PERFORMANCE OF CHILDREN OF VARYING AGES UNDER CONDITIONS OF DELAYED SPEECH FEEDBACK

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by

JOHN JAMES GAWRONSKI

AN ABSTRACT

Submitted to the College of Science and Arts
Michigan State University of Agriculture and
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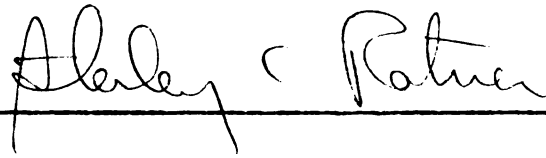
Approved 

THESIS ABSTRACT

Delayed speech feedback refers to an experimental condition of which the time component of auditory feedback or side-tone is delayed beyond .03 seconds. This modification in the monitoring system that constantly informs the speaker of his continuous speech performance, leads to certain speech disturbances. Research with adults using delayed speech feedback(DSF) had indicated that these disturbances are generally in the form of increased vocal intensity, retarded reading rate and increased number of articulatory errors(the most prominent being syllable repetition characteristic of stuttering). The present study was designed to investigate the behavior of children under DSF, with the consideration that the degree of disturbance effected in these children under DSF might reflect the developmental level of training in linguistic skills.

Fifty Ss (ages: 6.9 - 13.6) were used in this study forming 4 groups of male Ss, 10 Ss per group and one female group of 10 Ss. The instrumentation used to induce and amplify the delayed signal was: (a) a tape recorder modified to produce a delay of 0.63 seconds, which pre-tests had shown to be considerably disturbing to children, (b) a pre-amplifier and amplifier system used to amplify the delayed signal which was not limited at the headset and (c) a microphone and headset used to transmit and receive the delayed signal. Each S was presented with 6

synchronous feedback trials(SSF) followed by 6 delayed feedback trials. The Ss were instructed to recite a simple 6 word sentence which was identical for all groups.

The initial encounter with DSF eventuated in detrimental changes in the speech performance of all groups in terms of increases in sound pressure, syllable duration and articulatory errors. During this first delay trial significant positive correlations were found between sound pressure and articulatory errors and syllable duration and articulatory errors. As DSF trials progressed, all groups responded with continuous increases in sound pressure. The only group showing speech control during DSF was the eldest group(mean:12.6-13.6), who maintained the same level of syllable duration and decreased in articulatory errors. This finding seems to suggest a dichotomy between earlier and later speech development in terms of those factors which mediate stable speech behavior when the speech situation becomes far from ideal. The female group as compared with all other groups exhibited the highest levels of sound pressure during DSF. When compared with a comparable male,age group on the first delay trial, no significant differences were found for any measure.

It is suggested that further research with DSF might employ Ss similar in age to the eldest group used in this study, investigating the relationship between behavior under DSF and those linguistic skills requiring considerable concentration, such as fluent silent reading and comprehension and those experiences requiring a considerable amount of speech control, such as formal classroom speaking.

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INTRODUCTION

The speaker is constantly being informed of his continuous speech performance and guided accordingly by a system composed of several feedback channels, the most prominent of these being feedbacks via bone conduction, muscular movements of the speech organs, and the vocalized aspect of this system referred to as auditory feedback or side-tone. Interference with any of these feedbacks should eventuate in certain speech changes. Recently research on the auditory feedback or side-tone has been implemented by use of the Audio-Signal Delaying Unit which delays the side-tone at various time delays. Invading this system of synchronous air-conducted speech by delaying the side-tone leads to certain speech disturbances. Characteristic of these experimentally induced speech disturbances are the following:

(a) retarded speaking rate (1)

(b) increased phonation time (2)

(c) increased sound pressure (3)

(d) increases in articulatory errors, the most prominent being syllable repetition, characteristic of stuttering (4)

(e) physiological changes, such as increased heart and blink rate and decreased GSR (5)

(f) qualitative reactions such as blocking, facial contortions and trembling (6)

Most of the research employing delayed speech feedback has been conducted with adults who are instructed to read or recite a given passage. A number of independent and dependent variables have been investigated in this way:

(a) varying the time interval of delay (7)

(b) varying the intensity of delay (8)

(c) varying the verbal material employed (9)

(d) assessing the effects of practice on performance under delayed conditions (10)

(e) employment of delayed speech feedback as a a stress producing condition (11)

(f) using delayed speech feedback for detecting auditory malingering and psychogenic (functional) deafness (12) (13)

(g) using delayed speech feedback as a method to investigate certain personality characteristics (14) (15)

(h) using delayed speech feedback to investigate the physiological correlates of disrupted speech (16)

(i) using this device to assess the quasi-permanent effects of disrupted speech (17) and the adaptation to these effects (18)

At the time this study was undertaken no known research had employed children as subjects for the study of reactions

to delayed speech feedback.[1] Developmental changes in language are known to occur from birth through the grade school period, and may occur throughout the entire life span of an individual. Beginning from the time the child hears his own voice for the first time (supposedly during the "birth cry") typical changes follow (20): from the random vocal behavior occurring during the first few weeks of life, the first aspect of speech to be controlled by the organism seems to be volume, later control extends to the vocal cords thus over pitch. Thereafter, at about five months, the complicated muscles mediating speech sounds are regulated by the infant.

During later development, after the production of several words, the child learns to express himself in a meaningful way to others in his immediate environment. As the child reaches the school period, emphasis on primarily the vocalised aspect of speech is reduced as he begins reading, increasing the complexity of his verbal constructions, accumulating a wider vocabulary, attending to meanings implied in written and spoken discourse, and attaining a broader frame of reference. During the closing stages of the school period and throughout adult life, language development continues,

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[1] A recent study reports the use of delayed speech feedback with children but no data is given (19).

enhanced by the various experiences afforded an individual. Thus, not only does the type of language experience probably change from childhood to adulthood, but also the absolute amount of practice with language, speaking and listening, increases with age. Therefore, the degree of interference in speaking performance caused by delayed speech feedback may be related in some simple fashion to language development.

With the above consideration in view, this study was conducted to investigate the characteristic reactions of children of varying ages under conditions of delayed speech feedback.

METHOD

Subjects

From a total of 72 elementary students subjected to conditions of delayed speech feedback, 40 male and 10 female subjects were selected to comprise four groups of male subjects, 10 per group and one group of 10 female subjects. The four male groups range in age as follows: (a) Group 1, ages 6.9 - 7.9 (6.9 meaning here 6 years, 9 months etc.); (b) Group 2, ages 8.6 - 9.11; (c) Group 3, ages 10.7 - 11.9; (d) Group 4, Ages 12.6 - 13.6. The single female group ranged in age from 8.2 - 9.1. These subjects were selected from the larger group of 72 subjects in terms of age and grade requirements propose for this study, normal speech and hearing and compliance with the instructions. These subjects represented grades 1 through 8 from a summer session at Resurrection Parochial School, a center for summer school students for the various Catholic schools in Lansing, Michigan. It is of significance to note, that, in general, these students were attending summer school because they were either slow learners or had a considerable number of absences during the regular school year. Consideration of sex differences with regard to performance under delayed speech feedback were incidental to the main purpose of this experiment, therefore the female group was omitted from

the major statistical analysis. Appendix A shows the classification of these subjects in terms of ages, grades, schools attended, IQ scores, and number of other siblings in family, when reported.

