DOCUMENT RESUME

ED 347 988 IR 015 725

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TITLE	Systematically Designed Text Enhanced with Compressed Speech Audio.
PUB DATE	Feb 92
NOTE	21p.; In: Proceedings of Selected Research and Development Presentations at the Convention of the Association for Educational Communications and Technology and Sponsored by the Research and Theory Division; see IR 015 706.
PUB TYPE	Speeches/Conference Papers (150)
EDRS PRICE	MF01/PC01 Plus Postage.
DESCRIPTORS	Analysis of Variance; *Audiotape Recordings; *Comprehension; Instructional Effectiveness; *Intermode Differences; Learning Modules; Pretests Posttests; Reading Skills; Secondary Education; Tables (Data); *Time on Task; Vocational Education
IDENTIFIERS	*Compressed Audiotape Recordings; *Printed Materials

ABSTRACT

This study was designed to determine whether systematically designed text augmented with compressed speech could increase the number of objectives achieved and reduce the amount of learning time needed for mastery of the objectives. Subjects were 78 students from 5 Florida schools with vocational education programs. Their reading levels ranged from grade levels of 3.1 to 12.9, with the mean score of 8.8. The instructional material used was the unit "Good Work" from the Employability Skills Series, which includes a text module covering the introduction, knowledge objectives, and instructional objectives, together with practice activities and audiotapes corresponding to the text. The tape recordings of the text were made by a professional radio announcer at an average speed of 175 words per minute; a compressed speech tape was created at 262 wpm. Subjects were divided into three groups: the control group (n=28) received the text only, and each of two experimental groups received the text and one of the audiotapes (n=28 for normal speech, n=22 for compressed speech). Subjects worked in a laboratory setting and project monitors timed the use of the tapes and administered a posttest. Statistical results of the study showed systematically designed text to be highly effective; all three groups reached a ceiling effect on the mastery of the objectives. Another finding was that the overall variance in the amount of time used for the lesson was reduced by the use of compressed speech. Successful comprehension in combination with the other findings for efficiency, time savings, and reduced variability, demonstrate that the use of compressed speech tapes to augment systematically designed instruction may be a valuable instructional method when a cost-benefit is determined. Data are displayed in 10 tables. (31 references) (BBM)

Title:

Systematically Designed Text Enhanced with Compressed Speech Audio

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Currently there is a high-paced search for the perfect medium. One that delivers instruction so that learning is effective and efficient. Is it possible that with all the focus on "high-tech," one viable solution is being overlooked? Audio tapes are one of the most popular forms of entertainment we have today. Just walking down the street you see many people "plugged in." Audio is also increasingly being used for instruction because it is inexpensive, convenient, and portable. Unlike text, audio provides a human touch to instruction. The voice can motivate the learner through the enthusiasm expressed for the subject.

Statement of the Problem

One problem with audio is the time it takes to listen to a program. When involved in a two-way conversation, the average rate of speech is comfortable; with one-way audio, the pace seems dreadfully slow. It has been shown that the human brain can comprehend information that is delivered nearly twice as fast as the original speed of delivery (Carver, 1982). Through the use of speech compression technology, it is possible to accelerate a recorded voice without significant distortion of the pitch or natural quality (Olson, 1985).

Another problem associated with audio programs is that they are just taped versions of books, lectures, or seminars, and like extemporaneous conversation may contain information that is extraneous. It has been shown that the effectiveness of instructional materials can be increased by employing a systematic design process that removes irrelevant information (Mengel, 1982).

Augmenting systematically designed text with audio may help increase learners' attention to the material because of it's steadily paced, non-stop information flow. By using audio along with text, learners maintain the benefit of visual design features. It is possible, since systematically designed materials have a high density of information, compressed speech technology may "over-compress" the instruction. All that may be needed is a normal speech audio tape for pacing. Therefore, this study compared two forms of audio augmentation, normal and compressed speech.

Cognitive Theory

Most individuals have sufficient semantic cognitive capacity to carry on a conversation at a rate of 125 to 150 wpm and responding at about the same rate internally until the response is voiced. If added together, one might theorize that the average semantic cognitive capacity would be about 250-300 wpm. If involved in a one-way semantic communication such as reading, or listening, the cognitive capacity should remain the same. Increasing the input level to 250 to 300 wpm through the use of compressed speech should help keep attention levels high and optimize learning.

Research has shown that the average reading level of most Americans is between 250-300 wpm, with the average college student reading at about 280 wpm (Taylor, 1965). Humans can successfully listen at rates of 250-300 wpm using speech compression technology. Carver (1981), refers to this optimal efficiency rate (300 wpm) of reading or listening (auding) as the "rauding rate." This rate is highly efficient, but somewhat less effective than lower rates when tested using traditionally developed learning materials. Effective comprehension of this type of material begins to decline around 250 wpm using compressed speech (Foulke, 1966).

