Acoustic Analysis of Stuttering Children's Fluent Speech: Pre- and Post-Therapy[1)]

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Hyun-Sub Sim. Acoustic Analysis of Stuttering Children's Fluent Speech: Pre- and Post-Therapy. ***Korean Journal of Communication Disorders, 2,*** **119-136.** This study compared absolute durations of temporal acoustic parameters at the subsegmental level of fluent speech produced by stuttering children (N = 4) before and after "Normal Talking Process" therapy. These measures were compared with those of an age- and gender-matched control group of normally fluent children. The find- ings indicated that voice onset time (VOT) and CV(consonant-vowel) transition duration decreased significantly after therapy. Children who stutter produced signi- ficantly longer vowel duration than control group both before and after therapy. The results were discussed in light of differential aspects of the treatment.

I. Introduction

A number of acoustic studies have compared the pre- and post-therapy fluent speech of both children and adults who stutter. The primary motivation for such in- vestigations is to ascertain whether decreases in stuttering as a result of intervention are associated with alterations in various temporal speech events as represented in the acoustic wave forms. According to Metz, Samar, and Sacco (1983), observed changes in the acoustic properties of fluent speech following stuttering therapy may be impor- tant indices of ". . . changes in the operation of motor control process that underlie fluency enhancement, whereas others may be systematic by-products of the particular fluency-enhancing condition"(p. 531).

Results from previous works have shown that following therapy, the fluent speech of adults who stutter is characterized by longer vowel and phrase durations and increased proportion of voicing during the closure for stop consonants (Mallard & Westbrook, 1985; Metz, Onufrak & Ogburn, 1979; Metz, Samar & Sacco, 1983), in- creased proportions of voiced segments (Franken, 1987), decreased periods of silence during the intervocalic intervals for voiced stops (Metz, Samar & Sacco, 1983), and longer voice onset times (VOT) (Metz, Schiavetti & Sacco, 1990). The relatively few studies which have examined the pre- and post-therapy fluency of children who stutter have reported increased vowel durations and percent vocalized time (Robb, Lybolt & Price, 1985), decreased vowel durations and VOT (Zebrowski, 1991) or no significant change in any of these parameters (Onslow, Doorn & Newman, 1992). Although some discrepancies among findings exist, the majority of results from these studies suggest that the post-treatment fluency of individuals who stutter can be characterized by a general pattern of increased duration of voiced speech segments or subsegments, and decreased duration of silent intervals or unvoiced speech segments or subsegments.

However, an important question remains: That is, as Metz et al. (1983) sug- gested, are the increases in the proportion of voicing and decreases in the proportion of unvoiced segments directly associated with the

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necessary conditions of the fluency, or are they merely residual effects of the specific strategies taught by various stuttering treatment approaches (Guitar, 1991)? For example, in most of the previously cited studies, participating subjects received stuttering therapy which emphasized (1) "stretched" or prolonged syllables (e.g., Franken, 1987; Onslow et al., 1992), (2) reduced articulatory rate (Metz et al., 1979), (3) slow initiation of phonation and prolonged voicing during speech (e.g., Metz et al., 1979; Robb et al., 1985), or some combination of these strategies. Furthermore, it seems reasonable that techniques or program "target" behaviors such as these results in fluent speech characterized by, among other findings, increased vowel and syllable duration and decreased speech rate.

Presently, there is a need to continue to try and uncover those features of post-treatment fluent speech which represent certain speech production behaviors un- derlying fluency, as opposed to features which are by-products of specific fluency- enhancing strategies taught in therapy. One reasonable method for an attempt to answer this question is to analyze the post-therapy fluent speech of individuals who stutter who have not received therapy which teaches the use of lengthened or prolonged syllables ("prolonged-speech"), slow initiation of voicing, or reduced speech rate. Methodologically, in order to improve interpretation of such an analysis, pre- and post-therapy fluencies obtained from these individuals should be compared with similar samples produced by normal speakers. With theses considerations in mind, the purpose of the present study was to compare pre- and post-therapy measures of (1) stop-gap duration, (2) voice onset time (VOT), (3) consonant-vowel (CV) transition duration, (4) vowel duration, and (5) consonant-vowel (CV) segment duration (stop- gap duration + CV transition duration + vowel duration) in the fluent speech of chil- dren who still stutter after an intensive stuttering therapy program. A second purpose of this study was to compare the pre- and post-therapy measures of the perceptually fluent speech of these stuttering children with those measures of the age- and gender- matched normally fluent children.

