THE EFFECT OF MANIPULATING PHONATION DURATION ON STUTTERING

ROGER J. INGHAM  JACK MONTGOMERY  LOUISE ULLIANA
Cumberland College of Health Sciences, Sydney, Australia

Two single-subject experiments with two adult stutterers were conducted to assess the effect of changing the frequency of phonation intervals that were shorter or greater than prescribed durations during spontaneous speech. Both subjects modified the frequency of prescribed phonation intervals and showed changes in the frequency of these intervals that were positively related to decreases and increases in stuttering frequency. A perceptual analysis of the subjects' speech quality during phonation control conditions showed that when stuttering frequency was reduced, listeners could detect changes in the speech quality of both subjects; however, only one subject's speech during these conditions was described as nonnormal sounding. The therapeutic and theoretical implications of these findings are discussed.

One of the paradoxes concerning the behaviorally oriented stuttering therapies is that, in spite of their emphases on measurement and replicable operations, the centerpieces of many treatments are vaguely described techniques whose replicability depends on clinician judgment (Ingham, 1975; Ingham & Lewis, 1978). Many of these techniques are derivatives of Goldiamond's (1965) procedure for inducing "prolonged speech" via DAF. The questionable replicability of this procedure was clearly recognized by Goldiamond. For not only did he point out that DAF may be unnecessary to achieve prolonged speech (Goldiamond, 1967), but also during DAF conditions he identified at least three other "competing" patterns: voice lowering, proprioceptive increase, and tuning out. Indeed, it was necessary for the clinician to instruct the subject on the most appropriate speech characteristics to ensure the appearance of the desired speech pattern. Thus, in inspection, this essentially behavioral treatment rests on relatively ill-defined operations. This is not to deny the possibility that such clinician judgments might be managed reliably—The fact is, however, this has not been demonstrated.

The subsequent variations on Goldiamond's procedure also rely on vaguely defined operations based on clinician judgments. Indeed, the labels for some of the current operations, such as "gentle contacts," "smoothed speech," "rate control," and "breathstream management," were applied to techniques that flourished during the 1940s (cf., Bender & Kleinfeld, 1938; Hahn, 1941). The decline in use of earlier versions of these techniques was probably largely due to their lack of specificity as well as to the uncontrolled fashion in which they were administered. Some justifiable claims for operational replicability of some of these techniques should be possible with equipment described by Agnello (1975) and Webster (1977) for producing "easy onsets" within the speech of stutterers. However, to date there have been no data-based demonstrations of the effects of this equipment on stuttering.

Arguably, Goldiamond's (1965) research was the main stimulus for the recently revived interest in respiration, phonation, and articulatory factors in stuttering research. This was expressed most visibly in the research program of Adams and colleagues on aerodynamic aspects of stutterers' speech behavior (Adams, 1974). It was also linked with the emphasis that Wingate (1969, 1970, 1976) placed on the role of modified vocalization within the "artificial" fluency produced during different conditions. Since altered vocalization implicated phonatory behavior (in spite of Wingate's 1979 assertions to the contrary), it was almost inevitable that this aspect of speech should form a central element in the research that emerged in this area.

Extensive research has shown that increased phonation time is prominent among the variables that change during DAF conditions. Subsequent research suggested that phonation-time modification was also necessary to effects produced by singing (Colcord & Adams, 1979), reduced speaking rate (Healey & Adams, 1981), and, to a lesser extent, chorus reading (Adams & Ramig, 1980). Yet, in spite of this interest in phonation time, no direct attempt has been made to assess the effects on stuttering of manipulating this variable. Some tangential approaches have been made via studies that have used oral reading passages containing various proportions of potentially voiced speech (cf., Adams & Reis, 1971, 1974). But the extent to which phonation-time changes may affect stuttering has not been established.

