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TEXT EDITING PERFORMANCE AS A FUNCTION OF SCREEN SIZE

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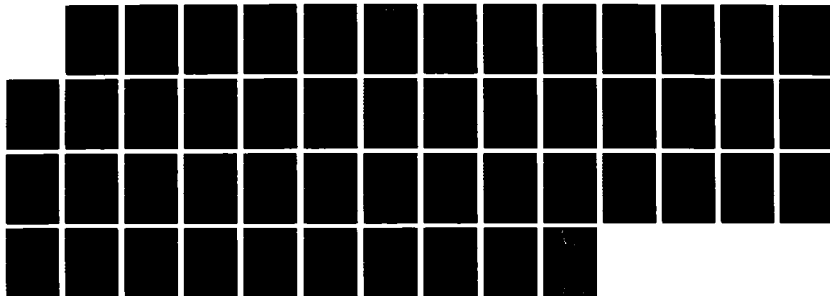
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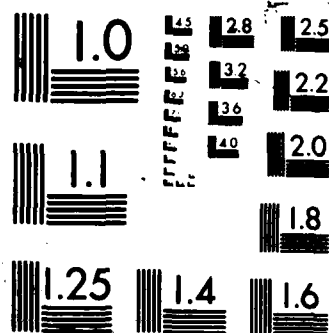
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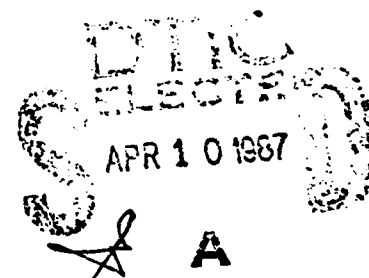
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FINAL REPORT

TEXT EDITING PERFORMANCE AS A  
FUNCTION OF SCREEN SIZE

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**FINAL REPORT**

**TEXT EDITING PERFORMANCE AS A  
FUNCTION OF SCREEN SIZE**

Prepared for:

U. S. Army Human Engineering Laboratory  
Aberdeen Proving Ground, Maryland

Contract No. DAAA15-86-D-0005, Task Order 0001

Prepared by:

CARLOW ASSOCIATES INCORPORATED  
8315 Lee Highway, Suite 410  
Fairfax, Virginia 22031

31 December 1986

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19 ABSTRACT (Continue on reverse if necessary and identify by block number) A pilot study was performed to experimentally assess the implications of CRT screen size and definition on text editing performance. The study manipulated line length (16, 32, and 64 characters displayed per line), window height (1, 4, 8, and 19 line text pages) and edit field location (text to be edited was located at the beginning, middle, or end of text messages) to measure effects on text editing performance as measured by edit field location time, editing time, and errors. Of these, text location time and location errors (as measured by vertical scroll reversals) were significantly influenced by line length and edit field location.					
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## 1.0 INTRODUCTION

Computer interface has become a necessary element of a soldier's job. Much of the new and developing tactical equipment, including weapons, sensors, and communication devices, requires that the soldier know how to access, edit, or otherwise modify, information resident in a computer. One aspect of this data acquisition and input task concerns the presentation of information on a computer screen. Information acquisition may be affected by the height of the text window, the width, (character string length) of the line, and the length of the text. These in turn determine the amount of information presented on a page of text. Human performance data concerning these display elements, in the context of retrieval of text-imbedded data, can have significant implications for computer interface display design. This will particularly be the case where constraints on display size may exist, such as in portable and transportable military hardware. Research that will identify screen design elements associated with text editing performance is required. These data will be valuable in the generation of soldier-computer interface design requirements and criteria, and in the conduct of design trade-off studies.

A previous study (Larkin, 1986) manipulated window height (number of lines presented per page) and message length to study their effects on text editing performance, using error rates, text locating time, text editing time, and total time on task as dependent measures. In the Larkin study, no significant main or interaction effects were found for window height. There were significant effects for message length, both for mean locating time and mean total time. A logical extension of the above study is to expand the design in order to examine the effects of line length (characters per line), window height (lines presented per page), and edit field location on text editing performance.

A pilot study was performed to experimentally assess the implications of the above on text editing performance. This pilot study manipulated line length (16, 32, and 64 characters per line), window height (1, 4, 8, and 19 line text pages) and edit field location (beginning, middle, and end of text message) to measure effects on text editing performance as measured by: edit field location time, editing time, and errors.



## **2.0 METHOD**

### **2.1 Objectives.**

The objectives of this investigation were: 1) to conduct a pilot study to experimentally compare the effects of line length and window height on text editing task performance, and 2) as a result of the pilot study, to generate an experimental protocol to perform a larger study of the effects of the independent variables on text editing performance, using Army personnel as subjects.

### **2.2 Subjects.**

Nine civilian personnel served as subjects for this study. Seven subjects were employees of Carlow Associates, Inc., and two were employees of HEL. Four subjects were female and five were male. All had experience and familiarity with the QWERTY typewriter keyboards. Each subject was tested individually in a session that lasted about one hour.

