

Realizations of linguistic stress in preschool children who stutter and controls

Ulrich NATKE, Patricia SANDRIESER, Claas P. BENDELS, Reinhard PIETROWSKY, and
Karl Theodor KALVERAM
Institute of Experimental Psychology, Heinrich-Heine-University Düsseldorf
Universitätsstr.1, 40225 Düsseldorf, Germany
natke@uni-duesseldorf.de

Abstract. The purpose of the study was to compare realizations of linguistic stress in stuttering and non-stuttering children. Participants were 24 children who stutter and 24 fluently speaking children aged 2.1 to 5.0 years. Controls were matched according to age and sex. In a picture naming task children produced 30 words with different prosodic patterns. Vowel duration was determined as one parameter characterizing linguistic stress for perceptually fluent long stressed, short stressed and unstressed syllables. It was found that children who stutter produced longer vowel durations in long stressed syllables than children who do not stutter. Results are discussed with regard to sensorimotor automation processes in early speech development.

1. Introduction

One major component of early speech development is the increasing of speech rate. This can be achieved, for example, by shortening certain parts of speech. Pollock, Brammer, and Hageman (1993) observed a continued improvement in the ability to reduce the duration of unstressed syllables with age in 2, 3, and 4 year-olds. By the age of 4 to 5 years more unstressed syllables are produced and speech rhythm becomes more adult-like (Allen & Hawkins, 1980). The reduction of unstressed syllables' duration is therefore part of a general prosodic development.

In adults it was found that long stressed syllables are produced under control of auditory feedback, whereas short syllables are almost independent of re-afferent feedback (Natke & Kalveram, 2001; Donath, Natke, & Kalveram, 2002; Natke, Donath, & Kalveram, 2003). Because speech rate is low in young children and unstressed syllables become shorter with age, it is supposed that all syllables are first produced under auditory control. That leads to the assumption that the prosodic development is accompanied by a reduction of auditory control in short syllables. When syllables become shorter, children learn to inhibit re-afferent control via auditory feedback and learn to apply efferent control using internal signals. Long stressed syllables persist auditorily controlled. Kalveram, Natke, Sandrieser, and Pietrowsky (2001) describe in detail how stuttering-like disfluencies may occur during this learning task. This theory of *stuttering as a developmental disorder of sensorimotor automation processes* (see Kalveram, 2001; Kalveram & Natke, 1998; Kalveram et al., 2001) predicts that disfluencies are centered around stressed syllables. Stressed syllables are indeed prone to stuttering in adults (Brown, 1938; Natke, Grosser, Sandrieser, & Kalveram, 2002) and also in preschool children (Natke, Sandrieser, Pietrowsky, & Kalveram, 2001; Natke, Sandrieser, van Ark, Kalveram, & Pietrowsky, submitted).

According to this theory a small percentage of children experience fluency breakdown only because of the structure of the learning task, which mathematically represents a so called "inverse problem" (see Kalveram & Natke, 1996). Therefore, the occurrence of stuttering-like disfluencies is at least partly a system-immanent difficulty in controlling the speech apparatus. However, heredity plays an important role in stuttering (Kidd, 1985) and some neurophysiological predisposition may exist (see De Nil, 1999). In the framework of our theory such a predisposition may lead to a deviation of normal prosodic development in children who stutter. Prosodic development in this context means the continued improvement in the ability to reduce syllable duration and, therefore, to increase speech rate. An abnormal prosodic development would contribute to difficulties in mastering the learning task described above.

The purpose of this study is to examine the prosodic development of children who stutter and children who do not stutter. For this, the duration of vowels in target words with different prosodic structures is determined and compared between both groups. To reduce the influences of coping or compensation, only those young children who have been stuttering for a short time were included in the study.

2. Method

Twenty four children who stutter (CWS) and twenty four children who do not stutter (CWNS) aged 2.1 to 5.0 years and whose mother tongue is German participated. It was required of CWS that their parents as well as the

second author regarded them as having a stuttering problem. Groups were matched regarding sex and age. Mean duration of stuttering was 9 months. Children produced single words in a picture naming task originally serving to examine phonetic-phonological skills (Wagner, 1995). The audio signal was recorded with a clip-on microphone (MKE 2-1053, Sennheiser, Wedemark, Germany) attached at chest level to the child's clothing and digitized with a commercial personal computer with soundcard (sampling rate: 22050 Hz, sampling depth: 16 bits). From the total sample of 108 words, 12 with long stressed, 16 with short stressed and 8 with unstressed first syllables were selected as target words. Only target words which were perceptually fluent and not spoken by the investigator before the child were analyzed. From these words, vowel duration of first syllables was measured by taking durational measurements from the waveform display. Mild outliers were excluded from this data. Target words, which were spoken by less than 8 children per group, were excluded completely from analysis. Eleven long stressed syllables, 15 short stressed syllables and 6 unstressed syllables remained. Mean vowel duration for the three stress categories was calculated for each child. To test for differences, one-sided *T*-tests were calculated. In order to test intrajudge reliability, 27 % of the material was reanalyzed. A mean difference between both ratings of 12 ms was found.