It was against this background that the present study was designed. The principal objective was to seek a replicable procedure for manipulating stutterers' phonation time in order to provide a more controlled clinical method for modifying stuttering. This study stemmed directly from the need to operationalize one of the most obvious speech parameters that is altered during prolonged speech—that is, phonation duration. Specifically, the purpose was to assess the effect of manipulating the frequency of minimal durations of phonation in the spon-
taneous speech of two adult stutterers in order to (a) determine whether subjects could establish control over the frequency of these phonation intervals, and (b) measure the association between that control and changes in the frequency of stuttering. An additional purpose was to evaluate the perceptual quality of each subject's speech during phonation interval control conditions.

METHOD

Subjects and Apparatus

The subjects were two male stutterers who were on a waiting list for stuttering therapy. Subject P.A. (52 years) and Subject S.L. (19 years) had received treatment 10 years earlier. Their previous treatment, which had not succeeded in eliminating their stuttering, involved the use of a prolonged speech procedure in a program similar to that described by Ingham and Andrews (1973). Both subjects' stutterings could be categorized within the kernel characteristics of Wingate's (1964) definition of stuttering.

Throughout the experiment each subject was seated in an experimental sound-treated room. A microphone, a Counter Display Unit, an oscilloscope (Gould OS4000), and a Phonation Interval Monitor and Feedback Unit were also located in the same room. Each subject was monitored and recorded auditorily from a control room. The control room monitoring facilities included a data printer (Newport 810), a tone feedback unit, tape recorder (TEAC A-7300), and a dual button-press electronic counter. The experimenter (L.U.) counted, on line, syllables judged as stuttered or nonstuttered using the electronic counter.

The recording and feedback assembly arrangements in the experimental room enabled each subject's "phonation interval" counts to be illuminated on the subject's Counter Display Unit for 10 s at the end of each minute. That score, along with syllables and stutterings counted each minute, were registered concurrently on the control room data printer.

Phonation interval (PI) recording and feedback system. Each subject's phonation was registered through a miniature accelerometer (Koningsberg Type, A 1–4) housed to fit on the surface of the throat, slightly below the thyroid prominence. The accelerometer signal was fed to a Phonation Interval Monitor and Feedback Unit.1 Briefly, the Unit accepts a signal which is fed to a bridge amplifier and then filtered so that, generally, the frequency range 200–1000 Hz is accepted for phonation interval comparison. The intensity and frequency range of the accepted signal may be adjusted to ignore nonphonated signals. The duration of the accepted phonation signal is then compared with a preset duration interval. If the phonation signal is less than a prescribed duration, then a "phonation interval" (PI) count is recorded. The PI signal counts are stored for delivery to the subject's Counter Display Unit and the control room data printer. Each PI count signal also could activate a 50-ms, 750-Hz tone. Thus, whenever an interval of phonation was registered as less than a prescribed duration, the subject could instantly receive a tone and a PI count.

Each accepted phonation signal and its activated prescribed duration signal were displayed in dual-channel continuous-roll function on the digital storage oscilloscope. This gave the subject the option of viewing on line an analog depiction of his phonated response and comparing it with a depiction of the prescribed duration. The oscilloscope display also permitted the experimenter to set a threshold activation level for the phonation signal. This was determined immediately after the accelerometer was attached to the subject's throat and before each treatment session. The experimenter requested the subject to make a variety of physical movements, mainly vigorous head movements and swallowing actions followed by soft-voiced counting, to ensure that the "phonation signal" was essentially voice-related.

Perceptual analysis system. A perceptual analysis (Ingham & Packman, 1978) was made of speech samples obtained from conditions in which the subjects' frequency of phonation intervals of prescribed durations was reduced. Four audio recordings containing speech samples were heard individually by four groups of 20 listeners. The listeners were essentially naive; they were neither clinicians nor students training in the field of speech and language pathology. They were aged 20–45 years.

Procedure

Each subject spoke spontaneously in 5-min trials separated by 1-min rest periods. After four trials, the subject rested for 10 min. Each subject completed at least 12 but no more than 48 trials during any day of the experiment. The experimental design required each subject to complete a different series of four nontreatment trials (A conditions) and four treatment trials (B+ or B- conditions). Three data measures were obtained throughout each of the experimental conditions: percentage syllables stuttered (%SS), syllables spoken per minute (SPM), and PI counts per min. (Recall that the PI counts were intervals of phonation that were less than a prescribed duration.)