### **2.3 Apparatus and Materials.**

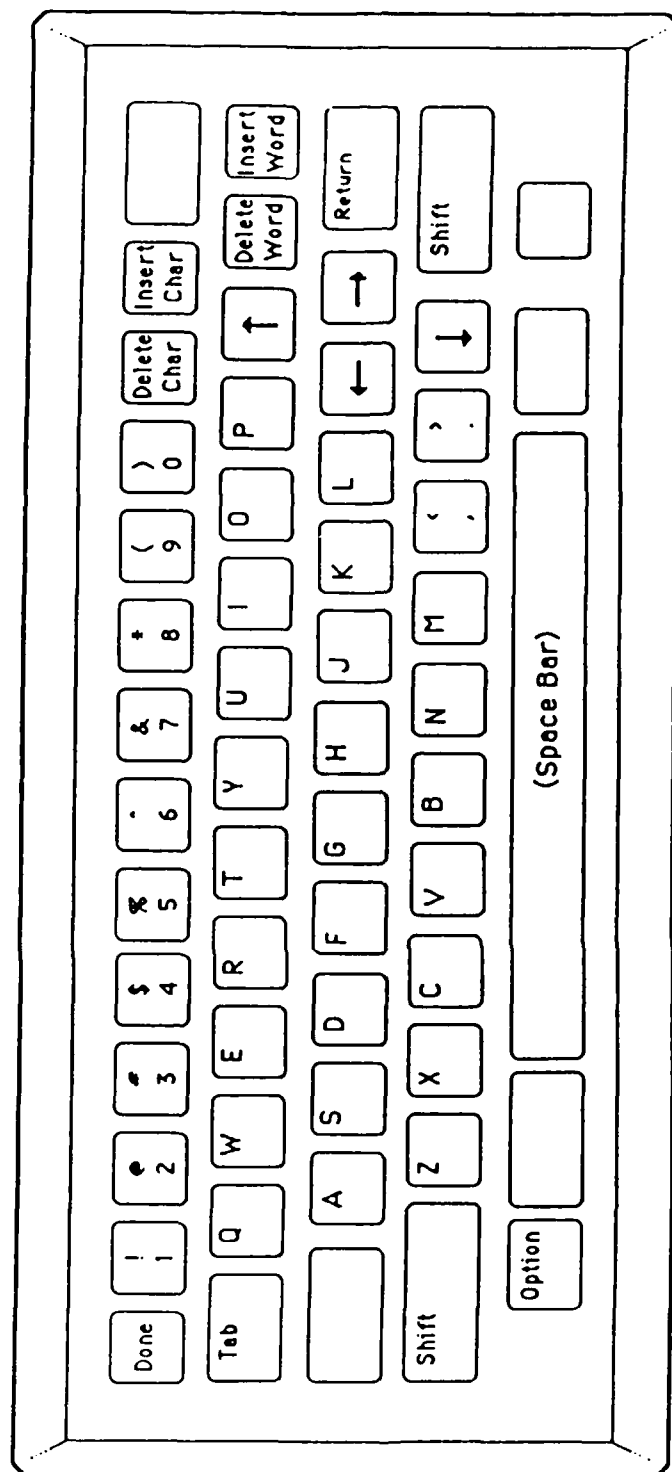
Stimulus messages were presented to subjects on an Apple Macintosh Plus microprocessor and display. The processor contained an internal clock and was running Microsoft BASIC. Subjects interacted with a Modified Macintosh keyboard, with edit function keys and cursor control keys. Data were logged using an Apple Image Writer printer with 20 foot serial cable for remotely locating the printer from the test subjects. Data were also stored on 800 kilobyte disk drive. These drives also contained the experiment software, which ran under Microsoft BASIC.

The modified keyboard used in the study is shown in figure 2-1. Nine key functions were modified and labeled for subject use. These modifications included provision of:

- four cursor keys (up, down, left, and right)
- four edit function keys (insert word, insert character, delete word, and delete character)
- a "DONE" key to exit edit mode and proceed to next edit task

### **2.4 Text Displays.**

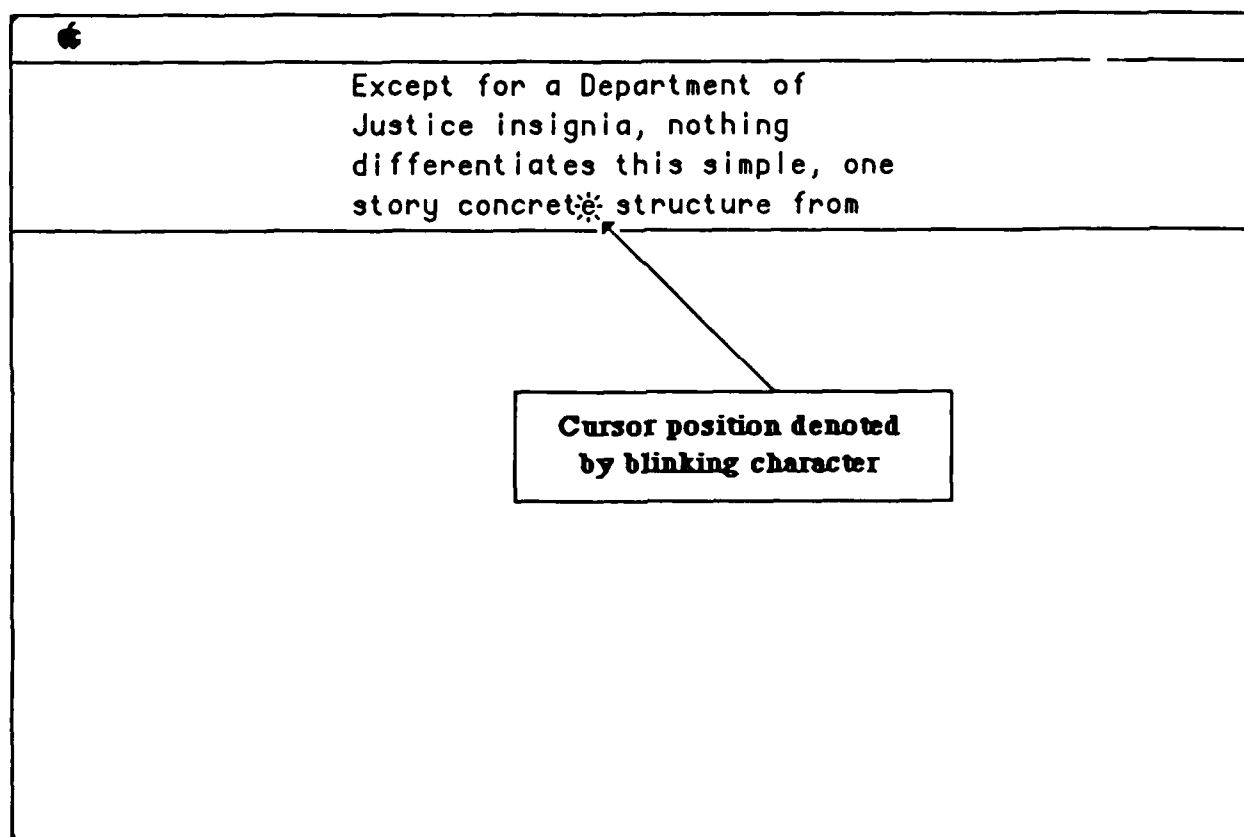
All edited displays were presented on the Macintosh monitor. Displays were generated by the experimental software for all combinations of window height and line length. All text messages were approximately 1300 characters in length. All text displays were single spaced and left justified. Text was displayed in black characters over a contrasting white background. Text font was monospaced (non-proportional) Monaco (resident in Macintosh operating system), 12-point plain. The active text editing window height was demarcated by a line above and a line below the displayed text field. Regardless of window height, the first line of text appeared on the first line of the monitor.