II. Methods

1. Subjects

Subjects for this study were four boys, with a mean age of 12 : 11 (year : months; range = 11 : 5 to 14 : 0) who were enrolled in a six-week intensive residential stuttering therapy program at the University of Iowa. The control group consisted of four age and gender-matched nonstuttering boys (mean age = 12 : 1; range = 11 : 0 to 14 : 2).

The boys who stuttered were referred to the intensive program by both school speech-language pathologists and their parents. Each child had undergone a stuttering therapy with varying lengths of treatment, before they participated in the present study. No subject displayed additional speech language problems, and all subjects had normal hearing. When referred to the intensive therapy of the present study, all four subjects in the experimental group complained about the unsuccessful treatment results of the prior therapies.

On the first and last day of therapy, each stuttering subject was videotaped while he engaged in conversation with a graduate-level clinician whose major was in speech-language pathology. These videotaped conversational samples were subsequent- ly analyzed in order to examine (1) the mean frequency of overall speech disfluencies in 100 words, as well as (2) the three most frequently produced disfluency types, and (3) the mean duration of within-word (stuttered) disfluencies. The Stuttering Severity Instrument for Children and Adults (SSI) (Riley, 1980) was administered to each stut- tering subject before and after therapy. The four nonstuttering subjects were recruited from the community through newspaper advertisement. All subjects were

paid volun- teers who were naive as to the purpose of the study.

2. Description of Treatment

Treatment procedures generally followed those described by Williams (1957, 1979), and elaborated upon by Conture (1990), which emphasize the processes under- lying "normal talking". In this approach, the emotional, psychosocial, and speech pro- duction behaviors associated with an individual's fluent speech are taught, and they are compared to those which underlie and perpetuate his stuttering disruptions. Ac- cording to Williams (1979), the main goal of the "normal talking" therapy model is to teach the person who stutter how to identify and attend to the things he is doing which interfere with talking, as well as those things he is doing which facilitate speaking.

In order to accomplish this aim, the therapy involved (1) discussion and iden- tification of the motoric processes underlying both fluent speech and within-word (stuttered) disfluencies (e.g., sound/syllable repetitions, sound prolongations), (2) dis- cussion of the main parameters of speech production, including airflow, physical tension, movement, timing, and sound, (3) behavioral awareness and comparison of fluent speech ("homebase" or "easy") with stuttered ("hard") speech, (4) "off-line" and "on-line" identification and description of the behaviors associated with the instances of stuttered speech, (5) "on-line" changes of stuttered speech compared with "homebase" or "easy" (fluent) speech, (6) uses of anticipatory cues to "stay at homebase", and (7) identification of relationships between stuttering and different emotional states, speaking situations and partners, and practicing strategies for "staying at homebase" when talking under these various conditions (Zebrowski, 1991).

3. Data Collection

Data were collected from the subjects who stuttered on the first and last day of therapy. Data from the nonstuttering subjects were collected in the interim between the first and last day of therapy for the stuttering subjects. Because this acoustic study was part of a larger investigation of articulator movement and inter-articulator coordination, all subjects' lower lips and jaw movements were simultaneously trans- duced via strain gauge while recording speech for subsequent acoustic analysis. For the purpose of the present study, four different test words (*pop, pea, Bob,* and *bee*) embedded in the carrier phrase "That's a _____ a day" were used as stimuli. Each subject was given an auditory model of the test words and was asked to repeat each phrase 10 times at a comfortable rate. Thus, 40 tokens (10 times X 4 target words) were obtained from each subject. Subjects spoke into a high-quality microphone attached to a headset at a fixed distance of 15 cm. All speech samples were recorded on a Sony (PC-108M) digital audiotape recorder.

4. Data Analysis

All subjects' perceptually fluent productions of word initial /p/ and /b/ were acoustically analyzed. These included the pre- and post-therapy fluent productions of the children who stutter and those of the nonstuttering peers. Only those utterances in which the test word and each word on the carrier sentence were judged to be fluent by both the first and second author were used in this study. Wide-band spectrograms (CSpeech, Version 3.1) displayed on a computer monitor (Gateway 2000) were made of each of the fluent test words, and cursors were used to delineate onset and offset points for measurements of stop gap duration, VOT, vowel duration, and CV transi- tion duration, along with the duration of the initial consonant-vowel (CV) segment in each of the fluent test words. Operational definitions of these measures have been reported elsewhere (Zebrowski,

Conture & Cudahy, 1985; Zebrowski, 1991) and are described below.

