

# Text Display by "Saccadic Scrolling"

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A novel method of displaying alphanumeric text is described, named "saccadic scrolling." Text is flashed onto an electronic display one line at a time and remains visible until replaced instantaneously by the next line. The user has manual control over the display by either advancing it line by line or adjusting the rate of automatic replenishment. Experiments are reported in which reading speeds and comprehension for various modes of this kind of display were compared with the conventional "Times Square" type scrolling as well as with print. Single-line manual and automatic saccadic scrolling modes yielded results approaching that of print, suggesting that this type of refreshable display could become an acceptable alternative under certain conditions to hard copy. (The Times Square mode proved inferior to the others in every respect.) Suggested applications for the technique are: autotrainer for the reading handicapped, communication terminal for the deaf, and general business use.

For centuries man has taken it for granted that the carrier of written communication is paper, even if electronics played a role in the transmission phase, as in telegraphy or telex. Yet once the information recorded on it has been made use of, the paper frequently gets discarded. The process of transmitting information in the form of marks on paper thus requires materials (trees, rags, dyes), energy (to run the printing presses and for the transportation of the paper), and space (for storage). When the information recorded on the paper is transitional rather than archival, all of the above, having been only auxiliary to the communication process, become in a sense wasted. Seyler (1975) argues persuasively against the use of hard copies for transmitting and storing non-archival information, and contrasts non-interactive information systems with interactive communication systems.

The case for a volatile display is presented by Marko and Farber (1978) from another viewpoint. They call attention to the (theoretical) 100:1 mismatch between the 5,000 bits/s data transmission capacity of a telephone channel (with special coding and equalization) and the approximately 50 bits/s limit on information-processing speed of an adult reader. They recommend resolving the inefficiency resulting from the mismatch by the installation of a 1-2 Mbit storage, corresponding to 100-200 pages of text, between the communication channel and the reader. (Actually their proposed scheme, couched in terms of a

"briefcase computer," allows the user both to receive and to transmit messages.) Short bursts of "on-line" transmissions are then separated by long periods of "off-line" reading, composing text, calculating, etc.

Given the advantages of a refreshable visual display, why not then use one presenting an entire page, as in print?

This obvious question could be countered by its less obvious opposite: why should one? After all, the notion of a "page" is inherited from printing technology, and is not germane to the process of reading text. (In contrast, single lines would not suffice for presenting graphic information.) Thus the conventional cathode-ray-tube displays are increasingly being challenged by solid-state flat panel displays (Tannas & Goede, 1978). These encompass a variety of physical phenomena, such as gas discharge, light-emitting diodes, electro-luminescence, liquid crystals, and so on (Pucilowski & Schlam, 1978). Their cost is generally a function of the display area, and so is the complexity of the driving circuit. They may be fixed-font symbols, such as the familiar 7-segment display, or consist of a matrix of "pixels" (picture elements), such as the Burroughs "Self-scan" panels.

These displays, unlike a cathode-ray tube can be manufactured in a wide range of shapes and sizes, including single lines of 40 characters or more. Furthermore, they are flat and can be driven with much lower voltages than a CRT, making them attractive for applications where portability is of importance.

The question then arises whether a single-line (or perhaps two-line) display would be acceptable for continuous rapid reading. One's first guess might be that it might not, for such an artificial restriction could well be expected to seriously impede the reader in reviewing an earlier part of the sentence, which we usually do to resolve ambiguities. In this paper we report on two experiments designed to explore this question, and on results that show definite promise for single-line displays.

## Method

**Objectives.** The long-term goal of the research described is to explore a text display mode, believed to be novel, which we call "saccadic scrolling." In this mode, text is presented on an electronic display one line at a time, as is the "Times Square" moving news and commercial displays. Unlike these, however, which are "scrolled" from right to left in either a seemingly continuous movement or jumping one letter at a time, in saccadic scrolling an entire line remains on display for a certain period of time, and is then replaced instantaneously by the next. Such a display can be derived from the familiar scrolling process of cathode-ray

display used in computer terminals, by blocking out the view of all but one line. The resulting effect is then of new material appearing instantly in the visual field, much as it does during the fixation pauses between saccades in normal reading (Bouma & de Voogd, 1974; Rayner, 1978; Young & Sheena, 1975). It is this feature that motivated the choice of the term "saccadic scrolling."