Instrumentation

The apparatus used for inducing and recording delayed speech feedback is shown in Figure 1 and consisted of the following components: (a) A Revere Magnetic Recorder modified to deliver the delayed signal. The chief modification consisted of the addition of two playback heads to the standard model. The delay interval was determined by the tape speed in conjunction with the established distances between playback and pick-up heads. By pairing each of the two tape speeds 3.75 ips and 7.5 ips with each playback head, four increments of delay were obtainable; 0.31 sec., 0.48 sec., 0.63 sec. and 0.67 sec. delay. In this research the 0.63 sec. delay was employed as pre-tests had indicated that this interval was most conducive for maximum interference in children's speech. (b) A Bell System Hi-Fi Phono-Radio Amplifier, Model 2122 A, was used in conjunction with a Viking PB 60 Magnetic Playback Pre-Amplifier Full Fidelity, Model F, 7 Watt 117 Volt, 50/60 cycles. (d) An Astatic Corporation Microphone, Model JT-30, # B 852550 with adjustable neck yoke, (e) A standard model Air Force headset.

The speech signal was transmitted as follows: through

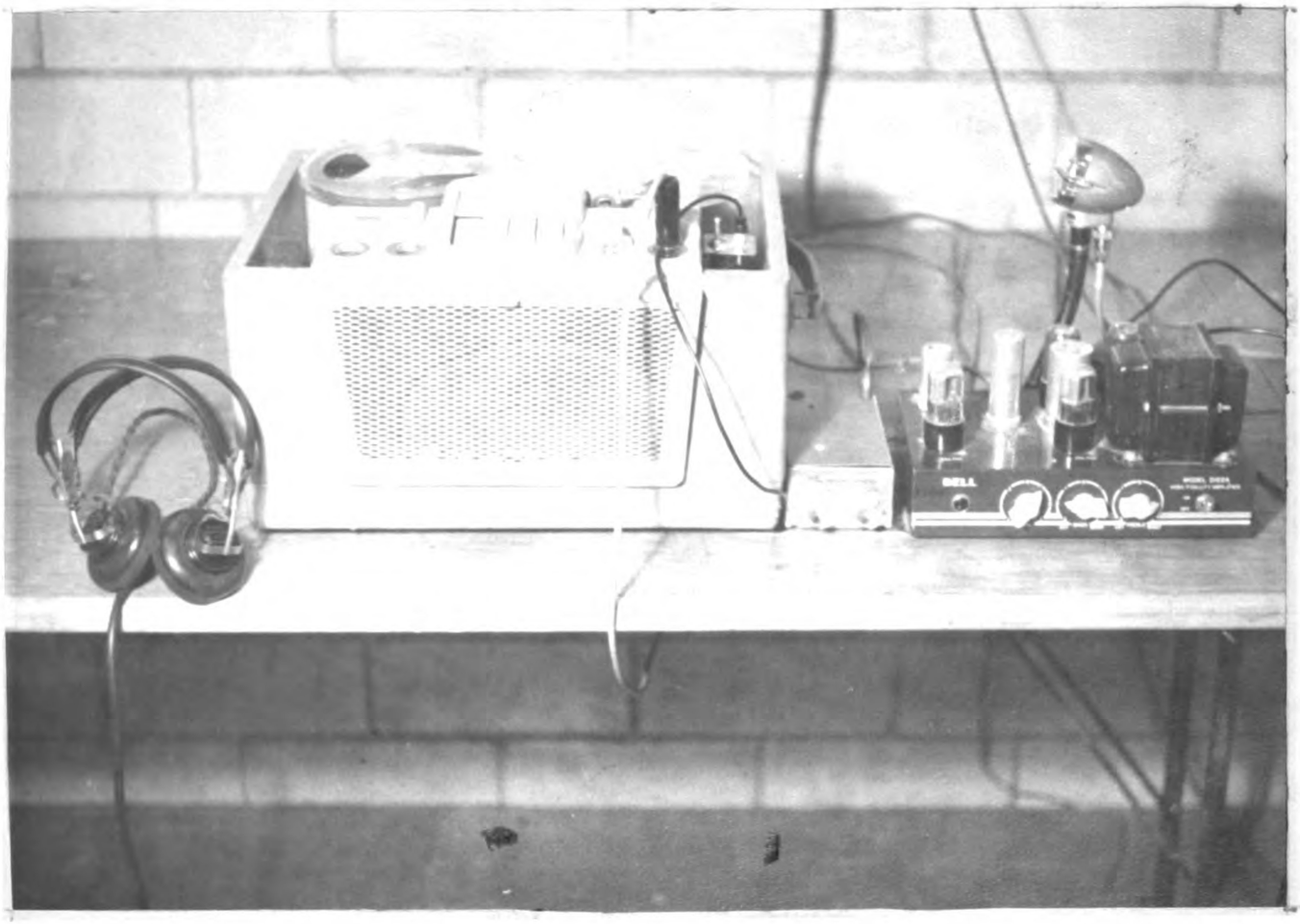

Figure 1. Instrumentation used to transmit amplified delayed speech signal and record speech responses.

Figure 2. Experimental set-up indicating position of Subject and the Experimenter.

the Astatic microphone to the input of the Magnetic Recorder. This was the maximum distance that the speech signal traveled during the synchronous speech trials.

During the delayed feedback, the Duo-Amplification System was activated by turning the amplifier gain up to 6. The speech signal was then delivered first through the 0.63 sec. delaying head, through the Duo-Amplification System and out via the headset. Experimental findings (21) indicate that when the speech signal at the headset is too weak it may be masked by the S's increasing the intensity of his speaking. Conversely, if the speech signal at the headset is too intense, it is painful to S. To avoid either extreme, pre-tests were carried out with other Ss to determine an intensity of feedback which reduced the effects of bone conduction on speech reception but did not lead to S's discomfort.

Procedure

The procedure was identical for all Ss and consisted of three phases. The first was an instruction and apparatus adjustment phase. The second was the synchronous feedback speaking phase in which S repeated the sentence "American boys go to school everyday" six times with a 5 second

interval between repetitions (trials). Ten seconds after this phase the delayed feedback phase began during which S repeated the sentence about American boys for six more trials with a delay of the delayed speech feedback of 0.63 sec. A 5 second intertrial interval was used for these trials.

Specifically, the Ss were taken individually from their classroom into the school auditorium and seated in front of the table which supported the apparatus. Ths S faced away from the apparatus but was not screened from E who was located to the left and adjacent to S (refer to Figure 2). This position of E was considered necessary for instructional purposes, especially with reference to the younger Ss who in certain instances temporarily avoided speaking as they encountered delayed speech feedback for the first time. The microphone with adjustable yoke was fitted over S's head so that the yoke rested upon his shoulders. The microphone was adjusted so that it was 5 inches away from S's mouth, thus approximating the distance from one's mouth to his ear. Each S was instructed not to manipulate the microphone but to keep his hands clasped in front of him. Next the earphones were fitted and were worn throughout both conditions, synchronous

speech feedback (SSF), and delayed speech feedback (DSF).

In cases where female Ss were used, the hair had to be sufficiently parted to insure the proper fit of the earphones. Following this initial seating and adjustment, S received the following set of instructions with additional comments in those cases warranting them:

> "We want to see how well you can speak, try not to make too many mistakes. Now here is what you have to say, 'American boys ---- go to school--- everyday'. This is all you have to say, just one sentence. And you will repeat this sentence every time I raise my hand like this (demonstrated). Later on, it may get a little harder to talk because the tape recorder will be on, but try to finish each sentence. Remember to finish each sentence ___ that is the important thing. You will say this sentence every time I raise my hand; 'American boys --- go to school --- everyday' "

For the younger Ss (generally the 1st grade group) extra-instructional precautions were necessary when the S; (a) anticipated the hand signal, (b) forgot the sentence, (c) was not speaking into the microphone or (d) began to laugh. Complications, when occuring during SSF, generally occured during the first few trials. If necessary, further corrections were made during the 10 sec. interval between conditions. In the event that these complications, such as prolonged laughing, had pronounced effects upon S's speaking

this data was discarded from the statistical analysis.

