DOCUMENT RESUME

ED 223 229 IR 010 480

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TITLE The State of the Art in Rate-Modified Speech: A Review of Contemporary Research.
PUB DATE May 82
NOTE 36p.; Paper presented at the Annual Meeting of the Association for Educational Communications and Technology, Research and Theory Division (Dallas, TX, May 1982). For other papers, see IR 010 442-487.
PUB TYPE Information Analyses (070) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS *Audio Equipment; Communication Research; *Efficiency; Electromechanical Technology; *Instructional Innovation; *Listening Comprehension; Literature Reviews; Media Research; *Speech Compression; *Technological Advancement
IDENTIFIERS *AECT Research and Theory Division Meeting; Listening Rate; *Rate Controlled Speech

ABSTRACT

This review of the literature on rate-controlled or compressed speech begins by tracing the historical development of compressed speech with emphasis on earlier approaches to the problem, e.g., changing speaking rate, simplifying text, changing tape speed, or using a sampling technique. An overview of research from 1917 to 1974 highlights the major contributors and important issues and findings. Four main categories of research are discussed: (1) comprehension and intelligibility; (2) trainability; (3) retention; and (4) applications of compressed speech to various instructional situations. Current basic and applied research is then reviewed, including research related to the use of compressed speech with the blind, visually impaired, and handicapped; its use in reading and language instruction; and its use in other instructional applications. Contemporary uses of rate-modified materials are summarized, and new research directions are suggested. An extensive 105-item bibliography is included. (LMM)

THE STATE OF THE ART IN RATE-MODIFIED SPEECH:

A REVIEW OF CONTEMPORARY RESEARCH

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A paper presented at the national convention
Association for Educational Communications and Technology
Research and Theory Division
Dallas, Texas
May 1982

INTRODUCTION

In an everchanging society with an increasing rapid pace, it becomes more important for an individual to acquire knowledge and information in the most efficient and expedient manner. This imperative is compounded by the fact that individuals learn at different rates. Since time spent in instruction is an important factor in maximizing instructional efficiency, technology has provided a means of altering recorded speech so that instructor or student may adjust the rate of spoken presentation to suit his needs. This technique has been generally referred to as rate controlled speech or "Compressed Speech," Silverstone (1974) described this method of rate control as the "...reproduction of an original recording in which the word-per-minute ratio is changed to a slower or faster rate of speech without eliminating the pitch or natural quality of the voice." In an earlier publication, Silverstone (1972) describes this technique as the process by which consonant sounds are maintained as the original production, vowel sounds are reduced and pauses are eliminated as often as possible.

HISTORICAL DEVELOPMENT

The historical development of rate-modified or compressed speech goes back over 40 years. Early research attempted to isolate a means of increasing the amount of information that could be communicated over a limited period of time. The advent of modern electronic recording technology made a means of effectively compressing speech a reality. The earliest interest and research in speech compression began, however, linguistically rather than technologically.

Change in Speaking Rate

Initially, the most efficient and feasible method of changing the rate of speech was to have the speaker produce the words more rapidly so that the faster speech could be recorded. This method had the advantage of being very simple and required no special equipment or conditions. The increase in speaking rate, however, was limited because the voice inflection, intensity and articulation were affected when the speech rate became too fast. (Foulke and Sticht, 1969)

Studies were conducted that examined the effectiveness of speaking rate. One study done by Goldstein (1940) summarized many findings which included:

a. Listening comprehension was found to be superior to reading comprehension.

b. The easier the material becomes, the greater the listening comprehension.

c. Listening comprehension is less variable than reading comprehension.

d. Comprehension in reading and listening both decline when the rate is increased.

e. The decline of comprehension continues as the rate increases.

A study by Nelson (1948) estimated a speaking range of 125 to 250 words per minute and found no significant difference between the two rates. It was found though, that the subjects preferred a rate of 175 words per minute to be the most acceptable rate.

Simplification of Text

Alterations in the text offered an easy and accessible way to change the rate of spoken material. By making minor changes in the text, one was able to read them faster and with greater enunciation. The use of shorter words and a vocabulary that was simplified, enabled the reader to proceed to greater speed. Grammatical structure in a less complex form was also

found to be of importance when considering speed (Duker, 1974). In presentations varying from 175 to 375 words per minute, passages containing a simplified version of grammatical structure were found to be understood more easily than more difficult versions (Reid, 1968).

Speed Changing Method

Changes in word rate were also achieved by simply changing the speed at which the recorded material was played back. By using a slower playback speed, the word rate is slowed down. Similarly, by using a faster playback speed, the word rate is speeded up. Thus, the recorded speech can be expanded or compressed respectively. A change in pitch of one octave occurs, however, when the speed of the playback is double that of the recorded speed (Foulke and Sticht, 1969).

The use of this method dates back to 1919 when phonograph records were speeded up for listening experiments. Since then, it has been found that speeded up material could be dealt with in this manner as long as the material was simple enough in context (Klumpp and Webster, 1961).

