Acoustic Characteristics of the Adaptation of Stuttering
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ABSTRACT
Changes in duration of 90 dysfluent words in three successive readings of a passage by adults who stutter were measured. Durations of initial dysfluent consonants and vowels and vowels following dysfluent consonants were measured. Significant reductions occurred from 1st to 2nd but not 2nd to 3rd reading for both initial dysfluent consonants and vowels. However, vowel durations following dysfluent consonants did not change. Implications for understanding the nature of stuttering and for diagnosis are presented.

INTRODUCTION
The phenomenon of stuttering adaptation was first reported by Johnson and Knott (1937). While subsequent investigations have attempted to explain the mechanisms involved in adaptation (1939; Gray & Brutten, 1965; Hull & Van Riper, 1955; Janssen & Wiendkd, 1987; Johnson & Inness, 1939; Johnson & Marjory, 1939; Quarrington, 1962; Sheehan, 1956; Wishner, 1950), the specific changes that occur in the stutterer’s “path to fluency” during repeated readings of a passage remain largely unexplored.

Technological advancements have given us the ability to quantify the acoustic parameters of adaptation between successive readings; however, very little acoustic analysis of the changes that occur during adaptation has been reported. This study was designed to examine the specific characteristics of whole word length (WWL), length of the consonant in the initial position (CIP), length of the vowel/sonorant following the consonant in the initial position (VFCIP), length of the vowel in the initial position (VIP), nature of the dysfluency, and the progression of the adaptation across three readings. Specifically, the following questions were addressed, using the 110-sample corpus of single-word adaptation sequences extracted from repeated reading passages:

1. What changes occur in the overall duration of the word?
2. What changes occur in duration of the initial phoneme of the word?
3. What changes occur in the duration of the initial vowel or semivowel of the word?
4. Do changes occur in the vowel duration of words beginning with consonant or consonant clusters?

METHOD
PARTICIPANTS
Recordings of 65 adults who stutterer (58 males, 7 females) of repeated readings of either the Muscle Passage or Arthur the Young Rat involved in previous studies were de-identified for IRB approval. Tokens were selected from samples that demonstrated complete adaptation by the third reading.

PROCEDURE
Stimuli were digitized at 22,050 SPS with 16 bit resolution. Using CoolEdit Pro (version 2), waveform measurements were taken from the end of the preceding word to the end of the dysfluent word. Duration measurements were obtained for whole word length (WWL), the consonant in the initial position (CIP), the vowel following the dysfluent consonant in the initial position (VFCIP), and the vowel/semivowel in the initial position (VIP). To create evenly weighted ratios, each segment duration was divided by the duration of the corresponding fluent production. Data were analyzed using repeated measures analysis of variance for each dependent variable (WWL, CIP, VFDC, and VIP).

RESULTS
Inter-rater consistency and intra-rater reliability were measured using a random sample of ten percent of the analyzed segments. Correlations were greater than .99 and mean differences were not significant (p>.24).

The results for the experimental questions are shown in Table 1. Overall word length, consonant in initial position, and vowel/sonorant in initial position all showed a similar pattern: the decrease in duration from first to second reading was significant, but the change from second to third reading was not. This contrasts with the durations of the vowel following the initial consonant which showed no significant change across the three readings. Significant F values in the analysis of variance (ANOVA) were followed with the Bonferroni correction for multiple comparisons for the three readings. Huynh-Feldt adjustments of df were used.
Table 1. Means and standard deviations of ratios in readings 1, 2, and 3 (R1, R2, R3).

ANOVAs comparing mean ratios across three readings were performed.

<table>
<thead>
<tr>
<th></th>
<th>WWL Mean</th>
<th>WWL DS</th>
<th>CIP Mean</th>
<th>CIP SD</th>
<th>VIC Mean</th>
<th>VIC SD</th>
<th>Vowel/Semivowel Mean</th>
<th>Vowel/Semivowel SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>4.33</td>
<td>5.21</td>
<td>9.58</td>
<td>9.00</td>
<td>1.79</td>
<td>2.96</td>
<td>9.46†</td>
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</tr>
<tr>
<td>R2</td>
<td>1.63</td>
<td>1.21</td>
<td>2.97</td>
<td>5.04</td>
<td>1.17</td>
<td>0.25</td>
<td>2.54</td>
<td>4.55</td>
</tr>
<tr>
<td>R3</td>
<td>1.05</td>
<td>0.13</td>
<td>1.13</td>
<td>0.45</td>
<td>1.09</td>
<td>0.17</td>
<td>1.45</td>
<td>1.06</td>
</tr>
</tbody>
</table>

† Reading 1 was significantly > Reading 2 and 3, but Reading 2 was not significantly > Reading 3

The overall F for the three means was not significant.

Figures 1 through 4 display the results for the experimental questions.

Figure 1. Mean ratio of whole word length with consonants in the initial position, as compared to their fluent production.

Figure 2. Mean ratio of consonants in the initial position compared to its fluent production.

Figure 3. Mean ratio of vowel length following consonants in the initial position compared to its fluent production.

Figure 4. Mean ratio cross comparisons of vowel and consonant lengths in the initial position compared to their fluent production.

It can be seen that for overall word length, initial consonant, and initial vowel a significant reduction of duration occurred from reading 1 to reading 2, but not between reading 2 and reading 3. A further comparison between the CIP and VIP was made. An ANOVA indicated that there was no significant effect of consonant versus vowel \[ F(1,88) = 0.01, p >0.90 \] and no significant interaction of phoneme type and reading \[ F(2,176) = 0.06, p >0.88 \].
However, the duration of the vowel following a dysfluent consonant (seen in the ratio of its duration as a function of the duration of the fluent production) showed very little change. The VFCIP was only slightly dysfluent on the 1st reading (mean ratio = 1.79) and demonstrated little adaptation between the 1st and 3rd reading (mean ratio = 1.09). These changes were not significantly different (p = >.05)

DISCUSSION

The adaptation process of initial consonants and vowels is very similar and markedly non-linear; indeed, one could speculate that individual PWS, who show a linear adaptation or fail to show adaptation, are significantly and probably clinically different than PWS who adapt in this manner. With more samples it would be possible to find a statistically significant reduction between reading 2 and 3, but the dominance of reading 2 was apparent. In fact, if one considers the range from the 1st reading to the 3rd reading to be 100% of the reduction due to adaptation, then the decrease from reading 1 to reading 2 was 78.2 % and 86.6 % for initial consonants and vowels, respectively, and would hold for overall word length, also

However, the duration of the vowel following a dysfluent consonant showed minimal adaptation. This observation suggests that dysfluency is confined to the initial phoneme of the word, at least for words in a repeated reading passage that show complete adaptation.

CONCLUSIONS

1. During production of the initial consonants and vowels, a significant reduction in duration occurred from the first to the second, but not from the second to the third reading. This suggests the major component of adaptation is non-linear.
2. In cases where 100% of adaptation has occurred by the third reading, our results indicate that the reduction in dysfluency from readings 1 to 2 was 78.2% for initial consonants and 86.6% initial vowels.
3. Consonants and vowels demonstrated virtually identical patterns of adaptation, indicating that the nature of the phoneme does not influence the adaptation process.
4. For words beginning with consonants, the duration reduction associated with the adaptation effect appears to be almost exclusively associated with that initial consonant.

REFERENCES