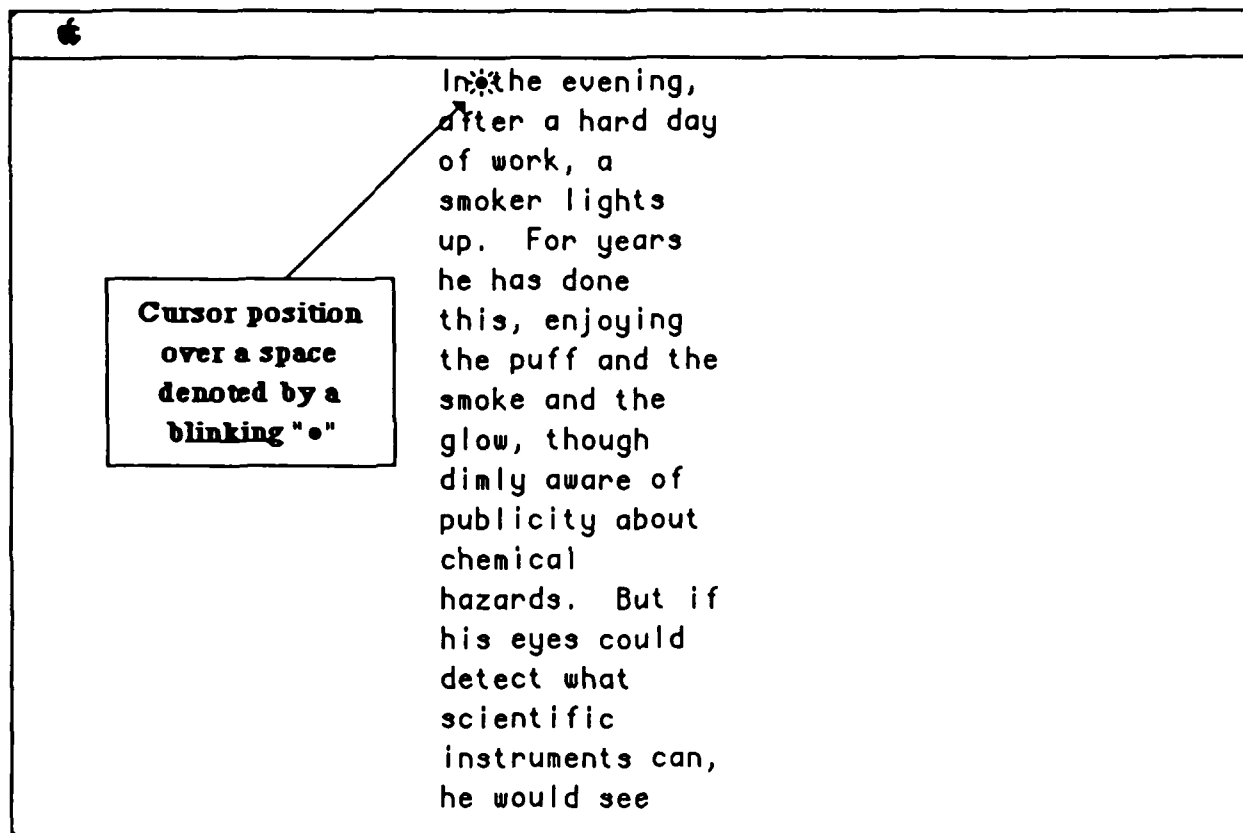
**Figure 2-1**  
Modified Keyboard  
(Blank keys unused)

Each of the three line lengths were centered in the display window. Figures 2-2, 2-3, and 2-4 demonstrate text appearance for three of the twelve window height by line length text display areas.

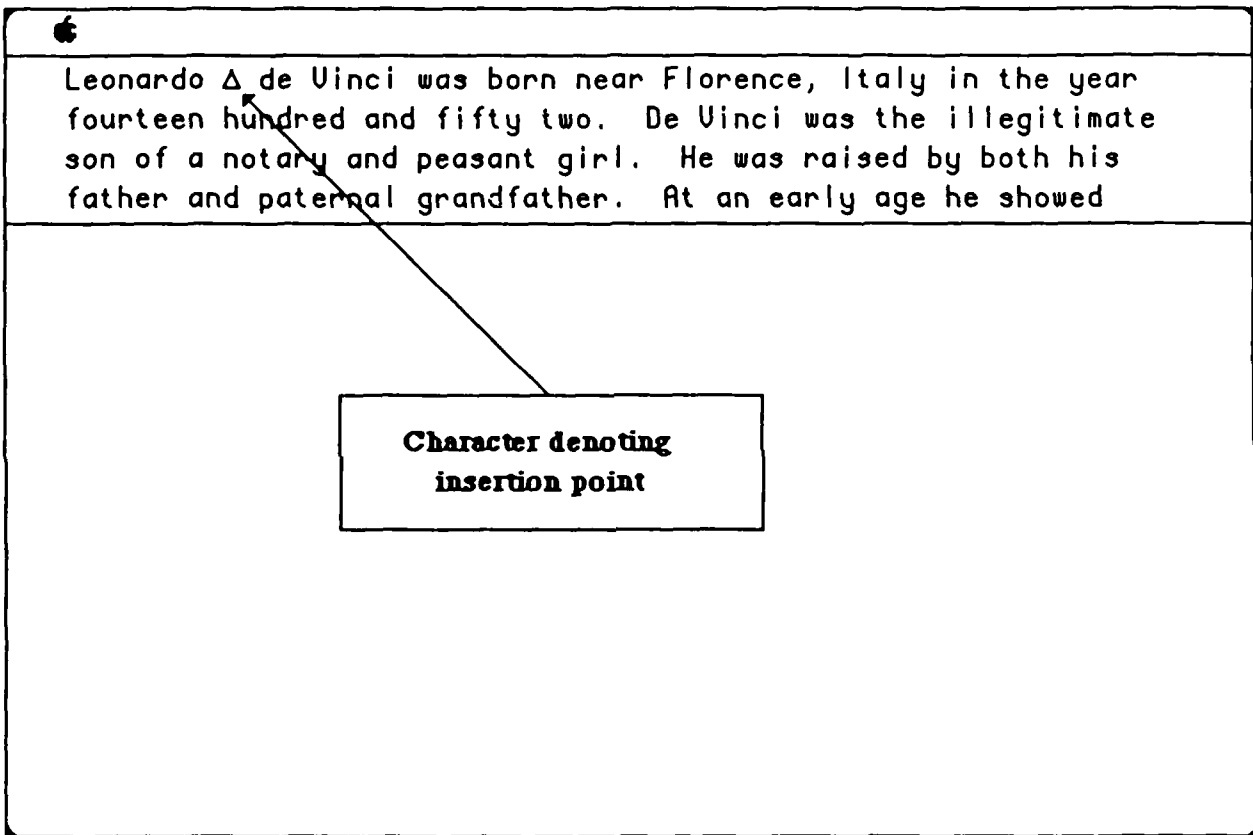
Cursor position was indicated by a flashing of the character over which the cursor resided. A cursor positioned over a space was indicated by a flashing "\*" (see figure 2-3). For word or character insertions in the text field, a special insertion character was used to indicate insertion point. Figure 2-4 demonstrates this insertion character.