These early attempts to alter speech rate enabled rudimentary research to be carried out, but also presented basic problems in that the degree of distortion interfered with messages. With more complex technological advances in the ensuing years, more complete and reliable experiments were conducted on compressed speech.

Sampling Method

A method of sampling speech by a switcher that intermittently sampled segments of a recorded tape was demonstrated by Miller and Licklider (1950). With this technique, it was found that up to 50% of speech could be eliminated before intelligibility dropped below 90%. These findings held true as long as the sampling was done at a frequency of at least 10 times per second. By demonstrating that a considerable amount of speech can be eliminated,

this study confirmed the contention of Shannon and Weaver (1949) that language is highly redundant.

Building upon the concept of discarding a portion of the speech signal, Garvey (1953) described a method of "cut and splice." Periodic portions of recorded tape were manually cut out and the remaining portions were spliced together. This technique allowed speech to be compressed without voice distortion but was too time consuming to be practical.

The electromechanical method presented by Fairbanks, Everitt and Jaeger (1954) sampled speech mechanically without the need for manually cutting and splicing tape. This sampling technique was periodic and unselective. Expanded speech could also be achieved by repeating speech samples. A study by Foulke (1966 a) comparing the sampling method and the previously used speeded method, found that intelligibility of the message was superior when the sampling method was used. Comprehension, however, was not significantly increased.

Two widely cited research efforts, (Diehl, White and Burk, 1959) and (Miron and Brown, 1968) examined the compression of speech by altering only the pauses that occur between words. These pauses were shortened or eliminated altogether by either manual adjustment or by use of a computer. In comparing rates of 126 to 175 wpm, no significant differences in comprehension were reported.

Speech compression achieved by a computer allowed more analytical and precise sampling to be done. However, the cost of this kind of sampling limited its use at the time of its introduction (Scott, 1967).

More recently, two techniques have been developed that provide a more sophisticated and technical means of speech compression. The speech synthesizer can produce speech at any given rate and according to the signal redundancy (Campanella, 1967). The Harmonic Compressor shortens the speech

signal in half by dividing the signal into frequency bands and then reduces them (Foulke, 1968a). This level of technology has provided a means of more analytical and complex research into compressed speech as well as a finished product that is more effective in terms of intelligibility.

REVIEW OF THE RESEARCH

The research conducted on compressed speech in the late 1950's and the 1960's was considerable. A complete review of the literature would go far beyond the length of this paper and has been previously compiled by Duker (1974). The following is an overview which highlights the major contributors and the important issues and findings.

Research studies have examined a wide variety of treatments and variables, the findings of which basically fall into four main categories: (1) comprehension and intelligibility, (2) trainability, (3) retention and (4) applications of compressed speech to various instructional situations.

Comprehension and Intelligibility

Foulke (1968a), in a paper presented at the Perception of Language Conference at the University of Pittsburgh, identified two indices for the evaluation of compressed speech: comprehension and intelligibility. These two variables have been investigated extensively in the study of the effectiveness of compressed speech. Comprehension of compressed speech is the ability to extract knowledge and information from a given text that has been accelerated. Objective tests have usually been given to measure the amount of information which has been attained.

Intelligibility refers to the extent that one is able to repeat information which was presented or to discriminate what one has heard. Tests of intelligibility usually require the subject to repeat given words or to choose a word from a selection based on their perception of the speeded text.

Tests of comprehension involve two or more groups that listen to a text

which has been compressed to various degrees and then complete a multiple choice test on the material presented. Comprehension studies have investigated variables related to speeded playback, various sampling methods and word rates ranging from 250 to 325 words per minute. Generally, studies have found no significant difference as far as comprehension of material is concerned (Foulke, 1966a; 1967b).

Foulke (1968a) indicates that in measuring comprehension, there are two groups of factors which must be taken into consideration: (a) organismic features and (2) characteristics of the signal. Organismic factors include age, sex, intelligence and previous experience with the subject. Characteristics of the signal are concerned with word rate, method of compression and rate of occurrence of the speech sounds.

In reviewing compressed tapes, the influence of the reader's voice and style does make a difference in the comprehension of material. However, there is no information available on what determines a better reader voice quality or how to choose an effective reader. It has been suggested that the same qualities necessary for comprehensible speech at compressed rates also apply to normal speech. These qualities must be identified so that the findings may be applied to both kinds of recordings (Foulke, 1967a).

Intelligence or mental aptitude of subjects using compressed speech has been investigated and it has been shown that there is no significant difference between high and low aptitude subject's comprehension of material at one third the compression of normal rate (Parker, 1971). This finding is supported by research that shows that not only is there no difference between high and low aptitude subject's comprehension at one third compression of normal speech, but also the subjects learned more efficiently at the faster speed (Sticht, 1971).