Upon encountering DSF for the first time if the Ss hesitated, they were prompted by E. The Ss had been told in the standard instructions, that their speaking may become more difficult later but were not told when. There were 4 possible cues for Ss' anticipating the onset of DSF: (a) length of time between experimental conditions, (b) E's movements to turn on the Amplification System, (c) the sudden burst of energy at the headset after the amplifier was activated, (d) the feedback of respiratory sounds which were themselves transmitted dysynchronously just prior to production of speech at the first trial of DSF.

After completion of these trials S was asked several brief questions concerning his experiences during DSF and then was instructed not to reveal information of the experiment to fellow students. Following the dismissal of the attending S, the amplifier gain was returned to the 0 reference point and the next S was summoned. The entire procedure for a given S took approximately 20 minutes.

Measurement

Three measurements typically employed in DSF research were used in the analysis of the speaking performance of the

subjects in each age group, sound pressure level (loudness), syllable duration and number of articulatory errors.[2] All measurements on each trial were taken from the recordings in the following ways:

Mean Sound Pressure - The means of three peak loudness levels were taken from the recordings of each trial for each S with a Bell System Research Sound Level Meter, set approximately 3 inches away from the recorder speaker. The amplification gain of the recorder was set at an arbitrary reference point, which was sensitive to the ranges of intensities employed by all Ss. In the event a given subject responded with a sustained intensity level, this single displacement was recorded and regarded equivalent to a mean of three peak displacements on the level meter. In stances where the meter indicator rapidly vacillated between a narrow interval of two calibrated units the higher reading between this oscillation was recorded.

Mean Syllable Duration - This measurement comprised two

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[2] While the time required to analyze the measures was not recorded, the following rankings give a fair estimate of the relative time taken to make the three measurements, rank 1 indicating the least amount of time taken: (1) syllable duration, (2) sound pressure readings, (3) recording and analyzing articulatory errors.

components, total speaking time for a trial and the number of syllables spoken for any given S on each trial. The duration of each trial was measured with a stopwatch, by playing back the recordings. Following this procedure the recordings were again played back, and the vocal passages were transcribed into writing. From these written records words were divided into syllables by standard dictionary classifications. The number of syllables for a trial then consisted of the number of syllables in the standard passage and all syllable repetitions. Syllable duration was obtained by dividing duration in seconds by the number of syllables produced by the subject on any given trial.

Mean Total Articulatory Errors - These errors were obtained by playing the recordings back several times and adding or subtracting notations to the passages already transcribed to writing when making the syllable classification mentioned above. One of the errors employed here, syllable repetition, was then already determined. Next a list was composed of the most prominent types of articulatory errors reported in the literature and was compared with the initial playback of one of the groups. This list constituted a model for recording errors of the subsequent groups and also functioned as a pool for additional errors detected throughout the playback period.

After this initial analysis of errors the playbacks were again conducted 24 hours later, starting with the first group and running through the remaining groups. The first group was now compared with a larger list of errors. It was considered essential to space the error analysis by 24 hour periods to control for certain familiar characteristics of selective perception. Following three playback sessions, a reliability of scoring was informally determined wherein most inconsistencies were corrected.

All articulatory errors were eventually reduced to three major classifications with related sub-headings:

1. Elongations
   a. slurs (eg. school - l)
   b. prolongations (eg. bo͞oys)
2. Repetitions
   a. word repetitions (eg. every every)
   b. syllable repetitions
      1. initial (ev-ev-ryday)
      2. medial (Amer-er-ican)
      3. final (American - can)
   c. homynous syllable repetitions
      (Amer-cer-ican)
   d. letter repetitions (s - school)

3. Miscellaneous (all other errors)

   a. misarticulations (eg. gora for go to) listed only if absent during synchronous speech.

   b. omissions, listed only if the words omitted were present in synchronous speech.

   c. extraneous words, those not listed in the instructions (eg. American boys and girls etc.)

   d. anticipatory errors (eg. words were out of temporal order; American schools go etc. instead of American boys go etc)

   e. incompleted words (eg. Americ boys etc.)

Two other errors characteristic of the younger Ss particularly which were not included in this analysis were: duration and number of blocks per trial and subvocalizations (generally whispers) preceeding and following a DSF trial. In certain instances, more than one type of error was manifested within a single word or syllable, for example: "Amerr-errican" denotes two slurs and a syllable repetition. In this instance only the most prominent error was recorded, ie, the syllable repetition. On the other hand, a single word might have more than one error where it was appropriate to record both errors; "s-school-l" where both a letter repetition and a slur were recorded as errors. However, any errors in a single position

were counted only once.

For final statistical analysis three categories of errors were summed to comprise a Total Articulatory Error score.

RESULTS

Performance During Synchronous Feedback

Inspection of the data had indicated that for each group considered independently, raw scores on the measures of sound pressure level (loudness) and syllable duration did not vary to any great extent from trial to trial during SSF. Therefore, an analysis of variance was applied to the last trial of the SSF condition (trial 6), illustrated in Figure 3 for sound pressure and in Figure 4 for syllable duration. Since articulatory errors, as classified in this research, were not apparent to any great degree during the SSF condition, they were excluded from the analysis made in this section.

For sound pressure, the Mean Square Between Groups (refer to Table I, Appendix B) was smaller than the Mean Square Within Groups, therefore, the null hypothesis that the groups are random samples from a common normally distributed population was not rejected.

For syllable duration the analysis of variance applied at trial 6 (refer to Table II, Appendix B) yielded an F ratio of 5.53, significant at the 1% level of confidence. The null nypothesis, being rejected in this instance, led to the conclusion that the groups differ in syllable duration

(a measure reflecting speaking rate) even before the onset of DSF.

Performance During Delayed Speech Feedback

Effects of Initial Encounter with Delay. All Ss were affected in terms of increases in the three measures employed, sound pressure level, syllable duration and number of articulatory errors as they proceeded from the SSF condition to the DSF condition. Refer to Figures 3, 4 and 5 wherein is shown a sharp rise in the responses on each measure as the groups encounter DSF for the first time, following trial 6, the last SSF trial. Since no great number of articulatory errors were observed on trial 6 of the SSF condition, increases in these errors as conditions change, may be interpreted as changes in articulatory errors from zero. From the analysis in this section, it is concluded that DSF conduces to changes in speaking behavior for all subjects, regardless of age.

Age Group Differences Manifested in Response to Delay. An analysis of variance was applied to the first trial of the DSF condition, for the three measures employed in this research. The graph of Figure 3 indicates that all groups