The technical and economic justification of a single-line display lies in the cost of electronic display devices, as well as their size, weight, and power requirements. If a single-line display could be shown to be an adequate substitute for conventional multi-line ones, at least for some reading activities, then a display device would need to have only a one-line capacity, so that even complex text could be carried about in a small hand-held word processor.

**Specific Aims.** The experiments were aimed at comparing several modes of single- and double-line electronic displays with conventional Times Square scrolling, as well as with print. The criteria for the comparison were reading speed and comprehension. Also, subjective reports about the preference for various modes were solicited from subjects.

Two experiments were conducted, separated in time but under almost identical conditions. Experiment 1 was intended to explore single- and double-line manual and automatic modes (described below), with printed text serving as a reference condition. Experiment 2 was specifically designed to compare single-line automatic and manual modes with Times Square and conventional page-printed text.

**Subjects.** In both experiments subjects were recruited from university students and staff. In Experiment 1 there were 8 volunteers (3 females and 5 males); in Experiment 2, 24 subjects (8 females and 16 males) were paid \$5 for their participation. All subjects were over 18 years of age, and reported having normal vision in both eyes, with correction where necessary. They were told in advance that the purpose of the experiments was to compare reading efficiency attainable for various modes of text display.

**Apparatus.** The two main forms of presenting text were designated *page format* (reading conventional print from a sheet of paper) and *screen format*. In the latter the text appeared as white letters on a black background of a Perkin-Elmer 1100 CRT terminal. The screen was about 40 cm from the subject's eyes, with its center slightly below eye level. The capital letters on the display were about 4.5 mm high and 2 mm wide (0.65° by 0.29° visual angle, about 50% larger than when reading average-sized print). Each line of text contained 39 (Experiment 1) or 40

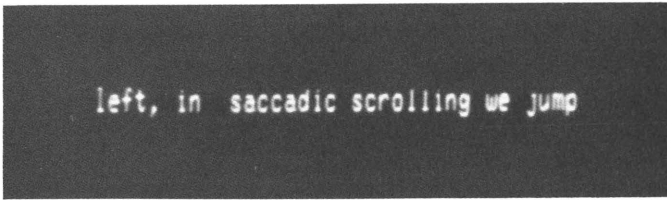


Figure 1. Single-line display on computer terminal.

(Experiment 2) upper and lower-case characters, including spaces, and was about 9.7 cm. long.

The text was made visible either one or two lines at a time, by placing an appropriate opaque mask on the CRT screen, with a slit approximately at center height. The separation between the lines in the double-line display was about 1.5 mm. A typical line of display, as it appeared to the reader, is reproduced in Figure 1.

**Modes of Presentation.** In the *screen format* three modes of presentation were employed: (i) saccadic scrolling, automatic mode; (ii) saccadic scrolling, manual mode; and (iii) Times Square mode.

In *saccadic scrolling* an entire line remained on display for a predetermined length of time, and was then instantaneously replaced by the next line, until the final line was displayed. Each text began with the words "ready" and "begin" on consecutive lines, followed by the first line of text. The word "end" appeared after the final line.

Shifting of text lines was accomplished in one of two ways. In the *automatic mode* the text advanced automatically at a uniform rate. This rate was determined via a counting process in the computer, and was initially adjusted by the experimenter. During the reading process, however, the subject could, by pressing the "s" key on the terminal's keyboard, augment the cycle time by a fixed number and thus slow down the display rate; likewise, pressing the "f" key made it faster. Each pressing of the key thus caused a constant increase/decrease in the rate, so that by repeated pressing the subject could adjust the rate at will to a comfortable reading speed. Furthermore, by pressing the "b" key the subject could back up to the previous line; this remained visible until the "k" key was pressed, which reinstated the automatic stepping at the rate in effect prior to pressing "b."

In the *manual mode* only two keys were needed: the key "l" advanced the text by one line at a time, while the key "b" caused it to return to the previous line. Any change in the displayed material thus required the pressing of a key.

The third mode was the conventional *Times Square* mode, in which the text appears to flow from right to left, moving one character space at a time, until the end of the passage. This was accomplished by re-writing the text with each character moved one position leftwards, causing the leftmost character to vanish and a new character to enter from the right. The subject could increase the speed of movement by pressing "f" and slow it by pressing "s." Each key press caused an increment or decrement in the apparent speed (i.e., frequency of re-writing the line with a character shift) of the text across the screen. The "b" key caused the text to reverse direction and move from left to right, while pressing "k" caused the resumption of right to left motion. As in the saccadic modes, the passage began with the words "ready . . . begin" and ended with the word "end."