The evidence strongly indicates that the cognitive capacity of the conscious working memory is limited. Input from the five senses fill it to the limit moment by moment. As the working memory is filled, information is moved to long-term memory or is lost. Humans are constantly being bombarded by biological, physiological, and psychological input, which takes up this limited cognitive capacity. To some extent, humans determine what is placed in the working memory through a process known as selective perception. What we choose to perceive often relates to what Gagne (1985) terms executive controls, made up of the sum of our past experience and future expectations. Selective perception provides attention to those things we perceive as important. Research has shown that attention itself utilizes cognitive capacity. Therefore, to optimize learning, attention to distractions must be reduced and working memory input should be limited to the information required for learning. It is also desirable to fill the cognitive capacity with the learning stimulus at an optimum rate so that distractive thoughts do not have time to enter the working memory.

Examination of the research (Mengel, 1982) shows that systematically designed materials have a higher concept density than traditionally developed materials. In effect, the instruction is already compressed to some extent. It is possible that this would increase the rate of concepts flowing into the working memory requiring less compression from another source to total the cognitive capacity. In fact, designing instruction (increasing density) could create too dense an information flow at rates suggested by past research.

Since the process of attention (or selective perception) itself uses up vital capacity, reducing the need for attention by systematically designing instruction may provide even more capacity for learning. Berlyne (1960) suggests that a higher degree of involvement with learning materials should correlate with a higher degree of recall.

Systematically designed instruction is objectively based so that all of the information is aimed toward mastering the objectives. Practice actively involves the student in the learning process. In addition, redundant information presented in two channels (reading and listening) and using two modes (linguistic and iconic) should create an even higher degree of involvement with the materials, thus increasing learning (Bradtmueller, 1978; Nugent, 1982). If the need for attention is further reduced by providing an environment with a low level of noise, learning should be increased even more (Hsia, 1968). By combining these methods the involvement with the learning materials should be at a maximum level and the effectiveness of higher compression rates should be increased.

Measuring Compression Rates

Research has identified several methods of measuring compression rates. Many studies use a percentage of compression with the original tape defined as 0% and the experimental tapes from 25% to 100% compression. Other studies define the original tape as 100% and the experimental tapes as 125% to 200% compression. The problem with both percentage methods is that the speed of the original tape is usually not stated.

Conversational speed has been measured at 125-150 wpm. Professional voices have been identified as averaging 175 wpm. 25% (or 125%) compression of

125 wpm equals 156.25 wpm, which is barely out of the conversational speech range. 75% (or 175%) compression of 125 wpm equals a 25% (or 125%) compression of 175 wpm which is 218.79 wpm. These large differences make the studies difficult to interpret. What does 1.5 times or 2 times normal speed mean?

Other studies do identify the exact wpm used (Boyle, 1969), but don't always clearly state the rationale behind their choices of experimental speeds. It would seem that in early research it was necessary to experiment with a variety of speeds; with a more solid research base, compression rates can now be deliberately chosen.

Bradtmueller (1978) states that "It is theoretically possible to speed up tapes to any rate but the human hearing mechanism begins to have difficulty processing messages somewhere between 300 and 500 words per minute" (p. 4). Acceptable comprehension occurs up to 300 words per minute and is most efficient at that level (Carver, 1982; Sticht, 1968). Given discretionary control over the rate of presentation, students prefer to work at a rate around 225 wpm, well below the limits of their capabilities (Lass et al., 1974; Foulke & Sticht, 1967).

The four rates have appeared in the research that are of interest:

175 wpm - This is the approximate rate reportedly used by professionally trained readers (Foulke, 1966). It is still within the normal speech range. Media sophistication has probably acclimated most people to this rate of speech. Rates below this level were not chosen or ranked very highly by subjects (Lass et al., 1974; Orr et al., 1969). Slow speakers generate negative evaluations by the listeners, whereas fast speakers are described as fluent, persuasive, and credible (Apple, Streeter, and Krauss, 1979; Miller et al., 1976).

225 wpm - This is the rate reported to be preferred by learners (Lass et al., 1974; Foulke & Sticht, 1967; Orr et al., 1969). At this rate learners are working below their abilities (Foulke & Sticht, 1967). It is 29% compression of 175 wpm.

262 wpm - This rate is a half-way point between 225 wpm and 300 wpm. It is also a 50% compression level for 175 wpm. In a study of radio advertising using professionally made recordings, LaBarbera and MacLachlan (1979) state: "As long as the speech is not speeded up by more than 50% the listener will be unaware that there has been an electronic alteration of the original recording" (p. 30). Some studies show (Foulke, 1966) comprehension of traditional materials begins to decline somewhere between 250 wpm and 300 wpm.