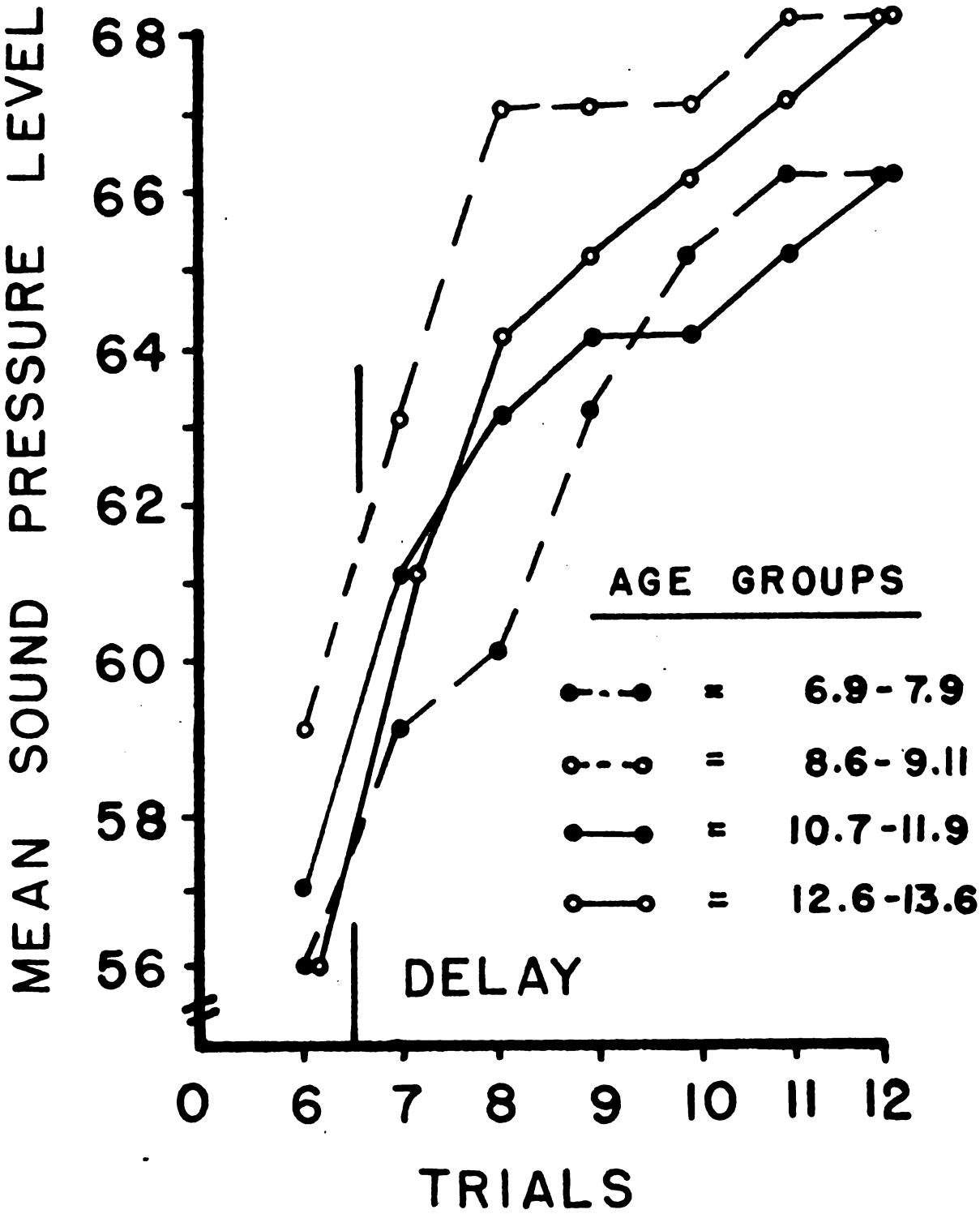

Figure 3. Mean Sound Pressure Level: Mean of three peak readings of sound pressure indicated for groups for the final synchronous trial and six delayed feedback trials.

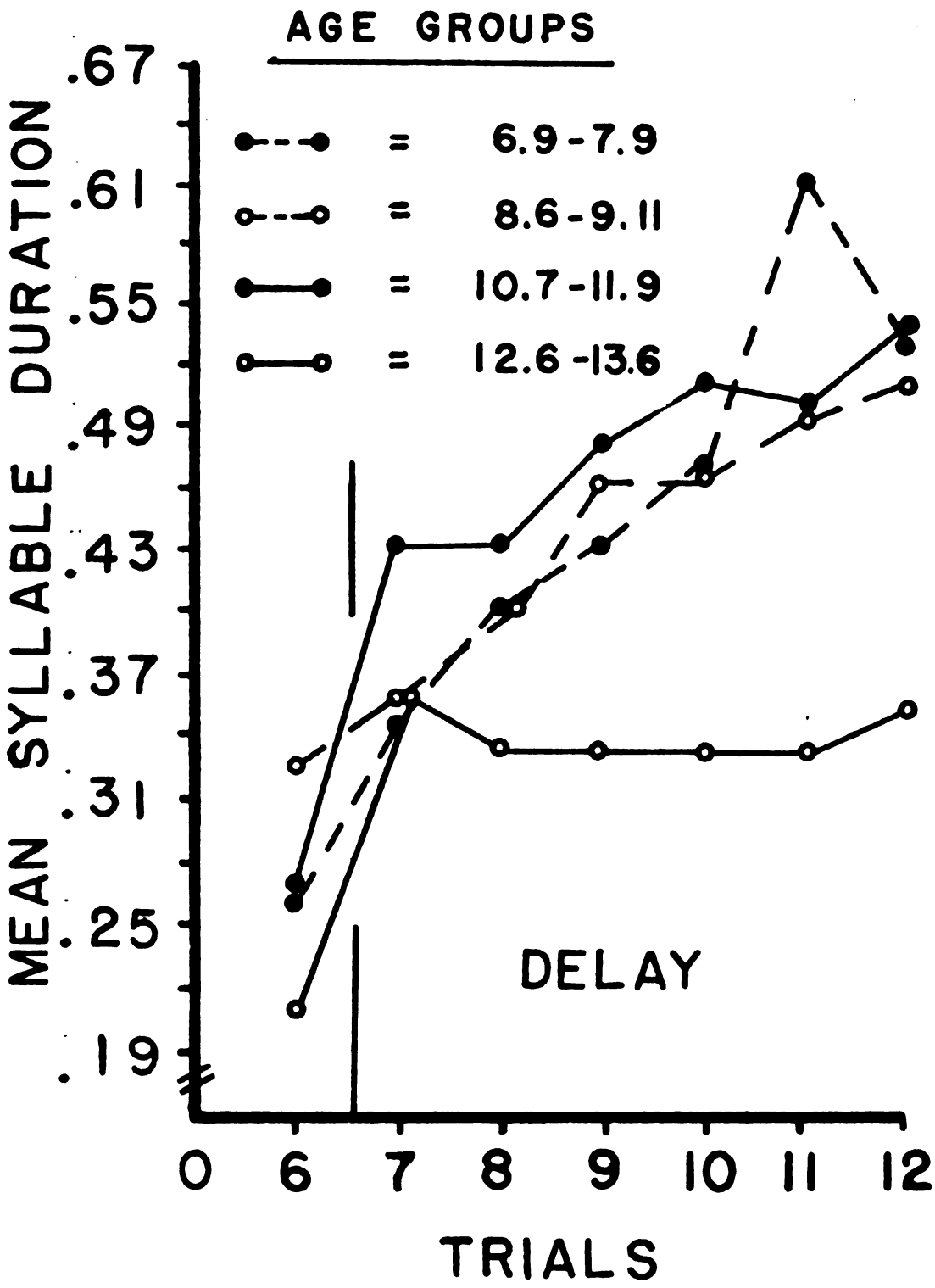

Figure 4. Mean Syllable Duration: obtained by dividing number of syllables produced in total time in seconds per trial, indicated for the final synchronous feedback trial and six delayed feedback trials.

