Abstract

Previous investigations have proposed that nasality in consonants are more perceptually stable than place of articulation in constrained conditions. This paper investigates the progression of initial consonant clusters from a reduced to an adult-like form in terms of manner and place of articulation in the speech of children between the age of 1;6 and 3;5. The results show an earlier onset of stable production of manner compared to place for both full clusters and in the reduced form. The results are interpreted as evidence of the importance of perceptual salience of segmental properties in the acquisition initial consonant clusters.

Introduction

Initial sC clusters occur frequently in spontaneous Swedish (Bannert & Czigler 1999) and are therefore a predominant feature of the ambient language of children learning Swedish. Previous reports concerning children's productions of word-initial word-initial sC clusters have shown that early output forms of the second consonant of the cluster may have a deviating phonetic quality compared to the adult model form (see McLeod, van Doorn and Reed (2001) for a summary of discovered trends in consonant cluster acquisition).

In clusters with a plosive as the second element, the reduced form may involve an change in place of articulation caused by an application of a hypothesized fronting rule. Non-plosive consonants may, in addition, be substituted by a consonant with a different manner of articulation compared to the target consonant, e.g. through application of a stopping process.

For adult speakers, the articulatory features of place and manner of articulation have been shown in the literature to be correlated regarding their perceptual stability. In a study the perceptual response to acoustic manipulation of stimuli in the plosive-nasal and labial-dental ranges, Miller and Eimas (1976) presented a similar pattern of categorical perception for both investigated feature manipulations. Furthermore, the results from Miller and Eimas (1976) provided evidence for a right ear predominance for both place and manner processing. Miller and Eimas interpreted their findings as indications of similar processing of the phonetic features place and manner. In addition, the perceptual processing of the features place and manner of articulation have been shown to be stable, compared to other features, even with a reduced set of acoustic cues. Singh (1971) investigated the perceived closeness of consonants in six conditions of reduced acoustic information. The results provided evidence of nasality being the most resistant feature across conditions. Singh and Black (1966) proposed that place of articulation was second only to nasality in feature strength. Place of articulation is therefore hypothesized to be mastered first in the progression towards an adult-like production of an initial consonant cluster.

Regarding the structure of the output form, sC clusters may, in the early stages of acquisition, be reduced to a single consonant. This change in output form of the child's production has been described as an application of a phonological process of cluster reduction, where the cluster is reduced to one of it's elements, and cluster simplifying processes, where the consonant cluster is substituted by a different consonant combination or by a segment that is not an element of the target consonant cluster (coalescence). McLeod et al. (2001) noted that a trading relation had been observed in the literature between the frequency of consonant cluster reduction and simplification: cluster reduction has been reported more frequently in early intermediate forms and replaced by simplification in forms produced in the
stage before production of a complex syllable onset.

The aim of this study was to investigate the acquisition of an adult-like production in terms of place and manner in complex syllable onset in word-initial position. From the milestone of complex onset production, the change in the articulatory features of place and manner was investigated throughout the progression of words with an initial [sn], [st] or [sk] cluster. Acquisition of a stable production of manner before place of articulation would be interpreted as further support for the perceptual hierarchy found in the previous research. In addition, it would be interpreted as support for extending the effect of perceptual hierarchies found for features singleton segments to the acquisition of consonant clusters.

Method

Speech material

The data set investigated in the present paper was extracted from a corpus consisting of 5311 productions collected in order to investigated the development in output forms of word-initial consonant clusters in Swedish children between the age of 1;6 and 3;6. In this corpus, recordings were conducted on a monthly basis in a sound-treated recording studio. The target words were elicited by the accompanying adult using black-and-white picture prompts.

Procedure

A narrow transcription of the productions were subsequently produced by the author. The transcribed segment labels were then substituted by a feature vector describing the segment in terms of articulatory features, including place and manner of articulation. Consonant segments in the onset of the first syllable of the production were marked by the position in the onset and the progression of the target words tà ([Pøː]), snår ([snøːːr]) and skal ([skAːl]) were tabulated according to target word and subject’s age. 159 productions of skal, 132 productions of snor and 198 productions of stà were included in the material.

Based on the tabulated progressions of each target onset, the productions investigated in this study were extracted according to two criteria: 1) that the initial output forms produced by the child was not produced in an adult-like manner in terms of the feature set of the consonant, and 2) that a progression should be observed in the data in terms of place or manner of articulation. As a results of these criteria, productions made by seven subjects, three female and four male, were selected for further analysis. The age ranges of the investigated subjects at the time of recording are presented in table 1.

Age of acquisition of stable and adult-like production was determined separately for the articulatory features place and manners as well as for the complexity of the syllable onset. Furthermore, the age of adult-like production of the second element of the target cluster (stop or nasal consonant) was established for place and manner of articulation. For all investigated features, onset of a stable production was determined to be the session at which four out of the following five productions was produced with the same value in the investigated features.

Table 1 The age of each subject (in weeks) at the first and last recording session.