In comparing high and low aptitude subjects, the influence of speech rate on comprehension is greater than the signal degradation which might

occur. This indicates that regardless of the listener's mental ability, other human factors have a greater effect on comprehension than factors that are of a technical nature (Sticht, 1970).

Characteristics of the signal that may influence comprehension of the compressed speech have also been extensively examined. Research conducted by Sticht (1969) reveals that speech rate and signal distortion may affect listening comprehension. Material that has a low redundancy content is particularly affected by signal distortion because missed portions cannot be obtained in another form. Linguistic cues that are included in the text are considered to be aids to listening comprehension. Inflection, use of syntax and sequencing of words can provide cues which the listener can use to comprehend material that might not otherwise be understood.

The use of a summary or precis and introduction of key words preceding the listening exercise has also shown to have no significant effect on the level of comprehension (Orr and Freidman, 1967).

Results of research in comprehension of compressed speech may be influenced by inadequacies of the measurement techniques used. Orr (1971) indicates that there is a need for reliable and valid tests of comprehension which will measure these factors more accurately for research purposes.

Nolan and Morris (1971) found that comprehension and word rate are negatively related since comprehension decreases as the word rate is increased. Motivation, however, was found to have no relation to comprehension of material at different word rates, a fact which seems to indicate that even though a person's motivation may be high, his comprehension at faster word rates may nonetheless be lower. Foulke (1968b) reported that, with word rates ranging from 125 to 400 words per minute, comprehension was found to be adequate until the word rate exceeded 250 words per minute. As the word rate rose higher, the level of comprehension decreases in an

inverse proportion. Foulke hypothesized that adequate processing time is needed for perception of words in order for comprehension to occur. If processing time is reduced, a decrease in comprehension results. Lost processing time was indicated to be a contributing factor in the level of comprehension.

Studies have shown that compressed speech is intelligible at rates compressed up to 50% of the original rate (Fairbanks, Guttman and Miron, 1957) while others report intelligibility at even higher rates of compression. The use of longer words in the text have also shown to be an aid in the intelligibility of the compressed passages (Heise, 1971).

Factors such as age and hearing loss also have a direct effect on intelligibility. Older subjects (over sixty years old) were found to score lower on tests of intelligibility than younger subjects. Even in cases of normal hearing, older subjects suffered a loss of intelligibility which Stichť and Gray (1969), suggest may be due to loss in the speech spectrum brought about by old age or a slower processing time.

Trainability

The variables of listener trainability in compressed speech and retention were investigated as additional factors which related to the effectiveness of compressed speech as an instructional tool. Blind students receiving only two hours of instruction on compressed speech demonstrated a superiority in performance over those who received no training (Resta, 1971). Although as previously cited, the use of precis and key words did not affect comprehension, training sessions of only five hours resulted in better performance (Orr and Friedman, 1967).

Training of eight to ten hours that involved compression rates as high as 325 to 475 wpm revealed no signigicant decline in comprehension. These findings led to the conclusion by Orr, Friedman and Williams (1965) that

training in compressed speech will yield better results and in a shorter period of time.

Along with improved comprehension of material, training may provide the necessary listening skill to improve processing of connected discourse. The time needed to process information may be a function of training and may be reduced with practice (Orr, 1964).

Experiments conducted by Friedman and Orr (1967) which used speeded rates up to 475 words per minute further supported the effect of training on increasing comprehension of compressed material.

Retention

The process of perception, storage and retrieval of the compressed information, generally referred to as retention, is undoubtedly of utmost concern for educators.

Studies using rates ranging from 175 to 325 words per minute and different methods of compressing tested subjects after 0 days, 7 days and one month. No significant difference was found between the groups using compressed speech and those using normal rates of speech (Foulke, 1966b). Their results are further supported by Friedman, Orr, Freedle, and Norris (1966) in their finding that retention of speeded information is as good as retention of information presented at normal speed.

Lecture presentations reduced as much as one-third the original length resulted in no significant difference in the retention of material in a study reported by Barabasz (1968). Studies involving sighted and blind subjects revealed that although there was no significant difference in retention of material at speeded rates up to 280 words per minute, blind subjects retained even more information than sighted subjects over a longer period of time (deHoop, 1967).

A study using rates of speech from 238 to 328 words per minute,

described by Woodcock (1968), showed that the efficiency for learning was superior and more information was retained at these rates than at a rate of only 178 words per minute.

Research involving retention of material presented in a simplified form suggests that more information is preserved when material is used that contains less complexity. George (1970), in a paper, suggests the need for increased research attention toward the retention variable.

Application

The use of compressed speech has been applied to many areas of education for dissemination of knowledge and training. Compressed speech has been used with the Audio-Tutorial method of instruction in an effort to contrast learning with this method as opposed to traditional approaches. No difference was found using compressed speech for information contained on audio tapes (Smith, 1979). In addition, compressed speech was found to make no difference in the comprehension of material presented in a self-paced format. Not only did students achieve as well with the use of compressed speech, but they also preferred this method of presentation over a presentation of normal speech (Orr, Friedman and Graae, 1969).