Stage One experimental procedure. The experimental procedures were designed to assess whether subjects could modify the frequency of PI counts during spontaneous speech when receiving PI count feedback and instructions to reduce these counts. A concurrent purpose was to assess the effect of modifying prescribed PI counts on stuttering. The effect of these phonation-modifying procedures was evaluated in a series of ABA experimental conditions involving systematic increases in the phonation interval necessary for a PI count.

During the first A condition the PI duration setting

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1The circuit diagram for this unit is available on request from the senior author.
was 50 ms. Each subject spoke spontaneously for four 5-min trials while the frequency of PI counts was recorded. The subject was not fed back information about his PI counts. In the succeeding B+ condition the subject received auditory and visual feedback of each PI count; each interval of phonation less than 50 ms activated the tone signal and recorded a count on the Counter Display Unit. At the beginning of this and all other B+ condition trials, the subject was instructed to try to reduce the number of PI counts per min to below 50% of the mean counts per min recorded during the A condition. This figure was displayed on the Counter Display Unit. In addition, the subject was able to monitor the oscilloscope’s dual signals. This permitted him to observe the association between duration intervals in his phonation signal and an activated 50-ms interval. Consequently, in each B+ condition the subject received three sources of feedback to assist him to modify PI counts: the tone signal, counter display, and oscilloscope signal display.

The instructions to the subject preceding the B− condition involved considerable care to ensure that no explicit instructions were provided about a particular manner of speaking that should be used to reduce PI counts. The subject was told only how the equipment operated with respect to the duration of throat-surface vibration. A series of vowel utterances were requested, and these were frozen on the oscilloscope’s dual channel display. This was used to demonstrate the relationship between the subject’s voice signal duration and the prescribed duration. Recall from the previous description of the oscilloscope display that the onset of the phonated signal, which was displayed on one channel, also activated a comparison-time signal (prescribed duration) on the second channel. The subject was informed that any of his signal durations that were less than the prescribed duration would also activate the counter and the feedback tone. To ensure that the subject was not instructed inadvertently about using a particular speech pattern, the counter and tone activation were demonstrated by tapping the accelerometer and indicating (on the oscilloscope display) that signals which would activate a PI count also produced a tone burst and a count on the Counter Display Unit. The subject then was informed of the maximum number of PI counts he should produce by the end of each minute. This figure was attached alongside the PI counter on the Counter Display Unit.

The criterion for establishing that a subject could modify his PI counts was a mean number of PI counts during the B− condition that was 50% of the mean number of PI counts across the eight A condition trials. If PI control was not demonstrated during the 50-ms PI level, then the next A/B−/A sequence was introduced using a 100-ms duration level and replication of the above mentioned procedures. Again, if PI control was not obtained, then the next A/B−/A sequence was introduced with a PI level of 150 ms. These procedures continued until (a) PI control was established or (b) the initial A condition PI counts were not 10% greater than those obtained in the final A conditions of a previous A/B−/A sequence.

This stepwise experimental design requires comment since it would appear that any identified “treatment effect” might be confounded. The first potential confounding effect involves learning. Because the subject may be exposed to increasingly larger PI counts, his control over these may result simply from learning to alter phonation length, rather than being caused by a particular PI duration level. It would seem that the most logical control for this variable would be ascertaining a treatment effect at a particular PI duration level, then re-introducing the preceding PI duration level (that is, 50 ms less), and checking that a treatment effect still did not obtain at that level. The difficulty with this procedure is that if a treatment effect is obtained at the shorter PI duration, it too may be due to learning rather than associated with the particular PI level. In this event, the subject’s strategy for reducing PI counts could be to use the long intervals of phonation learned at the previous level. The present design was preferred since the primary purpose was to determine whether the subject could manipulate a duration level. The second potential confound is the fixed number of 5-min trials in each experimental “run.” It is customary to allow subjects to demonstrate a data trend over variable trials when employing single-subject experimental designs. However, this becomes exceedingly difficult when more than one data measure is monitored. For this reason, a fixed number of trials (four) per condition was preferred, and any ambiguity in the data trends was regarded as reflecting the absence of a treatment effect (Hersen & Barlow, 1976).

