A PROCEDURE FOR INCREASING ORAL READING RATE IN HARD-OF-HEARING CHILDREN¹

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This study investigated the effects of systematic training on the oral reading rate of four hard-of-hearing children. In training, systematic increases in pulsing rate of a vibrotactile stimulus were arranged. The children received points, exchangeable for money when their reading rate equalled the pulse rate of the stimulus. The training procedure was effective in increasing the oral reading rate in all children. Generalized increases in reading rate on untrained word lists, sentences, and paragraphs were also observed.

The voice quality of hard-of-hearing and deaf speakers has been described as tense, flat, nasal, and throaty. Their speech has generally been considered less intelligible than normal-hearing speakers (Calvert, *unpublished*). Hudgins and Numbers (1942) found that this difference in voice quality and speaking intelligibility appeared to accompany 45 dB or greater hearing losses and that it increased with the degree of hearing loss. Among other factors, speech rhythm was found to account partially for this deficit in speech intelligibility (Hudgins and Numbers, 1942). The more natural the rhythm of the spoken sentence in a deaf speaker, the higher intelligibility ratings the sentence received.

The mean overall reading rate for normal fourth-grade subjects has been established at 2.40 syllables per second (Caraway, *unpublished*). Pickett (1968), in a study of oral reading rate in normal children, noted that high-

school age subjects read at the rate of 3.3 syllables per second. In contrast, reported rates of speaking for the deaf are usually described as two to four times slower (Voelker, 1938; Peterson, 1953; Hood, 1965; Jones, 1967). Among other things, the differences have been ascribed to prolonging vowels (Boone, 1965) and an abnormal vowel-consonant ratio (Calvert, *unpublished*). A consistent extension of typical durational values for phonemes in the plosive and fricative class contributes to the deaf slow rate (Calvert, *unpublished*). For normal-hearing speakers, the rate of speech within a sentence remains constant, whereas considerable variability in rate is present within a single sentence for deaf speakers (Jones, 1967). Further, there is a lack of overlap of speech sounds in deaf speakers who typically emit each syllable or word as a separate entity with excessive pauses between words (Peterson).

Only a limited amount of research has been directed toward changing speaking rates in hard-of-hearing and deaf speakers. In a study by John and Howarth (1965), 6- to 14-yr old deaf children were trained to repeat three and four word phrases after a teacher produced it at a normal rate. The pre and posttraining analysis indicated a 50% increase in intelligibility following training. Although training methods were not specified and training was not extensive, the results suggest that effort should be directed toward investigating procedures to

¹This article is based on a Master's thesis completed at the University of Kansas Medical Center by Michele Drisko, now Michele Wilson. The authors are most grateful for the invaluable help provided by Dr. Albert W. Knox in setting up the instrumentation for the project. This research was partially supported by Research Grant HD 00870 from the National Institute of Child Health and Human Development to the Bureau of Child Research at the University of Kansas. Reprints may be obtained from Leija V. McReynolds, Speech and Language Research Laboratory, University of Kansas Medical Center, 39th and Rainbow, Kansas City, Kansas 66103.

determine whether speaking rate in hard-of-hearing speakers can be increased without decreasing intelligibility.

Some procedures that have been successfully employed to change speaking rates in stutterers have been concerned with principles of reinforcement (Goldiamond, 1968; Martin, 1968). These procedures appear particularly amenable to be used to modify hard-of-hearing speakers' rates. Most of the reinforcement research in modifying speaking rate in humans has been concerned with slowing down the rate of speaking. For this purpose, schedules in which reinforcement is contingent upon responses occurring at a specified slow rate or slower (differential reinforcement of low rate or DRL schedule) has been shown to be effective. Goldiamond, for example, used DRL schedules as an alternative method for establishing a new speech response pattern. Bradford (1970) examined the effects of a DRL schedule for decreasing rate of reading word lists, contextual reading, and impromptu speaking in individuals with cluttered speech. Voice operated relays and pause or duration analyzers implemented the reinforcement schedule. Bradford found that a DRL schedule of reinforcement resulted in reduction of vocalization rates for all subjects, ranging from 16% to 52% of the original baseline.