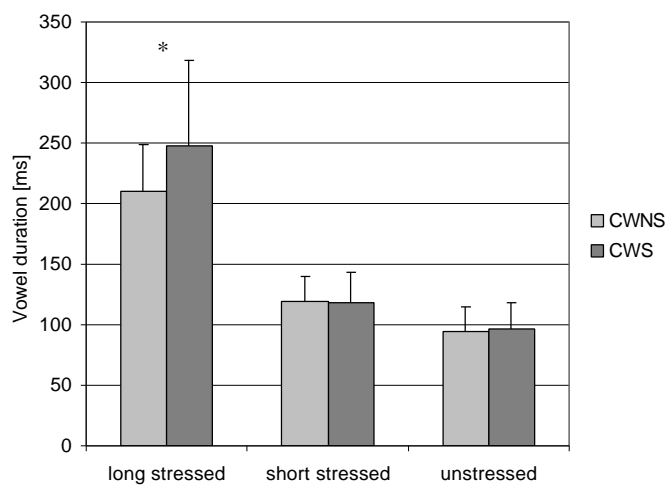


Figure 1: Mean vowel duration and *S.D.* of long stressed, short stressed, and unstressed syllables in initial position of words for children who do not stutter (CWNS) and children who stutter (CWS). Significant differences are marked with an asterisk evaluated by *T*-tests.

3. Results

Figure 1 presents the mean vowel duration for the three stress categories long, short, and unstressed. According to operationalization, vowel duration of long stressed syllables (229.2 ms) was longer than that of short or unstressed syllables (both about half as long). Vowel duration of short stressed syllables (118.8 ms) was slightly longer than of unstressed syllables (95.4 ms). CWS produced a longer vowel duration in long stressed syllables than CWNS ($T(43) = 2.14, p = .019$). However, in short and unstressed syllables vowel duration did not differ significantly (short: $T(43) = -0.18, p = .430$, unstressed: $T(41) = 0.27, p = .393$). Corresponding values can be found in Table 1.

Table 1: Mean vowel duration (*S.D.* in brackets) of long stressed, short stressed, and unstressed syllables in initial position of words for children who do not stutter (CWNS) and children who stutter (CWS).

	long stressed	short stressed	unstressed
CWNS	210.7 (38.7)	119.4 (20.6)	94.4 (20.3)
CWS	247.7 (71.7)	118.2 (24.6)	96.4 (22.2)
Total	229.2 (60.3)	118.8 (23.0)	95.4 (23.2)

4. Discussion

In this study, the production of linguistic stress was investigated using a picture naming task. Only perceptually fluent productions of syllables in initial position of words were analyzed. It was found that CWS produced vowels with longer duration in long stressed syllables than CWNS, whereas short stressed and unstressed syllables' vowel duration did not differ significantly.

Vowel duration may be related to speech rate. Former studies regarding speech rate in preschool children who stutter and who do not stutter yielded inhomogeneous results. Meyers and Freeman (1985) found slower fluent speech rates in CWS than in CWNS, whereas Kelly and Conture (1992) found no differences between the groups. Kloth and colleagues (1998) studied at-risk children (with parental history of stuttering) and found higher articulation rates in children who later began to stutter than in those who remained fluent. However, when the two groups were tested one year later – with one group now classified as children who stutter –, the rates were not found to differ significantly between the groups. In the children participating in this study, we found slower articulation rates in CWS compared to CWNS (CWS: 3.11 syllables/second, CWNS: 3.37 syllables/second, $T(50) = -2.37$, $p = .022$; unpublished data). Rates are based on speech samples taken from a play situation consisting of at least 1000 syllables. Supposing that the result regarding words spoken in isolation can be generalized to utterances, slower speech rate in CWS than in CWNS may be the result of longer vowel duration in long stressed syllables.

It can not be ruled out that results such as those found in this study are a consequence of stuttering, due for example to compensation, rather than being related to its origin. Stuttering events occur predominantly on stressed syllables (Natke et al., 2001; Natke et al., submitted). The “prolongation” of long stressed syllables in CWS compared to CWNS could be a successful strategy in avoiding the occurrence of stuttering events on these syllables – as by prolongation techniques in stuttering therapy. However, because children selected for the study were close to the onset of stuttering, the likelihood of results being a consequence of stuttering is reduced. Furthermore stuttering rarely appears in the isolated production of single words, as was also experienced in this study. Therefore, there is little necessity to use compensation strategies in such a task.

The findings of this study may indicate a difference in the prosodic development of CWS and CWNS, which could be due to a predisposition in CWS (see Introduction). According to the theory outlined in the introduction, CWS obviously master the learning task to produce short syllables with efferent control (i. e. without using auditory feedback). However, there is a difference compared to CWNS in long stressed syllables, in which re-afferent control via auditory feedback normally is still applied. As Kalveram (1998, 2001) shows by means of a control theoretical model, a reduction of auditory control in long stressed syllables can lead to a prolongation of vowels. This is because in this framework, auditory feedback of the vowel onset is used to determine the vowel offset. If auditory feedback is missing or reduced, a prolongation of the vowel is the consequence. This prolongation is therefore a sign of a lower degree of audiophonatory coupling (Kalveram & Natke, 1998). In CWS the prolonged vowels in long stressed syllables – compared to CWNS – might show that CWS not only learn to automate the production of short syllables, but that of long stressed syllables as well. Also long stressed syllables are produced in the absence of auditory control, whereas in non-stuttering persons auditory control remains effective in these syllables. The consequence is a prolonged vowel duration in long stressed syllables in CWS. The “deficit” in CWS, therefore, would consist of exaggerating the learning task of sensorimotor automation by expanding it also to long stressed syllables. It is therefore not a delay in the prosodic development; rather an advance. It remains unclear which kind of predisposition might contribute to this.

Investigations of the role of auditory feedback in the control of speech in early speech development are necessary to provide empirical evidence for these theoretical considerations. The methodology applicable to 3 to 5-year-olds must still be developed. Finally, the study shows again that linguistic stress, especially the duration of syllables, is an important factor in research about speaking and stuttering.

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