Linguistic Stress, Within-Word Position, and Grammatical Class in Relation to Early Childhood Stuttering

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Abstract. The purpose of the present study was to investigate whether the link that has been established between stuttering and linguistic stress in adolescents and adults (the so-called stress effect) can also be observed in childhood stuttering. To account for confounding variables, both within-word position and grammatical class were measured, because these factors covary with linguistic stress. Speech samples of twenty-two preschool children (mean time of 9 months since onset of stuttering) were analyzed. The relative stress of each syllable was rated and syllables were categorized into long and short stressed, unstressed and intermediately stressed syllables. Results showed that 98 % of stuttering events occurred on first syllables of words, i.e. a clear word-initial effect. Stuttering frequency on first syllables of function words was 16.9 % and significantly higher than the frequency of stuttered first syllables of content words (11.5 %). In function words short stressed syllables and intermediately stressed syllables were stuttered more often than unstressed syllables. The analysis for individual disfluency types revealed that, for function words, stuttering on short stressed syllables was associated with prolongations and syllable repetitions. However, in intermediately stressed syllables stuttering coincided most often with one-syllable word repetitions. This differentiation of the stress effect may suggest different causal mechanisms underlying these disfluency types.

Keywords: Stuttering, linguistic stress, accent, within-word position, grammatical class
1. Introduction
Since the early work of Brown in the 1930s numerous studies have replicated his finding that stuttering events occur more often on stressed syllables than on unstressed syllables (e.g. Hahn, 1942; Wingate, 1984; Bergmann, 1986; Klouda & Cooper, 1988; Prins, Hubbard, & Krause, 1991; Natke et al., 2002). The investigation of the stress effect has so far only been carried out with adolescents and adults who stutter, i.e. persons with a long history of stuttering. It has not been established, whether there is also a relationship between linguistic stress and stuttering in infants. This is crucial to the question whether the stress effect is a consequence of stuttering for several years (in some way due to coping or compensation), rather than being related to its origin. The purpose of the present study is to investigate whether the stress effect is also present in the speech of preschool children who stutter.

In the investigation of the stress effect at least two confounding variables must be controlled for. Firstly, within-word position and stress are confounded, because stuttering events occur predominantly on first syllables of words (word-initial effect) and in English as well as in German the majority of syllables containing stress is in the first position of words. Secondly, a difference in stuttering frequency for content and function words is also related to variations in stress patterns for these two grammatical classes. Studies on grammatical class in adults who stutter report either a higher stuttering frequency for content words than for function words or no difference (for an overview see Dayalu et al., 2002). In English as well as in German function words are usually unstressed, whereas content words carry stress, which means that grammatical class and stress are confounded. Restricting the analysis to the individual group of words and syllable position within the words allows for the effects of these two variables to be partialled out. Within-word position was already studied by Brown (1938). His results showed that there is an effect of stress in syllables in the first position, as well as in subsequent positions of words. So far grammatical class was not considered in studies dealing with the stress effect in stuttering.

There seems to be a developmental pattern in grammatical class and stuttering. With increasing age, there is an increase in content word stuttering and a decrease in function word stuttering (Au-Yeung, Howell, & Pilgrim, 1998; Bloodstein & Gantwerk, 1967; Bloodstein &

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1 Words can be classified in content (nouns, main verbs, adjectives, adverbs) and function words (prepositions, conjunctions, pronouns, articles, auxiliary verbs). Content words belong to an open class of words, which carry full lexical meanings, whereas function words belong to a closed class of words, which are grammatically or functionally important but do not carry a full lexical meaning.
Grossman, 1981; Dworzynski, Howell, & Natke, in press; Howell, Au-Yeung, & Sackin, 1999; Rommel, 2001). It has been suggested that the relationship between stuttering events and stress is weaker in children (Bloodstein & Gantwerk, 1967; Howell, Au-Yeung, & Sackin, 1999) due to the fact that function words are less frequently stressed. However, to date it has not yet been investigated, whether there is a stress effect in childhood stuttering.