An Air Force study used compressed speech to train officers with positive results. Consideration, it was suggested, should be given to the difficulty level of material included in such a format and the intended audience. Material of moderate difficulty should be used rather than very complex material when speech is to be compressed (Watts, 1970).

Research conducted by Thames and Rossiter (1972) investigated the case of compressed speech as a pacing device to aid in reading instruction. Findings of the study showed that compressed speech pacing resulted in a significantly greater increase in reading rates without any significant loss in reading comprehension. After nine months, the increased effects were still found to be present.

In the 1960's, the Perceptual Alternatives Laboratory at the University of Louisville was established under the directorship of Dr. Emerson Foulke. This facility experimented with compressed speech and its uses with the visually impaired (Foulke and Robinson, 1970).

Other early applications of compressed speech were made in the fields of instructional broadcasting (Jamison, 1971), medical education (Boyle, 1971) and foreign language instruction (Friedman and Johnson, 1971).

CURRENT RESEARCH: BASIC AND APPLIED

The preceeding summary reviewed the relevant research literature on compressed speech published during the period 1919 to 1974. During the mid part of the 1970's, research interest in compressed speech lagged. In part this hiatus was due to the thorough and comprehensive nature of the early research, however, another major inhibiting factor was the high relative cost of speech compression technology and the subsequent limited availability of such hardware and software.

During the late 1970's interest in speech compression was renewed as a result of new innovations in electronics and an increased need for the transmission of large amounts of instructional material in short periods of time (George, 1976).

Until recently, compressed speech was achieved by sampling methods which selected portions of the original tape recording. Developments in new technology have made other methods possible by which material recorded at normal speed can be played back at a faster speed with pitch control devices that reduce distortion and allow the faster speed to be intelligible. This new technology is available at a fraction of the cost of former speech compression methods and provides the opportunity to make this technique available to users for a variety of applications that

until recently would have been impractical. This new technology has also provided a means to individualize instruction that would match the individual's rate of learning with the rate of presentation of material (Hartjen, 1977).

The Variable Speech Control Co. of San Francisco currently holds the patent rights on one "new generation" speech compressor. This device, using both analog and digital electronics, when joined with a variable speed tape recorder/player can take normal speech of approximately 150 words per minute and either speed it up to 2.5 times its rate (375 wpm) or slow it down to .6 time its rate (105 wpm) (Dickstein, 1977). This unit, known as the Variable Speech Control Module provides a number of advantages over earlier speech compressors in that (1) through the use of micro-processor technology, the degree of pitch distortion has been reduced below levels previously achieved. (2) The VSC unit is a playback, rather than recording device, a fact which has further reduced the cost. (3) The playback rather than record nature of the device permits the use of any previously recorded, normal rate material. (4) The playback speed of the unit is continuously variable from .7 to 2.5 times normal rate, making adjustment to individual listener needs possible. A number of other, similar variable speed playback modules and players have been recently made available to the public as well as a unit similar to the VSC module which is available to the blind through the American Printing House for the Blind (Dickstein, 1977; Mowinski and Lauer, 1980).

The majority of basic research that has been conducted in recent years in the area of compressed speech has continued to examine many of the same issues that were of interest in past studies. The focus in contemporary work has, however, expanded on previous studies in order to gain more insight into the effectiveness of this method as it relates to

individual aptitudes. Researchers have begun to measure the effects of variables that had not been previously examined. One such study by Grosjean and Lane (1976), examined the independent variables of articulation rate, number of pauses and duration of pauses to determine how the listener can integrate them into an overall impression of the rate of speech. The researchers found that, although it was possible to develop a predictive model, articulation rate contributed most to the listener's concept of speaking rate.

In a comprehensive study conducted by Adelson (1975), the researcher utilized hour long lectures rather than short passages, presented at rates of 175 and 275 wpm. The researcher suggested that shorter passages such as those used by earlier researchers do not adequately assess a listener's overall comprehension. Findings of the study indicate that the length of stimulus materials is a critical factor. Significantly larger comprehension losses were apparent when materials reflected the more realistic length of most instructional presentations. Also of importance was the conclusion of the researcher that the efficiency index of Fairbanks et al.,(1957) should be questioned because it fails to take into consideration the factors of: density of ideas, number of items not learned, importance of items learned and not learned, the relative difficulty of items learned and not learned, and a criterion of acceptable comprehension which is stated in advance. The efficiency index was further questioned on the grounds that it justifies a method which appears to only encourage skimming of material at the expense of analytic thinking. More research was suggested to establish the optimal length of a presentation for realistic situations at different educational levels and the establishment of criteria to measure idea density.

The traditional measures of intelligibility and comprehension were

investigated by deHaan (1977) in an attempt to determine if an individual's self-selected rate threshold could be used as a measure of either variable. Results indicated that an individual's threshold is an extremely reliable indicator of compressed speech intelligibility but not of comprehension.