300 wpm - This rate consistently appears in the research as the top end level for efficient comprehension (Carver, 1982), although subsequent recall may not be as great as it is for lower levels of speed. A large number of studies show that rates beyond this level cause comprehension to drop off precipitously (Carver, 1982; Sticht, 1968).

For this study, 175 wpm was selected as the speed of the original recording, and defined as "normal" speech. For the compressed speech recording, 262 wpm was chosen. Since this rate approaches the cognitive capacity limit of 280-300, it was believed that it would not push slower students past their personal limits. Higher rates were not chosen because comprehension may have been sacrificed.

Purpose & Hypotheses

The purpose of this research was to determine if systematically designed text augmented with compressed speech could increase the number of objectives achieved and reduce the amount of learning time needed for mastery of the objectives. The effectiveness of learning was defined as the number of objectives mastered. Efficiency was defined as the effectiveness divided by instructional time multiplied by 100. A self-report method was used to reveal the actual instructional time elapsed. This allowed investigation of the actual time the students used to complete the instruction, including rewinding, practice activities, and review.

It was hypothesized that: 1. The text materials augmented with compressed speech audio tapes would be more effective than text alone. 2. The text materials augmented with compressed speech audio tapes would be more efficient (concepts learned per minute) than either text alone or text augmented with normal speech audio tapes.

Method

The methodology was designed to determine the optimal type of audio augmentation for systematically designed text materials. The optimal augmentation was defined as the one that allowed for the highest comprehension and the largest time savings.

Subjects

The participants in this study were 78 students from 5 schools with vocational education programs in the State of Florida. Urban and rural schools were both included. 23 program areas were represented. There were 28 males and 50 females of which 54 were white and 24 non-white. The ages ranged from 16 to 67 years.

The participants had reading levels that ranged from the 3.1 to 12.9 grade level according to their total reading scores on the Test of Adult Basic Education (TABE). The mean reading score was 8.8; the standard deviation was 2.0. Subjects were randomly assigned to the control group and the treatment conditions by placing them in groups in rotating order as they entered into the lab.

Materials

The instructional materials selected were designed for the State of Florida by the Center for Instructional Development and Services, The Florida State University.

> The Employability Skills Series is a set of instructional materials designed to teach secondary students and adults the skills involved in getting and keeping a job. The purpose of the series is to provide educators with ready-to-use student materials that are competency-based and validated for effectiveness and acceptability in actual classrooms. Oriented to young adults but written at a reading level of approximately fifth grade, the materials have a flexible format that can be used in a variety of instructional settings. (Florida, 1979, p. 6)

This series was selected because it was developed using a rigorous instructional design process including formative and summative evaluations and periodic updates (Kromhout, Farrow, Foster, & Morse, 1978). The materials were written at a reading level that would produce efficient and effective learning for the specified population.

The unit Good Work (Florida, 1979) was chosen because it was the most widely and regularly used module. The total instructional package included: 1. A text module from the series covering the introduction, knowledge objectives, and instruction for these objectives. 2. Practice activities corresponding to the text. 3. Audio tapes corresponding to the chosen text.

The text of the written materials was used as a script for the audio tapes, as suggested by other studies (Nasser & McEwen, 1976; Nugent, 1982; Rohwer & Harris, 1975). Only the text portion of the materials were recorded, the practice exercises were not. A male voice was selected to read the text (Foulke & Sticht, 1967). This narrator was a professional radio announcer. Additionally, to enhance quality, the scenarios pictured in cartoons or described in the text were read by a variety of male and female character voices. The recording was made in a professional sound studio.

In order to record the tape at an average speed of 175 wpm the narrator used a script with 175 word segments marked off and used a stop watch to pace the segment to a minute. After the audio tapes were recorded at normal speed, copies were made at the compression speed using a Model H910 Eventide Harmonizer/Pitch Shifter. The same technique was used to pace the compressed speech tape where 262 word segments were marked off and the speech was digitally compressed to complete each segment in one minute. Music and tone signals for page turning were added after the compressed copies were made so that the music would not sound distorted and the tone would not be too brief. Music was used only at the beginning and end of each lesson.

Variables

The first dependent variable was effectiveness defined as the mastery of knowledge objectives as measured by open-ended tests that asked students to list, to identify, and to name. Mastery is defined in the answer keys provided in the instructor's guide of the learning materials. The tests had already been validated during the development of the instructional materials to insure their ability to measure the objectives (Kromhout et al., 1978). A mastery level of 80% was used for field testing the materials, and for the purpose of determining mastery. If the tests had been altered to a multiple choice for ease of scoring, the validity of the tests might have been altered.