Stage Two experimental procedure. The first experimental stage was designed to identify a PI level that the subject could modify. The second experimental stage then was introduced to assess the effect on stuttering when the subject manipulated his PI frequencies relative to his base rate PI level. This was carried out using either a B−/B+/B+/B+ or B+/B−/B+/B− experimental design. In this experiment the subject received the three sources of PI feedback throughout all conditions (i.e., tone, counter display, and oscilloscope). However, in B− conditions the subject was instructed to reduce his PI counts per min to 50% of the A condition mean PI counts per min. In the B+ conditions the subject was instructed to increase his PI counts per min to 50% above his A condition mean PI counts per min. The A condition PI
count in this case was obtained from the first A condition in the Stage One experiment.

Once again a treatment effect was considered to have occurred only if the subject’s mean PI counts for four 5-min trials were either 50% above (in the case of B+ conditions) or 50% below (in the case of B− conditions) the A condition mean PI level. In other words, the prescribed PI level during the first B− condition was identical to the PI level which (by necessity) yielded a treatment effect in the Stage One experiment. If PI count control was not demonstrated in the first B−/B+/B−/B+ (or vice versa) sequence, then the PI level was increased by 50 ms and a new sequence introduced. This was preceded by an A condition in order to establish the B− and B+ PI criterion levels. This procedure was repeated for a maximum of three occasions.

Perceptual analysis. Subsequent to both experiments, recorded samples of each subject’s stutter-free speech were selected for two purposes: (a) to assess whether perceptual differences were evident in each subject’s speech during B− conditions relative to A conditions, and (b) to assess whether listeners described speech samples drawn from B− conditions as normal or non-normal sounding.

The procedure for (a) involved selecting samples from A and B− conditions that enabled sample pairs, matched for number of words, to be organized so that listeners heard pairs drawn from same or different conditions. Ten pairs of samples were obtained from same conditions (i.e., both from B− or both from A conditions) and 10 pairs from different conditions (i.e., A and B− conditions). This produced two sets of tape recorded samples. Tape One contained 20 sample pairs from Subject P.A., with 2 of the 20 pairs repeated at the end for reliability assessment. This recorded material was followed by a similar set of 22 pairs of samples from Subject S.L. The number of words in each sample ranged from 11 to 21 for P.A. and 27 to 48 for S.L. Tape One contained samples from B-100 ms conditions for P.A. and B-150 ms conditions for S.L. Tape Two was identical to Tape One except that it contained B-50 ms condition samples for P.A. (14–20 words per sample) and a repeat of the B-150 ms condition samples for S.L.

The procedure for (b) involved selecting 1-min stutter-free samples from both subjects’ speech during B− conditions and equivalent samples from normal speakers of the same age and sex as each subject. A clinician determined that neither control subject evidenced a speech or language problem and had not received treatment for such a problem. Each sample was judged as stutter-free by two independent clinicians and did not contain identifying content. Tape Three was prepared so that listeners heard the following four 1-min samples: Subject P.A. from B-100 ms conditions (176 syllables), P.A.’s control (175 syllables), Subject S.L. from B-150 ms conditions (151 syllables), S.L.’s control (156 syllables). Tape Four was prepared so that the listeners heard the following samples: S.L.’s control, S.L., P.A.’s control samples from Tape Three, plus P.A.’s sample from B-50 ms conditions (174 syllables). Thus, Tape Four contained only one sample that distinguished it from Tape Three, thereby permitting intergroup listener reliability to be discerned for three of the four samples.

Each tape was heard individually through headphones by one group of 20 listeners. Thus, 80 listeners were involved in this part of the study. For Tapes One and Two, the listeners were read aloud instructions which asked them to decide whether the samples in a pair were drawn from “same” or “different” speaking conditions. The listeners to Tapes Three and Four were asked to decide whether each sample was obtained from a normal or nonnormal sounding speaker. Thus, for Tapes Three and Four it was possible to derive a count, out of 20, of the number of listeners who judged a sample to be from a normal speaker.

