RETENTION AS A FUNCTION OF RATE OF INFORMATION TRANSMISSION AND DEGREE OF COMPRESSION

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Psychologists have long been concerned with discovering the conditions under which information can be most effectively transmitted from one person to another through the use of speech. In a classic study Goldstein (1940) presented recorded speech at speeds varying from 100 to 322 words per minute (wpm) and found an almost linear loss in comprehension as the speed of presentation was increased. However, Goldstein did not take into account that the amount learned per unit of time might vary differently from the overall amount learned. While in the Goldstein data the least amount of learning occurred at the highest speed, this finding does not exclude the possibility that a greater amount might have been learned per unit of time at the highest speed than at any other speed. However, Goldstein did not compute an efficiency index to indicate amount of learning per unit of time at each speed, and this problem was not studied until nearly a quarter of a century later when Fairbanks, Guttman and Miron (1957a) conducted research on the problem. The latter research workers were able to show that when learning from recorded speech was measured, in terms of the number of objective test questions correctly answered, the optimum rate of presentation was about 280 wpm. They also showed in a later study (1957b) that subjects learned more when the material was presented twice at 282 wpm than they learned when the same material was presented once at 141 wpm.

While Goldstein speeded his material partly by increasing the original rate of speech and partly by increasing the rate at which the record was played, Fairbanks, Guttman and Miron used a different approach. They increased speed of presentation by removing small segments of the recorded speech producing what has been termed compressed speech. They were able to show that such compressed speech produced greater comprehension than speech that had been speeded through the efforts of the speaker. The compression procedure is designed to remove redundancy of speech at the phoneme level by removing a small fraction of phonemes identified at random. The removal of redundancy does not alter the amount of information presented.

Fairbanks, Guttman and Miron used a device referred to as a speech compressor which Fairbanks himself had invented. A similar machine has been produced commercially and is marketed under the name of the Time and Tempo Regulator.

While some of the redundancy in speech can be removed by the excision of small sections of phonemes, speech also has redundancy of another kind. To some extent whole words can be dropped from speech without an appreciable loss of information. The writer of a telegram performs this kind of compression hoping to transmit the greatest amount of information through the fewest number of words. This process we will refer to as word compression to distinguish it from time compression which Fairbanks and others have used.

Thus, messages can be compressed either by the partial elimination of either intra-phoneme redundancy or inter-word redundancy or by a combination of both of these methods of redundancy reduction. Both of these methods of compression, however, are likely to do more than eliminate mere redundancy, for a level is soon reached in the dropping of material when further elimination results in the reduction of the information available. For example, the phonemes in a particular word can be cut only so far and still retain intelligibility; beyond that point the word becomes unintelligible and information is lost. Again, some words can be dropped from a typical sentence without loss of information, but the dropping of additional words reduces the amount of information available to the receiver. If this position is correct, then one might expect that a combination of both forms of compression would provide more effective high-speed transmission of information than would either one alone. This study explores the relationship of degree of compression by both of these procedures to level of comprehension and, in addition, attempts to determine the optimum combination of these two compression processes for producing material from which there will be a maximum amount of learning in a given time.

Method

Design.--Materials from the first half of the Davis Reading Test Form 1A were presented to subjects in one of a combination of compressions by time and words. Five levels of time and word compression, making a total of twenty-five

treatments, were used with ten subjects per treatment. The treatment used as a base contained 100 percent of the words in the first half of the Davis Reading Test, and was presented at 200 wpm. This latter speed was chosen because it is reasonably within the experience of subjects, and in keeping with other studies in the series. This speed established the base time for subsequent time compressions.

Compression by words was undertaken by requesting a group of thirty-five undergraduate students at the University of Utah to eliminate those words from the passages which would not alter their essential meaning. Compressions were obtained by this method so as to have remaining 80, 60, 40 and 20 percent of the original material. Each of these word compressions, and also the 100 percent version of the original material, was presented at each of the five time compressions produced by a Tempo-Regulator. These time compressions removed 20, 40, 60, and 80 percent of the material and, hence, reduced the time taken to present each passage to a corresponding percentage of the original time. Thus, treatments ran from 100 percent of the material at 100 percent of the time to 20 percent of the material at 20 percent of the time, organized in a 5 x 5 design. The rate of presentation in words per minute is shown in Table 1.