For adults, the relationship between stuttering on stressed syllables and the duration of these syllables has recently been investigated (Natke et al., 2002). Apart from loudness, fundamental frequency, and accuracy of articulation, the duration of the syllables is one physical parameter characterizing stressed syllables (Lehiste, 1970). On average, stressed syllables have a longer duration than unstressed syllables, but obviously there are short stressed syllables with a duration comparable to that of unstressed syllables. This duration component of stress could be important for the location of the stuttering event, because in the production of long stressed syllables auditory feedback plays a greater role than in the production of short syllables (Natke & Kalveram, 2001; Donath, Natke, & Kalveram, 2002; Natke, Donath, & Kalveram, 2003). There is also a long history of studies revealing deviant auditory control in persons who stutter (cf. Bloodstein, 1995; Natke, 2000). Natke et al. (2002) found a higher stuttering frequency for short than for long stressed syllables, but the comparison failed to reach significance. This meant that the results did not show a conclusive pattern. An investigation of the stress effect in children who stutter can help to clear up the role of the duration component of stress.

The purpose of the present study was to investigate the stress effect in preschool children who stutter. Children close to the onset of stuttering were recruited in order to reduce effects which may be attributed to consequences of stuttering. Results should answer the questions, how stuttering frequency is distributed in function and content words, whether the stress effect is also apparent in childhood stuttering, and whether the duration component of linguistic stress plays a role for the incidence of stuttering. Furthermore, individual disfluency types were analysed in order to explore differential effects. Preliminary results of six children who stutter were already reported by Natke, Sandrieser, Pietrowsky, and Kalveram (2001). Here the results of the whole group of children are reported.
2. Method

A. Participants
Twenty-two children who stutter (native speakers of German), 14 boys and 8 girls aged from 2.1 to 5 years ($M = 3.7$ years), participated in this study. In order to avoid a floor effect the precondition for participation was a minimum stuttering frequency of 5 % (See Data Analysis). The mean age at stuttering onset was 2.9 years (2.0 years to 4.7 years), as reported by the parents. The mean number of months between onset and evaluation was 9.0 (1 month to 23 months). All participants had no reported hearing, neurological, developmental, intellectual, or emotional problems. Apart from two children, who were treated for stuttering, the children did not receive formal treatment for stuttering or any other speech or language disorder before evaluation.

B. Data Collection
Each child was videotaped in two sessions of a play situation conducted by the investigator. The audio signal was digitally recorded (sampling frequency: 22,050 Hz, sampling resolution: 16 bits). The play took place with both the child and investigator seated at a table, usually in the presence of a parent (who was instructed not to actively engage in play). A clip-on microphone (MKE 2-1053, Sennheiser, Wedemark, Germany) was attached to the child’s clothing at chest level to ensure high quality of the audio signal recording. The video recording was focused on the child’s head and also showed the arms and upper torso. Speech samples were taken over two sessions one week apart to reduce the effects of fluctuations in stuttering frequency.

C. Data Analysis
Transcription
Speech samples were transcribed orthographically and analyzed using the computer program CLAN (MacWhinney, 1991). CLAN shows the waveform of the digitized audio signal and each transcribed utterance can be linked to the corresponding region of the waveform. Unintelligible utterances as well as isolated affirmatives (“yes”, “okay”) and negatives (“no”), which are generally produced fluently, were not included. The first 100 syllables of each speech sample were excluded from disfluency analysis. Resulting speech samples consisted each of at least 500 syllables summing up to a minimum of 1000 syllables for every child.
Disfluency Analysis

A special coding system for disfluencies was added to CLAN, in which information about the disfluency itself and the affected syllable and word was coded. Stuttering events were defined as prolongations, blocks, and repetitions of sounds, syllables and one-syllable words, which represents a differentiation of Yairi’s stuttering-like disfluencies (Yairi, 1997). Stuttering events were identified and classified by listening to the audio signal repeatedly using headphones. Recordings of the video were consulted in cases where a clear decision could not be reached. Stuttering events were coded directly in the transcript indicating the event by a code (each code was positioned directly after the stuttered syllable). Blocks were assigned to the syllable following the fixation. Within-word position (number of disfluent syllable within the word) and grammatical class of the affected word were also coded.