Other research related to the comprehensibility of compressed speech found that comprehension is closely related to subject's habitual reading speed (Hausfeld, 1981). Strong evidence was presented for a working-memory processing limit of approximately 275 wpm. Speaker familiarity was also investigated as a factor influencing comprehension of compressed material, but was rejected as a significant variable in a study by Thompson and Silverman (1977).

A study of the effects of sex, age, passage structure and speech rate on listening comprehension of children and young adults conducted by Riding and Vincent (1980) yielded the following results: 1. Both sexes performed best with passages that contained related sentences that were positioned together and were presented at a slow rate of speed. 2. Girls were better than boys when the rate was slow and content details separate but were inferior to boys when the rate was increased. 3. Girls at age 15 showed the greatest drop in recall of compressed material, a finding which the authors suggest may be due to more complex processing strategies employed by women. The authors further suggest that if such a trend continues into adulthood, women may learn best in situations which involve no time pressure.

The comprehension measure itself has been put in question in a study by Behnke and Beatty (1977). The researchers contend that comprehension cannot be accurately measured by the standard multiple-choice question technique. They suggest that it is not clear, how sure the respondee is to the accuracy of the response. This study used a confidence-weighting technique to measure comprehension and found a significant drop in weighted

comprehension when speech rate was doubled (275 wpm). The researchers speculate that for longer passages such as occur in classroom instruction, the drop in comprehension could be of major proportion.

A series of studies (Beasley, Maki and Orchik, 1976; Riensche, Konkle and Beasley, 1976; Beasley, Bratt and Rintelmann, 1980) investigated the variable of intelligibility using clinical measures of speech discrimination. Findings generally supported early research to the effect that children have more difficulty discriminating compressed material than adults and that sentences are more intelligible than monosyllables, an effect the authors attribute to redundancy within the sentence.

Training in rapid reading was shown to improve comprehension of compressed material by Boatson (1978). Other findings, while non-significant, indicated that such training may be more effective with highly compressed speech.

Compressed speech has continued to be used with the blind and visually handicapped as a valuable listening tool. Different rates used for compression are still of interest to researchers who wish to determine if rates affect learning efficiency. Findings obtained by Myers (1978), indicate that learning is more efficient at the faster rates of compression and that factors of intelligence, grade level, sex and comprehension level were insignificant in determining learning efficiency. It is implied that compressed speech may provide an alternative to blind students to keep up with their sighted peers who can read much faster in a shorter period of time. Results of this study conducted in a residential school should be confirmed with research done in an integrated setting so that the findings can be applied to other situations and learners.

Affective dimensions of the use of compressed speech have been explored with respect to learner anxiety and its relationship to the technique, in a study by Beatty and Behnke (1978). Results support the notion that as

the rate of presentation increases so does learner anxiety. The use of this technique may indeed be counter-productive to the learning task unless sufficient measures can be taken to lessen anxiety. The researchers suggest that a reduction in anxiety may result in greater information processing efficiency. The authors further suggest, however, that the decreased efficiency may be due to a combination of both anxiety and perceptual limitations.

Moderate compression of up to 30%, has been found to have no effect on comprehension or evaluation of emotional variables in reviewing tapes of dialogue for counseling sessions. Empathy, warmth, genuineness and depth of self-exploration were all comprehended without any significant variation in a study conducted by Schwab and Travers (1975).

A number of studies have examined the rates at which subjects prefer to listen to compressed material. One study (Leeper and Thomas, 1978), has reported that generally children preferred a rate of 200 wpm the most and least preferred a rate of 100 wpm. Although younger children tend to prefer faster rates than older children and adults, this may be due to the fact that children need to process information as a whole instead of piece by piece as older subjects do. Consequently, it is more helpful for them to receive the information faster so that they can process it as units in short-term memory. The researchers make a strong case for the existence of a "chunking process" in this type of processing. Findings of Short (1978) further support learner's preference for faster rates.

Age in adults has also been found to have a significant effect on preference for listening rate (Riensche, Lawson, Beasley and Smith, 1979). Older listeners tend to need more time to process information, a fact which may be due to increased auditory perception problems that occur with older age. Although it has been found that older people prefer the slower rates of speech, there has been no significant difference found between males and females.

College students were found to prefer compression up to 300 wpm with no difference in performance. It was suggested that more students over time would begin to prefer compressed speech to normal speed tapes as their use became more common (Primrose, 1975). Rippy (1975), in an earlier study also found strong preferences for compressed speech among college students. It was also reported that students do not always use a constant rate of speed but rather vary the speed according to their needs in the listening task. He further found that students may prefer speech compression if they were permitted to control and vary the rate.

Beatty, Behnke and Froelich (1980) investigated the effect of achievement incentives on compression of rate-controlled speech and found that although comprehension was less, incentives significantly reduced the magnitude.