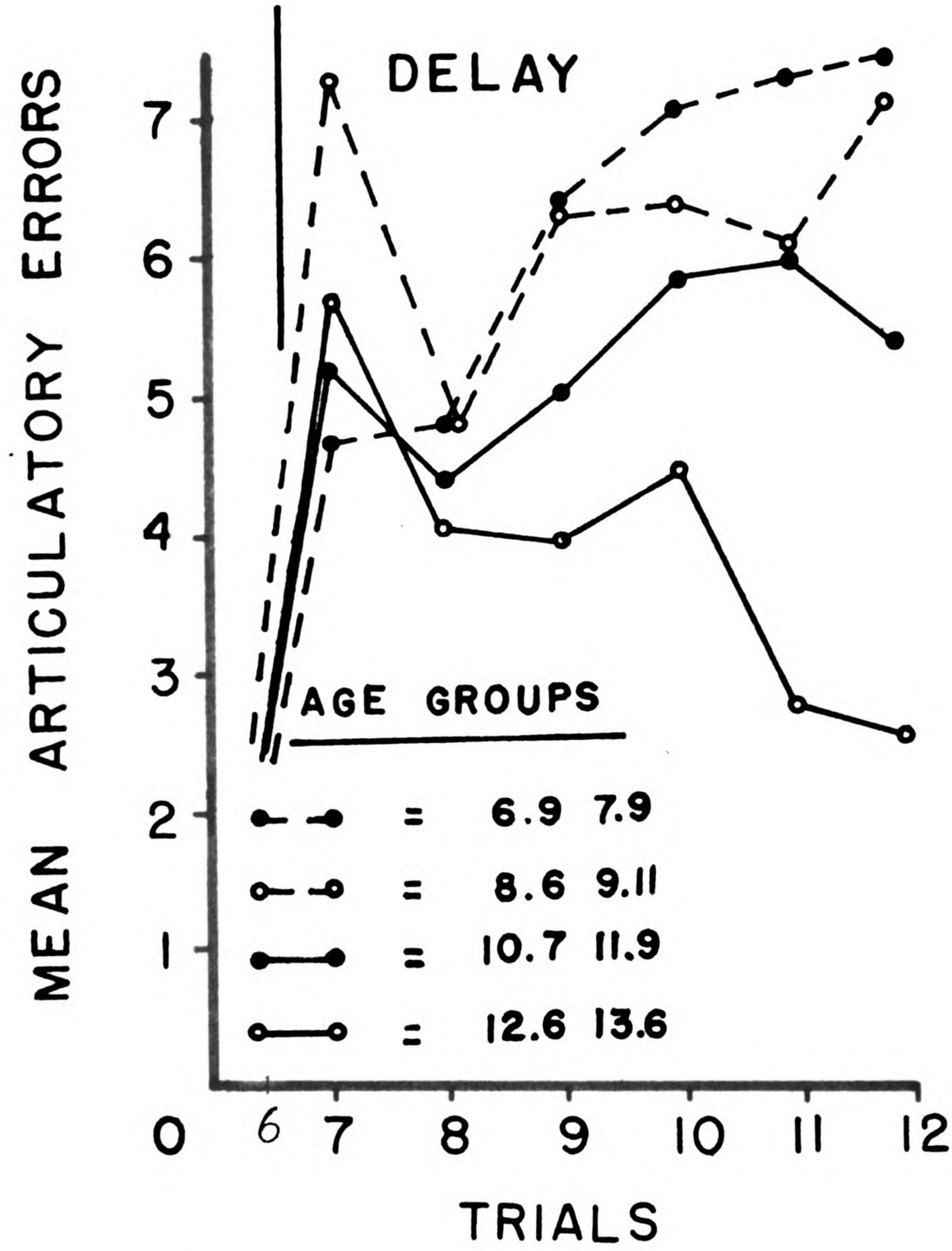

Figure 5. Mean Articulatory Errors: mean of total number of articulatory errors produced by groups during each of six delayed feedback trials.

are positioned fairly close together on trial 7, with respect to the sound pressure variable. The analysis of variance yielded a smaller Mean Square Between Groups than the Mean Square Within Groups (refer to Table III, Appendix B) therefore the null hypothesis was not rejected. It was thereby concluded that the level of sound pressure level under conditions of DSF does not manifest an age difference with respect to speaking performance.

The graph shown in Figure 4 with reference to trial 7 indicates that the groups are even more closely clustered graphically in terms of syllable duration than for sound pressure with the exception of Group 3 (age range, 10.7-11.9). The analysis of variance with respect to this measure indicated an F ratio of 1.47 (refer to Table IV, Appendix), which was not significant. However, since the groups differed during the SSF condition with respect to syllable duration, it was considered necessary to control for these initial differences in performance level by statistical methods. Therefore an analysis of covariance was applied to the syllable duration measure of the last SSF trial (trial 6) and the initial trial of DSF (trial 7). This analysis yielded an F ratio of 1.91, (refer to Table V, Appendix) which was also not significant. Hence, even when taking into account certain

age differences in performance during normal speaking conditions, syllable duration does not discriminate between groups first encountering DSF.

The final analysis for this section (referring to trial 7) was applied to the measure of total articulatory errors. Figure 5 indicates that the groups are positioned closely together with respect to this variable, with the exception that Group 2 (age range, 8.6 - 9.11) is positioned higher than the other three groups. The analysis of variance (refer to Table VI, Appendix) resulted in an F ratio of 1.02 which was not significant. It was therefore concluded that the varying age groups do not significantly display a differential reaction in terms of total articulatory errors when presented with DSF for the first time. In summary, it was concluded that none of the measures employed in this study discriminated significantly between groups of varying ages during an initial encounter with DSF.

Changes in Performance Accompanying Subsequent Encounters with Delay

In contrast to performance during SSF, speech performance during DSF led to certain changes for all groups on particular variables. Refer to Figure 3 where it is

shown that as trials progress during DSF, the groups responded more loudly. An analysis of variance for sound pressure was applied between the initial (trial 7) and the final (trial 12) DSF trials, resulting in a smaller Mean Square Between Groups than the Mean Square Within Groups (refer to Table VII, Appendix). The null hypothesis was not rejected, which led to the conclusion that this measure of sound pressure does not significantly discriminate between the age groups, with respect to the amount of change occurring during DSF.

Refer to Figure 4, where it is indicated that as the trials progressed during DSF, increases in syllable duration were observed with a single exception. The group representing the eldest Ss (Group 4, ages: 12.6 - 13.6) showed decreases in syllable duration following the initial encounter with DSF. The level of syllable duration to which Group 4 regressed remained constant throughout most of the DSF trials, except on the last trial of this series (trial 12), where a slight increase in syllable duration was shown. This increase in syllable duration during trial 12 was the first increase in this variable for Group 4 since the initial delayed trial. The analysis of variance testing for differences in syllable duration

between trials 7 and 12, yielded an F ratio of 4.72 (refer to Table VIII, Appendix) which was significant at the 1% level of confidence. This led to the conclusion that with respect to syllable duration, significant increments of change occured during DSF trials and these changes were significantly different between the age groups. Therefore, a series of t tests were made between each pair of groups on the different amount of change that occurred between trials 7 and 12 in terms of syllable duration. The t ratios for each group compared with each other group are entered in Table IX of the Appendix. The groups which differed significantly at beyond the 5% level were: (a) Group 1 (Mean: 42.4) with Group 3 (Mean: 31.6); (b) Group 1 with Group 4 (Mean: 20.1); (c) Group 2 (Mean: 36.4) with Group 4, and (d) Group 3 with Group 4. The conclusions which were made from these comparisons were that the eldest group, Group 4 had shown a significantly lesser amount of change in syllable duration between trials 7 and 12 than any other group.

The final analysis in this section was made for the articulatory error variable. Refer to Figure 5 which indicates increases in articulatory errors during subsequent encounters with DSF for all groups with one exception.