It is common to assign a stuttering event to only one disfluency type, but often it can be found that a stuttering event bears parts of several types. Examples for these multiple stuttering events are a prolongation combined with a syllable repetition (“ssssy-syllable”) or a sound repetition combined with a syllable repetition (“c-c-co-combined”). If these events were assigned to one disfluency type, information is lost. Therefore, in this study multiple stuttering events were identified and counted separately. For example, “c-c-co-combined” counts as one sound repetition (with two repetition units) and one syllable repetition.

Disfluency analyses were carried out by the first and the second author, both experienced researchers in fluency disorders. In order to test interjudge reliability, nine of the total of 22 speech samples were randomly selected and analyzed by both judges. A Wilcoxon-signed-rank-test revealed a nonsignificant difference between mean stuttering frequencies ($Z = -0.840; n = 9; p = 0.401$). Pearson correlation coefficient between the scores of both judges was 0.973.

Stress Rating

Each syllable’s stress was rated along a continuum applying a method that had previously been used by Prins et al. (1991) and Natke et al. (2002): Two adults read the transcription of the speech samples in unison. It is assumed that under these circumstances each speaker uses the stress pattern that he expects other individuals to use, so he employs the typical prosody of his mother tongue. The reading was recorded and played back repeatedly, so that the relative stress of each spoken syllable could be rated on a scale from 1 (lowest stress) to 9 (highest
stress). Three stress categories were defined: “Stressed syllables” are surrounded on each side by syllables with a lower stress value, while “unstressed syllables” are surrounded by syllables with higher stress values. Syllables with stress values in-between were called “intermediate syllables”. Syllables at the beginning and at the end of utterances were categorized as stressed/unstressed syllables, if the adjacent syllable had a lower/higher stress value and if the stress of the syllable was rated above 6/below 4. Additionally, stressed syllables were further classified in short and long stressed syllables.

This specific analysis of syllabic stress was chosen for three reasons: (1) In this way stress can be assigned to syllables which were actually stuttered by the children. (2) Stress ratings between children can be compared because the same speakers read all transcriptions. (3) Stress analysis is based on a model of adult prosody, which is assumed as being the target pattern for the children.

In order to test reliability of the assignment of syllables to the resulting four categories, six of the speech samples were randomly selected and judged by a second rater. A syllable-by-syllable agreement of 79.2 % was found.

Statistical Analysis

Overall stuttering frequencies for the first and second syllables and for syllables in later positions than the second were calculated. In order to control the confounding between within-word position and stress, subsequent analyses were restricted to first syllables of words.

For each child the total number of syllables in initial position of words of the four stress categories (short stressed, long stressed, intermediate and unstressed) with respect to grammatical class (content and function) was counted. Then stuttering frequencies for each selected group of words were calculated. For example stuttering frequency of short stressed syllables in initial position of content words was calculated by dividing the total number of short stressed syllables in initial position of content words that were disfluent by the total number of short stressed syllables in initial position of content words (fluent + disfluent) spoken for each child.

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2 In a former study (Natke et al., 2002) this classification was made using durational measurements of the vowels. Additionally a rating was performed and a high agreement between these two methods was found. Because the measurement is much more time consuming, in this study the rating was preferred.
Before inferential statistical analyses, proportional data were arcsine transformed. This is recommended because the means and the variances are correlated and, therefore, proportional data are not well suited to inferential statistics (Studebaker, 1985; Winer, 1991). Differences in stuttering frequencies of stress categories were evaluated using one-factor repeated measures ANOVAs. Post hoc $t$-tests were performed using the Bonferroni correction.
3. Results

A. Within-Word Position
Speech samples of all participants consist of 22,588 syllables with 16,841 words. A total of 2,474 stuttering events were found which equaled a percentage of 9.1. Table 1 reports the percentage of stuttering events dependent on word position (consecutive number of affected syllable within the word), whereby one-syllable words and multi-syllable words were both included in the analysis. Almost 98% of stuttering events occurred on first syllables of words. Children showed a preference for one-syllable words which is one reason for this effect. However, a percentage as high as this can be seen as further evidence for a clear positional effect. Subsequent analyses were restricted to syllables in first positions of words. In this way, confounding between stress and within-word position was controlled.

