USE OF SYLLABLES BY CHILDREN WITH DEVELOPMENTAL APRAXIA OF SPEECH

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ABSTRACT

In the present study the syllabic organization of utterances from children with DAS is compared to that of normally speaking children by extracting the course of the second formant (F2) across and within syllables. The utterances of children with DAS show more variability within as well as between subjects. There are no syllable boundary effects found in the formant trajectories of either the normally speaking children, nor the children with DAS. However there is a clear effect of shifting syllable boundary in the error percentages and error patterns of the /sx/-sequences produced by children with DAS. These results suggest that children with DAS show deviant coordination of syllabic gestures, and that they experience difficulties in restoring syllable programs.

1. INTRODUCTION

Developmental apraxia of speech (DAS) is a speech disorder that interferes with the ability of the child to correctly produce speech. More precisely it is the inability to produce speech sounds by moving the articulators (tongue, lips, jaw) in the right position, and to correctly sequence sounds into syllables and words. Non-speech actions, like coughing, chewing, and swallowing, do not necessarily cause difficulties. Children with DAS are characterized by speech that is often unintelligible due to a large number of phonemic speech errors (substitutions and omissions), and articulatory abnormalities. The most salient speech characteristics of children with DAS are: largely unintelligible speech, high consonant error rates, many context-related substitutions, groping, and inconsistency of errors [3, 9].

Several models have been proposed to describe the underlying deficit in DAS [2, 3, 8]. These models have in common that the origin of the speech problems in children with DAS must be localized somewhere in the transformation from a phonological representation into an articulo-motor program. In his model of speech production Levelt [4] postulates a ‘syllabary’, i.e. a store of articulatory representations of syllables, as the intermediate between the phonology and motor output. Children with DAS seem to have difficulties in acquiring and automating the processes of restoring or building a syllable program. According to this model also phonemically correct utterances contain articulatory deviations due to over- or under-coarticulation, which appear in the acoustical analyses of the speech.

In a previous study [1, 5], we compared the coarticulation in utterances produced by children with DAS and normally speaking children. These experiments were based on a series of studies by Nittroer and colleagues [6, 7]. The results of our study show that the speech of children with DAS is more variable, and shows larger coarticulation effects between and within syllables than the speech normally speaking children [1, 5].

The aim of the present study is to further test the ‘syllabary’ hypothesis, by manipulating the syllable boundary in the speech material, in otherwise identical context, and by varying syllable frequency. If children with DAS have problems in restoring or building a syllable program, rather than programming the motor output, manipulation of the syllable boundary should have an effect. On the other hand, if these children show difficulties in programming the motor output, only the sequence of speech sounds is relevant. Moving the syllable boundary in an unchanging sequence of sounds should not have any consequences. In addition a frequency effect is expected if children with DAS have problems with accessing the syllabary, supposing the syllabary contains the motor programs of high frequency syllables (meaningful utterances), yet not those of low frequency syllables (nonsense utterances).

2. METHODS

2.1. Subjects

Subjects were 19 children with DAS (14 boys and 5 girls between the age of 4;11 and 6;6 years) and 19 normally speaking, control children (matched for sex, age, and dialect region).

The children with DAS are clear cases of DAS, referred and selected according to clinical criteria described by Hall et al. [3] and Thoonen et al. [9]. All subjects are native speakers of Dutch; they have no history of hearing problems, receptive language problems, organic disorders in the orofacial area, or gross motor disturbances or dysarthria. They all have IQ-scores on at least average level. In this paper results are presented of 6 children with DAS and 6 control children.