Finally, in the *page format* the subject read the passage printed on paper in the STEP booklet described below.

The display and key functions were controlled by a PDP 11/45 computer. Before each trial the experimenter, seated at a second CRT terminal approximately 1 m to the left of the subject, selected the (pre-recorded) text to be displayed and, when applicable, also set the initial scrolling speed. The text then appeared on the subject's terminal. The experimenter measured with a stopwatch the time taken by the subject to read each passage. After the last line of the text had been displayed (i.e., when the word "end" appeared on the screen) the computer recorded the length of time each line was displayed on the screen, the number of times the "b" key was pressed, and the numbers of text lines that were displayed via the backup key.

Reading passages (eight in Experiment 1, four in Experiment 2) were selected from the STEP (Sequential Tests of Education Progress) Series II reading tests. The passages were chosen from four different topic areas, and their average length was 470 words; they were accompanied by multiple-choice questions to assess comprehension, also taken from STEP.

**Procedure.** The subject was seated in front of the display terminal in a normally illuminated room (fluorescent fixtures) and was given preliminary instructions on the use of the special function keys for controlling the display. In Experiment 2 a card summarizing the use of the keys was placed directly above the keyboard. The subject was told to read as fast as possible, keeping in mind that fairly detailed questions on the text would be asked at the completion of the reading. The subject was then allowed to practice the use of the keys to speed up, slow down, and back up the text, on a practice text not subsequently used in

experimental trials. When the subject reported understanding how the keys affect the display, the trial began.

An additional purpose of the practice sessions was to determine, approximately, a comfortable reading speed for each subject, which was then set as the starting speed of display in automatic modes.

Experiment 1 was based on a balanced design having the following characteristics: (1) All subjects viewed all the passages; the order of the four topic areas was the same for all subjects. (2) Screen-format presentation of each passage was paired with a page-format presentation of another passage in the same topic area. (3) Half the subjects saw each passage in one of the four modes in screen format, while the other half saw it in page format. (4) The four different modes in screen format were cyclically rotated among the subject.

Experiment 2 also had a balanced design: (1) All subjects viewed all four passages; each subject viewed them in a different order. (2) All subjects viewed all four modes of presentation; each subject viewed them in a different order. (3) The combinations of the four texts and the four modes of presentation were cyclically rotated so that each text was combined six times with each mode, and vice versa.

The subject was told before each trial which mode would be used, so that he could place his fingers over the appropriate keys on the terminal's keyboard. He then read the text and reported when finished. Immediately after finishing, the subject was asked to answer a set of four-alternative multiple choice comprehension questions (typically 5-6 questions for each passage). There was no time limit on answering, but the subject could not refer back to the text. No feedback was given on the correctness of the answers. Completing the test took about 70 minutes (Experiment 1) and 30 minutes (Experiment 2).

## Results: Experiment One

**Reading Speed.** The mean reading speeds averaged over all subjects for each condition are shown in Table I. The average reading speed over all four modes in the screen format, 222.3 wpm, was 14.5% slower than the 259.8 wpm in the page format, a difference which, while statistically significant ( $F[1/7] = 6.4, p < .05$ ), is surprisingly small considering the gross difference in display methods and the novelty of screen format.

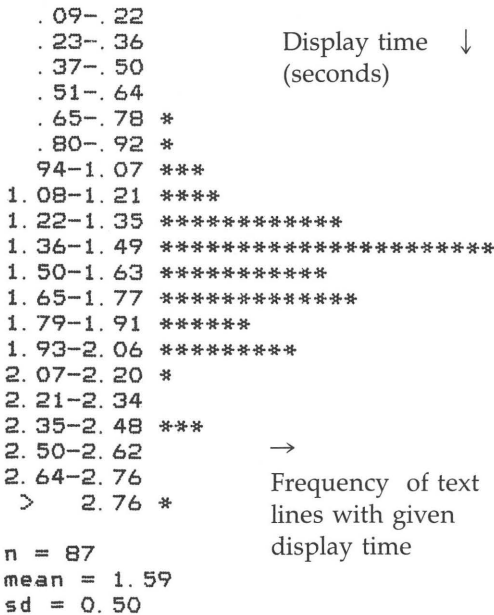
Though there were no significant differences among the four screen modes, some tendencies should be noted. In general, single-line displays were read faster than double lines, while the averages of automatic and manual modes are about equal. The absence of any difference in the latter is surprising, for the flexible self-pacing was expected to be more efficient than the tyrannical automatic mode.