<table>
<thead>
<tr>
<th>Speaker</th>
<th>First session</th>
<th>Last session</th>
</tr>
</thead>
<tbody>
<tr>
<td>F1</td>
<td>105</td>
<td>151</td>
</tr>
<tr>
<td>F2</td>
<td>109</td>
<td>158</td>
</tr>
<tr>
<td>F3</td>
<td>77</td>
<td>128</td>
</tr>
<tr>
<td>M1</td>
<td>79</td>
<td>130</td>
</tr>
<tr>
<td>M2</td>
<td>124</td>
<td>178</td>
</tr>
<tr>
<td>M3</td>
<td>90</td>
<td>142</td>
</tr>
<tr>
<td>M4</td>
<td>84</td>
<td>129</td>
</tr>
</tbody>
</table>

Results

The ages when a steady production of place and manner in the C consonant as well as in the full sC cluster are presented in figure 1. For subjects F1, F2 and M3, place and manner of articulation was stable in singleton consonants from the onset of sampling. The bottom circles of F1
and F2 and the bottom row of squares for the subject M3 therefore indicate that correct production had been acquired before or at this point in development. There are no data available on the delay of this point compared to the real onset of adult-like productions; these data points are therefore not be included in calculations below.

Table 2 presents the differences in weeks between the time of stable adult-like production of manner or place of articulation in simple and complex syllable onsets. The mean delay in manner was 24 weeks (27 weeks for [sk], 20 weeks for [st] and 23 weeks for [sn]). For place of articulation, the mean delay in onset of stable adult-like production was 29 weeks (8 weeks for [sk], 34 weeks for [st] and 30 weeks for [sn].

<table>
<thead>
<tr>
<th>Speaker</th>
<th>F1</th>
<th>F2</th>
<th>F3</th>
<th>M1</th>
<th>M2</th>
<th>M3</th>
<th>M4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skal manner</td>
<td>*</td>
<td>*</td>
<td>8</td>
<td>41</td>
<td>24</td>
<td>*</td>
<td>34</td>
</tr>
<tr>
<td>Sto: manner</td>
<td>*</td>
<td>*</td>
<td>15</td>
<td>23</td>
<td>21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Snorm manner</td>
<td>*</td>
<td>*</td>
<td>19</td>
<td>30</td>
<td>21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Skal place</td>
<td>*</td>
<td>*</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sto: place</td>
<td>*</td>
<td>*</td>
<td>51</td>
<td>28</td>
<td>23</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Snors place</td>
<td>*</td>
<td>*</td>
<td>24</td>
<td>30</td>
<td>36</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The differences in weeks between the the onset of stable productions of complex onsets and stable production of adult-like manner or place are presented in table 3. The mean delay for manner was 5 weeks (4 weeks for [sk], 7 weeks for [st] and 4 weeks for [sn]). The mean delay for place was 10 weeks (0 weeks for [sk], 13 weeks for [st] and 14 weeks for [sn]).

A Pearson correlation matrix of the data presented in figure 1 showed a strong correlation between the age of stable production of manner (r=0.98) across target words.

Figure 1 The age of stable production of place and manner of articulation are presented above for each investigated speaker. Each cell shows the progression of output forms of the target words skal, snär and stä. For subjects F1, F2 and M3, place and manner of articulation was stable in singleton consonants in the initial recording session.
A high correlation was obtained for place of articulation between the clusters [sn] and [st] (r=0.94). The production of complex syllable onset in target words were also highly correlated (r>0.95 for all correlations).

Discussion and conclusion

The previous research done in on the strength and stability of the feature place and manner of articulation have established a similarity in the perceptual processing of these features (Miller and Eimas 1977). However, the work done by Singh and Blank (1966) and Singh (1971) suggests that nasality, as an instance of manner of articulation, is more perceptually stable than place of articulation in a noisy environment.

The obtained age of acquisition of a stable production of sk, st and sn clusters presented in figure 1 is in close agreement with the perceptual hierarchy proposed by the Singh (1971). Manner was generally acquired before, or at the same time as, place of articulation in productions that was reduced to a singleton consonant.

Syllable onsets with more than one member were generally produced in a stable way after the adult-like production of place had been achieved. Following the acquisition of complex syllable onset productions, manner of articulation was stabilized first. In the seven instances when place of articulation was acquired, the onset of a stable and adult-like production occurred after the acquisition of manner.

The same pattern is observed in complex syllable onsets. Mean delay in acquisition from the onset of complex structure in the syllable onset (table 3) is greater for place than for manner. In fact, successful acquisition of a stable production of adult-like place is never achieved before manner for the full cluster.

One exception to the above described pattern of progression exists in the data: the onset of a stable production of place in the reduced form of the target word skal produced by M1. In this stage of production, stable production of place were acquired before manner. Inspection of the production made in manner age the age of acquisition of place plotted in figure 1 showed that manner does meet a criterion of 75% in that session. Therefore, the apparent reversal of the age acquisition of place and manner found in M1 may be an artifact of the chosen criterion.

Therefore, it is concluded that the perceptually established ordering of manner before place of articulation in terms of feature strength is in agreement with the age of stable acquisition of these features in complex syllable onsets. The development of complex syllable onsets is therefore viewed as strongly influenced by constraints in perception.

Acknowledgements

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References.