In hard-of-hearing speakers, however, a change in the opposite direction is desirable. That is, the hard-of-hearing speaker needs to be trained to increase his rate of speaking. A schedule in which reinforcement is contingent upon responses occurring at a specified high rate or higher (a differential reinforcement of high rate or DRH schedule) should accomplish this rate increase. A suggestion for programming an appropriate stimulus to provide feedback pertaining to the amount of increase required for reinforcement was presented by Boone (1968). He suggested the use of a metronome or other rhythmical pulsing device to aid the deaf in monitoring their speaking rate for the purpose of accelerating it. However, a metronome with the deaf speaker necessarily precludes the use of

reading material in training as the speaker must attend visually to the movement of the metronome to benefit from its rhythmic characteristics.

An instrument constructed by Azrin, Jones, and Flye (1968) to treat stutterers appears more useful for the hard-of-hearing population because it utilizes a vibrotactile stimulus to pace rate. Their apparatus consisted of a bone conductor (oscillator) connected to a transistorized circuit to produce a 250-Hz millisecond vibrotactile stimulus at a rhythmic rate of 1.5 pulses per second. In their study, the pulsing rhythm exerted a distinctive control on the speaking rate of a subject as speech became synchronized to the rhythmic stimulus. This finding suggests that speaking rate in the deaf population may be increased by matching speech rate with a pulse from a vibrotactile stimulus. As the pulse gains control, the rate of the pulse can be gradually increased, thereby raising requirements for speaking rate increases under a differential reinforcement of high rate (DRH) schedule.

The purpose of the present study was to investigate the effectiveness of the vibrotactile pulser and a differential reinforcement for high rate schedule for training increases in reading rate in deaf speakers. More specifically, the study was designed to explore whether training an increase in oral reading rate of monosyllabic words in deaf speakers effects any changes on reading rate of words, sentences, and paragraphs on which no training had been given.

METHOD

Subjects

Only children with moderate to severe hearing losses, functioning adequately within a hard-of-hearing classroom, were considered for the study. The experimenter and classroom teacher selected children judged to have intelligible speech in spontaneous conversation. In addition, classroom teachers were requested to recommend children who were cooperative and had sufficient reading ability to experience no difficulty with the training and probe reading

material. Only children whose oral reading rates for monosyllabic words did not exceed 1.6 syllables per second (sps) on a pretraining reading sample were selected. The selected rate criterion was one-half the average speaking rate of normal hearing children.

Of the six children meeting the above criteria, four participated in the experimental training program and two served as controls. Subject 1, a 13-yr-old female, and Subject 2, a 14-yr-old male, were students in the Kansas City, Missouri hard-of-hearing classroom. Subject 3, a 15-yr-old female, was a resident student in the Kansas State School for the Deaf. Subject 4, a 7-yr-old female, was enrolled in the elementary classroom for the hard of hearing, Shawnee Mission, Kansas. The two control subjects were 9-yr-old males who were also enrolled in the elementary classroom for the hard of hearing in Shawnee Mission, Kansas.

Instrumentation

To provide the vibrotactile stimulus a Grason-Stadler noise generator, Model 901-A was used to generate a 500-Hz to 4000-Hz noise spectrum at approximately 2 V pressure. A Grason-Stadler Electronic Switch, Model 829-D, controlled the rise and decay time of the signal to eliminate the click and to allow for discrete signals. A Grason-Stadler Interval Timer, Model 471-1 was used to control the duration of the signal and the intervals between the signal pulses. The signal output was recorded on a Phonic Mirror, Model HC-20, from which a B 70-A bone oscillator delivered the discriminative stimulus to the subject. The loudspeaker within the Phonic Mirror was disconnected to eliminate auditory signals in order to provide only the vibrotactile stimulus.

When channel A of the electronic switch was on, the signal fed into the electronic switch from the noise generator, rose to full intensity in 5 msec and stayed on for 100 msec as determined by channel 1 of the interval timer. Channel A of the electronic switch then alternated to channel B for the duration that channel

2 of the timer had selected. Because no signal had been imposed on channel B of the electronic switch, the duration of channel B constituted off-time of the signal of interest. The off-time was mediated by channel 2 of the interval timer. Adjustment in the off-time produced signals at the selected discrete rates. The signals at all rate levels were 100 msec in on-time duration.