In research performed by Lase and Leeper (1977), listening preferences were compared using two different compression techniques: Vocom-1 selective vowel compression/pause deletion vs. the VARISPEECH 1 systematic expand/deletion process. There was an overall similarity found between the two groups for listening preferences. The researchers conclude, however, that differences in preferred rates in past studies may be due to the earlier methods that were used to compress the speech rather than the rates themselves.

Research Related to the Use of Compressed Speech with the Blind, Visually Impaired and Handicapped

Extensive research has been and continues to be conducted in the area of rate controlled speech and the blind, visually impaired and handicapped. It is possible that in this area the most benefits have been derived from compressed speech.

Bishoff (1979) presents an excellent review of the literature relative to the teaching of listening skills to the blind and visually impaired and makes a number of recommendations for the improvement of

these skills based upon the research, many of which incorporate speech compression techniques and applications.

The average reading speed of braille is 90 wpm and the speed of a professional recording is around 175 wpm. Visually impaired and blind students have had difficulty in keeping pace with their sighted peers who read about 250 to 300 wpm. College students facing this problem have used compressed speech to record class lectures and then played them back at a higher rate or have occassionally slowed the tapes down when the tape quality or extraneous noises interferred with comprehension. Speeding up commercially prepared tapes has also enabled these students to keep up with their reading assignments (VSC means top grades, 1979).

A study involving blinded veterans revealed that 86% of them were able to comprehend material that was compressed to almost 475 wpm (De L'Aune, Lewis, Needham and Nelson, 1977). It was also found that the younger subjects performed better than the older ones and that WAIS, IQ and educational level did not have any significant relationship to performance. It was found, however, that scores on the MMPI (Minnesota Multiphasic Personality Inventory) and the CPI (California Personality Inventory), which reflect positive mental health factors and psychological adjustment, were significant predictors of comprehension of compressed speech.

Although the use of compressed speech by the blind and visually impaired probably represents the most extensive as well as intensive application of the technology, other uses have been identified to aid other individuals with handicaps or as diagnostic tools.

Children with auditory processing problems may benefit from the use of time-compressed speech. Compression of 30% not only did not interfere with performance, but also appeared to be an aid in that it exercised a neutralizing effect on the decay of stimuli from short-term memory (Manning, Johnston and Beasley, 1977). Compression may also be credited with motivating the student. Woodcock and Clark (1968) suggested

that information that is presented at a rate which is slower than the students optimum processing rate may be blocked by extraneous information. Manning, Johnston and Beasley (1977) feel that this phenomena may be particularly acute with children who experience auditory processing problems and consequently, may be able to use compressed material to minimize this effect. Results of this study indicated that 30% time-compression for children with auditory perceptual problems helped them to perform approximately as well as normals.

In addition to general auditory processing problems, compressed-speech may prove useful in the diagnosis of central auditory lesions in children. There appears to be poorer speech discrimination in the ear contralateral to the site of lesion at 60% time-compression. The use of this method has been put forth by Oelschlaeger and Orchik (1977) to help to determine the site of lesion. The authors suggest the incorporation of compressed speech techniques into an auditory test battery for children.

The use of time-compressed speech has also been suggested for inclusion in a test battery for the diagnosis of peripheral and central auditory processing problems as a function of aging. Increasing age and time-compression rates showed a decrease in intelligibility and with an accompanying decrease in sensation level (Konkle, Beasley and Bess, 1977).

Aphasics demonstrated a need for more processing time in order to produce more complex and developed language. Manipulation of processing time may be indicated for use in the beginning stages of therapy or for introducing new concepts to the patient, although the optimum processing time has not been established (Goldfarb and Halpern, 1981).

Reading and Language Instruction

Success with the use of compressed speech tapes has been achieved for teaching reading skills. High school students with Learning Disabilities have been able to increase their reading speed and comprehension by reading

the printed text while listening to the compressed version (Variable Speech Control Co., 1979). Other findings have reported that reading speed achieved by this method can approach a 50% increase in speed and that this increase can be maintained over a period of time (Reading speed up 50%, 1978). Higher Education not only used the compressed tapes along with the written text but also used it for building vocabulary. Such application has been important for remedial purposes to aid the student who cannot keep pace with his peers. Advanced students also benefit from such materials as they prepare for GRE's, skim through reading material or simply use it for a motivation and challenge (University students increase reading, 1982).

Children with reading impairment differ from normal readers on scores used to measure compressed speech. It has been suggested by Freeman and Beasley (1978), that compressed speech could be used as a diagnostic tool in identifying these children with reading problems by their scores and the types of errors they make on these measures.

The use of compressed and expanded speech in foreign language instruction may appear to work against the attainment of correct pronunciation, however, it was found by Wingfield (1975) that normal intonation of language minimizes loss of intelligibility. These findings were further supported using both French and English materials by Wingfield, Buttet and Sandoval (1979). The implication of these findings is that even with the partial pitch distortion common to compressed speech, a sentence spoken with normal intonation will still retain a high degree of intelligibility in several languages.

