text{[k]} \]

• Stemberger (1995: 262-263) reports data suggesting that simplification takes place when word-final consonants and word-final unstressed syllables co-occur. These simplifications will arise even when the child is capable of producing each of these complexities independently.

<table>
<thead>
<tr>
<th>Target</th>
<th>Child 1</th>
<th>Child 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>stressed, with coda</td>
<td>hit</td>
<td>hit</td>
</tr>
<tr>
<td>unstressed, no coda</td>
<td>kitty</td>
<td>kitty</td>
</tr>
<tr>
<td>unstressed, with coda</td>
<td>pocket</td>
<td>pocket</td>
</tr>
</tbody>
</table>

• Levelt, Schiller & Levelt (1999/2000) report a sequence of syllable structure production for Dutch that includes cases of apparent non-local interaction between onset and coda complexity – e.g., production of [CCV] and [CVC] before [CCVC]...

In general, it is somewhat difficult to interpret these claims based on the data provided for a variety of reasons – e.g.,:

• Prosodic factors are typically not considered – see Demuth, Culbertson & Alter (2006)

• Natural variation in the data is not taken into account; multiple structures are produced in some cases – see (3)

\[ H = \sum_{k=1}^{K} s_k w_k \]

• Level's study is based on a small (1999/2000) report a sequence of syllable structure production from child Dutch that includes cases of apparent non-local interaction between...

Semenyclerk (1992: 242ff.) reports data suggesting that simplification takes place when word-final consonants and word-final unstressed syllables co-occur – precisely the type of effect that is available in the data. This phenomenon will arise even when the child is capable of producing each of these complexities independently.

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Two predictions for learning

(4) Example – HG weighting produces a different result than OT ranking

\[
\begin{align*}
W_1 &= 4 \\
M_1 &= 3 \\
M_2 &= 2 \\
H &= 1 + 3 + 1 = 5 \\
\text{faithful} \\
\end{align*}
\]

\[
\begin{align*}
W_1 &= 1 \\
M_1 &= 1 \\
M_2 &= 4 \\
H &= 1 + 4 = 4 \\
\text{unfaithful} \\
\end{align*}
\]

This does not expand the predicted typology as much as one might think, however (see esp. Pater 2009).

As scenario like that in (4) requires that it is possible for the two markedness violations to be resolved simultaneously. This is generally only possible when markedness violations are local to one another.

E.g., Onset clusters, which violate *COMPLEXONSET, are generally realized faithfully, but not when a member of the cluster is a velar fricative violating *X.

(5) a. Clusters are realized faithfully

\[
\begin{align*}
W_1 &= 4 \\
M_1 &= 3 \\
M_2 &= 2 \\
H &= -1 -3 + k + 1 - 3 - 1 = 5 \\
\end{align*}
\]

b. … but deletion applies if the target cluster includes a velar fricative

\[
\begin{align*}
W_1 &= 4 \\
M_1 &= 3 \\
M_2 &= 2 \\
H &= -1 -1 -5 + x + 1 - 3 + 4 = 5 \\
\end{align*}
\]

E.g., *COMPLEXONSET cannot interact cumulatively with NOCODA. If complex onsets are realized as such when there is no coda, they must also be realized as such when a coda is present.

(6) a. Onset clusters are realized faithfully

\[
\begin{align*}
W_1 &= 4 \\
M_1 &= 3 \\
M_2 &= 2 \\
N &= 2 \\
H &= -1 -3 + c + 1 - 3 - 1 = 5 \\
\end{align*}
\]

b. … and adding a coda consonant (non-local complexity) does not change this

\[
\begin{align*}
W_1 &= 4 \\
M_1 &= 3 \\
M_2 &= 2 \\
N &= 2 \\
H &= -1 -1 -5 + c + 1 - 3 - 1 + x + 4 = 5 \\
\end{align*}
\]

This gives rise to two predictions – both of which hinge upon whether or not the sources of markedness are local to one another.

Simulations were conducted in Praat (Boersma & Weenink 2009). Figures 1-4 each show the mean results of ten simulations. Simulation parameters: Decision mode = “LinearOT”; initial weight of Markedness constraints = 100; initial weight of faithfulness constraints = 0; plasticity of markedness constraints = 1.0; plasticity of faithfulness constraints = 0.1; noise = 2.0. All inputs were of equal frequency unless otherwise noted; results were sampled by drawing 100,000 input-output pairs after every 5 learning trials.

3. Two predictions for learning
Prediction 1: Over the course of learning, marked structures will be realized less accurately, on average, when they are in locally more complex contexts, but not when they are in non-locally more complex contexts. The learner acquires complex onsets earlier when the onset does not include the increased local complexity of the marked fricative. However, when sources of complexity are non-local, the grammar cannot represent a stage where complex onsets are acquired in only one of the contexts. The learner acquires complex onsets at the same time in syllables with and without target coda.

Looking across time, we expect to see higher degrees of cluster realization for input /kla/ vs. input /xla/. No such differences should be observed for input /CCV/ vs. /CCVC/.

Prediction 2: A different pattern of repairs will exist for locally more complex structures vs. their less complex counterparts, but not for non-locally more complex structures vs. their less complex counterparts. Deletion is preferred in cases of increased local complexity, because it allows multiple markedness violations to be resolved simultaneously. Deletion is therefore preferred to a greater extent with /xla/ vs. /kla/. However, when sources of complexity are non-local, the grammar cannot express a different local complexity of the marked fricative. The learner acquires complex onsets at the same time in syllables with and without target coda.