**Table I:** Reading speed and comprehension scores in Experiment 1, averaged over all subjects

	Screen Format (N = 8) (Saccadic scrolling only)		Page Format (N = 32)		
	Single line automatic	manual	Double line automatic	manual	
	<u>Reading speed (words/minute)</u>				
Mean	229.5	226.2	214.0	219.4	259.8
Std. Dev.	82.8	39.8	59.0	52.4	66.9
	<u>Comprehension (% correct)</u>				
Mean	81.5	61.1	55.8	69.8	74.0
Std. Dev.	23.3	25.4	25.8	31.6	27.2

Our computer program recorded the reading time for every line in each manual-mode presentation. A typical bar graph, representing a single run with one subject, is shown in Figure 2. It is evident that the subjects did vary the rate of scrolling, presumably skipping quickly over easy lines and spending more time on difficult ones. Nevertheless, this line-by-line control did not yield a significantly different reading speed from that of the automatic mode, in which a more "sluggish" control was exercised.

Figure 2. Distribution of line display times in a single experiment.



**Table II:** Reading speed and comprehension scores in Experiment 2, averaged over all subjects

	Screen Format (N = 24) (Single line only)		Page Format (N = 24)	
	Saccadic automatic	manual	Times Square	
	<u>Reading speed (words/minute)</u>			
Mean	225	206	96	278
Median	213	203	88	305
Std. dev.	66.1	56.8	36.3	60.8
	<u>Comprehension (% correct)</u>			
Mean	58.9	60.5	53.5	63.2
Median	50.0	67.0	58.5	69.0
Std. dev.	25.3	32.2	24.0	22.6

**Comprehension.** The mean comprehension scores (percentage of correct answers to multiple-choice questions) are also shown in Table I. Again, none of the differences were statistically significant in an ANOVA, but several apparent trends are worth noting. The mean score for the page format, 74%, was greater than the average for the various modes in screen format, namely 67%, in agreement with the reading speed results. Also consistent with the speed data and the subjects' reports is that the lowest comprehension was attained with the double-line, automatic method. The single-line manual, however, led to rather poorer comprehension scores than the automatic mode, even though subjects preferred the former. Within the automatic mode, there was an advantage at the 0.10 significance level ( $F[1/7] = 5.12$ ) in favor of single-line display.

We also tabulated, for page format only, individual scores for reading speed and comprehension. The correlation coefficient is 0.36— not significant. Considering that the group included three Ph.D.'s and a graduate student, the average reading speed (260 wpm) may seem relatively slow. However, the comprehension questions were rather difficult, and subjects soon realized that careful reading was required.

Of the total 29,550 lines displayed during the experiment, the backup key was pressed only 10 times. This was rather unexpected in view of the frequent regressive eye fixations reported in the literature (Carpenter & Just, 1978), and will be discussed later.

## Results: Experiment Two

**Reading Speed.** The mean reading speeds averaged over all subjects for each condition are shown in Table II. Analysis of variance showed significant differences among the four means ( $F[3/69] = 52.77, p < 0.01$ ). Specifically, the Duncan test showed that the Times Square mode took significantly longer ( $p < 0.01$ ) than any of the other modes. Further, the page format took significantly less time ( $p < 0.05$ ) than the saccadic, manual mode. There was no significant difference between the time for the page format and automatic saccadic mode, nor between the two saccadic modes.

The order of the various modes, from fastest to slowest, thus were: page format, saccadic automatic, saccadic manual, Times Square.

Of the last 15 readers (#9–#24), 10 used the backup key during the manual saccadic presentation, 6 presses on the average, and 4 used it in the automatic, saccadic method, with 7 presses on the average. Reversal in the Times Square mode was not recorded by the computer, but the experimenter observed only 2-3 instances throughout the entire test.

A comparison among the distributions of different reading times is offered by Figure 3; by far the largest variation is observed for the Times Square display.

**Comprehension.** The mean percent correct scores on the comprehension questions are included in Table II. While the descending order of comprehension is seen to be page format, saccadic manual, saccadic automatic, and Times Square, the differences among the means are not significant, as determined both by analysis of variance and by the Friedman two-way analysis of variance.