**Figure 2-2**  
Example of Screen Display with Cursor Positioned Over a Letter  
(32 Characters per Line by 4 Lines per Page)



**Figure 2-3**  
Example of Screen Display with Cursor Positioned Over a Space  
(16 Characters per Line by 19 Lines per Page)



**Figure 2-4**  
Example of Screen Display with Insertion Symbol  
(64 Characters per Line by 4 Lines per Page)

## 2.5 Text Editor.

A limited function text editor was written in MicroSoft BASIC. This editor provided the following text editing functions:

- text display
- cursor movement
- edit functions (insert or delete words or characters)
- exit

During the interval between text presentations, the experimental software 1) read into memory the text of the next message to be edited, 2) partitioned the text into the appropriate line length segments (up to 16, 32, or 64 characters, including blanks) and stored these in an array, and 3) displayed the appropriate number of lines (window height) on the display screen. The text was partitioned such that the lines were up to 16, 32 or 64 (as appropriate) characters without splitting words. Hyphenations were not used. During editing, the software monitored the keyboard for inputs. While in the cursor mode, all keys except the cursor direction keys were ignored. Cursor key depression invoked a routine that moved the cursor position to the appropriate location (one character left or right, or, one line up or down). Scrolling up or down through text, when at the top or bottom of a window, invoked a screen move (window scroll) of up or down one line and the print of the new text line. Screen scroll time was immediate (about the same length as it took to write a single character to the screen).

The edit mode was entered by pressing and holding down the "Option" key and then pressing one of the four edit function keys. Word or character insertions occurred at the character position to the immediate left of the cursor position. When entered, the text on the edit line separated one character position and the insertion character appeared. For character insertion, one subsequent keystroke replaced the insertion character, closed the text, and exited the edit mode. For a word insertion, subsequent keystrokes inserted characters appropriate to the keystroke, separated the text line, and reprinted the insertion character. Exiting the word insertion edit mode required a stroke of any cursor direction key or the "DONE" key. These resulted in removal of the insertion character and closure of the text line. In the case of word insertion, a leading or trailing space had to be inserted along with the inserted characters. In the case of word or character deletion, the option key along with the "Delete Word" or "Delete Char" were depressed. To delete a character, the cursor had to be placed directly over the character to be deleted. Depression of the option key along "Delete Char" immediately deleted the character and exited the edit mode. To delete a word, the cursor had to be placed anywhere within the word (continuous string of non-blank characters) to be deleted. Depression of the option key along with the "Delete Word"

key immediately deleted the entire word, along with its trailing blank, and then exited the edit mode. At any time after screen presentation of the text, use of the "DONE" key terminated both the text scroll mode or the edit mode, initiated data logging and storage, and began preparation of the next message to be displayed and edited.

## **2.6 Subject Tasks.**

For each subject, the four editing tasks were performed under each combination of window height (1, 4, 8, and 19 lines of text displayed per page), line length (16, 32, and 64 characters per line of text) and edit field location (beginning, middle, or end of text). There were, therefore, 3 by 3 by 4, or 36 combinations of text presentation. Each subject was exposed to 36 messages of approximately equal length. The text for the messages was taken from articles in volumes of Readers Digest.

Each of the 36 stimulus messages was presented to subjects both on 8 1/2 by 11 inch sheets of paper and on the Macintosh monitor. Each printed sheet was marked with an editing comment indicating the text editing which was required to be made by subjects. An example of a printed edit message is presented as Figure 2-5. Three different orders of message presentation were used. For each order, printed messages were contained in a three-ring binder.

## **2.7 Procedures.**

**Briefing** - Each subject was given an overview of the experiment describing the purpose of the study and the procedures to be employed. Appendix A contains the briefing materials presented to each subject.

**Training** - Each subject received a description of the editing tasks to be performed (word insertion, character insertion, word deletion, character deletion, cursor movement, and text scrolling). The exact messages to be edited, along with the edit annotations, were presented to the subject in book form. Use of the edit message book was explained to each subject. The experimenter demonstrated each type of editing task, using four demonstration text messages contained in the edit message book. Once this was complete and the subject understood use of the keyboard and the nature of the editing tasks, subjects performed eight practice editing tasks, two for each of: word deletion, word insertion, character deletion, and, character insertion.

**Testing/Data Collection** - After the eight training edit messages were completed and the subject asked any questions and ultimately asserted he or she understood the task, the experimenter left the subject to complete the 36 editing tasks in the book. Distribution of the tasks (delete word, insert word, etc.) was randomly distributed throughout the messages. Presentation order of line length and window height was counterbalanced. As each message was edited, as signified by the

Drivers are entering a new golden age of the automobile. After more than a decade of pursuing drab, utilitarian goals automakers are tempting consumers with an array of high tech innovations, from fluorescent dashboards to computerized gears to hood raindrop detectors that automatically activate the windshield wipers. By the nineties, the most advanced cars may be shaped more alike than are the cars of today, as they converge on an aerodynamic ideal that makes them look like fish without fins. But each will be a custom car underneath. Evolving between driver and car is a network of computer controls that will make the car better able to heed the drivers instructions, adjust to road conditions, and rescue the driver from mistakes. Such cars should be more fun to drive, more economical to operate, and less bother to own. The automotive electronics revolution has brought an explosion in passenger compartment amenities, among them computerized rear view mirrors that adjust automatically to day and night driving, and memory seats that automatically assume the settings four different drivers prefer. With a trip computer, available in cars today, a driver can monitor gas mileage and the outside temperature, and find out how much time will pass before he reaches his destination.

INSERT THE WORD " many "

**Figure 2-5**  
Example of Printed Text Showing Editing to be Performed



subjects' depression of the "DONE" key, the CRT screen blanked. A three second pause occurred, and the message "Press Space Bar to Continue" appeared on the screen.

When the space bar was depressed, the next text message appeared on the screen, and the subject turned to the next page of the text edit message book to identify the text passage to be located and edited.

Upon completion of all messages, the CRT screen blanked, and the message "Thank you, this session is over. Please go to test director", appeared on the screen.

**Data collection and storage** - All data was automatically captured and stored by the experiment software. Data collected and stored for each message edited was as follows:

- file record number - a random access file structure is used
- subject identification number - subjects are numerically identified
- counterbalance order
- number of characters/line - 16, 32, or 64
- number of lines/page - 1, 4, 8, or 19
- text message number
- locating time - clock begins upon initial presentation of text, clock stops when edit mode initially entered
- edit time - internal clock starts upon entering edit mode, clock stops upon depression of DONE key
- total time on task - sum of edit and locating time monitored, total of search and edit time
- total keystrokes - total number of keystrokes (cursor movement, edit task, DONE key) for each edit task
- error assessment - editing correctness was automatically assessed by the experiment software, as follows:
  - performs in-string search for incorrect text; if found, assigns an accuracy value of 0 (incorrect); also reports line number and character position of incorrect text
  - if not found, performs an in-string search of correct text; if correct text is found, assigns an accuracy value of 1 (correct); also reports line number and character position of correct text
  - if neither correct nor incorrect text string is found, incorrect editing is determined; assigns an accuracy value of 0, and also reports line number edited
  - in all cases, the text line edited is printed, as well as the correct and incorrect text strings (e.g., "incorrect string <--> correct string")
- edit line number - the line number of the text in which the edit field resided

An example of printed output for each edited message is presented as figure 2-6.