Stop-gap duration (SG). Measures from cessation of acoustic energy for [ə] im- mediately preceding the test word (e.g., "a *pop*") to the onset of acoustic energy ("burst") associated with the release of oral closure for either /p/ or /b/.

Voice onset time (VOT). Measures from the beginning of acoustic energy associated with supraglottal release for /p/ or /b/, to the onset of voicing (appearing as the first regularly appearing vertical striation in the region of the second formant).

CV transition duration (CVD). Measures from the onset of supraglottal release for the stop-plosive to the onset of the steady-state portion of the vowel at the level of the second formant.

Vowel duration (VD). Measures from the offset of the CV transition to the point where the second formant ceases its horizontal orientation.

CV segment duration (CVS). Measures from the offset acoustic energy for [ə] preceding the test word to the point where the second formant in the vowel of the test word ceases its horizontal orientation (i.e., end of steady-state portion). This measure reflects the sum of stop-gap duration, VOT, CV transition, and vowel duration.

5. Reliability

To assess intrajudge reliability, the first author remeasured four randomly selected test words from each of the nonstuttering subjects and eight from each of the children who stutter; four pre-therapy and four post-therapy words. There were 48 remeasured words in total. Twenty-eight of these 48 words consisted of /p/ in the initial position and 20 consisted of /b/ in the initial position. The means of the intrajudge measurement error for each of the five acoustic measures for /p/ and /b/ respectively were as follows: (1) stop-gap duration: 3.8 ms and 5.3 ms; (2) VOT: 3.8 ms and 3.5 ms; (3) CV transition duration: 5.4 ms and 6.4 ms; (4) vowel duration: 3.8 ms and 3.5 ms; and (5) CV segment duration: 6.2 ms and 5.0 ms.

For interjudge reliability, a doctoral student of speech-language pathology familiar with the methods of acoustic analyses separately measured the same set of 48 test words. The average interjudge measurement error for each of the five acoustic measures for /p/ and /b/ respectively was as follows: (1) stop-gap duration: 2.3 ms and 2.2 ms; (2) VOT: 1.4 ms and 1.6 ms; (3) CV transition duration: 4.3 ms and 3.9 ms; (4) vowel duration: 2.4 ms and 3.3 ms; and (5) CV segment duration: 4.5 ms and 3.7 ms.

III. Results

1. Pre- vs. post-therapy comparisons of stuttering and disfluency

Table 1 provides a comparison of pre- and post-therapy percentages of speech disfluency. Following therapy, each subject exhibited a decrease in the percentage of speech disfluency and mean duration of disfluency in 100 words of conversational speech. However, there were individual variations in the most-frequently observed within-word disfluency type. For example, while no change in the most frequent disfluency type between subjects 1 and 4 was found, the most frequent disfluency type of subject 2 changed from inaudible sound prolongation to audible sound prolongation. Also, for subject 3, the most frequent disfluency type changed from audible sound prolongations to interjections.

Table 1. Pre- and Post-Therapy Measures of Speech Disfluency

	Pre-therapy				Post-therapy			
	1	2	3	4	1	2	3	4
mean percentage of speech disfluency per 100 words	37%	35%	12%	26%	28%	31%	8%	15%
*most frequently produced speech disfluency type per 100 words	ISP	ISP	ASP	ISP	ISP	ASP	INT	ISP
mean duration of disfluencies (seconds)	.68	1.5	.43	.94	.46	1.0	.35	.59
** Stuttering Severity Instrument	SV	VS	MO	VS	MO	VS	MI	SV

* ISP = Inaudible sound prolongation ASP = Audible sound prolongation
SSR = Sound/syllable repetition INT = Interjection

** VS = Very Severe SV = Severe MO = Moderate MI = Mild

2. Pre- vs. post-therapy comparisons of temporal acoustic measures

Figures 1 and 2 show the means and standard deviations of all measures obtained from the perceptually fluent productions of word-initial /p/ (Figure 1) and /b/ (Figure 2) of the nonstuttering subjects, as well as means and standard deviations of pre- and post-therapy measures produced by the children who stutter. For the data from the stuttering subjects, separate one-way repeated ANOVA's were conducted for each acoustic measure to ascertain any pre- vs. post-therapy differences. As Figure 1 shows, results of this analysis for word initial /p/ revealed a significant decrease in stop-gap duration following therapy [$F(1, 106) = 6.46$, $p < .01$], as well as significant decreases in VOT [$F(1, 105) = 5.19$, $p < .02$], CV transition duration [$F(1, 106) = 7.79$, $p < .005$], and CV segment duration [$F(1, 106) = 5.77$, $p < .02$].