It would thus appear that subjects were reading with the intent of maintaining a constant comprehension, and varied their speed accordingly.

## Subjects' Comments

In Experiment 1 most subjects preferred the single-line manual mode, and found the double-line mode confusing. This mode was thus omitted from Experiment 2.

In Experiment 2 when asked which of the four methods they found easiest or most comfortable, 9 subjects chose the page format. Of the screen formats, 17 subjects preferred the manual saccadic mode, 4 the automatic saccadic mode, and only 3 preferred the Times Square mode.

When asked to select the hardest to read or least comfortable mode, 15 named the Times Square, 7 the automatic saccadic, and 2 the manual

**Automatic saccadic**

MEAN= 2.293  
SD= 0.608

FREQUENCY	0	7	14	3	0	0	0	0	0
14			*						
13			*						
12			*						
11			*						
10			*						
9			*						
8			*						
7		*	*						
6		*	*						
5		*	*						
4		*	*						
3		*	*	*					
2		*	*	*					
1		*	*	*					
INTERVAL	1	2	3	4	5	6	7	8	9

**Page format**

MEAN= 1.788  
SD= 0.521

FREQUENCY	0	16	7	1	0	0	0	0
16		*						
15		*						
14		*						
13		*						
12		*						
11		*						
10		*						
9		*						
8		*						
7		*	*					
6		*	*					
5		*	*					
4		*	*					
3		*	*					
2		*	*					
1		*	*	*				
INTERVAL	1	2	3	4	5	6	7	8

**Manual saccadic**

MEAN= 2.530  
SD= 0.685

FREQUENCY	0	6	12	6
12			*	
11			*	
10			*	
9			*	
8			*	
7			*	
6		*	*	*
5		*	*	*
4		*	*	*
3		*	*	*
2		*	*	*
1		*	*	*
INTERVAL	1	2	3	4

**Times Square**

MEAN= 5.738  
SD= 2.497

FREQUENCY	0	0	3	4	4	6	4	0	1	1	0	0	1
6						*							
5						*							
4				*	*	*	*						
3			*	*	*	*	*						
2			*	*	*	*	*						
1			*	*	*	*	*		*	*			*
INTERVAL	1	2	3	4	5	6	7	8	9	10	11	12	13

Figure 3. Distribution of reading times (in minutes) among the different modes of presentation in Experiment 2.

saccadic. The manual saccadic method was thus the overwhelming favorite, while Times Square was least liked. Typical comments about the Times Square mode were: jerky, jumpy, uneven, blurry, shaky, and fatiguing.

## Discussion

While our data do not permit us to draw definite conclusions, we think that they do support the viability of a single-line electronic display. First, note that in neither experiment was there a statistically significant difference among the comprehension scores, and while in Experiment 2 page format scored highest, in Experiment 1 automatic saccadic mode performed even better. This fact, as we suggested before, may reflect a perhaps-unconscious effort on the part of the reader to maintain a fairly constant comprehension rate over all conditions. The price is paid, of course, in reading speed. However, even here the advantage of the page format was significant only against the *average* of the four screen modes (in Experiment 1), or against two of the three screen modes (in Experiment 2). This must be set against the fact that while subjects had years of experience reading in the page format, they had only a few minutes of practice in the screen format. It may therefore be reasonable to expect considerable improvement with practice in single-line reading skills.

It is interesting to relate our results to some prior research in reading. Several theories of how eye movements are controlled are discussed by McConkie and Rayner (1976), though none appear to have been universally accepted. Most relevant to our scheme, however, are regressive fixations, by which the eye takes a second look at a word or part of sentence previously read. Rayner (1978) quotes that for skilled readers typically, 10-20% of the saccades are regressive (defined here as right-to-left eye movements). Much higher figures are cited by Carpenter and Just (1978), but they employed specifically constructed ambiguous sentences which necessitated more frequent regressions than usual. In addition, their instrumentation permitted the inclusion of vertical regressions (i.e., to the preceding display line) as well. (See also: Tillson, 1955; Bayle, 1942; Rubino & Minden, 1973.)

Mitchell and Green (1978) have used a technique similar to ours but with a different constraint: each single-line display contained exactly three words. Letters were all upper-case, 0.6 cm high. No punctuation was used, except a square symbol to mark the end of each sentence. They were mainly interested in exploring reading speed variations *within* sentences as a function of syntactic and semantic variables. Never-

theless, their measured reading speed and comprehension figures were not substantially different from ours.