The second dependent variable was efficiency defined as effectiveness divided by instructional time multiplied by 100. Instructional time was measured by a self-report method of beginning and ending times for each of the four lessons in the instructional materials. (Mengel, 1982)

The independent variable was the augmentation of the text materials. A control group received only the text materials with no augmentation. One treatment group received the text with a normal speech audio tape of 175 wpm. The other treatment group received a compressed speech audio tape of 262 wpm.

Analysis

The data were analyzed using a one-way analysis of variance for each of the dependent variables, effectiveness (mastery of objectives), and efficiency (effectiveness per unit of time). Three groups were examined: a control group with text only; and two treatment conditions, text with normal speech and text with compressed speech. Reading scores for the Test of Adult Basic Education (TABE) were used as a covariate measure. The alpha level was set at .05 using a two tailed test. A sample of 21 subjects per treatment group (63 total), would generate a power of .80 where the alpha level was .05 and the desired effect size (the minimum difference considered to be of practical importance) was .40 standard deviation, (Cohen, 1977, p. 384). Data were collected from 83 participants in six schools. One school was dropped because protocol was not maintained. The final sample consisted of a control group containing 28 subjects, a normal speech group containing 28 subjects, and a compressed speech group with 22 subjects. The sample totaled 78 subjects.

Procedure

The learning environment. A learning laboratory was used for this study to enhance the ability to examine the augmentation levels by reducing error caused by noise. Students used individual tape recorders with headphones and were allowed to work at their own pace.

The experimental procedure. Before the study was conducted, management packages were produced to ensure consistency in the data collection. The use of the packages was demonstrated in a site visit to each school. An accordion file folder was labeled and organized with management information, student documents, and the audio materials. The file also provided space for forms in progress and completed forms. Supervisory materials were located in a large envelope held in the front of the package. All paperwork was color-coded for ease of handling.

The unit was used in the same manner as other instructional materials in the media center to provide a true picture of how management and setting might impact the use of compressed speech. For example, students were able to choose the amount of the module they would complete at each sitting. The module was divided into four 10-20 minute lessons over the eight objectives to provide convenient stopping places. The students were also able to choose their own schedule for taking the lessons and the post-test. The range was from 10 to 15 days. Through a self-report method, the participants kept track of the actual times spent on each lesson.

The materials contained an introduction and several units of instruction. According to the literature a slight practice listening to compressed speech is enough to acclimate the student to the speed of the tape (Perry, 1970). For this reason, the introduction found in the text materials was used on the audio tapes. The introduction on both normal and compressed speech audio tapes described the purpose of the audio tape and informed the learner that the voice of the speaker may have sounded faster than normal (Williams et al., 1983-84).

Timing started with the first lesson. The subjects were allowed to replay or re-read the introduction as many times as they felt necessary. The students were requested to try to complete all of the instruction in a lesson before taking a break. They were informed that if they needed to stop the instruction for any reason, they were to write down the time they stopped and then restart the instruction. The audio introduction informed the learners that they could rewind the tape if necessary to repeat portions they hadn't understood. This allowed the researcher to investigate the actual timing of the use of the tapes in a media center. If the participants needed to rewind the compressed speech tapes more often, the analysis would show that these rates are not as efficient for learning.

The project monitors retrieved the instructional packages and information sheets from the subjects and gave them the posttests when all the lessons had been completed. The project monitors were asked to make sure that all of the blanks were filled in on both the information form and the tests. The tests were scored using information in the instructor's guide and rechecked later for consistency in scoring.

Results

Two separate one-way analyses of covariance (ANCOVA) were used to test the statistical significance of the hypotheses. Reading scores from the Test of Adult Basic Education (TABE) were used as a covariate measure. Alpha was pre-set at .05 for both analyses. The total n = 78.

First, the internal consistency of the comprehension posttest was evaluated for the sample. There were no comparison statistics from the original field-test since the objective was to create a criterion-referenced measure that worked with 80% of the population. This would have necessarily biased any internal consistency statistics. Since the purpose of this study was to use the information in a norm-referenced context, an internal consistency reliability coefficient, (Cronbach's alpha) was calculated. The comprehension posttest had a reliability coefficient of alpha = .65. This result was considered acceptable due to the original objective of the measurement instrument and the small number of items (n = 8) on the test.