Group 4 (ages: 12.6 - 13.6) showed decreases in articulatory errors following the initial encounter with DSF. This direction of change following the first delay trial was also shown by this group for syllable duration as mentioned in the previous analysis. The analysis of variance on the changes in number of articulatory errors yielded an F ratio of 4.49 (refer to Table X, Appendix), which was significant at the 1% level of confidence. It was thereby concluded that significant changes in articulatory errors occurred during DSF and these changes indicated group differences. To determine which groups differed in the amount of change in articulatory errors, a series of t tests were run on these changes which occurred between trials 7 and 12. All comparisons with their respective t ratios have been entered in Table XI of the Appendix. The significant differences obtained were : (a) Group 1 (Mean: 12) with Group 4 (Mean: 6.2), (b) Group 2 (Mean: 8.9) with Group 4 and (c) Group 3 (Mean: 9.3) with Group 4. The comparisons indicate that the eldest group (Group 4), differed significantly from all other male groups in terms of the amount of change in articulatory errors made between DSF trials 7 and 12. The changes for Group 4 between trials 7 and 12 were in terms of decreases in articulatory

errors, while for Groups 1, 2 and 3 the changes were with respect to increases on this variable.

Age Group Differences Manifested During the Final Encounter with Delay

It was considered quite pertinent to this study to investigate the level of performance which the groups had reached following the series of encounters with DSF. The comparison of the groups on trial 12 was considered the valid comparison for this analysis. The graph of Figure 3 indicates that on trial 2, with respect to sound pressure, Groups 2 and 4 are positioned together and higher than Groups 1 and 3 who are also located together. The analysis of variance yielded a smaller Mean Square Between Groups than the Mean Square Within Groups, (refer to Table XII, Appendix) therefore the null hypothesis was not rejected. It was thereby concluded that the level of sound pressure attained after a series of encounters with DSF, does not discriminate between the various age groups. For syllable duration with respect to trial 12, Figure 4 indicates that all groups, with the exception of Group 4, are clustered together with respect to syllable duration. Adaptation, mentioned earlier for Group 4, was still in effect at trial 12, which segregated them from the other groups who increased

syllable duration from trial to trial. The analysis of variance for this measure on trial 12 yielded an F ratio of 2.16 (refer to Table XIII, Appendix) which was not significant. The null hypothesis was not rejected. Therefore, it was concluded that the level of syllable duration reached after a series of encounters with DSF does not distinguish between the various age groups.

For the final analysis in this section, refer to Figure 5, with reference to trial 12, where the number of articulatory errors made by each group following a series of encounters with DSF is shown. The two youngest groups, Group 1 and 2 are clustered together while the eldest groups, Group 3 and 4 are separated and away from 1 and 2. Group 4 had made the least number of errors on trial 12 than on any other previous encounter with DSF. The analysis of variance for articulatory errors on trial 12 yielded an F ration of 3.40 (refer to Table XIV, Appendix) which was significant at the 5% level of confidence. It was thereby concluded that the groups significantly differed in the number of articulatory errors made following a series of encounters with DSF. A series of t tests were then run to determine which of the groups paired for this analysis differed. Table XV in the Appendix contains the t ratios

of each group compared with each other group. The significant differences obtained were: (a) Group 1 (Mean: 7.6) with Group 4 (Mean: 2.8) and (b) Group 2 (Mean: 7.0) with Group 4. From these comparisons the conclusion drawn was that with reference to the number of articulatory errors made on the last trial of DSF, the only significant differences occurred between the eldest group, Group 4 and the two youngest groups, Groups 1 and 2, with Group 4 making the least number of articulatory errors.

Relationship Between the Measures

Since three measures of responses were employed in this study, the relationship between these measures was examined. Because the groups had not displayed a significant differential reaction on the initial encounter with DSF (trial 7) with respect to any of the measures, all 40 Ss were combined for the analysis in this section. The Pearson Product - Moment Correlation Coefficient was applied to the data of trial 7 between sound pressure and syllable duration and between each of these measures and the number of articulatory errors. The correlation coefficient between sound pressure and syllable duration yielded an r of .30 which was not significant. The

correlation coefficients for sound pressure versus articulatory errors and syllable duration versus articulatory errors yielded r's of .38 which were significant at the 5% level of confidence. Therefore, it was concluded that on an initial encounter with DSF, significant and positive relationships were manifested between each measure, sound pressure and syllable duration versus the number of articulatory errors.

Performance of Female Speakers With Delay

Although the female group had been omitted from the major statistical analysis in this study, certain other analyses and comparisons were made. Upon the first contact with DSF, following synchronous speech the female group had shown, increased sound pressure, used longer syllable duration and increased in number of articulatory errors. As mentioned previously, the male groups had also responded this way when encountering DSF for the first time. Other comparisons made between the female group and the other four male groups indicated that the female group: (a) along with Group 1 made the least amount of errors during the initial trial of DSF, trial 7, (b) used approximately the same syllable duration during DSF as

Groups 1, 2, and 3, (c) employed the highest levels of sound pressure during DSF and (d) made the greatest amount of increases in number of articulatory errors between trials 7 and 12.

Because its members were of similar ages, the female group (ages: 8.2 - 9.1) and Group 2 (ages: 8.6 - 9.11) were run in an analysis of variance for the three variables used in this study on trial 7, the first delay trial. The F ratios have been entered in Tables XVI, XVII, XVIII, Appendix. These analyses, none being significant, indicated that the female group and Group 2, (males) did not differ in terms of sound pressure, syllable duration and articulatory errors during the initial trial of DSF. It was concluded that within the restrictions of this study no significant sex differences were indicated during the initial encounter with delay.

Performance During Synchronous Speech Feedback.

The analysis of the synchronous speech feedback data at the first trial of this condition indicated that the varying age groups had not differed significantly in terms of sound pressure level or articulatory errors. The groups had differed significantly, however, in terms of syllable duration with the eldest group speaking most rapidly, the next to youngest group speaking most slowly, and the youngest and next to oldest group speaking at a rate between the two extremes. Perhaps due to greater training in linguistic skills such as speaking and reading, the finding that the eldest group had spoken at the most rapid rate is not unexpected but the ordering of the other three groups does not yield to any simple explanation in regards to existing information.

Performance During Delayed Speech Feedback

The Ss' first encounter with DSF, trial 7, led 85% of them to increase sound pressure and syllable duration and led 100% of them to increase the number of articulatory errors. That is, these children showed a similar mode of reaction to DSF as adults do under conditions of DSF. Fairbanks (22) using various time delays with the speech

output amplified by a constant amount found that adult subjects reading a prose text increased sound pressure, employed a higher fundamental frequency, and increased duration of speaking time and number of articulatory errors. Ratner and Gawronski (23) in an unpublished study, observed that all 20 male adult Ss following a series of undelayed trials, reduced speaking rate as DSF was introduced for the first time. Tiffany and Hanley (24) employing DSF as a test for detecting auditory malingering, found that in spite of the fact that the Ss were instructed as to the properties of DSF and following a five minute period of familiarization with a 100 word passage, responded with significant decreases in reading rate when subjected to DSF for the first time.

Statistical analyses of the reactions to DSF as a function of the ages of the children yielded non-significant differences on the initial delayed trial for all measures employed. Even the analysis of covariance, adjusting for the group differences displayed for syllable duration during the last synchronous trial, yielded a non-significant difference. That is, the ages of the children and thus their varying levels of practice with the language, did not lead to significant levels of reaction when the age

groups encountered DSF for the first time. Disregarding statistical significance, the means of the groups on each measure do not order themselves in terms of the ages of the groups employed.

Changes in Performance During Subsequent Encounters with Delay.

Statistical analyses of the changes in performance from the first to the last DSF trials indicated that the groups differed significantly on changes in articulatory errors and syllable duration, but not in sound pressure. To a large extent these significant differences arose from the behavior of group 4, the eldest group, which tended to make less errors while the other groups became poorer (increased in number of errors) and which tended to maintain a constant level of syllable duration while the other groups increased syllable duration. All groups tended to increase sound pressure between trials 7 and 12 which seems to be a common reaction to any acoustical interference in the ongoing speech process, eg. noise. Of significance in these findings is that only the eldest group, Group 4 (ages: 12.6 -13.6) showed any consistency in improvement between trial 7 and 12 such as decreases in the number of articulatory errors.