(Table 1)

B. Grammatical Class and Stress
All words in the speech samples were categorized as function or content words. There were 56.6% function words, 40.4% content words and 3% could not be assigned to a grammatical class because they were unintelligible. All syllables were assigned to one of the four stress categories (short stressed, long stressed, intermediate and unstressed) by the rating procedure. Table 2 displays the percentage of syllables in first position of content and function words dependent on stress categories. 70.1% of the first syllables of content words were stressed (long or short), but only 27.6% of the first syllables of function words. More than half of the first syllables of function words belong to intermediate syllables. First syllables of function words were about three times more often unstressed than first syllables of content words. This is another clear indication of the strong relationship between grammatical class and stress. To control for this, content and function words were analyzed separately.

(Table 2)
C. Stuttering Frequency

Figure 1 presents the stuttering frequency for each group of words. Calculation of percentages is based on the total number of syllables in the respective category. Table 3 displays the corresponding values and additionally the total values for the stress and grammatical class categories. Stuttering frequency of function words was significantly higher than of content words \( t(21) = 5.04, \ p < 0.001 \). In content words no effect of stress was found \( F(3, 21) = 1.31, \ p = .279 \). However, in function words a significant effect was found \( F(3, 21) = 5.18, \ p = .003 \). Post hoc tests revealed that short stressed syllables as well as intermediate syllables were stuttered significantly more often than unstressed syllables.

(Figure 1)

(Table 3)

D. Stuttering Frequency with Respect to Disfluency Type

Stuttering frequencies were also calculated for each disfluency type dependent on stress category (e.g. percentage of blocks in short stressed syllables in initial position of content words, percentage refers to the total number of syllables in this category). These were then analyzed descriptively for content and for function words. Figure 2 shows the results for first syllables of content words. There was no indication for a stress effect for sound and syllable repetitions and for blocks. However, prolongations occurred rarely on unstressed syllables and one-syllable word repetitions occurred predominantly on intermediate syllables.

(Figure 2)

Figure 3 shows the results for first syllables of function words. Again, in sound repetitions and blocks there was no indication for a stress effect. Prolongations occurred predominantly on short stressed and intermediate syllables. Syllable repetitions occurred predominantly on short stressed syllables. One-syllable word repetitions occurred most often on intermediate syllables, as was the case for content words.

(Figure 3)
4. Discussion

Results of the present study for the first time confirm that there is a stress effect not only for adults and adolescents but also for preschool children who stutter. The preschool children, here tested, stuttered more often on short stressed syllables than on unstressed syllables. Further analysis indicates that stress affects the incidence of individual disfluency types. Moreover, two findings were confirmed: Children stuttered more often on function than on content words and they showed a clear word-initial effect.

Results showed that very few stuttering events occurred on other than the first syllables of words in preschool children. Therefore, the word-initial effect, a feature of stuttering often taken for granted, was confirmed for early childhood stuttering. In this study within-word position refers to syllables. Stuttering events were linked to the syllable, which contains the affected speech segment. In the study of Rommel (2001), however, position refers to the number of transcribed letters in a word and, according to Wingate’s view of stuttering as a phonetic transition defect (Wingate, 1988), stuttering events were linked to the sound, which supposedly can not be produced (Dieter Rommel, 2003, personal communication). Rommel found stuttering events in the middle of words in children, which can be explained by the differences in operationalization of the loci of stuttering events.

Consistent with several previous studies, it was found that children who stutter were more disfluent on function than on content words (Au-Yeung, Howell, & Pilgrim, 1998; Bloodstein & Gantwerk, 1967; Bloodstein & Grossman, 1981; Dworzynski, Howell, & Natke, in press; Howell, Au-Yeung, & Sackin, 1999; Rommel, 2001). With regards to stress, first syllables of function words are mainly unstressed which was expected. However, this was not always the case since a considerable percentage of function words was found to be carrying linguistic stress (about 28%).