### 3.0 EXPERIMENTAL DESIGN

#### 3.1 Model.

A 3 by 3 by 4 completely within subjects analysis of variance design was used, with each subject being exposed to each combination of line length (16, 32, or 64 characters per line), window height (1, 4, 8, or 19 lines per page), and edit location within the text (beginning, middle, or end). Counterbalancing order of presentations of messages, window heights, and line lengths was employed. Figure 3-1 demonstrates the experimental design.

			Place								
			Beginning			Middle			End		
Window Height (lines per page)	1		S1 to S9	S1 to S9	S1 to S9	S1 to S9	S1 to S9	S1 to S9	S1 to S9	S1 to S9	S1 to S9
	4		S1 to S9	S1 to S9	S1 to S9	S1 to S9	S1 to S9	S1 to S9	S1 to S9	S1 to S9	S1 to S9
	8		S1 to S9	S1 to S9	S1 to S9	S1 to S9	S1 to S9	S1 to S9	S1 to S9	S1 to S9	S1 to S9
	19		S1 to S9	S1 to S9	S1 to S9	S1 to S9	S1 to S9	S1 to S9	S1 to S9	S1 to S9	S1 to S9
			16	32	64	16	32	64	16	32	64
			Line Length			Line Length (characters per line)			Line Length		

Figure 3-1  
Experimental Design

#### 3.2 Independent Variables.

Independent variables for the study were line length (16, 32, and 64 characters per line), window height (1, 4, 8 and 19 lines per page), and text edit location (beginning, middle, or end of message).

### **3.3 Dependent Variables.**

In order to determine a sensitive measure of the effects of the experimental treatments, a number of measures were analyzed. These included edit field locating time, edit time, total time, edit errors and scroll errors (scroll reversals).

## **4.0 FINDINGS**

### **4.1 Analysis of Covariance).**

An initial test applied to the data was an analysis of covariance, using characters per line and lines per page as independent variables, using number of keystrokes required to access text as a covariate (the analog to edit location in text) and location time, total time, and editing correctness as measures in separate covariate analyses. A nearly significant interaction between characters per line and the covariate were observed using total time ( $F = 8.7$ ,  $P \approx 0.1$  with  $df = 2,8$ ) and location time ( $F = 6.1$ ,  $P \approx 0.2$  with  $df = 2,8$ ) as dependent variables and for both tests. As a result, analysis of covariance was rejected as a legitimate means to analyze the data (Wilkinson, 1985). Subsequent analyses considered edit location in the text as an independent variable with three fixed levels (beginning third of text, middle third of text, and end third of text).

### **4.2 Multivariate Analysis of Variance (MANOVA) Tests.**

Initial planning of the pilot study included analysis of the data using MANOVA, following up with separate ANOVAs to identify measures statistically sensitive to the treatments, given a significant MANOVA. Use of MANOVA techniques were not used for the following reasons:

- The technique is not statistically dictated by subsequent use of the information (discriminant analysis using multiple predictors of multiple effectiveness measures). Rather, the data are to be used in the development of screen design and trade-off guidelines and criteria.
- The present is a pilot study conducted to identify sensitive performance measures to the experimental treatments. The most sensitive measures to the treatments were of more interest than levels of significance observed.
- According to Kirk (1976), ANOVA generally affords greater power than MANOVA for designs using small sample sizes, as in the present case.
- In summary, MANOVA was not performed on the pilot study data, nor is it explicitly recommended for the main study.

### **4.3 Univariate Analysis of Variance (ANOVA) Tests.**

Multiple univariate ANOVAs (3 by 3 by 4 - within subjects) were applied to the data, with the following as dependent measures for each:

- total editing time
- edit field location time
- edit performance time
- editing correctness
- vertical scroll reversals (scrolls up)

Tables 4-1 through 4-5 present ANOVA table for these tests. As discussed by Kirk (1968) and Myers (1979), the error terms for estimating F values are the "by subjects" mean squares for each main effect and interaction. Vertical scroll reversals were analyzed upon review of the logged data concerning keystroke sequences for each subject for each message edited. It appeared that subjects frequently "missed" the edit string, as a function of line length, and had to scroll up to find it.

As indicated in the ANOVA tables, line length significantly influenced both edit field location time and total time, while edit time and editing accuracy were not significantly effected. As would be expected, location of the edit field in the text significantly affected location and total time. There were no significant interaction effects for total time, edit time, location time or edit accuracy. Vertical scroll reversals were significantly influenced by line length, and by a line length by place in text interaction ( $P < 0.001$  in both cases). Interestingly, horizontal scroll reversals were not significantly influenced by any main effects or interactions.

Figures 4-1 to 4-5 graphically demonstrate the above findings. Figure 4-6 presents mean times to locate text for all combinations of line length, window height, and edit location. Figure 4-7 presents means for vertical scroll reversals.

#### 4.4 Discussion.

Two-tailed Bonferroni t statistics, using  $\alpha = 0.05$  as the error rate per family of comparisons, were computed for the measures location time and vertical scroll reversals, and the independent variables of line length and location of edit field in text. The number of comparisons (k) for each family was three (for example, 16 with 32, 16 with 64, and 32 with 64 for the line length family of comparisons). The error term for each factor (line length and place in text) and each measure (location time and vertical scroll reversals) were the within subjects error terms used in the calculation of the F statistics. Significant contrasts (mean differences criteria) for each of the above were computed to be:

##### Location time as DV

Line length differences between means: 2.38 seconds

Place differences between means: 3.37 seconds

##### Vertical scroll reversals as DV

Line length differences between means: 0.34 reversals

Place differences between means: 0.47 reversals

Considering these values in light of the data presented in Figures 4-1 through 4-7, the following summarizes statistical significance between pairs of means:

- for the line length factor and location time dependent variable, significant differences exist between 16 characters per line and 32 and 64 characters per line (mean differences 5.7 and 5.8 seconds), while contrasting 32 and 64 characters per line was not significant (mean difference = 0.01 second)
- for the place in text factor and location time dependent variable, all contrasts are significant (beginning - middle = 14.3 seconds, beginning - end = 20.4 seconds, and middle - end = 6.1 seconds)
- for the line length factor and vertical scroll reversal dependent variable, a significant difference exists between 16 and 64 characters per line (mean difference 0.42 reversals). Contrarily, 32 and 64 characters per line and 16 and 32 characters per line contrasts were not significant (mean differences 0.11 and 0.31 reversals, respectively)
- for the place in text factor and vertical scroll reversal dependent variable, a significant difference exists between the beginning and middle positions and the beginning and end positions ( 0.67 and 0.66 reversals, respectively). Contrarily, middle and position mean difference was not significant (0.01 reversal).