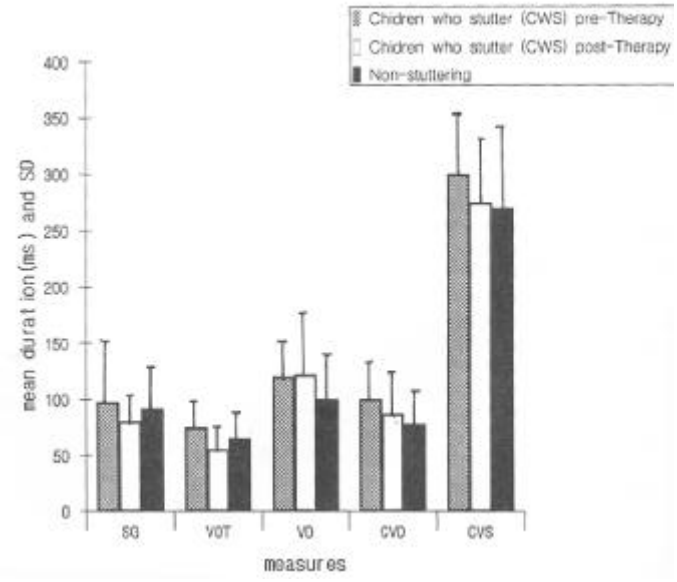

Figure 1. Means and standard deviations of five temporal acoustic measures from fluent productions of word initial /p/ obtained from children who stutter (CWS) (pre- and post- therapy) and nonstuttering (NS) children.

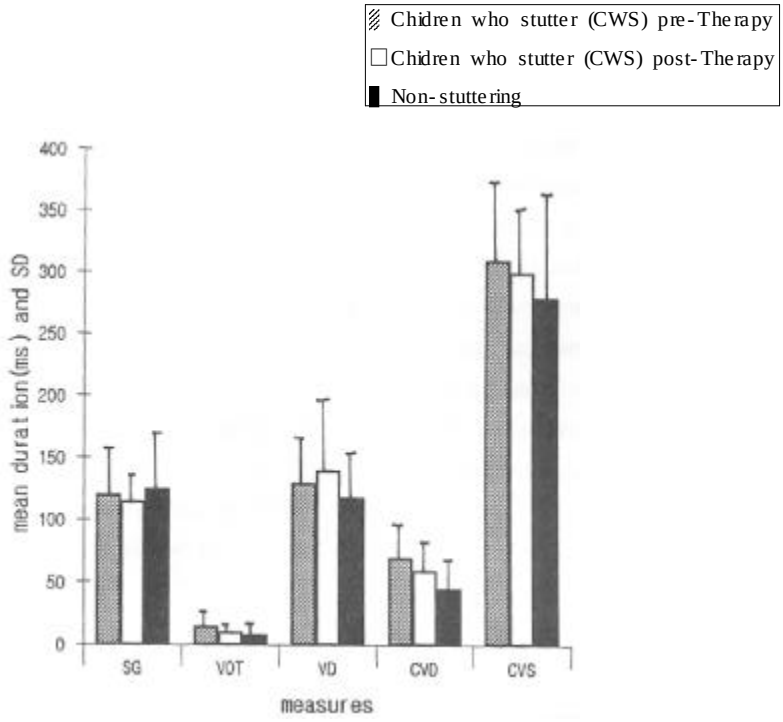

Figure 2. Means and standard deviations of five temporal acoustic measures from fluent productions of word initial /b/ obtained from children who stutter (CWS)(pre- and post- therapy) and nonstuttering (NS) children.

While Figure 2 shows pre- vs. post-therapy differences in all temporal mea- sures for /b/, only the post-therapy differences in VOT was significant [$F(1, 193) = 9.57$, $p < .003$], while a decrease in CV transition duration approached, but did not reach, the significance level [$F(1, 91) = 2.87$, $p < .09$].