Cochran's C statistic was used to check for homogeneity of variance for both hypotheses. There were no significant differences among the variances of the treatment groups on either dependent variable. There was a significant difference for the time variable used in a post hoc analysis. (Table 1)

TABLE 1

Cochran's C Test
for Homogeneity of Variance

Dependent Variable	Cochran's C	# of Variances	df	Probability
Effectiveness	.431	3	27	.312
Efficiency	.427	3	27	.343
Time	.533	3	27	.020*

*Significant at $p<.05$.

A test for homogeneity of regression was used to determine whether the TABE scores could be used successfully as a covariate measure. No significant differences were found among the regression line slope. of the covariate on each dependent variable for each treatment group. An ANOVA for reading scores showed no significant differences between the means of the treatment groups.

For a measure of the relationship between the variables and the covariate, Pearson's Product-Moment Correlation Coefficients were calculated. There was a significant correlation between TABE and efficiency, and, TABE and effectiveness. There was a significant correlation also between time and efficiency. (Table 2)

TABLE 2

Pearson's Product-Moment Correlation Coefficients

	Effectiveness r/p	Efficiency r/p	Time r/p
Reading Scores	.45/.001**	.36/.001**	-.06/.312
Effectiveness	....	.51/.001**	.09/.222
Efficiency	....	....	-.67/.001**

*Significant at p<.001.

Histograms were used to check the assumption of normality. It was clear from the results that the comprehension posttest to measure effectiveness created a ceiling effect in all groups. When examining a histogram of the sample for the efficiency measure, a skewness of 1.2 was found. The tail was toward higher efficiency scores.

It is probable that this tail was created by the ceiling effect of the comprehension posttest which is a component of the efficiency formula. These extreme scores represented subjects who hit the ceiling in a short time and are considered efficient learners. Since their scores were legitimate, they represent a segment of the population. These scores were not deleted.

It was decided that since no other assumptions were violated and considering the robust nature of ANOVA regarding the normality assumption, these scores could still be used. However, since the ceiling effect was pronounced, and could possibly bias the efficiency measure, it was determined that a post-hoc analysis of the time component should be examined as well. The results of this analysis will be given after the two primary analyses.

A one way ANCOVA was then used to test the null hypothesis that all treatment groups would be equivalent with regard to effectiveness. Effectiveness was defined as: the number of correct objectives on a comprehension posttest. The null hypothesis could not be rejected. Table 3 presents the means and standard deviations and Table 4 summarizes the ANCOVA statistics.

TABLE 3

Means and Standard Deviations
Of Effectiveness Scores by Treatment Group
with Reading Scores as the Covariate Measure

Treatment Group	Covariate Mean	Effectiveness Actual Mean	Effectiveness Adjusted Mean	Effectiveness Standard Deviation	Group Size
Text Only	9.19	6.82	6.70	1.77	28
Normal Speech with Text	9.03	6.89	6.82	1.10	28
Compressed Speech with Text	8.02	6.32	6.59	1.70	22
Total	8.80*	6.71**	6.71	1.54	78

* TABE reading scores ranged from 3.1 to 12.9.
**Total possible score = 8.00.

TABLE 4

Summary of ANCOVA
for Effectiveness Scores by Group
with Reading Scores as the Covariate Measure

Source of Variation	df	SS	MS	F Ratio	Sign. of F	% of Var.
TABE-Reading Comprehension	1	36.54	36.54	18.66**	.000**	20%
Treatment	2	.66	.33	.17	.845	0%
Residual	74	145.02	1.96	....	....	80%
Total	77	182.22	2.37	....	....	100%

**Significant at $p<.001$.

Another one way ANCOVA was used to test the null hypothesis that all treatment groups would be equivalent with regard to efficiency. Efficiency was defined as: effectiveness/number of minutes to complete instruction X 100. The null hypothesis was rejected; significant differences among the groups at the p<.05 level were indicated. Means and standard deviations are presented in Table 5, and ANCOVA statistics are summarized in Table 6.

TABLE 5

Means and Standard Deviations
Of Efficiency Scores by Treatment Group
with Reading Scores as the Covariate Measure

Treatment Group	Covariate Mean	Efficiency Actual Mean	Efficiency Adjusted Mean	Efficiency Standard Deviation	Group Size
Text Only	9.19	6.95	6.74	3.07	28
Normal Speech with Text	9.03	5.61	5.48	1.82	28
Compressed Speech with Text	8.02	6.99	7.43	3.08	22
Total	8.80*	6.48**	6.48	2.74	78

* TABE reading scores ranged from 3.1 to 12.9.
**Individual Scores ranged from 1.10 to 17.78.

TABLE 6

Summary of ANCOVA
for Efficiency Scores by Group
with Reading Scores as the Covariate Measure

Source of Variation	df	SS	MS	F Ratio	Sign. of F	% of Var.
TABE-Reading Comprehension	1	74.95	74.95	12.22**	.001**	13%
Treatment	2	48.38	24.19	3.94*	.024*	8%
Residual	74	454.03	6.14	......		79%
Total	77	577.36	7.50	......		100%

*Significant at p<.001.
*Significant at p<.05.