By adjustment of off-time interval durations, the signal of interest was calibrated to pulse rhythmically at nine discrete rates ranging from 1.2 to 2.8 signals per second. The signals, once selected and calibrated, were reduced on cartridges for use in a repeater-type tape recorder (Phonic Mirror). The output of the Phonic Mirror had sufficient drive (2.65 V) to operate the B 70-A bone oscillator, which was selected to deliver the vibrotactile stimulus into the palm of the subject's hand. The nine cartridges delivered the signal through the bone oscillator at 1.2, 1.4, 1.6, 1.8, 2.0, 2.2, 2.4, 2.6, and 2.8 rhythmic pulses per second.

Reading Materials

The word lists used in this study were obtained from Auditory Test W-22² (Hirsh *et al.*, 1952) and N.U. Auditory Test No. 6 (Tillman and Carhart, 1965). These were selected because each list of 50 words contained a weighted distribution of speech sounds as would be found in conversational speech. Two W-22 word lists and one N.U. Test No. 6 word list were selected for baseline, midtraining, and posttraining rate measures. No word list was used for more than one measurement session. The word lists for midtraining and posttraining measures were not used during training sessions. Twenty four 50-word lists, not used for measurement session, were used as training material during the experimental sessions.

The sessions for measure of oral reading rate were selected from Schoolfield's (1959) diag-

²These tests were adapted by Central Institute for the Deaf from the Phonetically Balanced Word Lists of the Psycho-Acoustic Laboratory, Harvard University.

nostic sentences. Ten sentences were used for each measurement session. The posttraining probe sentences were selected to balance in syllable length with the 10 pretraining sentences.

The 200-syllable contextual reading passages selected for measures of oral reading rate were obtained from Childcraft, Vol. III (1964). Passages were read directly from the selected volume and no passage was used more than once.

Procedure

In baseline and generalization measurement, the subject was presented with three word lists, 10 sentences, and two contextual reading passages. Following a silent reading, and the opportunity to ask for clarification of words, the subject read the designated material aloud without the oscillator pulser. Word list reading was timed from onset of phonation to completion of the fiftieth word. Each sentence was timed from onset of phonation to completion of the final word in each sentence. Contextual passages were timed from onset of phonation to completion of the two-hundredth syllable.

During training sessions, a differential reinforcement of high rate (DRH) schedule was in effect. Training was administered on a daily weekday basis until the subject either reached criterion or had completed 20 training sessions.

At the initial training session, the cartridge calibrated to produce 1.2 discrete pulses per second was inserted in the Phonic Mirror. The subject was seated at a table with the experimenter beside him in the experimental room. To demonstrate the task the experimenter first read alone while sharing the oscillator pulse with the subject. The experimenter's prompt was gradually faded until the subject was holding the oscillator and reading alone in synchrony with the pulse. When the subject read a single 50-word list orally, in synchrony with the pulser, reading for that list was completed. The experimenter timed each reading from onset of phonation at the first word to completion of the fiftieth word. Time obtained for reading the word list was matched with the correspond-

ing syllable per second (sps) rate using a conversion table based on a 50-syllable unit measure. If reading rate for a word list was equal to the pulsing rate of the pulser, the subject received a point. A training session was completed when the subject read twenty-five 50-word lists or participated for 30 min in the training session.

Subjects were required to read a minimum of 10 lists at each increment of increase in rate, and earn three consecutive points at each pulse setting before they progressed to the next rate increase. At this point, the cartridge was removed from the Phonic Mirror and replaced by another that produced the next faster pulse rate. If a subject omitted a word or a sound from a word, he was stopped and instructed to begin with the next list, thus losing an opportunity to earn a point on the previous list.

To permit a "warm-up" period, each training session started with a 0.2-sec slower rate level than the termination rate of the previous session. When the subject successfully completed three consecutive reading trials at the slower rate he progressed to the next increment. Points obtained in training were exchanged for money (one point was redeemable for five cents) at the completion of each session.

When criterion had been reached at the 1.8 pulses per second level, midtraining probes were administered. Posttraining probes were administered when subjects reached criterion of 2.8 syllables per second or had participated in 20 training sessions.

Control Subject 1 was used to determine whether a rate contingency was necessary to obtain an increase in reading rate. Although the pulser was activated at the 1.2 pulse setting, and held in his hand, during all control sessions, there was no contingency for either maintaining or increasing reading rates. Instead, he read 25-word lists at his own rate at each session, and regardless of his rate received a fixed amount of money (\$0.50) at the end of each session. He continued to read at his own rate until he had participated in as many sessions as the

first subject to complete training. After post-training probes, Control Subject 1 was placed in the experimental training program.