Figures 4-1 to 4-5 show these differences clearly.

The interaction of line length and edit field location using location time as a measure is nearly significant. The additional power of more subjects, assuming trends hold up, during the main study, will approach significance at the 0.05 level. This interaction, as well as the significant line length by window height interaction for vertical scroll reversals, is nearly apparent through review of Figures 4-2 and 4-4. Reviewing Figure 4-1, additional power may also reveal a significant interaction between line length and window height using location time as a performance measure, as the figure suggests.

Should the above trends be evident within the data of the main study, using a larger and more representative population sample, a number of specific screen design guides can be identified for systems requiring similar user tasks, and where screen size constraints exist. Most interesting of these is the task based trade-off of required response time (to locate a field) vs. allowable error rate (scroll reversals, which suggests visual scanning and target location were affected by window definition). Where response time constraints exist, a line length of 32 or more characters would facilitate rapid location. On the other hand, where low error rates (detection/location failures) are required, shorter lines of text would better support the user. Therefore, the design guidance to be provided would have to be based on the response limitations imposed on the user.

TABLE 4-1

## ANALYSIS OF VARIANCE WITH TOTAL TIME AS DEPENDENT VARIABLE

<u>SV</u>	<u>df</u>	<u>Sum of Squares</u>	<u>Mean Squares</u>	<u>F</u>
S - Subjects	8	5615.90	701.98	
A - Characters/line	2	2231.15	1115.57	14.46**
AS	16	1234.56	77.16	
B - Lines/page	3	293.53	97.84	0.37
BS				
C -Place	2	25520.59	12760.30	59.67**
CS	16	3421.62	213.85	
AB	6	653.81	108.97	0.87
ABS	32	6011.13	125.23	
AC	4	2951.87	737.97	2.29
ACS	32	10290.75	321.58	
BC	6	4285.46	714.24	0.86
BCS	48	39799.63	829.16	
ABC	12	51916.72	4326.39	1.14
ABCS	96	363585.60	3787.35	
Total	323			

\*\* P &lt; 0.001

\* P &lt; 0.005

TABLE 4-2

## ANALYSIS OF VARIANCE WITH TIME TO LOCATE AS DEPENDENT VARIABLE

<u>SV</u>	<u>df</u>	<u>Sum of Squares</u>	<u>Mean Squares</u>	<u>E</u>
S - Subjects	8	3423.52	427.93	
A - Characters/line	2	2400.73	1200.37	28.04**
AS	16	685.04	42.81	
B - Lines/page	3	49.65	16.55	0.16
BS	24	2416.45	100.68	
C -Place	2	23077.50	11538.75	126.74**
CS	16	1456.61	91.04	
AB	6	284.93	47.49	0.49
ABS	32	4694.62	97.80	
AC	4	2320.06	580.02	1.97
ACS	32	9402.82	293.83	
BC	6	2972.41	495.40	0.80
BCS	48	29558.16	615.79	
ABC	12	41516.78	4326.39	1.22
ABCS	96	271154.60	2824.53	
Total	323			

\*\* P &lt; 0.001

\* P &lt; 0.005



TABLE 4-3

ANALYSIS OF VARIANCE WITH TIME TO EDIT AS DEPENDENT VARIABLE

<u>SV</u>	<u>df</u>	<u>Sum of Squares</u>	<u>Mean Squares</u>	<u>F</u>
S - Subjects	8	599.58	74.94	
A - Characters/line	2	92.59	46.30	1.15
AS	16	646.54	40.40	
B - Lines/page	3	156.15	52.05	0.71
BS	24	1757.26	73.21	
C -Place	2	62.04	31.02	0.41
CS	16	1187.85	74.24	
AB	6	540.98	90.16	1.75
ABS	32	2470.19	51.46	
AC	4	112.61	28.15	0.50
ACS	32	1803.84	56.37	
BC	6	665.53	110.92	2.01
BCS	48	2641.46	55.03	
ABC	12	1731.07	144.26	1.22
ABCS	96	11301.37	117.72	
Total	323			

TABLE 4-4

ANALYSIS OF VARIANCE WITH EDITING CORRECTNESS  
AS DEPENDENT VARIABLE (SS and MS times 100)

<u>SV</u>	<u>df</u>	<u>Sum of Squares</u>	<u>Mean Squares</u>	<u>F</u>
S - Subjects	8	88.88	11.11	
A - Characters/line	2	12.96	6.48	1.27
AS	16	81.48	5.09	
B - Lines/page	3	13.27	4.42	2.69
BS	24	39.50	1.64	
C -Place	2	1.85	0.926	1.60
CS	16	9.26	0.578	
AB	6	4.32	0.72	0.34
ABS	32	101.24	2.10	
AC	4	1.85	0.46	0.0109
ACS	32	1353.71	42.30	
BC	6	408.02	68.00	0.66
BCS	48	4914.20	102.37	
ABC	12	5188.28	432.35	1.16
ABCS	96	35681.17	371.67	
Total	323			