And only this group displayed any constancy in response, such as maintaining the same level of syllable duration throughout most DSF trials. Although the eldest group displayed these trends, in no instance had they regressed to their level of speech performance observed during synchronous speech. This type of speech behavior displayed by Group 4 under conditions of DSF is in some ways characteristic of the performance of adults employed under DSF, who, under these conditions, had shown considerable improvement in speech performance. Melrose (25) using 20 Ss who read a series of 40 matched sentences, found that the number of correct words per sentence for each individual reading increased in the general pattern of a sigmoid learning curve, while duration increased steadily during the first half of the readings and then decreased. Tiffany and Hanley (26), using 20 Ss who were subjected to 80 db. of delayed side-tone, found that during 24 readings of a 45 word prose passage Ss, in general, tended to avoid omission of words, syllables and sounds, but did not learn to overcome the rate effect. Miller (27) found while reading a 100 word passage over a 200 massed trial period, he reduced the number of articulatory errors to almost zero, however, no significant decreases in duration

time of trials were observed. The literature on DSF research with adults had not reported any studies which found any consistent decreases in sound pressure level during DSF, which was also indicated for children in the findings of the present study.

Since the speech behavior of adults under conditions of DSF reported in the literature, resembled in some ways the behavior of the eldest group in this study and because no improvement was found for the younger groups used here, it is suggested that perhaps the eldest group (Group 4, ages: 12.6 - 13.6) represents a breaking point between earlier and later language development, i.e., especially in terms of those processes which mediate stable speech behavior as the speaking situation becomes far from ideal. It should also be noted that Group 4 is approaching the age period of puberty during which certain biological and behavioral changes are known to occur, such as increases in strength, deepening of the voice, acceleration in growth, increases in sexual sensitivity and increases in number of social contacts. Important in this respect is the report by Hockett (28) who finds that fundamental speech habits are firmly established by the age of puberty and the most important force shaping dialect

is the speech of others.

As the three younger age groups used in this study showed no significant improvement as their contacts with DSF increased, it would seem that these groups are in some way dominated by the effects of the delayed feedback. This would seem to indicate, that as language development is a gradual process, and since the three younger groups performed significantly poorer than Group 4, under DSF, that these younger groups are still in the process of acquiring the necessary skills that call for a considerable amount of control over the speech monitoring system.

With regard to the speech performance of the age groups on trial 12, the only significant group differences found were on the measure of articulatory errors. The *t* tests had indicated that to a large extent this significant difference found for errors could be attributed to the behavior of Group 4, which although making the first increase in articulatory errors since trial 7, made a significantly smaller number of errors than either Groups 1 and 2 on trial 12. Despite the finding that Groups 3 and 4 did not differ significantly in errors, the groups were systematically ordered in terms of age,

in articulatory errors with Group 1 making the most errors, Group 2 making the next highest number and so forth. It is of significance to note that at trial 12 all groups had some degree of familiarity with DSF, and the ordering of the age groups in terms of performance at trial 12, may be some conservative estimate of the age group level of training in terms of linguistic skills. This may be even more so when articulatory errors are considered more directly related to language than either syllable duration and sound pressure.

In summary, it was found that all groups reacted to DSF, in some ways the same, for instance, all groups showed increases in sound pressure, syllable duration and number of articulatory errors when encountering DSF for the first time. And in some certain ways they had differed significantly, that is, significant group differences were found for the amount of change in articulatory errors and syllable duration occurring between trials 7 and 12, and the number of errors made at trial 12. As pointed out earlier, these significant differences were attributed to the findings that Group 4 remained the same in syllable duration during DSF while the other groups increased syllable duration and that Group 4 decreased in articulatory errors and other groups increased.

Relationship Between Measures.

The significant correlations obtained in this study were between sound pressure and articulatory errors and syllable duration and articulatory errors. Since these correlations were positive, they suggest that as either increases in sound pressure or syllable duration occur, concomitant increases in articulatory errors are made when the groups encounter DSF for the first time. That is, as the children are responding in one way to DSF, such as increased syllable duration, they are also responding in another way, such as increased number of articulatory errors. Although the relationship between sound pressure and syllable duration was not significant, the obtained r of .30 suggested a positive relationship between these two variables. This is in agreement with the findings of Peters (29) who reported the tendency of adult readers to decrease their reading rate as sound pressure was increased during DSF. Reading rate can be considered an estimate of syllable duration.

Performance of Female Speakers With Delay.

Upon the initial contact with DSF, trial 7, 70% of 10 female speakers increased sound pressure, 90% increased

syllable duration and 100% of them increased in terms of articulatory errors. As compared with all of the other male groups, the female group employed the highest levels of sound pressure level throughout the DSF condition and displayed the greatest increase in number of errors when progressing from trial 7 to 12, although these were not tested for significance. No significant differences were found, when the female group (ages: 8.2 - 9.1) were compared with Group 2, males, (ages: 8.6 - 9.11), for the three measures herein employed during the initial encounter with delay. From the extent of these findings, no significant sex differences were shown in this study.

SUMMARY

The present study using 40 male and 10 female Ss, ranging in age between 6 years, 9 months, and 13 years, 6 months, was designed to investigate the performance of children of varying ages under conditions of delayed speech feedback (DSF). Research with adults using DSF had indicated profound disturbances in their ongoing speech behavior, generally reported in terms of stuttering-like responses, retardation in speaking rate and increases in vocal intensity.

The apparatus employed in this study were; a tape recorder modified to deliver a delayed signal of 0.63 seconds, an amplification system and the equipment necessary for the transmission and reception of the delayed signal, i.e. a microphone and headset. Each age group consisting of 10 Ss, comprising 4 male and 1 female group(s), experienced 6 trials of synchronous speech feedback (SSF), followed by 6 trials of DSF during which they recited a simple sentence composed of six words.

The initial contact with DSF eventuated in decremental changes in the speech performance of all groups in terms of increases in sound pressure, syllable duration and number of

articulatory errors. This finding suggested that speech behavior is not a static process but requires constant changes in the monitoring system as conditions under which a person is speaking change. During further encounters with DSF all groups performed progressively poorer, with the exception of the eldest group (ages: 12.6 - 13.6). For the most part the eldest group displayed no changes in syllable duration during DSF and improved on articulatory errors. This performance displayed by only that group is characteristic of adult performance under DSF which was reported in the literature. It was suggested that the eldest group employed in the present study may represent a dichotomy between early and later stages in language development, in terms of those factors which mediate stable speech performance when the speech situation becomes far from ideal.

During the initial delayed trial, results indicate significant positive correlations between sound pressure level with articulatory errors and between syllable duration with articulatory errors. Although no significant correlations were found between sound pressure and syllable duration, results show a positive trend.

The female group employed in this study reacted in much

the same way as the other male groups during the first encounter with DSF. That is, at the first trial of delay the female group increased sound pressure, syllable duration and number of articulatory errors. When compared with a male group whose Ss were similar in age to the female group, no significant differences were found for any of the variables during the initial DSF trial. Comparisons made during subsequent DSF trials indicated that the female group employed the highest sound pressure than any of the male groups.

The wide individual differences in reacting to DSF displayed by the children used in this study are consistently reported for adults in the DSF literature. That is, some Ss respond to DSF in a manner somewhat resembling their normal speech behavior while other Ss seem for a period of time to be completely captivated by the effects of this condition.

It is suggested that further research with DSF might employ Ss similar in age to the eldest group used in this study, investigating the relationship between behavior under DSF and those linguistic skills requiring considerable concentration, such as fluent silent reading and comprehension and those experiences requiring a great deal of speech control, such as formal classroom speaking.