3. Comparisons of temporal acoustic measures obtained from stuttering and nonstuttering children

a. Fluent speech of nonstuttering children and children who stutter pre- therapy

Recall that the second goal of this study was to compare each of the pre- and post-therapy fluent speech of the children who stutter with that of their nonstuttering counterparts. Again, Figures 1 and 2 provide means and standard deviations for the five acoustic measures obtained from the fluent speech productions of both groups of children for word-initial /p/ (Figure 1) and /b/ (Figure 2).

Results of separate Wilcoxon-Mann-Whitney analysis, with an adjusted alpha level of 0.1 for each of the five comparisons (0.05 for all five comparisons as a family for each sound) revealed that prior to therapy, the children who stutter produced fluent speech subsegments and segments both of which were longer in duration than those of their normally fluent peers. Specifically, the children who stutter exhibited significantly longer vowel durations ($p < .003$), CV transition durations ($p < .004$), and CV segment durations ($p < .0001$) in their pre-therapy fluent productions of /p/, when compared to the nonstuttering children (Figure 1).

Similar results were observed for /b/; that is, the pre-therapy fluent produc- tions of the children who stutter were characterized by significantly longer vowel durations ($p < .01$) and CV transition durations ($p < .0001$). In addition, while longer CV segment durations were produced by the stuttering children for /p/ but not /b/, a finding unique to /b/ for the children who stutter is that they produced significantly longer VOT's ($p < .1$) than the nonstuttering children during their pre-therapy fluent productions of this sound.

b. Fluent speech of nonstuttering children and children who stutter post- therapy

In order to provide an insight into the extent to which stuttering therapy might influence fluent speech production, we compared the post-therapy fluent productions of word-initial /p/ and /b/ produced by the stuttering children with those produced by the nonstuttering children. Again, separate Wilcoxon-Mann-Whitney analysis with an adjusted alpha level of .01 for each of five comparisons (.05 for all five comparisons as a family for each sound) was performed. Results for vowel duration were similar to those observed in the pre-therapy comparison, that is, following intensive therapy the children who stutter continued to show significantly longer vowel durations ($p < .01$) for /p/ than the nonstuttering children (Figure 1). However, as shown in Figure 1, no other significant between-group differences were found among the remaining four temporal acoustic measures for post-therapy fluent productions of /p/.

For /b/ (Figure 2), the children who stutter as a group showed significantly longer CV transition duration ($p < .0001$) and vowel duration ($p < .0005$) after therapy, similar to the pre-therapy comparison. However, unlike the pre-therapy analysis, fol- lowing treatment there were no other significant between-group differences for any of the remaining three acoustic measures obtained from fluent productions of /b/.

IV. Discussion

The principal finding of this study is that following therapy, children who stutter exhibited decreased duration of a variety of temporal measures in their precep- tually fluent productions of /p/ and /b/. These durational decreases were seen primarily in measures representing dynamic, rather than static aspects of speech production, those requiring fairly rapid, precise coordination between or within supralaryngeal and la- ryngeal systems (e.g., VOT, CV transitions as opposed to steady-state portion of vowels).

Results from this investigation are inconsistent with those from the majority of the published acoustics studies of the pre- vs. post-therapy fluent speech of children and adults who stutter. As described earlier, these studies have shown a general ten- dency for the post-treatment fluency of people who stutter to be characterized by longer voice onset times (e.g., Metz et al., 1979; Metz et al., 1990), longer vowel du- ration (e.g., Metz et al., 1979; Metz et al., 1983; Robb et al., 1985), and longer speech segments (e.g., intervocalic interval) containing either increased portion of voicing (e.g., Franken, 1987), decreased periods of silence (Metz et al., 1983), or both. Present findings do, however, support preliminary work (Zebrowski, 1991) which reported decreased durations of stop-gap, VOT, and steady-state vowel production in the fluent speech of two children who stutter enrolled in the same therapy program as that reported here.