Wingate (1988) assumed implicitly that children who stutter show the prominence of stuttering on stressed syllables, too, but evidence for this was never provided. The discussion about studies using the fluent speech paradigm (Armson & Kalinowski, 1994), however, suggests that actually no finding in stuttering research can be ruled out as being due to consequences of stuttering. In the present study the stress effect, which has so far only be found in adolescents and adults who stutter, was observed for childhood stuttering. Since the participating children were recorded near to the onset of stuttering (mean time of 9 months), the results of this study suggest that the stress effect is related to its origin, rather than being a consequence of stuttering.
Similar to results in adults who stutter (Natke et al., 2002) short stressed syllables were stuttered most often and unstressed syllables least often. Interestingly this stress effect in children who stutter was restricted to function words, i.e. the word class stuttered most often by children. Previously grammatical class was not considered in studies dealing with the stress effect in adults who stutter. This means that it remains unclear whether there is a developmental pattern in the stress effect with regards to function words.

A development in the stress effect seems to exist for syllables rated as carrying intermediate stress. In adults the stuttering frequency increases from unstressed, then intermediately stressed to that of stressed syllables, i.e. with increasing linguistic stress stuttering frequency rises (Natke et al., 2002). This can be contrasted to the childhood pattern, reported here, in which stuttering on intermediately stressed syllables was almost as high as on short stressed syllables. When individual disfluency types are considered a clearer pattern emerges: In function words it was the case that when stuttering occurred on short stressed syllables, these disfluencies were most often prolongations and syllable repetitions. However, when stuttering occurred on syllables rated as carrying intermediate stress, both in function and content words an association to one-syllable word repetitions was observed. In other words, in this study the stress effect was further differentiated since it showed that there was a relationship between linguistic stress and certain types of disfluencies.

One-syllable word repetitions are frequent in the speech of children who stutter as well as in children who do not stutter. As the only type of stuttering-like disfluencies they represent no within-word disfluency (Conture, 1990). There is also some evidence for qualitative differences between one-syllable word repetitions shown by children who stutter and children who do not stutter (Ambrose & Yairi, 1999; van Ark et al., in press). In the further course of stuttering, repetitions become less frequent (Bloodstein, 1960). Adults stutter less frequently on intermediately stressed syllables than children which might be explained by the link between intermediately stressed syllables and one-syllable word repetitions in children.

Howell and colleagues (1999) found that 2-6-year-old speakers who stutter show a higher stuttering frequency on function words which precede, rather than follow, content words. They hypothesize that repetitions of function words serve as a delaying strategy when the speech plan for a content word is not available. In the present study more than the half of function word first syllables were rated with intermediate stress. The prominence of one-syllable word repetitions in syllables with intermediate stress, therefore, fits into the theory of Howell and colleagues. Post hoc analysis of the data in the present study revealed that
syllables following one-syllable words, which are repeated, were predominantly short stressed syllables. If one-syllable word repetitions build a delaying strategy then the problem seems to be the production of the following short stressed syllable, as is the case for prolongations and syllable repetitions in function words.

The relationship between prolongations, syllable repetitions and short stressed function words (on the first syllable) might suggest another causal mechanism for these disfluency types. Kalveram and colleagues suggest in their theory of stuttering as a developmental disorder of sensorimotor automation processes (Kalveram, 2001; Kalveram & Natke, 1998; Kalveram et al., 2001) that the prominence of stuttering on short stressed syllables is connected to the task of increasing speech rate in early speech development. It is assumed that at an early stage the production of all syllables require auditory feedback. The increase of speech rate could then be achieved by automation of certain parts of speech, namely unstressed syllables. Actually by the age of 4 to 5 years speech rate increases and more unstressed syllables are produced, so the rhythm becomes more adult-like (Allen & Hawkins, 1980). The learning task of automation would require the reduction of auditory control of unstressed syllables, whereas stressed syllables are uttered under control of auditory feedback. Evidence for this is provided by experiments with adults in which manipulations of auditory feedback (frequency shift, delay) results in altered production of long stressed syllables, but leaving short syllables almost unaffected (Natke & Kalveram, 2001; Donath, Natke, & Kalveram, 2002; Natke, Donath, & Kalveram, 2003). The learning task is complicated by the fact that short stressed syllables, which have timing similar to unstressed syllables, have to be produced, too. This may lead to the conflict whether the speech controller should switch auditory control to high or low levels in short stressed syllables, which has also consequences for higher levels of speech processing. If, as outlined in detail elsewhere (Kalveram, 2001), the controller has acquired an inappropriate switching, disfluencies especially on short stressed syllables could occur.