An additional control subject was used to determine whether practice alone with a fixed rate contingency would function to change rate. For this subject, the pulser was set at 1.2 syllables per second and remained at that rate throughout the study. Control Subject 2 was told that if he stayed at or below the 1.2 syllables per second setting he would receive a point for each 50-word list read at that rate. Control Subject 2 continued in the training sessions until the first experimental subject had completed training. After posttraining probes, he was terminated from the study.

Reliability

All reading sessions were tape recorded. Using a stopwatch, reading duration was determined by listening to the tapes after the sessions. Each segment was listened to at least twice to ensure accuracy. Reading duration was converted to a syllable-per-second rate.

Tape recordings of the reading tasks were run through a Bruel and Kjaer Sound Level Recorder, Model 2305, at a paper roll rate of one centimeter per second. Each subject's average syllable per second reading rate, as measured by the recorder, was compared to the reading rate obtained by the stopwatch timing. Agreement between the measure provided by the level recorder and the stopwatch count ranged between 95% and 100%, with a mean agreement of 97.4%.

RESULTS

One concern of this study was to determine the usefulness of the procedure for training children to read monosyllabic words at an increasingly rapid rate. Results for all children in the program are presented in Table 1.

Subject 1 reached the criterion of 2.8 syllables per second in the fifteenth session whereas training for Subject 3 continued through the twentieth session, at which time criterion was

Table 1

Word list reading rate increases for all subjects during training.

Child	Syllables Per Second	
	Rate Level Session 1	Rate Level Final Session
Experimental		
1	1.2	2.8
2	1.2	2.4
3	1.2	2.8
4	1.2	1.8
Control		
1	1.2	1.2
(Experimental)	1.2	2.2
2	1.2	1.2

reached. Subject 2 participated in 20 training sessions and was successfully reading at a rate of 2.4 syllables per second output. Although he had not reached criterion of 2.8 syllables per second during training, he had doubled his reading rate for words at termination of the study. Subject 4, the youngest child to participate in the study, reached the 1.8 sps midtraining criterion only in the twentieth and final session of training.

During the control condition for Control Subject 1, the pulser was set at the 1.2 sps rate throughout the sessions, but a rate contingency was not in effect. With the pulser set at 1.2 sps, the subject's rate ranged from 1.0 to 1.6 sps, but did not stabilize at the 1.2 sps rate of the pulser. Without the rate contingency, the subject's rate fluctuated below and above the rate of the pulser. After being placed in the experimental program, his rate increased to 2.2 syllables per second by the twentieth session, at which time training was terminated. Control Subject 2, who received reinforcement for maintaining his 1.2 sps rate during training, made no change in rate.

As the results show, all the children in the experimental program increased their rate. Two of the children reached a criterion of 2.8 sps within 20 sessions. Subject 2 and 4 did not increase their rate to 2.8 sps within 20 sessions,

but a rate increase also occurred for them. Control Subject 1's rate varied until he was placed in the experimental training program, and Control Subject 2 maintained his rate of 1.2 syllables per second.

The subjects were probed on untrained word lists, sentences, and paragraphs once during the training program and directly after completing the program. Performance of all subjects on baseline, and on midtraining and posttraining probes is presented in Figure 1.

Three of the children (Subjects 1, 2, and 3) were presented with midtraining probes, and as the data show, they increased their rate of reading on all three measures over baseline. Subject 4 did not reach the 1.8 sps rate until the twentieth session, so no midtraining probes were presented. Posttraining probes for Subject 1 and 2 showed an increase in rate for all three measures over baseline as well as over midtraining probes. Subject 3, in the posttraining probe increased his rate over the midtraining probe in sentences and words, but not in paragraph reading. In the posttraining probe, Subject 4's reading rate increased over baseline on all three measures.

Although not posed as a specific experimental question, some interest was directed toward carry-over beyond the posttraining probe. Three weeks after she had finished the program, Subject 1 was brought back and probed once more. Her average reading rate for word lists was 2.8 sps, for sentences 3.68, and for paragraphs 2.96 sps. Results for probes presented three weeks after training indicated that the child had maintained rate increases effected during training.

The 9-yr-old male who served as the first control subject averaged 0.63 sps on the word list at the beginning of the experiment. When he was probed at the end of the fifteenth session, word list rate had increased from 0.63 to 1.02 sps, but rate for sentences and paragraphs showed a decrease. After completing the experimental program, however, the child made progress in rate changes in all reading tasks,

which were more comparable to the rate changes for the experimental children.