Discrepancies between the present findings and most prior studies could be explained by differences in both subject and treatment characteristics. For example, with the exception of the studies by Robb et al. (1985) and Zebrowski (1991), all of the previously discussed investigations examined the pre- and post-therapy fluent speech of adults who stutter, as opposed to that produced by children. Several researchers have made the case that studying the fluency of adults who stutter is problematic in that any anomalous or disrupted speech behaviors observed might be related to a history of stuttering (effect) rather than its etiology (cause) (e.g., Conture, Colton & Gleason, 1988; Hulstijn, Starkweather & Peters, 1991; Zebrowski, Conture & Cudahy, 1985). For example, in a recent review of studies comparing the fluent speech of children who stutter with that of their nonstuttering peers, Armson and Kali- nowski (1994) concluded that older children (and, therefore adults as well) with a longer history of stuttering, as opposed to young children relatively close to stuttering onset, are more likely to exhibit fluency which is "contaminated" or influenced by this history. Specifically, these older children and adults might have established strategies for coping with or compensating for their instances

of stuttering, and such strategies are most likely manifest in speech production behaviors underlying the entirety of their speech, both stuttered and fluent. Therefore, between-group differences can be observed more frequently in the fluency of stuttering and nonstuttering adults than in the fluent speech of children who stutter and their nonstuttering peers.

The second reason for disparate findings between the present and previous research is related to treatment effects. One issue here of course is related to treatment itself, with regard to the amount and duration of therapy received. However, a second, but equally important issue relates to the type of therapy received and the techniques or strategies employed to produce fluent speech. Most of the pre- vs. post-therapy studies discussed here obtained acoustic measures from the subjects who underwent therapy which emphasized one of the following: (1) reduced speech rate (e.g., Metz et al., 1979; Metz, et al., 1983), (2) "stretched", prolonged or increased syllable duration (e.g., Franken, 1987), (3) a slow, prolonged phonation pattern (e.g., Robb et al., 1985), and (4) a combination of these strategies. In contrast, as in Zebrowski (1991), the children in the present study received a form of "stuttering modification" or "stutter more fluently" therapy (see Gregory, 1979; refer to Guitar & Peters, 1985 for discussion of "speak more fluently" vs. "stutter more fluently" approaches to the treatment of stuttering). In the approach used here, a general identification and "relearning" of the normal (fluent) speech process was the focal point of therapy, and slowed speech rate or prolonged syllables were not emphasized (see Methods section for a discussion of specific goals of therapy). One of the important goals of this approach is "acceptable stuttering" in which the speaker produces "noticeable but not severe disfluency and feels comfortable speaking despite his disfluency" (Guitar & Peters, 1985, p. 15). While "noticeable but not severe disfluency" is arguably ambiguous, for the program used here it is interpreted to describe stuttered speech characterized by sound, syllable and word repetitions, and audible sound prolongations of relatively short duration (500 ms and below), or with no or minimal accompaniment of associated (non)speech behaviors (e.g., visible physical tension, consistent loss of eye contact, extraneous facial, arti- culator, head, torso or limb movement, audible inhalations or exhalations, vocal pitch rise or break) or both.

Considering the different emphases of the different therapy approaches, it seems reasonable to conclude that the inconsistent findings from a number of studies might be the result of specific targets taught in the therapy, and they do not necessarily represent speech production behaviors which are essential for fluent speech. For example, the consistent findings of fluency characterized by longer vowel duration and increased phonation time or proportion of voiced segments probably stem from the fact that the individuals for whom these changes were observed were taught to "stretch" or prolong syllables in order to speak fluently. Further support for this speculation can be found in a recent study of lip and jaw movements associated with fluent speech (McClean, Kroll & Loftus, 1990). In this investigation, McClean et al. observed that stuttering adults with no recent history of therapy were not significantly different from their nonstuttering peers with regard to 15 parameters of articulator movements during the lip closure associated with fluent speech. However, an additional experimental group of stuttering adults enrolled in an intensive fluency shaping program showed significantly longer jaw movement duration and time to peak velocity of the upper and lower lips and jaw following treatment, when compared with the control group. In addition, the treated experimental subjects more frequently showed "reversals" in the typical sequencing of upper lip, lower lip and jaw velocity peaks accompanying lip closure. The authors deduced that in general, the lip and jaw move- ments associated with stuttering and nonstuttering adult's instances of fluent speech do not differ "unless the stutterers have completed a speech therapy program that targets prolongation of speech segment durations" (p. 758). Results from the present investi- gation offer support for this conclusion, in that the subjects participating in this study did not receive therapy which focused on fluency shaping through the modification of specific aspects of

speech timing. Consequently, their post-therapy fluency was gener- ally characterized by segment and subsegment durations which were shorter in duration than those observed pre-therapy, but they were not significantly different from the same measures produced by nonstuttering children.