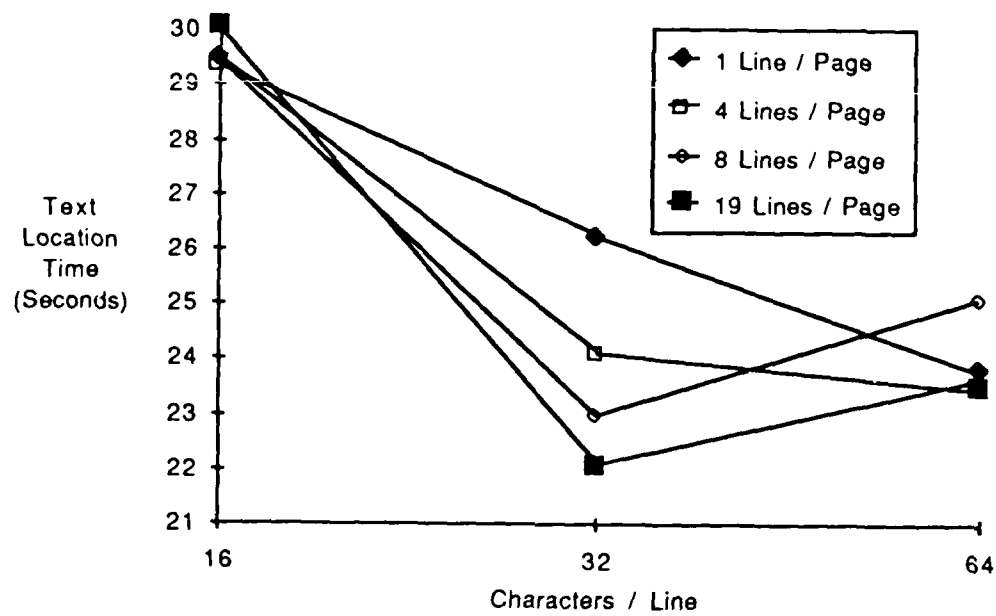
TABLE 4-5

ANALYSIS OF VARIANCE WITH VERTICAL SCROLL REVERSALS  
AS DEPENDENT VARIABLE

<u>SV</u>	<u>df</u>	<u>Sum of Squares</u>	<u>Mean Squares</u>	<u>F</u>
S - Subjects	8	37.33	4.66	
A - Characters/line	2	16.12	8.06	9.19*
AS	16	14.04	0.87	
B - Lines/page	3	0.18	0.06	0.03
BS	24	43.01	1.79	
C -Place	2	40.05	20.03	11.96**
CS	16	26.77	1.67	
AB	6	4.07	0.68	0.42
ABS	32	77.32	1.61	
AC	4	36.09	9.02	6.48**
ACS	32	44.57	1.39	
BC	6	14.43	2.41	1.06
BCS	48	108.28	2.26	
ABC	12	68.45	5.70	1.53
ABCS	96	358.24	3.73	
Total	323			