Flaherty (1979) reviewed much of the literature related to compressed speech and foreign language instruction and concluded that (1) speech compression and expansion techniques appear to have considerable influence in the learning of a foreign language and (2) that much of the basic research previously conducted on speech compression should be replicated in the area of foreign language applications.

Students of foreign languages in the past have experienced a lack of control over commercially prepared tapes. With the use of compressed tapes the advanced student may be challenged or the tapes can be used as aural pacers while the student reads along silently. Foreign language that has been prerecorded also has the problem of eliminating the redundancies and pauses that are present in regular conversation. As a result, the listener is expected to comprehend the foreign speech at a rate that is faster than conversation. With the aid of a speech expander, the student is able to slow down the rate of speech in order to allow for more processing time and thus prevent cognitive overload. This expansion replaces the juncture pauses that are lost in prerecorded text which are essential to comprehending spoken speech (Speed control provides effective foreign language, 1980).

The teaching of English as a second language has also been an area where the use of speech compression has been researched with important findings. It was found by Neville and Pugh (1975) that foreign speakers who are learning to read English have more difficulty with pacers than silent reading because they cannot go back and reread a passage that was not clearly understood. Nonetheless, rate-altered speech is useful in helping foreign students to read and comprehend written English. Expanded speech that slows the rate down can make the task easier while speeding the text up can provide more advanced practice. The difficulty of the task can also be increased by simply speeding up the rate without having to change the existing text. Vocalisation of the text while reading was also found to decrease as students became more proficient in their reading due to the use of compressed tapes. Bruns (1978), in a study, found that daily English language training via compressed speech tapes facilitated achievement on an English criterion measure and improved learning efficiency.

Other Applications of Compressed Speech to Learning and Instruction

Speech Compression has been utilized for general instructional purposes in an increasingly frequent manner. A variety of specific instructional areas have made use of compressed speech and it has become an important study device in college and university instruction and learning skills centers. These centers generally offer services to an entire institution and consequently aid a variety of subject areas. Bimodal programs that combine listening and reading serve to increase reading speed without decreasing comprehension. Second language learners can review tapes that are slowed down to make the foreign language more comprehensible (Olsen, 1978). Media services have recorded lectures so that students can benefit from listening to rate-altered versions without having to rely on their own poorer quality recordings that may prove to be more distracting (Special media services help students, 1979). A course in Listening Dynamics has also been offered to students so that they might profit from developing listening skills that otherwise would not have been refined. Listening centers can service students by providing an opportunity to review material, preview large quantities of information, slow material down that is difficult, unusual or complex (Listening programs at Mesa College, 1981).

Controlling the rate of speech has also been applied to paramedic nursing. Emergency calls that are received in a hospital can become both legal and medical records. Hospitals can also use these tapes as training materials to review the procedures and methods used with each call. In one hospital, reported in Biomedical Communications (The Reviews are In, 1979), weekly review sessions are held to evaluate performance and procedures on half a dozen tapes. These tapes are played at the highest speed unless otherwise requested, thus saving time. The tapes are also played at this high speed when they are reviewed for selection for these weekly sessions. In situations where background noises may interfere with

intelligibility during a critical situation, the tapes can be played at a slower speed in order to extract the important information.

Time spent commuting to work is usually considered wasted time. With the use of time-compressed speech, this wasted time can be transformed into a profitable experience. In a study by Singer, Dilloway and Ganjamie (1976), subjects, while driving to work, listened to material presented at three different compressed speeds: 200, 230, 260 wpm. No significant differences were found between the varying rates and the control group who simply read the material. This implies that compressed speech can be used while driving in order to study for examinations, review material, preview material or simply use the time to listen to any chosen material the user may want. The authors further suggest the feasibility of using compressed material for study in environmental conditions that impair reading such as poor lighting or during times of restricted activity, possibly during hospital stays.

Time-compressed speech has also been used for in-house employee training. (Variable speech control saves, 1981).

Other Contemporary Uses of Rate-Modified Materials

Increasingly, rate controlled speech is being used to maximize the input of information to the public as well as for other, persuasive and economic applications.

In the legal and law enforcement area, the use of compressed speech has been investigated. Time-compressed speech in moderate rates was found to have no negative effects on juror's ability to comprehend legal discourse or to make legal decisions. In a study conducted by Levison (1978), jurors tested were able to listen to information of "relative difficulty" and recall more "factual information" than those who listened to natural speech. Included in the compressed material was the attorney's summation, cross-examination of a witness and the judge's charge to the jury. Law enforcement has applied speech expanders/compressors in cases

of hysterical phone calls to a dispatcher or instances where a foreign speaker may be difficult to understand. By slowing the tape speed down, an official is better able to decipher what was said, especially if requesting the caller to repeat the message may not be a convenient or possible alternative. Slowing down recorded speech has also been used for surveillance to understand "street talk" that at normal speeds of delivery is almost unintelligible. The law official can slow the speech down to a point where he can transcribe the words as he listens to them. Speeded speech, however, also serves to be a useful tool when used to review testimony that is lengthy and has previously been examined (The talk of the town, 1978).