Reliability

The reliability of the data measures obtained in Stages One and Two experiments involved an assessment of (a) the accuracy of the Phonation Interval Monitor and Feedback Unit in identifying prescribed intervals of phonation, and (b) the reliability of %SS and SPM scores from both speakers.

The calibration of the Phonation Interval Monitor and Feedback Unit was checked during the course of the experiment by two separate procedures. In the first, a series of 750-Hz signals of prescribed duration were fed to the unit, which permitted interval detections within ±2 ms. The second was obtained by arranging for one of the two subjects and a third, P.S., to produce a series of vowels of varying duration while fitted with the phonation modification equipment. (The performance of P.S. is described in the Discussion.) The duration of each vowel production was recorded from the Phonation Interval Monitor and Feedback Unit on oscillographic display. The duration of each signal was read off and then compared with the duration derived independently from spectrographic print outs (Voice Identification Unit, Model 700) using the average duration in the 250-1000-Hz range. Twelve oscilloscope-measured samples for Subject S.L. ranged 180–750 ms. The spectrographic measures were identical for six and differed by 10–25 ms for the other six. Fourteen similar samples from Subject P.S. were measured at 175–900 ms on the oscilloscope. The spectrograph measures were identical for eight but differed by 10–25 ms for the other six. These differences are of some concern, but average on-off measuring points on spectrographs are expected to have close rather than exact correspondence with the phonation signal on-off measuring points (Peterson & Lehiste, 1960).

The reliability of %SS and SPM scores was estimated by obtaining syllable and stuttering counts made by an independent clinician from recordings of each subject. The clinician was provided with two 5-min-trial recordings from each of the experimental conditions in each experiment. The recordings were selected randomly, and the clinician was not familiar with their source. The scores obtained by the second clinician were converted
to %SS and SPM scores and are displayed within the results figures (see Figures 1-3, shown later) for each subject. The trend of the second clinician’s (rerated) scores shows a pattern consistent with the trend produced by the experimenter’s original scores.

The reliability of the perceptual analysis procedure was investigated by (a) independent measures of the experimenter’s syllable counts and timing for samples, and (b) between-listener comparisons of judgments made on some of the samples. In addition, only reliable listeners were used in the perceptual analysis investigation of similarities or differences between sample pairs. “Reliable listeners” were judges whose second judgments on both repeated sample pairs from both subjects on Tapes One and Two were identical.

All word counts on the samples for Tapes One and Two were agreed upon by an independent clinician, and differences in the times of both samples in a pair were confirmed by the same clinician as not exceeding 3 s. The 1-min samples were checked by an independent clinician for syllable counts, and none differed from the experimenter’s counts by more than 3%.

The listener-groups’ judgment reliability on Tape One and Tape Two was estimated from judgments for identical samples from Subject S.L. that appeared on both tapes. The listeners to Tape One confidently identified the different condition samples for this subject, and this effect was repeated by the listeners to Tape Two. The 1-min samples on Tapes Three and Four also contained identical samples for S.L., S.L.’s control, and P.A.’s control. The percentage of “normal” judgments for the two listener groups are shown in Table 1, which includes all findings for this part of the perceptual analysis study. These data show that the Tape Three and Tape Four listener groups were reasonably consistent in their judgments of the normalcy of P.A.’s control, S.L., and S.L.’s control. However, fewer listeners judged S.L.’s control’s speech to be normal sounding when compared with P.A.’s control. Nevertheless, it is evident that both listener groups regarded the speech of S.L.’s control as much more normal sounding than the speech from S.L.

### Table 1. Total (n) and percentage (%) of listeners to Tapes Three and Four who made judgments of “normal” on 1-min samples of the speech of subjects and their controls.