Over time, we expect to see higher degrees of cluster realization for input /kla/ vs. input /xla/.
4. The data

The data I tested these two predictions using data from the 12 Dutch-acquiring children in the CLPF database (Fikkert 1994, Levelt ... CHILDES (MacWhinney 2000). The goal here is to look explicitly to see whether there are differences in the probability of accuracy and of different types of repairs for marked structures given different degrees of local and non-local complexity. Using Phon (Rose & Hedlund 2009), all data relevant to testing the interaction of complexity factors in either the local or non-local scenario were extracted.

Local scenario:
• factor 1: onset complexity (simple onset vs. complex onset)
• factor 2: presence of target fricative /θ/ based on all target onset clusters in word-initial stressed position

Non-local scenario:
• factor 1: onset complexity (no onset vs. simple onset vs. complex onset)
• factor 2: coda complexity (no coda vs. simple coda vs. complex coda) based on all target stressed V, VC, VCC, CCV, CCVC, CVCC and CCVCC syllables obeying the Sonority Sequencing Principle

5. Results

Local scenario:
In the CLPF database target onset clusters that include the fricative /θ/ are, on average, realized as clusters significantly less often than clusters that do not include this fricative. Results of mixed logistic regression model with child and by-subjects effect of age as random factors, cluster realization as dependent variable: *(8)*

| Fixed effects: | Estimate | Std. Error | z value | Pr(>|z|) |
|---------------|----------|------------|---------|----------|
| (Intercept)   | -9.811535| 2.429013   | -4.039  | < 0.001 * |
| age           | 0.011252 | 0.003227   | 3.487   | < 0.001 * |
| contains.x    | -1.795887| 0.120433   | -14.912 | < 0.001 * |

Furthermore, the probability of deletion vs. other cluster repairs is significantly higher when the target cluster contains the fricative /θ/ than when it does not. Results of mixed logistic regression model with child and by-subjects effect of age as random factors, deletion repair as dependent variable: *(9)*

| Fixed effects: | Estimate | Std. Error | z value | Pr(>|z|) |
|---------------|----------|------------|---------|----------|
| (Intercept)   | 5.556798 | 1.973888   | 2.815   | 0.005 *   |
| age           | -0.003468| 0.002658   | -1.305  | 0.192     |
| contains.x    | 1.460714 | 0.629303   | 2.321   | 0.020 *   |

Non-local scenario:
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In all cases, deletion is preferred to a greater extent here than would be expected based on the simulations from §3 – though the extent of this preference increases given \( \cdot \).

This suggests that there are additional general constraints that favour deletion over epenthesis – e.g., a constraint disfavouring initial weak syllables (Fikkert 1994). These differences cannot be attributed an absence of featural repair possibilities for target \(/\) – the mean deletion rate of singleton \(/\) is only 2.34\% (range: 0\% - 6.03\%).

More puzzling from the perspective the HG-GLA model:

- While the presence of \(/\) has a negative effect on probability of cluster realization and a positive effect on the probability of deletion repairs, the segment deleted from the marked clusters is typically not \(/\). In other words, when deletion applies and one of the target segments from the cluster is retained, that segment is most often \(/\).

(10) target /s/: 32.89\% /s/ retained

In the Dutch data, it appears that the short preference is for retaining the less sonorous of the segments in the target cluster. The presence of \(/\) in the target cluster appears to trigger deletion repairs at higher rates than are otherwise expected, but the choice of what is deleted unexpectedly falls to other factors.

In the CLPF database there is no consistent effect of coda complexity on accurate realization of onset marked structures, or vice versa. Being in a non-locally more complex context does not render a marked structure less likely to be realized as such. In other words, when deletion applies, the constraint that preserves the fricative is harmonically bounded.

The simple model predicts no benefit from retention of \(/\) in these contexts in \(/\) /\ as well as in the target cluster.

The likelihood of an onset cluster, coda cluster or onsetless syllable being realized as such is not reliably affected by non-local sources of complexity. The likelihood of an onset cluster, coda cluster or onsetless syllable being realized

\[
\begin{array}{|c|c|c|c|}
\hline
\text{H} & \text{X} & \text{X} & \text{X} \\
\hline
6 & 1 & 1 & 1 \\
5 & 1 & 1 & 1 \\
4 & 1 & 2 & 1 \\
3 & 3 & 1 & 1 \\
2 & 3 & 1 & 1 \\
1 & 3 & 1 & 1 \\
\hline
\end{array}
\]

Where the target is \(/\), the source is no \( /\). Where the target is not \(/\), the source is \(/\). Without the existence of \(/\) /\, there is no evidence of \(/\) /\, regardless of the other syllable components from the start.

The likelihood of \(/\) /\ being accurately realized is strongly correlated with the other syllable components.

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6. Conclusions

The results of this study support the importance of locality in cumulative interaction. The data do not support the idea that the grammar can cause cumulative interaction of non-local sources of complexity – contrary to various proposals formulated in response to Levelt, Schiller & Levelt’s (1991) proposal of the ‘principle of minimal interaction’ in acquisition (e.g., Boersma & Levelt 2003, Levelt & van de Vijver 2004, Albright, Magri & Michaels 2008, Jäger 2007). Rather, these data support the general distinction between local and non-local sources of complexity.

Furthermore, there is also no difference in preferred repairs based on the complexity of non-local elements. In Figure 9, we can see that the preferred repairs for complex and simple structures are similar. This suggests that the grammar does not differentiate between structures based on their complexity. Non-local repairs are also observed in the data, indicating that the grammar allows for cumulative interaction across non-local elements.

Non-local elements can interact cumulatively, non-local sources of complexity.

References


Praat: Doing Phonetics by Computer. [www.praat.org].

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