1. Significance of post-therapy changes in duration

The findings from this study may be interpreted in a variety of ways. First, when combined with those from similar preliminary work (Zebrowski, 1991), the results of the study suggest that stuttering therapy which emphasizes a "relearning" of the normal process of speech, as opposed to focusing on rate reduction, prolonged speech, or both, can help children who stutter produce fluent segment and subsegment durations which more closely approximate those produced by nonstuttering children. Moreover, as previously discussed, the post-therapy temporal changes seen here were primarily related to dynamic as opposed to static speech behaviors, associated with sound-to-sound transitions (e.g., VOT and CV transition duration). The nature of these changes, namely a reduction in duration, suggests that as a group the children who stutter showed post-therapy fluency characterized by faster or more efficient or coordinated transitioning between speech sounds (Wingate, 1976, 1988). More specifi- cally, as discussed by Metz et al. (1983), it may be the case that certain changes in acoustic parameters reflect a "regularization" of underlying timing relationships between articulatory and phonatory gestures, which facilitates smooth, fluent transitions between speech segments and sounds. Finally, as Guitar (1991) speculated, it may be the case that "at least for young stutterers, slowing rate and increasing duration of voicing may not be necessary. Speech may become more normal if the stutterer stops reacting to the stuttering so catastrophically" (p. 555).

2. Issues related to post-therapy fluency

A broader issue related to the findings from this and similar studies has to do with the identification of a treatment approach for children who stutter which is most likely to result in the highest degree of maintenance of both fluent speech and "ac- ceptable stuttering". Obviously, this is an empirical question of which data are long overdue. However, results from acoustic studies of pre- and post-therapy fluency, along with observations made in studies of speech naturalness, may provide a basis for some conjecture.

For example, as previously discussed, studies have shown that children and adults who stutter enrolled in therapy programs emphasizing rate reduction and pro- longed syllables and vowels, exhibit post-therapy fluency which is characterized by longer segment and subsegment durations. These findings may be related to the specific targets or behaviors taught in therapy, and may not represent behaviors necessary for fluent speech production by people who stutter. Further, as the present study suggests, and as supported by other works (e.g., McClean et al., 1990; Zebrowski, 1991) the post-therapy fluency of people treated for stuttering with the use of these "fluency shaping" procedures is less like the fluent speech of nonstuttering individuals than either their pre-therapy fluency or the fluency of people enrolled in other kinds of therapy programs (e.g., stuttering modification). Finally, a number of studies have consistently indicated that the perceptually fluent speech of stuttering individuals treated with fluency shaping techniques is judged to sound "unnatural" and "monotonous" by listeners (Ingham, Gow & Costello, 1985; Franken, Boves, Peters & Webster, 1991).

Taken together, findings from both perceptual and speech production studies of post-therapy fluency suggest that the use of stuttering modification or "stuttering more fluently" approaches with school-aged children who stutter may result in fluent and disfluent speech which more closely approximates the fluent speech of nonstut- tering children, both in the way it is produced and the way it sounds to listeners. An

obvious advantage here is that fluency is not contrived through the pervasive use of slowed rate, prolonged syllables, or reduced prosody, and therefore it is likely that children can retain both spontaneity and expressiveness in speaking (Franken et al., 1991; Guitar, 1991). Therefore, while this kind of approach requires a fairly high degree of cognitive ability, behavioral awareness and desensitization to stuttering and speaking, long-term results for school-aged children with a history of stuttering may be more consistent when compared to the results of fluency shaping approach. As previously discussed, data on treatment results for children who stutter are sorely needed before the validity of this and similar speculations can be addressed.

3. Limitations

The first limitation of the present study is that because of the small number of the subjects, the scope of interpretation and generalization of our results is limited. One of the ways in which the study could be strengthened would be to report indi- vidual data, which will be presented at a later date. The second limitation is that because of the limited phonetic contexts of the tokens analyzed, our ability to gener- alize our results to other phonetic contexts remains uninterpretable.

4. Future Research

Because of the inherent limitations of acoustic analysis (i.e., that it provides only indirect measurements of physiological events), in order to get a more complete understanding of how the fluency of children who stutter is achieved subsequent to a particular treatment program, the acoustic analysis should be done in conjunction with the analyses of respiratory, laryngeal, and supralaryngeal events. Further attempts to better understand the production of fluent speech following treatment might include a large number of subjects and the use of more diverse phonetic contexts. Such study will illuminate our understanding of how treatment goals are realized on the phys- iological level and treatment goals thereby will contribute most to the production of fluent speech in children who stutter.

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