<table>
<thead>
<tr>
<th></th>
<th>Tape three (N = 20)</th>
<th>Tape four (N = 20)</th>
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<tr>
<td></td>
<td>n</td>
<td>%</td>
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<tr>
<td>P.A. (B–50)</td>
<td></td>
<td></td>
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<tr>
<td>P.A. (B–100)</td>
<td>19</td>
<td>95</td>
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<tr>
<td>P.A.’s Control</td>
<td>18</td>
<td>95</td>
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<td>S.L. (B–150)</td>
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<tr>
<td>S.L.’s Control</td>
<td>16</td>
<td>80</td>
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### RESULTS

The results of the Stage One and Two experimental procedures for both subjects are shown graphically and reveal data patterns that are consistent with effects attributable to phonation interval modification.

#### Subject P.A.

The results of the Stage One experimental procedure for this subject are shown in Figure 1. From the data display it can be observed that the subject’s base rate PI count during 50-ms duration measurement (condition A50) ranged between approximately 2.5 and 1.5 per min. When feedback and instructions were provided during B-50 conditions, P.A. reduced that frequency of PI intervals to below 50% of the initial A50 level mean. PI control was regarded as established by evidence in the final A50 condition that the subject’s PI count returned to a rate consistently above the B-50 level. It can also be observed that a concomitant trend occurred in the subject’s stuttering frequency, without evidence of an associated reduction in speech rate.

![Figure 1. Frequency of phonation intervals (PI counts) less than 50 ms, percentage of stuttered syllables (%SS), and syllables per min (SPM) for Subject P.A. during A50/B–50/A50 conditions of the Stage One experiment.](http://jslhr.pubs.asha.org/)

The findings from the Stage Two experimental procedure for P.A. are shown in Figure 2. In the initial part of this experiment the criterion reduction in PI counts during B-50 was achieved, but the reciprocal criterion during B+50 conditions was not reached. (Recall that the “−” notation signifies that the subject was required to reduce his PI counts below 50% of the A condition mean PI counts, and the “+” notation signifies that the subject was required to increase his PI counts 50% above the A condition mean PI counts.) A subsequent replication of treatment conditions confirmed this data trend. However, it can also be noted that the subject’s %SS scores followed the same general trend as the PI counts. When the PI level was set at 100 ms, an increase in PI counts...
dutifully followed (see A100). Across the following A100/B−100/A100 conditions sequence, the subject once again displayed evidence of PI control and also revealed an equivalent effect on his stuttering frequency. During the subsequent B−100/B+100/B−100/B+100 conditions, P.A. showed a pattern of PI scores that was consistent with the criterion levels required within the experiment. The subject’s %SS scores also decreased, almost to 0, during all B−100 trials and increased above the A condition level during all B+100 trials.

The results from Subject P.A. were consonant with the aims of this study. The subject was consistently able to reduce and increase his PI counts appropriately during feedback conditions. In addition, there was clear evidence that his frequency of stuttering was associated with manipulations in PI counts.

The majority of listener judgments from those listeners identified as reliable in evaluating Subject P.A.’s A/B−50 condition sample pairs and his A/B−100 sample pairs are shown in Table 2. A Chi-Square Test (Siegel, 1956) of the distribution of the majority of listener judgments shows that the listeners were able to distinguish confidently between stutter-free A condition and B−50 condition samples but that they failed to make the same distinction between A and B−100 condition samples.

The listener judgments of normalcy from the 1-min samples from P.A. during B−50 or B−100 conditions are shown in Table 1. They indicate that P.A.’s speech quality under B−50 and B−100 conditions definitely did not sound abnormal. However, slightly fewer listeners judged this speech to be normal during B−50 conditions, a difference which is consistent with the distinction that other listeners made between samples obtained from B−50 and A conditions for this subject. The counterpart figures from P.A.’s control are generally similar to those produced for P.A., especially during B−50 conditions. In short, it would appear that only the B−50 condition altered the subject’s manner of speaking, but three quarters of the listeners still perceived his speech as normal sounding.

Subject S.L.