Table 1

Time Rates in Words Per Minute

Per Cent of Words	Per Cent of Original Time				
	100	80	60	40	20
100	200	250	333.33	500	1000
80	160	200	266.67	400	800
60	120	150	200	300	600
40	80	100	133.33	200	400
20	40	50	66.67	100	200

Subjects.--Subjects were derived from two sources. The original intent was to draw subjects entirely from English classes designed for non-college oriented seniors in an academic high school. A sample of 125 boys and 125 girls was thus selected with a mean Pintner I.Q. of 103. These were divided into 25 groups of 10 subjects each. However, since the performance of the last ten of the groups tested involving 100 subjects showed outstanding inconsistencies with other available data, these groups were replaced with subjects from pre-admission remedial reading classes at the University of Utah. These latter subjects were selected because of their similarity to the subjects in the original group in terms of I.Q. level. Two of the treatments of 12th grade subjects, which provided satisfactory data, were also rerun to check some of the original data against the new data. On these two groups the new data and the original data showed a close correspondence as will be indicated later in the presentation.

Apparatus.--Short sections of the passages about 20 words in length were shown to the subjects by means of a remotely controlled Victor Soundview filmstrip projector, model No. PS65, which was controlled manually by the experimenter who timed changes of frame by means of a Hunter Clockcounter.

Procedure.--The investigator sat behind the subjects, who were seated eight feet four inches from a screen onto which slides containing the test passages were projected. The height of the letters on the screen was 0.75 inch. The subjects were assigned at random to one of the twenty-five treatments. The projection time for each slide was determined by the word-per-minute rate for each treatment. After each passage, the subjects were asked to answer the questions concerning that passage derived from the original test. Subjects were given an explanation of the task and subjects were first exposed to a sample passage and a set of sample items. The subjects were instructed to answer every item in the test. Ample time to answer all items was given.

Results

Efficiency scores were computed by correcting the raw scores for guessing (rights minus one-fourth the wrongs) and then dividing the time for presentation by the scores. The means and standard deviations of these scores are shown in Table 2. The means are graphically represented in figure 1. The distribution represents a smooth surface indicating internal consistency of the data. While the data were derived from two separate classes of subjects, on two groups data were collected from both classes in order to check on the comparability of the two sources of subjects. The duplicated data is shown in parenthesis in two cells in the table. In these two cells the means for the 12th graders

Table 2

Means and Standard Deviations of Efficiency Scores

Per Cent of Words		Per Cent of Time Compression				
		100	80	60	40	20
100	M	1.678[a] (1.606)	1.511[a]	1.566[a]	1.739	1.196
	SD	.513 (2.395)	1.122	.968	1.863	2.202
80	M	1.432	1.430[a]	1.957[a]	3.027[a] (2.772)	1.739
	SD	2.114	.746	.623	1.9 (5.992)	4.704
60	M	1.280	1.437	1.633[a]	2.065	2.174
	SD	.584	1.435	1.245	1.772	3.904
40	M	.828[a]	.990[a]	1.377[a]	1.033	1.304
	SD	.527	.639	.868	1.159	2.574
20	M	.608	.634[a]	.847	.660[a]	.761
	SD	.745	.698	.945	1.148	2.178

The means and standard deviations in parenthesis are for those cases in which acceptable data were available for both the 12th grade students and for the students in the University remedial reading classes.

[a]These groups were derived from remedial reading classes at the University of Utah.