In order to determine which pair of groups were significantly different on efficiency scores, post-hoc Tukey pairwise comparisons were made. The results of these pairwise comparisons are presented in Table 7.

TABLE 7

Post-Hoc Pair-Comparisons
for Efficiency Scores by Group
with Reading Scores as the Covariate Measure

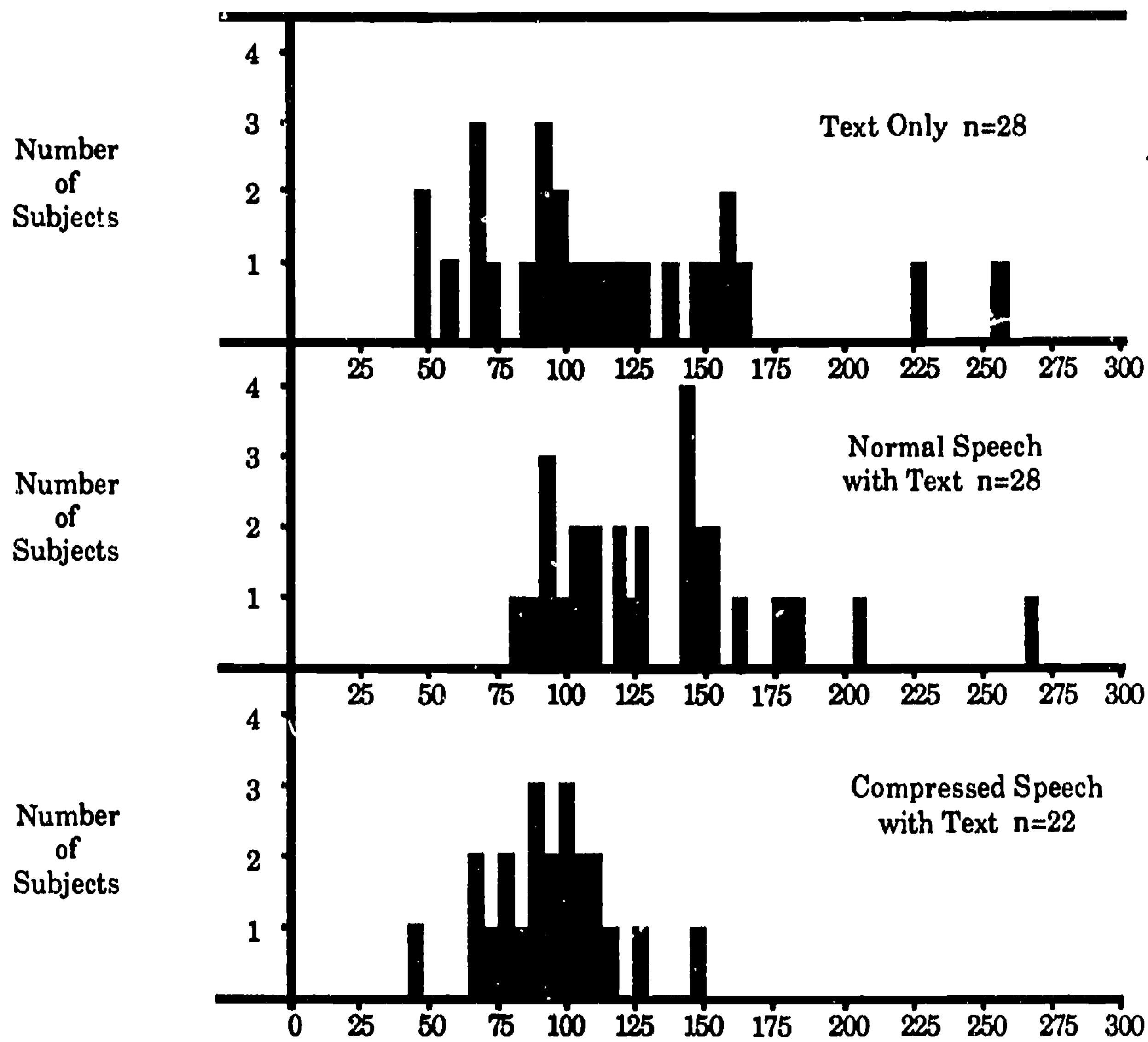
	Text Only t/prob.	Normal Speech with Text t/prob.
Normal Speech with Text	-1.90/.06	....
Compressed Speech with Text	.95/.34	2.71/.009*

*Significant at $p<.01$.