The results for the Stage One and Two experimental procedures with S.L. are shown in Figure 3. The Stage One procedures began with an abbreviated A50 condition, which showed virtually zero PI counts. Consequently, the A100 condition was introduced immediately. However, the subject’s 100-ms PI level counts also were relatively infrequent. During B−100 conditions the subject’s PI counts were reduced from the initial A100 level but continued virtually unchanged during the subsequent A100 condition. On the following day the PI level was increased to 150 ms, and over the subsequent A150/B−150/A150 conditions the subject’s response pattern was consistent with PI control. It will be observed that over each of the B conditions in Stage One, the subject’s %SS scores were generally substantially less than those produced during A conditions (the

<table>
<thead>
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<th>Listeners’ judgments</th>
<th>Origin of sample pair conditions for P.A.</th>
<th>Origin of sample pair conditions for S.L.</th>
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<td></td>
<td>A/B−50 (N = 9 listeners)</td>
<td>A/B−100 (N = 14 listeners)</td>
</tr>
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<td>“Same”</td>
<td>Same 10</td>
<td>Different 1</td>
</tr>
<tr>
<td>“Different”</td>
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<tr>
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<td>$\chi^2 = 16.4 (p &lt; .001)$</td>
<td>$\chi^2 = 2.0$ (N.S.)</td>
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exception is the second A100 condition). There was also no evidence that the reduced stuttering was related to reduced speech rate.

The data obtained from Subject S.L. during the Stage Two experimental procedures are shown in Figure 3 and present a relatively straightforward pattern. His data show that the PI counts were able to be manipulated in accordance with the prescribed criteria levels. In addition, with the exception of an ambiguous trend across A150 and B−150 conditions, the subject’s %SS scores show a pattern which is virtually identical to that achieved with the PI scores.

One of the most unexpected features of S.L.’s data was the change in stuttering frequency between the Stage One and Two experiments. By comparing the %SS scores at the beginning of each of these experiments, it can be seen that S.L. increased his stutterings by roughly 100% (note that the %SS scales on Figure 3 for Stage One and Two experiments are different). S.L.’s stuttering appeared to worsen over the course of the study, but this trend did not confound the effects that may be attributed to the manipulation of experimental conditions.

Like the first subject, S.L.’s data were consistent with the experiment’s aims. S.L. showed he was able to reduce his PI counts during B− conditions and that these reductions were associated with decreased stuttering. During B+ conditions the subject’s stutterings also increased, becoming generally more frequent than those produced during nonfeedback conditions.

The majority of listener judgments from listeners identified as reliable in evaluating Subject S.L.’s A/B−150 condition sample pairs on Tape One are shown in Table 2. A Chi-Square Test of the distribution of judgments shows that the listeners were able to distinguish between stutter-free A and B−150 condition samples. The listener judgments of normalcy from the 1-min samples by S.L. and S.L.’s control are shown in Table 1. They indicate that S.L.’s speech quality in B−150 was definitely not normal sounding. In summary, it is evident that S.L.’s speech during B−150 conditions was distinctly different from his usual speech and also not normal sounding.

Speech Rate Reassessment

The experimental procedure with both subjects made it necessary to collect SPM data that included stuttered syllables. Thus, any improvement in speech-rate during reduced %SS scores may have been an artifact of the measurement methodology. To test whether reduced %SS scores were associated with reduced speech rate, part of the data from both subjects was reassessed for SPM scores that excluded stutterings. The A100/B−100/A100 phase for Subject P.A. (see Figure 2) and the A150/B−150/A150 phase for Subject S.L. (see Figure 3) were reassessed by the experimenter so that each sequence of 10 (or more) stutter-free syllables within each trial was timed. The revised stutter-free SPM scores and the during-experiment scores are shown in Figure 4. The data trends from these phases show that reduced stuttering by both subjects was probably not associated with a reduction in speech rate.

![Figure 3](http://jslhr.pubs.asha.org/image)

**FIGURE 3.** Frequency of phonation intervals (PI counts) of less than 50 ms (A50 condition), 100 ms (A100 and B−100 conditions), and 150 ms (A150, B−150 and B+150 conditions); percentage of stuttered syllables (%SS), and syllables per min (SPM) for Subject S.L. during the Stage One and Stage Two experiments.

![Figure 4](http://jslhr.pubs.asha.org/image)

**FIGURE 4.** Comparison between SPM scores, including stutterings, and SPM scores calculated without stutterings, during experimental phases for both subjects.