In a series of studies by MacLachlan and others, time-compression techniques were applied to advertising messages presented via radio and television. Not only did the use of moderate compression rates (maximum 40%) permit more information to be encapsulated in a thirty second commercial, but its use had significant cognitive and affective effects on listeners. It was found that listeners recall of the products described was not significantly lessened, however, levels of interest in the message was increased in some cases by the use of compression techniques (MacLachlan and LaBarbera, 1978). It was also suggested that listeners prefer messages presented at a faster rate. MacLachlan (1979) also describes an experiment which indicated that viewer's attentional effort level was increased significantly by speeded messages. These findings were confirmed in a study by MacLachlan and Sigel (1980) where viewers watched time-compressed television commercials embedded in a news presentation. Viewers who watched the compressed messages recalled products more frequently and could describe the content of the message more frequently than normal speed, control groups. These studies confirmed an earlier study by Wheeless (1971) which indicated that the sales effect of a message was not reduced when rate of presentation was increased.

MacLachlan, (in press) found also that viewers perceptions of television spokespeople was altered when the messages were rate-increased. These speakers were seen to be more energetic and to a degree, more knowledgeable.

Other research in mass media has described the use of time compression technology to compress television or film presentations into shorter periods of time. Using relatively small rates of compression (8-10%) it is possible to encapsule a 130 minute film or video program into the standard 120 minute video cassette, thereby achieving an economic advantage (Angus, 1981).

New Research Directions

With the advent of the newer, variable speed compression technology, has come an increased interest in the application of time-compressed speech. A corresponding renewal of research in the area has emerged. It would appear useful, at this time, to put forward a number of recommendations for the directions this research should follow.

Replication of some of the past research in new areas of application would provide some insight into those specific instances where this technology can be of use. We also should bear in mind, however, that speech compression, like many other instructional technologies, is not a panacea for all instructional ills. Research should attempt to carefully delineate those areas or applications where the learning advantages of time-compressed material can be of most benefit, while at the same time identifying those areas of minimal benefit. It may also be possible that the relatively small decrease in comprehension at moderate rates can be accepted when the nature of the learning task is such that high information redundancy is present or the task is not critical in nature.

The variable speed advantage of the new technology probably is one of the most significant factors operating on the renewal of research. This advance can now make individualization of time-compressed material

possible. Until now, the range of compression rates was limited and listeners were generally forced to accept only one, experimenter controlled rate. Much like self-paced instruction, the variable speed feature will allow the listener to adjust the rate to his or her optimal listening or processing rate, with the added advantage of permitting a self-selected slow down or speed up based upon the specific material.

Research should focus on a number of interacting variables, primarily those of individual listening and processing aptitudes and how they interact with presentation rate, type of information, the specific learning objective/task and the purpose to which the information will finally be put. Current interest in the Aptitude Treatment Interaction (ATI) research paradigm has reflected our need to individualize instruction. This research orientation has enabled us to examine how individual characteristics of the learner interact with various types of instructional materials to meet the needs of specific types of learners.

Only limited research in the past has focused on an ATI approach to investigating the interaction between speech compression rate and individual learner characteristics. Current and future research should, however, proceed in this direction. Numerous variables such as comprehension, intelligibility, attention, processing rate, message complexity, etc., have, fortunately, been identified in previous research; a fact which should aid researchers in the formulation of new studies. Many other, as yet unexplored, variables are apparent however. Primary among which are those relating to the individual such as cognitive and perceptual styles.

Time-compressed speech can be seen as an auditory analog to visual complexity, a variable given extensive research attention in the past. Through the study of the interaction of both types of stimulus complexity, a clearer understanding of human information processing may be achieved. Speech compression would appear to present a useful tool for the continued

investigation of auditory information processing, especially relative to channel capacity, verbal complexity and both visual and auditory processing rates. Research currently underway at the University of Pittsburgh is directed toward the interaction of this auditory complexity variable and individual perceptual and cognitive styles.

Other directions for research are suggested by the past research on mass media effects of time-compressed speech. Marketing and advertising research is not too distant from learning research and indeed many of the same variables are concurrently being investigated. Contemporary research in television and radio messages presented at higher rates seems to have strong implications for instructional materials design in terms of the variables of recall, attention and motivation. Further research in this area would appear extremely worthwhile.

Recent, increased concern for the educational and training needs of the handicapped make research thrusts in this area obvious. Although much primary research was aimed at blind and visually impaired individuals, compressed speech can now be seen as a technique for the rapid transmission of information to a wide variety of individuals who have physical handicaps which impede or impair their ability to gain information in traditional manners.

Finally, the need of the general public, in times of what has been described as the "Knowledge or information explosion", to gain rapid access to useful information, makes time-compressed speech a significant compliment to "speed reading".

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