Another post-hoc analysis was used to examine the Time element of the efficiency formula because of the ceiling effect apparent in the effectiveness portion of the formula. Time was defined as: the number of minutes to complete instruction. Since the Cochran's C showed significant differences among the variances of the treatment groups (Table 1), the individual scores were placed on a graph for further examination. (See Figure 1 for the graph.)

FIGURE 1

Graph of Individual Scores
of Time to Complete Instruction
Using Five Minutes Intervals



An ANCOVA was used although the assumption of homogeneity of variance was violated. It was determined that the loss of power due to this violation was at an acceptable level. The ANCOVA demonstrated significant differences at the $p < .05$ level. See Table 8 for means and standard deviations and Table 9 for ANCOVA statistics.

TABLE 8

Means and Standard Deviations
Of Time Scores by Treatment Group
with Reading Scores as the Covariate Measure

Treatment Group	Covariate Mean	Time Actual Mean	Adjusted Mean	Standard Deviation	Group Size
Text Only	9.19	112.50	113.54	49.45	28
Normal Speech with Text	9.03	133.36	133.98	41.23	28
Compressed Speech with Text	8.02	96.18	94.05	21.07	22
Total	8.80*	115.38**	115.38	42.43	78

* TABE reading scores ranged from 3.1 to 12.9.
**Individual Scores ranged from 45.00 to 268.00.

TABLE 9

Summary of ANCOVA
for Time Scores by Group
with Reading Scores as the Covariate Measure

Source of Variation	df	SS	MS	F Ratio	Sign. of F	% of Var.
TABE-Reading Comprehension	1	442.42	442.42	.28	.602	0%
Treatment	2	19,077.62	9,538.81	5.93*	.004*	14%
Residual	74	119,120.43	1,609.74	....	....	86%
Total	77	138,640.46	1,800.53	....	....	100%

*Significant at $p<.01$.

In order to find out which pair of groups were significantly different, post-hoc Tukey pairwise comparisons were made. The results of these pairwise comparisons are presented in Table 10. To gain a complete picture of time savings, time elements for treatment groups were compared. (See Table 11.)

TABLE 10

Post-Hoc Pair-Comparisons
for Time Scores by Group
with Reading Scores as the Covariate Measure

	Text Only t/prob.	Normal Speech with Text t/prob.
Normal Speech with Text	-1.91/.06	....
Compressed Speech with Text	-1.66/.10	3.42/.001*

*Significant at p<.001.

TABLE 11

Comparison of Time Savings
in Minutes by Treatment Group

Treatment Group	Total Time*	Lesson Only**	Rewind Activ.***	Additional Time****
Text Only	113.54	....	....	21%
Normal Speech with Text	133.98	66.07	67.91	42%
Compressed Speech with Text	94.05	44.05	50.00	0%

* Total time = Adjusted means for each group.
** Lesson only + The exact audio tape lengths.
*** The rewind/activities + Total time - Lesson Only.
**** Additional Time = Total time/Compressed Speech Total Time (the shortest total time).

Discussion

The statistical results of the study showed systematically designed text to be a highly effective form of learning. Since all groups reached a ceiling effect with regard to the mastery of the objectives, augmentation made no difference with regard to the effectiveness of the materials.

Another finding of the study was that the overall variance in the amount of time used for the lesson was reduced by the use of compressed speech. The text only group had the largest variance. This might be expected since the participants paced themselves by their individual reading rates. The normal speech with text group had less variance that could be a result of the mechanical pacing of the tape, but the variance was still quite large.

Based on cognitive theory, these large variances could be due to some participants of the text only and normal speech groups having to repeat portions of the instruction because of their inability to maintain attention at the slower rate of information flow. The compressed speech with text group had the smallest variance. (See the graph in Table 8.) If the theory is correct, this compact variance may be due to the participants' ability to maintain their attention on the instruction using compressed speech augmentation. The difference in variances could, however, simply be due to the total instructional time. Since compressed speech shortens the instructional time, there could be less fatigue occurring in this treatment group. This raises a question for future research regarding the actual cause of the reduction of variance.

The post-hoc analysis examining only the time feature of the study showed considerable instructional time savings. The time data included time to rewind when necessary and to complete activities interspersed throughout the lessons; therefore, the time savings would not compare to studies that evaluate time savings using word rates. For example, 2 ?2 wpm (compressed speech) is 1.5 times or 50% faster than 175 wpm (normal speech) (Foulke & Sticht, 1967; LaBarbera & MacLachlan, 1979; Sticht, 1971.) However, the percentages found in this study should give a more accurate picture of the time savings that could be expected when compressed speech tapes are used with a full complement of text and practice activities. See Table 11 for a comparison of time savings.