**DISCUSSION**

The results of this experiment should not surprise those familiar with the effects of altered speaking patterns on stuttering. The existing evidence on the effects of both DAF-assisted and unassisted prolonged speech almost compels the conclusion that the fluency-producing effects of these procedures rely upon increases in the duration of intervals of voicing or phonation. However, there are some important differences in
the procedure described in this experiment that make some of the findings unexpected. The first is that the procedure by which phonation modification was achieved is the first application of a method for obtaining reliable control over the frequency of relatively short intervals of phonation time. It differs from DAF and other “strategies” for producing fluency-inducing patterns in that only one specific dimension of the speech signal was brought under control. Moreover, the procedure appears to be replicable. The second unexpected finding was the effect produced on stuttering frequency of both increasing and decreasing the frequency of intervals of phonation. These data strongly suggest that stuttering frequency may be brought under relatively tight control by manipulating this dimension of speech.

There are many potential sources of variance in this study that need investigation before it can be concluded that phonation interval manipulation will control stuttering. First, and most important, is the conceptual issue associated with this type of experimental design and its findings. That is, any demonstration of an apparent relationship between two variables does not exclude the possibility that other variables could be necessary (even peculiarly necessary to these subjects) to produce correlated variation. For example, it is not completely clear what aspect of the procedures used in this study achieved the phonation-time manipulation. The most obvious possibility is that the specific prescribed phonation intervals may have been unrelated to the durations that the subjects actually used to control their PI counts during the treatment conditions. In the most extreme case the subjects could have resorted to singing. In any event, such unusual speech behavior does not appear to explain these findings.

The perceptual analyses of both subjects’ speech quality during B− conditions reveals widely different findings. There is no evidence that subject P.A. adopted an unusual way of speaking to reduce his PI counts. He evidently used a perceptually different manner of speaking in B−50 conditions but not during B−100 conditions. Furthermore, the majority of listeners seem to have regarded his speech as normal sounding. By contrast, Subject S.L. does seem to have used an unusual speech pattern during B−150 conditions.

Furthermore, the increased stutterings during B+ conditions may have resembled stutterings but shared nothing with the stuttering behaviors produced during nontreatment conditions. Again, in an extreme case, “faked stutterings” could have been used to increase PI error counts. However, this may have been partially controlled since the experimenter and an independent clinician were instructed to count only those events that they perceived to be stutterings.

One important source of variance in the present study is the familiarity that these subjects had with “prolonged speech.” As indicated, both subjects had received treatment by this method 10 years earlier. It is possible that certain skills achieved in the course of that therapy could be invoked as an entire explanation for these results. The principal limitation in that explanation is that there was no consistent perceptual evidence that these “skills” were being used—at least not in a way that distinctively changed P.A.’s manner of speaking. Nevertheless, even if the subjects were making use of earlier training, that does not invalidate the observed effects. It may simply be the case that such effects are achieved more easily by treated subjects. It is noteworthy that the researchers’ experience in applying this phonation modification procedure with other subjects suggests that treatment history may not be an important variable. However, some initial trials with some subjects have shown that very long PI levels may be needed before PI error control is achieved. Subject P.S., who provided data for phonation interval testing (see Reliability), failed to display PI error control at each 50- ms level up to and including 450 ms. Unfortunately the subject’s school class schedule prevented him from continuing in the present experiment. P.S. was an extremely severe stutterer (both in frequency and duration of stutterings) and had not previously received therapy.

In conclusion, the findings from this study suggest that it is possible to manipulate the frequency of phonation intervals by means of various modes of feedback and that increases or decreases in the frequency of some intervals of phonation may produce correlated changes in stuttering frequency. The findings of this study also indicate the possibility of developing a clinically useful and replicable technique for treating stuttering. Current research is being directed towards refining this procedure and isolating the constituents of any relationship between the frequency of certain phonation intervals and stuttering.

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Requests for reprints should be sent to Roger J. Ingham, School of Communication Disorders, Cumberland College of Health Sciences, P.O. Box 170, Lidcombe, NSW, Australia, 2141.