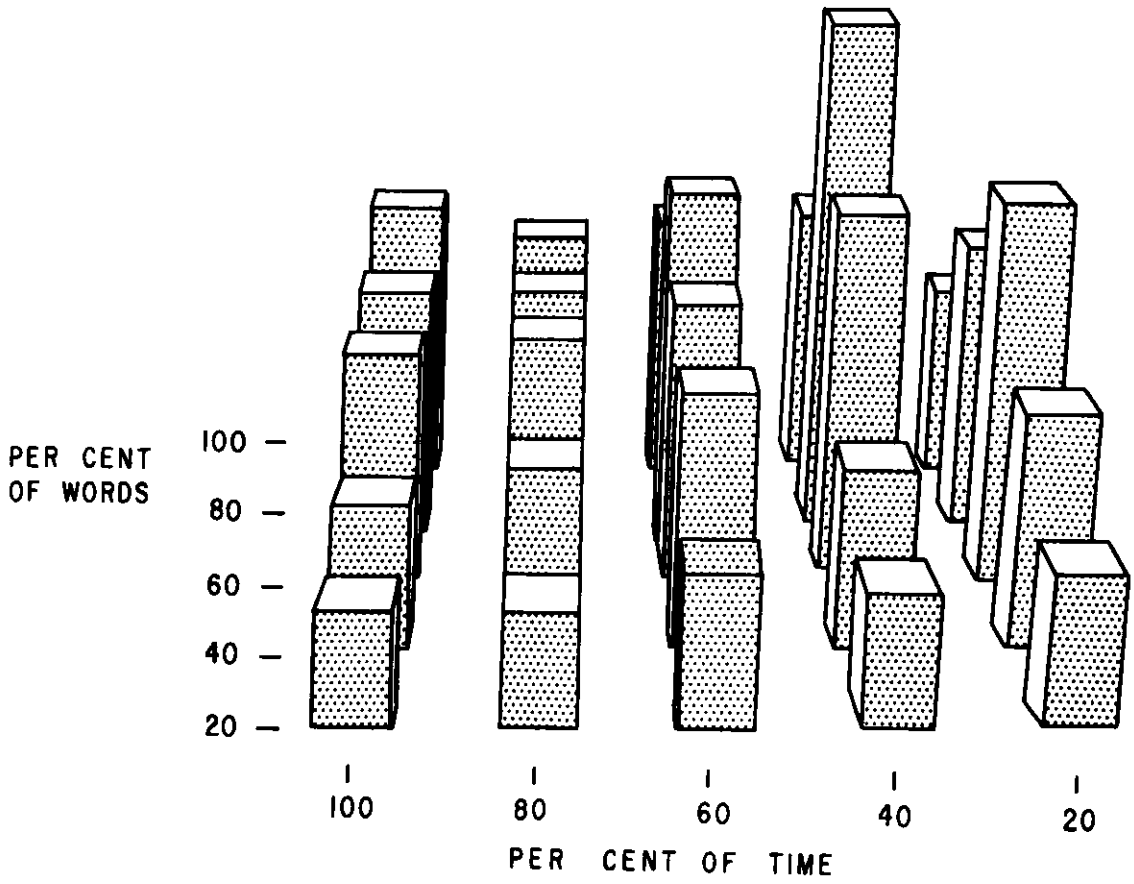

Fig. 1.--Graphic representation of the comprehension surface.

and the remedial reading students correspond very closely, a fact which validates our subject selection procedure. Maximum learning per unit time occurred when the version involving 80 percent of the words was compressed to 40 percent of the time.

Discussion

The data presented indicate that the most effective form of compression of verbal information, in terms of a short-term retention criterion, is one which combines both time compression and compression through the elimination of words. It was a matter of considerable surprise to the present authors to discover that the optimum rate of presentation was one in which material was presented at a rate of 400

wpm. This peak was clearly not a product of some freak operation of error factors operating in our particular group, for the distribution showed an overall tendency to peak in that particular category. The three-dimensional distribution represented a fairly smooth surface with an asymptote where the coordinate representing 80 percent of the words crossed the coordinate representing time compression to 40 percent. There would be considerable interest in determining whether the same asymptote would be achieved if the subjects were exposed to the material for more than one trial. An interesting question is whether the asymptote would move towards higher levels of compression if the subjects were derived from groups having higher scores on intelligence tests.

References

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