In a media center, or in a classroom, the small variation between students and instructional time savings could be a distinct advantage. Activities could be planned around more predictable beginning and ending times for all students. Since systematically designed text alone is already highly effective and efficient for most students, a cost-benefit analysis should be used to determine if the decreased variance and time savings is worth the additional expense of producing the compressed speech tape.

With regard to the choice of augmentation, the statistical results of the study did, however, indicate support for the hypothesis that with systematically designed instruction the text materials augmented with compressed speech audio tapes are more efficient (concepts learned per minute) than text augmented with normal speech audio tapes; however, they are equally as efficient as text alone.

It is not enough to assume that because the overall effectiveness of compressed speech was equivalent to normal speech and the word rate was faster, the result is greater efficiency. The results of this study were calculated using an individualized efficiency formula to examine the efficiency for each individual participant. In addition, this study was designed to investigate the actual time used to complete the instruction, rather than, the word rate or tape length alone. The result was, that even with the ability to rewind the tape and listen to the instruction again, the text augmented with compressed speech is still more efficient than the text augmented with normal speech and equal to the text alone. If augmentation were used with systematically designed text, compressed speech would be the better choice.

As in many studies (Foulke, 1967; Orr, 1968; Sticht & Friedman, 1974; Woodcock & Clark, 1969), the hypothesis regarding the effectiveness of compressed speech did not show any significant increase over the other treatment. It does, however, demonstrate that systematically designed materials can be successfully compressed without any significant loss in comprehension. The combination of compressed speech and terse text does not apparently overcompress the information flow.

Successful comprehension in combination with the other findings regarding efficiency, time savings, and reduced variability, demonstrate that the use of compressed speech tapes to augment systematically designed instruction may be a valuable addition to the instruction process when a cost-benefit is determined.

Limitations of the Study

A limitation of this study and other studies using systematically designed materials is creating a "ceiling effect" when examining comprehension. In the process of development, the instructional materials are revised until they are highly effective. The variance in performance, in effect, has been engineered out of the materials, and one might expect little variance in effectiveness among treatment groups. However, other variables of interest, such as, time and efficiency (as defined in this study) require that effectiveness be measured, even if it is a constant.

Suggestions for Further Research

A question was raised in this research as to whether compressed speech with text indeed reduces the variability of the amount of time needed to complete the instruction, or does the length of time spent on the instruction impact on the variability. Is the variability caused by unfilled cognitive capacity or by fatigue? By using systematically designed materials to exaggerate the ceiling effect, comprehension could be controlled. In this way, the instruction could be lengthened so that instructional time could be allowed to vary, thereby measuring time to mastery as the dependent variable.

The cognitive theory in this study has set forth an idea that rauding rate (Carver, 1982) and cognitive capacity are related. To fully examine this idea, future studies could employ a reaction time (RT) method (Johnson & Heinz, 1978) to find out how much cognitive capacity is being used when people are reading or listening at the rauding rate. The study could be designed much the same as this one using the text only, normal speech with text and compressed speech with text group. Added would be a reaction time task, such as, a light that would randomly turn on during the instruction. The length of the reaction time that it would take the participants to push a button indicating that they saw the light should indicate which group was using the most cognitive capacity.

As the technology for compressed speech improves to the point where there is no distortion for higher levels of compression, another important study will be to investigate the effect of practice on the comprehension of faster and faster levels of compressed speech. This research may provide clues as to the limits on the rate of flow the brain can accommodate.

Further research needs to include larger scale studies using classroom situation since most instruction is currently delivered in this manner. Most studies of this type have used adults in military or university settings. Researchers should consider using younger participants in subject areas that have a high degree of difficulty, such as science.

This study showed a large variance in the instructional time for the text only group. It appears that compressed speech may reduce that variance for the slow readers. Also, the question as to whether compressed speech can increase comprehension for slow readers is of interest. A study is needed that examines compressed speech augmentation with instructional materials that the population has more difficulty in comprehending. In addition to a reading level score, a measure of the participants' habitual reading rate should be calculated to use as a covariate measure. The correlation between participants' reading level and reading rate should be explored. Results of this type of study would determine whether it would be worthwhile to augment traditional school texts that are written above the capability of the low level reading population.

Another study might examine whether using compressed speech with text may help slow readers learn a new cognitive strategy for reading. A base-line reading rate and comprehension level should be tested at the beginning of the study. A control group would use the text only throughout the study. The treatment group would be given compressed speech with text. After each increment of the study reading rate and comprehension would be tested on a reading only task. The study may be able to show if a new cognitive strategy for reading can be learned and how many practice sessions with compressed speech could effect a change.

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