To determine if reading practice alone, with no change in rate, would effect a rate increase in the probe conditions, a second child served as a control. With the no change in rate contingency in effect, his rate for reading sentences and word lists decreased during the posttraining probe and increased slightly in paragraph reading.

Results indicated that the procedure was successful in training an increase in reading rate for word lists. Generalization to other reading tasks occurred from the training. The children increased their rates of reading new monosyllabic words, sentences, and paragraphs for which no training had been administered.

Intelligibility

To determine whether the increases in rate effected by the training program reduced listener understanding of oral reading, measures of intelligibility were made for the tape recorded baseline and posttraining probes for the sentence reading task. Two judges and the experimenter were used for the ratings. The judges were given a copy of the sentences read by the subjects during baseline and during posttraining probes. For each condition, the 10 sentences were played with pauses between each sentence. Judges were instructed to circle each word on the page that

Table 2

Examiner intelligibility ratings for all subjects for sentence reading task during the pretraining and during the posttraining probe.

<i>Subject</i>	<i>Pretraining</i>	<i>Posttraining</i>
Experimental		
1	96	91
2	96	96
3	100	98
4	86	86
Control		
1	89	88 90*
2	82	92

*Control Subject One Post-Experimental Probe

Fig. 1. Syllable-per-second reading rates during baseline, midtraining, and posttraining probes for all subjects.

they did not understand immediately after each sentence was completed. Experimenter intelligibility scores are presented in Table 2.

As shown in the table, intelligibility ratings were the same for the pre- and posttraining sentences for one of the experimental subjects. Two of the experimental subjects were rated by the experimenter as being less intelligible for the posttraining sentences; however, the percentage change from the pretraining ratings for each subject was 5% or less. One of the experimental subjects was rated as being more intelligible for the posttraining sentences.

Inter-judge agreement on intelligibility was computed. An agreement was scored if judges circled the same word on the sentence sheet. To compute percentage agreement, total agreements were divided by total number of agreements plus disagreements. Mean percentage agreement between the experimenter and Judge 1 was 94.6%. Agreement between experimenter and Judge 2 was 96.2%, and between Judge 1 and 2 was 96.2%. For all judges, the mean percentage agreement was 95.6%. According to the results obtained, the rate increases occasioned by the training program did not result in decreases in intelligibility in hard-of-hearing children's reading.

DISCUSSION

Comparison of the rate changes made by the control subjects *versus* those made by the experimental subjects for the probe reading tasks provided evidence to support the efficacy of using the vibrotactile pulse and the DRH schedule for accelerating reading rate. On the average, from pretraining to posttraining measures, experimental subjects doubled their rate of reading on the monosyllabic words. This compares with the smaller gain made by the control subject with no rate contingency, and the decrease for the control subject with the contingency for maintaining a 1.2 sps rate. While the average gain made by the experimental subjects for sentence reading was a 50% in-

crease in reading rate, both control subjects decreased reading rate for sentences by approximately 13%. The average gain for paragraph reading by the experimental subjects was 45%. Control Subject 1 decreased paragraph reading by 4% and Control Subject 2 increased by 8%. This increase compares with 36%, which was the smallest gain made by any of the experimental subjects for this task.

When comparing results of subjects who participated in the experimental program with the subjects who participated as controls, the results showed that it was possible to change reading rate for word lists, sentences, and contextual reading as a result of training systematic increases in reading rate for word lists with a vibrotactile pulser and a DRH schedule of reinforcement. Control Subject 1's rate fluctuated during the control sessions with the pulser set at 1.2 sps and no rate contingency. Since he did not maintain a consistent 1.2 sps rate, it appeared that the pulser alone did not effectively control rate. However, had he been exposed to systematic increases in pulse rate without the reinforcement contingency, it is possible the pulser alone might have been sufficient to effect rate changes.

For all subjects, reading rate for word lists in the probe was slower than reading rate for paragraphs. Both word list and paragraph reading rates were slower than sentence rate for all subjects. The proportion of change for the experimental subjects was greater for the task on which training had been given (word lists). The number of sessions to reach criterion in training was different for all children. In general, children with greater reading ability reached criterion faster.

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- Received 5 May 1972.
(Revision requested 16 August 1972.)
(Revision requested 26 September 1972.)
(Final acceptance 11 October 1972.)