Their technique (as well as ours) bears a distinct resemblance to that pioneered by the so-called Harvard Films (Perry & Whitlock, 1948 & 1954) in which consecutive parts of a line are illuminated and focussed so as to guide the eye. In the course of those films the span and speed of progression are gradually increased. While the text in the films is presented in a saccadic manner, it is scanned rather than scrolled. A characteristic of saccadic scanning is the need for *phrasing* — the somewhat arbitrary choice of the length as well as extent of overlap of illuminated regions (Perry & Whitlock, 1954).

The infrequent use of the backup key in our experiment suggests that subjects were reluctant to make this much effort for the benefit of seeing the previous line again. The unpopularity of double-line display, in which the previous line was always in sight, as well as the poorer results it yielded, cast further doubt on the importance of visual access to the previous line in this mode.

Notwithstanding the above, it must be realized that the simple multiple-choice comprehension questions, while including factual recall as well as some inferences and synthesis, may not have tapped some of the higher level learning that is enhanced by instant access to large chunks of text, such as a page. Likewise, subjects could not scan forward, though for readers with poor concentration this may have been a help rather than hindrance.

Experiment 2 has clearly borne out the inferiority, in comparison with saccadic scrolling, of the Times Square mode currently adopted for such electronic gadgets as pocket calculators, translators, the Texas Instrument Speak & Spell toy, etc. (Note, however, that if characters could scroll in continuously, rather than in steps of a character width, the results could differ.) The choice between the two saccadic modes is less clear, however. Perhaps both should be made available: automatic mode for the “cruising” reader, aiming at the fastest speed yet fair comprehension, and manual mode for a more meticulous study of important messages or text, with easy backup for further scrutiny.

### **Potential Applications**

We see the main potential application of our work in the development of a reading autotrainer — a self-contained, portable system for the electronic display under program control of alphanumeric information one line at a time. The value of such a device hinges on the basic premise that for poor readers, single-line display improves attention and can be

used as a basis for individualized literacy training. Before discussing our proposed device we shall briefly review the state of the art.

Devices aimed at increasing reading speed or efficiency by controlled rate and manner of text presentation have been available for several decades (Manolakes, 1952; Wilson & Leavell, 1957; Francis et al., 1973). Reports of their performance have been mixed, and rarely have they demonstrated a clear superiority over non-mechanical methods. Controlled readers — for example, the Craig Reader and the Tach X — employ filmstrips or slides; new material cannot readily be programmed for them. The rate of change of the display and sometimes also its direction are, however, controllable by the user. Such machines are cumbersome and cannot be carried around easily.

Shadow readers are easily portable and can be attached to most printed material with some size constraints. The reader controls the rate of descent of the shadow, but the only way the reader can pause on a particular line is by shutting off the driver. The amount of information displayed on each line is, of course, predetermined by the printed text. The transition between lines is unrealistic: the top of the current line gradually disappears while the new line seeps in from the bottom. This phenomenon has no parallel in the conventional reading mode. Also, page turning becomes a nuisance.

Reading trainers are always used in conjunction with a teacher in a learning environment. Whatever improvement they produce is not usually carried over to “real-life” reading.

By contrast, in our suggested application, the autotrainer *is* designed for independent work by the learner. A possible implementation is shown in Figure 4 and the corresponding block diagram in Figure 5. It operates as follows: alphanumeric information, most commonly narrative text, stored in ASCII format on a conventional magnetic tape cassette, is read into an elastic digital store via a controlling microprocessor. Entire lines are instantaneously transferred to the strip display and are held visible: the display is advanced either automatically at a predetermined rate of “on demand” for each line. Unlike conventional devices, the reading autotrainer can be pre-programmed and individualized; rate of presentation and regression to previous lines is under user control; equipment could be made portable and even battery operated; average reading speed could be displayed immediately upon completion of a passage; with an additional keyboard and programming the user could respond to, and be assessed on, self-evaluating comprehension questions; the trainer could be used as a “programmed manual” for step-by-step instruction on the job of slow processors of information. (A recent magazine article [Meredith, 1980] describes ongoing