Blocks and sound repetitions seem not to occur frequently on short stressed syllables. According to the theory of Kalveram and colleagues blocks are seen as secondary phenomena, resulting out of unconscious increase of tension as a reaction to other disfluency types – possibly appearing almost immediately after stuttering onset. Whether sound repetitions fit into the class of reactive behavior, maybe as a shortened form of syllable repetitions, is an open question.
Of course, many questions remain unanswered. For example disfluencies occur on syllables of all stress categories and both word classes, which must be explained. However, empirically testable conceptualizations of the underlying mechanisms that result in the core behavior of stuttering should be developed. The present study suggests that analysis of individual disfluency types can be useful in fulfilling this need.

Acknowledgments
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References


Table 1: Percentage of stuttering events dependent on word position. One-syllable and multi-syllable words were both included in the analysis.

<table>
<thead>
<tr>
<th></th>
<th>1st syllable</th>
<th>2nd syllable</th>
<th>&gt;2nd syllable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage of stuttering events</td>
<td>97.8 %</td>
<td>1.8 %</td>
<td>0.4 %</td>
</tr>
</tbody>
</table>

Table 2: Percentage of syllables in first position of content and function words dependent on stress categories.

<table>
<thead>
<tr>
<th>Grammatical class</th>
<th>short stressed</th>
<th>long stressed</th>
<th>intermediate</th>
<th>unstressed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function words</td>
<td>13.3 %</td>
<td>14.3 %</td>
<td>51.2 %</td>
<td>21.2 %</td>
</tr>
<tr>
<td>Content words</td>
<td>32.9 %</td>
<td>37.2 %</td>
<td>22.5 %</td>
<td>7.4 %</td>
</tr>
</tbody>
</table>

Table 3: Stuttering frequency dependent on stress category and grammatical class (S.D. in brackets). Calculation of percentages is based on the number of syllables in the respective category. Only syllables in word-initial position were considered.

<table>
<thead>
<tr>
<th>Grammatical class</th>
<th>Stressed total (%)</th>
<th>Short stressed (%)</th>
<th>Long stressed (%)</th>
<th>Intermediate (%)</th>
<th>Unstressed (%)</th>
<th>Total (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content</td>
<td>10.7 (7.8)</td>
<td>11.5 (8.6)</td>
<td>9.9 (7.2)</td>
<td>13.8 (9.8)</td>
<td>10.9 (13.2)</td>
<td>11.5 (9.9)</td>
</tr>
<tr>
<td>Function</td>
<td>18.4 (14.7)</td>
<td>21.2 (16.6)</td>
<td>15.6 (12.2)</td>
<td>19.2 (10.2)</td>
<td>11.5 (5.6)</td>
<td>16.9 (12.2)</td>
</tr>
<tr>
<td>Both</td>
<td>14.6 (12.3)</td>
<td>16.4 (14.0)</td>
<td>12.8 (10.3)</td>
<td>16.5 (10.3)</td>
<td>11.2 (10.0)</td>
<td>14.2 (11.4)</td>
</tr>
</tbody>
</table>
Figure Captions:

**Fig. 1**: Stuttering frequency of syllables in first position of content and function words and S.E., dependent on stress category. Significant differences are marked with an asterisk (evaluated by post hoc $t$-tests using Bonferroni correction).

**Fig. 2**: Stuttering frequency for individual disfluency types in first position of content words.

**Fig. 3**: Stuttering frequency for individual disfluency types in first position of function words.
Fig. 1:

![Graph showing stuttering frequency for different word types and stress levels. The x-axis represents word types: short stressed, long stressed, intermediate, and unstressed. The y-axis represents stuttering frequency from 0% to 25%. The graph compares content words and function words, with error bars indicating variability. Asterisks indicate significant differences.]
Figure 2:

![Stuttering frequency - content words]

- short stressed
- long stressed
- intermediate
- unstressed

Figure 3:

![Stuttering frequency - function words]

- short stressed
- long stressed
- intermediate
- unstressed