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APPENDIX A

Classification of Subjects by Age, Grade, School, IQ, and Number of Siblings.

	AGE	GRADE	SCHOOL	IQ	SIBLINGS
Group 1					
1	6.9	1	Resurrection	87	1
2	6.9	1	Resurrection	121	4
3	6.10	2	St. Mary's	131	-
4	7.0	1	Resurrection	*	-
5	7.0	1	Resurrection	101	1
6	7.2	1	Resurrection	110	2
7	7.3	1	Resurrection	*	-
8	7.4	1	Resurrection	*	6
9	7.8	2	Acquinas	*	5
10	7.9	1	Holy Cross	110	1
Group 2					
11	8.6	2	Resurrection	118	4
12	8.6	2	Resurrection	*	2
13	8.7	3	Resurrection	*	1
14	9.1	3	St. Casimir	*	-
15	9.3	2	Resurrection	*	1
16	9.5	3	Resurrection	*	2
17	9.8	2	Resurrection	*	-
18	9.8	3	Resurrection	*	1
19	9.9	4	Resurrection	116	1
20	9.11	3	Resurrection	*	2
Group 3					
21	10.7	6	St. Mary's	124	4
22	10.9	4	Resurrection	110	-
23	11.1	4	Resurrection	95	1
24	11.3	5	St. Mary's	98	3
25	11.2	5	Resurrection	100	1
26	11.4	5	Resurrection	90	1
27	11.8	6	St. Mary's	103	4
28	11.8	6	St. Mary's	---	4
29	11.9	6	St. Casimir	105	2
30	11.9	5	Resurrection	77	1

Classification of Subjects by Age, Grade, School, IQ, and Number of Siblings

Group 4

	AGE	GRADE	SCHOOL	IQ	SIBLINGS
31	12.6	6	Resurrection	79	1
32	12.10	8	St. Therese	116	-
33	12.10	7	St. Casimir	108	7
34	12.11	6	Acquinas	95	-
35	13.1	7	Resurrection	79	1
36	13.4	7	St. Casimir	98	5
37	13.4	8	St. Therese	111	-
38	13.5	7	Holy Cross	104	3
39	13.6	7	St. Casimir	91	5
40	13.6	7	Resurrection	*	2

Female Group

1	8.2	2	Resurrection	*	-
2	8.3	2	Resurrection	*	1
3	8.4	2	Resurrection	*	2
4	8.7	3	Resurrection	*	3
5	8.8	3	Resurrection	*	3
6	8.8	3	St. Casimir	*	1
7	8.8	3	Resurrection	*	2
8	8.9	3	Resurrection	*	1
9	9.1	3	Acquinas	*	1
10	9.1	3	Resurrection	*	1

* No IQ's obtained

APPENDIX B

TABLE 1

F. Ratio: Sound Pressure Level, SSF, Trial 6

Source of Variation	Sum of Squares	df	Mean Square	F
Between Groups	62.9	3	20.97	...
Within Groups	1088.6	36	30.24	
Total	1151.5	39		

TABLE II

Syllable Duration: SSF, Trial 6

Source of Variation	Sum of Squares	df	Mean Square	F
Between Groups	686	3	228.7**	5.53
Within Groups	1490	36	41.38	
Total	2176	39		

* Significant beyond the .05 level of confidence

** Significant beyond the .01 level of confidence

Note: These symbols will hereafter indicate confidence levels.

TABLE III

F. Ratio: Sound Pressure Level, DSF, Trial 7

Source of Variation	Sum of Squares	df	Mean Square	F
Between Groups	97.5	3	32.50	...
Within Groups	1264.9	36	35.14	
Total	1362.4	39		

TABLE IV

Syllable Duration: DSF, Trial 7

Source of Variation	Sum of Squares	df	Mean Square	F
Between Groups	515.7	3	171.9	1.47
Within Groups	4182.3	6	116.2	
Total	4698.0	39		

TABLE V

F Ratio (Covariance) Syllable Duration, SSF Trial 6 x DSF Trial 7.

Source of Variation	Sum of Squares of Errors of Estimate	df	Mean Square	F
Total	4301.0	38		1.91
Within Groups	3695.8	35	105.59	
Adjusted Means	605.2	3	201.73	

TABLE VI

Articulatory Errors: DSF Trial 7

Source of Variation	Sum of Squares	df	Mean Square	F
Between Groups	42.5	3	14.17	1.02
Within Groups	498.9	36	13.86	
Total	541.4	39		

TABLE VII

F Ratio: Sound Pressure Level, Between DSF Trials 7 and 12.

Source of Variation	Sum of Squares	df	Mean Square	F
Between Groups	37.40	3	12.46	...
Within Groups	971.00	36	26.97	
Total	1008.40	39		

TABLE VIII

Syllable Duration: Between DSF Trials 7 and 12.

Source of Variation	Sum of Squares	df	Mean Square	F
Between Groups	2676.90	3	892.3	4.72**
Within Groups	6812.10	36	189.2	
Total	9489.00	39		

TABLE IX

T Ratio: Syllable Duration, Between DSF Trials 7 and 12.

Groups	2	3	4
1	.980	1.76*	3.63**
2		.782	2.65**
3			1.87*

Means: Group, 1 (42.4); 2 (36.4); 3 (31.6); 4 (20.1).

TABLE X

F Ratio: Articulatory Errors, Between DSF Trials 7 and 12.

Source of Variation	Sum of Squares	df	Mean Square	F
Between Groups	172.50	3	57.50	4.49 **
Within Groups	460.60	36	12.79	
Total	633.10	39		

TABLE XI

T Ratio: Articulatory Errors, Between DSF Trials 7 and 12.

Groups	2	3	4
1	1.31	1.69	3.62**
2		.375	2.31*
3			1.94*

Means: Group, 1 (12.0); 2 (9.9); 3(9.3); 4 (6.2)

TABLE XII

F Ratio: Sound Pressure Level, DSF Trial 12.

Source of Variation	Sum of Squares	df	Mean Square	F
Between Groups	50.68	3	16.89	...
Within Groups	2344.10	36	65.11	
Total	2394.78	39		

TABLE XIII

Syllable Duration: DSF, Trial 12.

Source of Variation	Sum of Squares	df	Mean Square	F
Between Groups	2442.20	3	814.06	2.16
Within Groups	113557.40	36	376.59	
Total	115999.60	39		

TABLE XIV

Articulatory Errors: DSF Trial 12

Source of Variation	Sum of Squares	df	Mean Square	F
Between Groups	138.7	3	46.2	3.40*
Within Groups	488.1	36	13.6	
Total	626.8	39		

TABLE XV

T Ratio: Articulatory Errors, DSF Trial 12

Groups	2	3	4
1	.363	1.39	2.91**
2		1.03	2.54**
3			1.52

Means: Group, 1 (7.6); 2 (7.0); 3 (5.3); 4 (2.8)

TABLE XVI

, Female Group vs Group 2 (Males)

Sound Pressure Level:DSF Trial 7.

Source of Variation	Sum of Squares	df	Mean Square	F
Between Groups	1	1	1	...
Within Groups	748	18	41.5	
Total	749	19		

TABLE XVII

Female Group vs Group 2 (Males)

Syllable Duration: DSF Trial 7

Source of Variation	Sum of Squares	df	Mean Square	F
Between Groups	42.5	1	42.5	...
Within Groups	1340.5	18	74.5	
Total	1383.0	19		

TABLE XVIII

Female Group vs Group 2 (Males)

Articulatory Errors: DSF Trial 7.

Source of Variation	Sum of Squares	df	Mean Square	F
Between Groups	26	1	26	1.67
Within Groups	281	18	15.6	
Total	307	19