2.2. Speech material

The stimulus-set consisted of two-word utterances in a carrier phrase, in which the relevant part consisted of ‘schwa-/s/-/x/-V’. The second vowel V was /a/, /i/, or /o/. The syllable boundary in the utterances appeared in two different positions: either the articulatorily difficult sequence /sx/ was preceded by the syllable boundary (notation: #sxV), or the syllable boundary divided the cluster (#xV). A similar example in English is ‘I scream’ versus ‘ice cream’. The ‘schwa-/s/-/x/-V’ segment was placed in a consonant environment which resulted in two subsets, one with high frequency syllables (meaningful utterances) and one with low frequency syllables (nonsense utterances). Six tokens of each type were produced.
2.3. Acoustic analyses
The speech samples were digitized at 25 kHz and the relevant sections (i.e. schwa/sx/-V segments) were spliced out, using the Kay Elemetrics Computerized Speech Lab analysis system. The second formant (F2) trajectory was used as a measure of coarticulation. F2-values were subtracted at 7 locations through the utterance: at schwa-midpoint and -offset, in the fricative /s/ 30 ms before offset, in the fricative /x/ 30 ms before vowel onset, in the vowel transition onset and end, and at vowel midpoint (see figure 1). In the voiced sections of the signal (i.e. schwa and vowel) the formant values (with corresponding bandwidths) were obtained using pitch-synchronous LPC analyses followed by the root-solving procedure. An LPC-analysis at location was performed in the fricative 30 msec before offset.

3. RESULTS

3.1. Speech errors
The children with DAS show a lot of speech errors in producing the /sx/-sequence in a correct way, whether the syllable boundary (#) precedes or divides the cluster. Table 1 shows the type of errors made by these children. Since the error data of the meaningful and meaningless utterances did not show different patterns, these are joined in one table.

Table 1 shows that some children have very low percentage of correct productions (RL, JB, AA, KB). Striking are the percentages of errors showing that reduction of the sequence /sx/ to /s/ or /x/ occurs more often in the #sx-context (cluster reduction) than in the s#x-context (omission of one speech sound), especially in child JB and child PM. A pause between /s/ and /x/ occurs more often when the syllable boundary is in between those two sounds.

3.2. Formant trajectories
3.2.1. Normally speaking children. As the six normally speaking children performed very similar, data from one child are used to describe the pattern (see figure 2).

Table 1: Percentage of correct and error productions made by children with DAS in the segment /schwa-sx-vowel/.

<table>
<thead>
<tr>
<th>Target</th>
<th>Production</th>
<th>/sx/</th>
<th>omission</th>
<th>pause</th>
<th>/sx/</th>
<th>cluster reduction</th>
<th>pause</th>
</tr>
</thead>
<tbody>
<tr>
<td>RL (5:0)</td>
<td>12.5</td>
<td>20.8</td>
<td>16.7</td>
<td></td>
<td>28</td>
<td>41.7</td>
<td>5.6</td>
</tr>
<tr>
<td>JB (5:1)</td>
<td>48.6</td>
<td>1.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>JP (5:7)</td>
<td>51.4</td>
<td></td>
<td>1.4</td>
<td></td>
<td>44.6</td>
<td>50.0</td>
<td></td>
</tr>
<tr>
<td>PM (5:10)</td>
<td>48.6</td>
<td></td>
<td>1.4</td>
<td>48.6</td>
<td>1.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AA (5:11)</td>
<td>34.3</td>
<td>8.6</td>
<td>5.7</td>
<td></td>
<td>24.3</td>
<td>24.3</td>
<td>2.9</td>
</tr>
<tr>
<td>KB (5:11)</td>
<td>27.1</td>
<td>18.6</td>
<td>5.7</td>
<td></td>
<td>29</td>
<td>45.7</td>
<td></td>
</tr>
</tbody>
</table>
Figure 3: F2-traces of meaningful utterances of child PM (DAS)

Figure 4: F2-traces of meaningful utterances of child JP (DAS)

4. CONCLUSION AND DISCUSSION

Children with DAS, as compared to normally speaking children, show more difficulties in producing the /sx/-sequence, which is an indication of speech delay. There is a clear syllable boundary effect on the error percentages and the error patterns of the /sx/-sequence. This indicates that these children do have difficulties in restoring syllable programs.

The phonemically correct utterances of children with DAS show more acoustic variability, within as well as between subjects. Differences in F2 due to the upcoming vowel occur earlier (in /s/) in the utterances of children with DAS than in the utterances of the controls (in /x/) and the effects are larger. This leads to the conclusion that coarticulation of the vowel on the preceding sounds is stronger in children with DAS than in normally speaking children. Results suggest that children with DAS show deviant coordination of syllabic gestures.

The fact that there was no effect of frequency of syllables could indicate that both normally speaking children and children with DAS do not use a syllabary with stored motor programs. Before we can conclude this we have to look at other speech characteristics like segment durations.

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REFERENCES