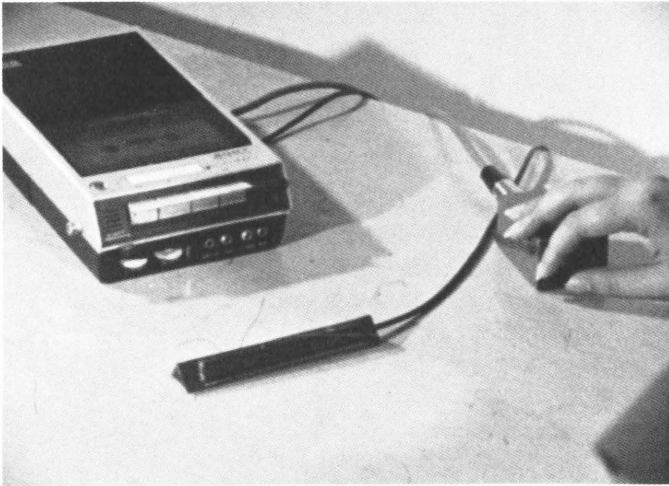


Figure 4. Mock-up of a self-contained reading autotrainer employing saccadic scrolling.

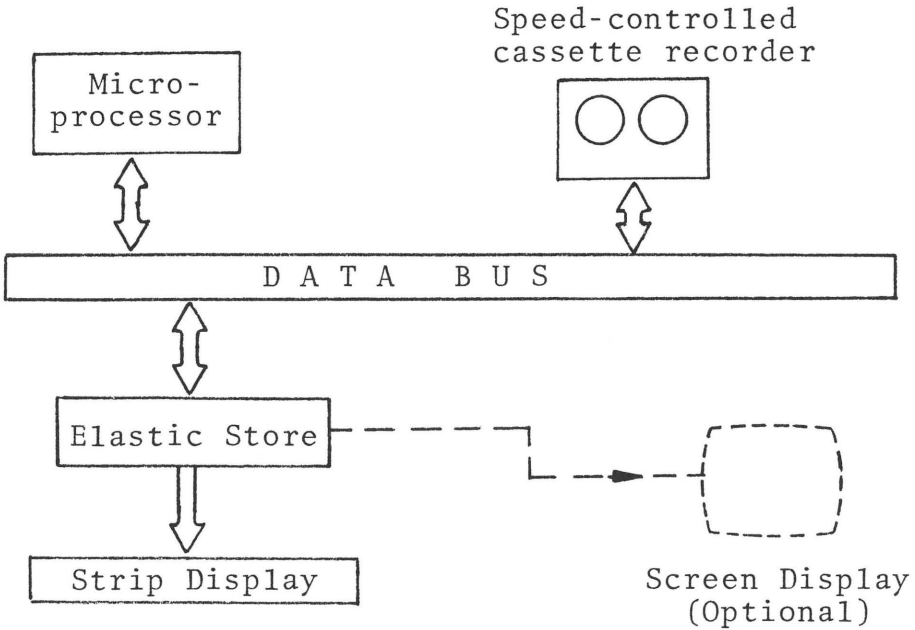


Figure 5. Block diagram of the system shown in Figure 4.

work at the California Institute of Technology by Raymond Briggs, William Rosar, and Dennis Hocevar using a 512 x 512 dot plasma screen, capable of changing 20-30 characters in a millisecond, for the study of saccadic eye motion as well as higher-level aspects of reading. Results of their work is likely to be of direct relevance to the design of the kind of device just described.)

A further application that we are considering is a telephone communication terminal for the deaf. This would be a simpler version of the Mailphone, a device currently being developed by Perceptronics, Inc. Like the Mailphone, our terminal would incorporate a touch-sensitive keyboard and a single-line display, as well as digital storage for messages. The deaf user could compose a message on the keyboard, review it on the single-line display, and only then make a telephone call for a rapid transmission of the stored message. With long messages the user could thus effect considerable saving on the cost of directly dialed toll calls by hanging up after transmission, yet use the same device in a true conversational mode whenever the cost of the call is not a factor.

Finally, we envision a device employing saccadic scrolling to be of value to proficient readers, such as businessmen or politicians, who often need to absorb rapidly the contents of urgent but volatile (i.e., non-archival) material, which may have reached them via electronic transmission. A small hand-held device using a single-line display could well meet such needs.

**Acknowledgements.** Funds for performing Experiment 1 (as well as for the production of a 7-minute sound film illustrating the technique) were provided by the Computer Systems Laboratory, University of California, Santa Barbara. Experiment 2 was performed under a contract with Perceptronics, Inc. Thanks are due to our colleagues Drs. Priscilla Drum and Robert Hanson and to two anonymous reviewers for helpful suggestions.

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