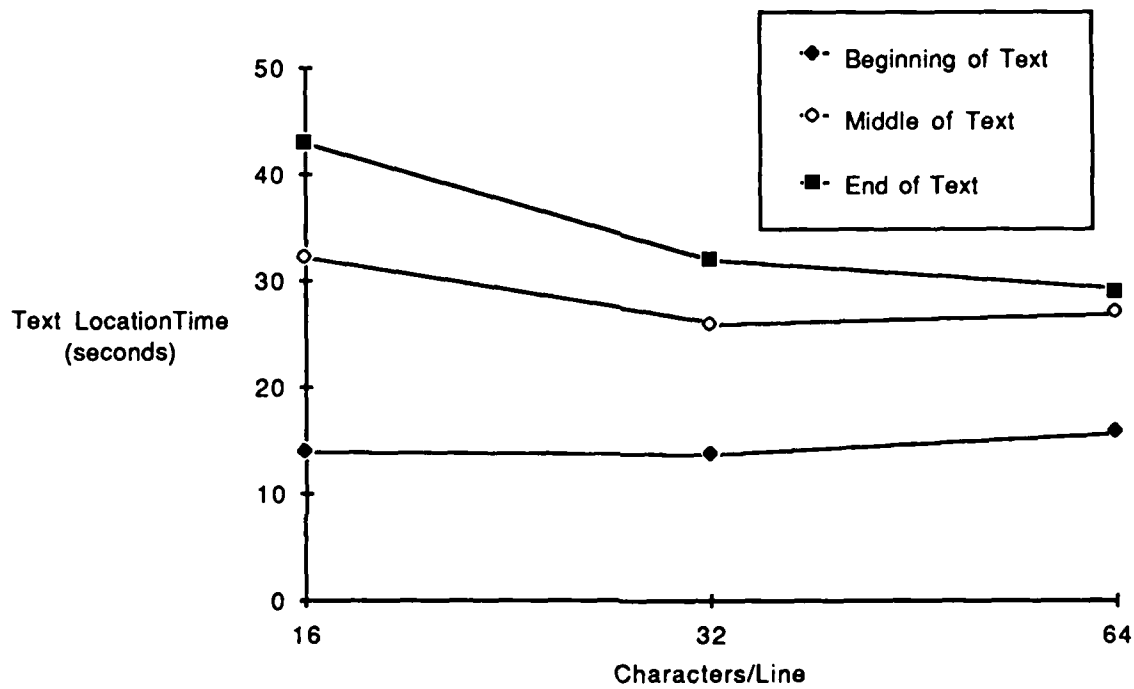
\*\* P &lt; 0.001

\* P &lt; 0.005



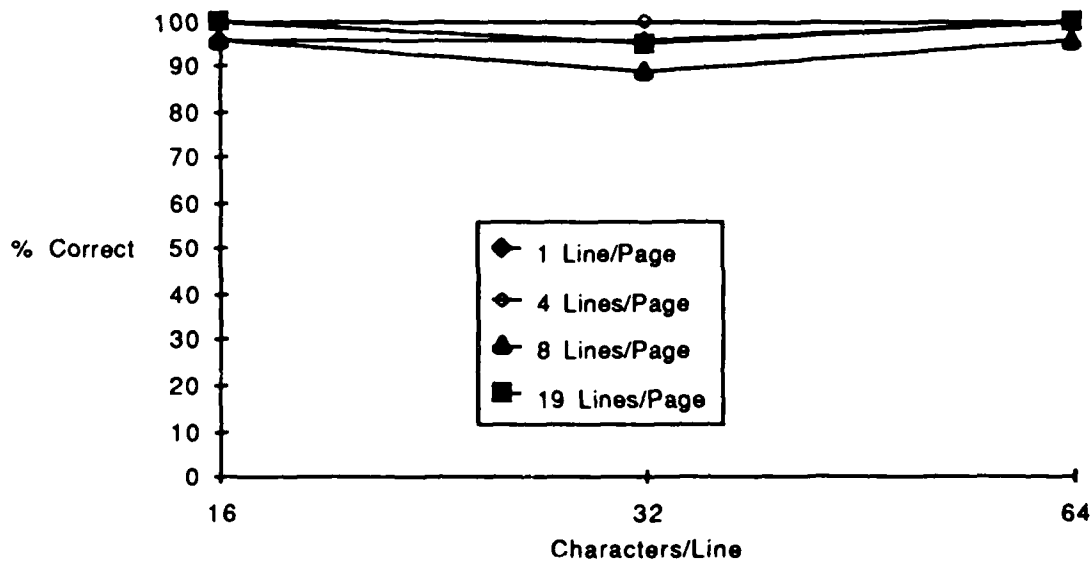
**Figure 4-1**

Mean Times to Locate Edit Field as a  
Function of Line Length and Window Height

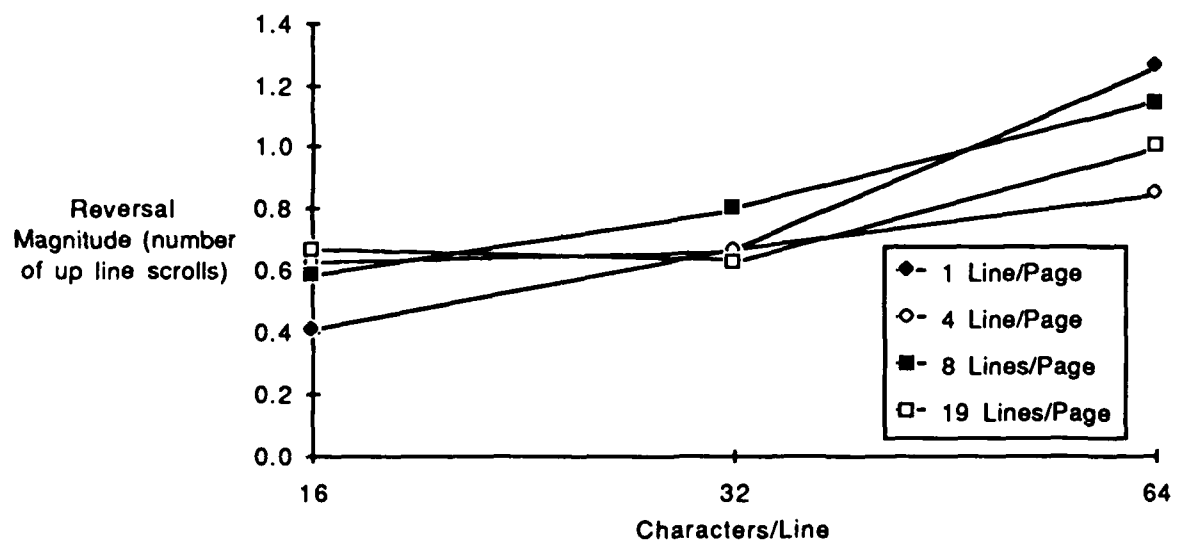


**Figure 4-2**

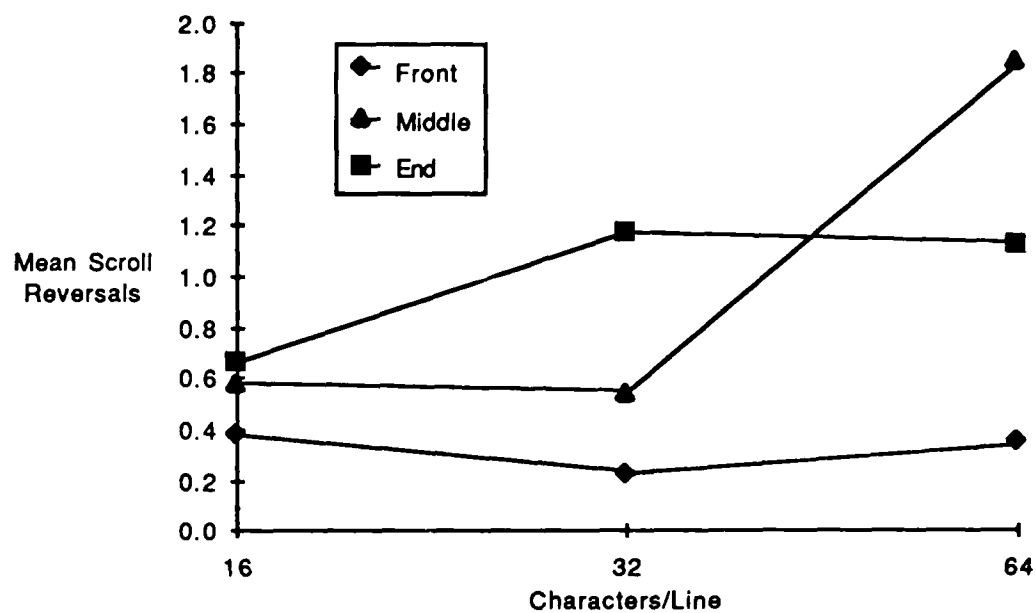
Mean Time to Locate Edit Field as a Function of  
Line Length and Edit Field Location in Text



**Figure 4-3**  
Mean Percent Correct Editing as a Function of  
Line Length and Window Height



**Figure 4-4**  
Vertical Scroll Reversals as a  
Function of Line Length and Window Height



**Figure 4-5**  
Vertical Scroll Reversals as a  
Function of Line Length and Edit Field Location



Characters per Line				
	16	32	64	Mean
Beginning	13.6	13.7	16.0	14.4
Middle	33.1	27.5	25.6	28.7
End	42.7	32.4	29.0	34.8
Mean	29.7	23.9	24.0	25.9

		Lines per Page				
		1	4	8	19	Mean
Characters per Line	16	29.4	29.4	30.5	29.5	29.7
	32	26.3	23.0	22.1	24.1	23.9
	64	23.8	25.8	25.5	23.4	24.0
	Mean	26.5	25.8	25.4	25.7	25.9

**Figure 4-6**

Mean Times to Locate Edit Strings as a Function of  
Line Length, Window Height, and Text Location

Characters per Line				
	16	32	64	Mean
Beginning	0.38	0.23	0.35	0.32
Middle	0.58	0.54	1.84	0.99
End	0.66	1.17	1.12	0.98
Mean	0.58	0.69	1.00	0.76

		Lines per Page				
		1	4	8	19	Mean
Characters per Line	16	0.41	0.63	0.59	0.67	0.58
	32	0.67	0.67	0.80	0.63	0.69
	64	1.26	0.85	1.15	1.00	1.00
	Mean	0.78	0.72	0.74	0.77	0.76

**Figure 4-7**

Mean Vertical Scroll Reversals as a Function of  
Line Length, Window Height, Text Location

## 5.0 RECOMMENDATIONS

Based on the findings of the pilot study, the following is recommended for the main study:

- Since no significant findings were noted for editing time or editing errors, two sensitive measures are location time and vertical scroll reversals.
- The completely within subjects design should be used to limit the number of subjects required.
- Using these two dependent measures (location time and vertical scroll reversals), two separate ANOVAs would be adequate to analyze the data, with alpha levels set at the 0.01 level.
- Approximately 21 to 30 subjects should provide adequate power, if current trends hold up. (The number used, however, should be evenly divisible by 3, so that each message order is applied equally). If a real characters per line by edit location interaction exists using time to locate as a measure, it should be detected if this range of subjects is used.

A draft Experimental Protocol incorporating the above is provided in Appendix B for HEL consideration. Appendix C contains a version of a Subject Consent Form.

## 6.0 REFERENCES

- Kirk, R. E., Experimental Design: Procedures for the Behavioral Sciences. Wadsworth Publishing Company; Belmont California, 1968.
- Larkin, M. M. Text-Editing Performance on a Visual Display Screen as a Function of Window Height and Message Length. U.S. Army Laboratory Command, Human Engineering Laboratory, January 1986.
- Myers, J. L., Fundamental of Experimental Design. Allyn and Bacon, Inc.; Boston Massachusetts, 1979.
- Winer, B. J., Statistical Principles in Experimental Design. McGraw-Hill; New York, New York, 1971.

**APPENDIX A**  
**INSTRUCTIONS TO SUBJECTS**

### **(WELCOME)**

**WELCOME AND THANK YOU FOR COMING TODAY!** This study will investigate people's abilities to use computer screens and keyboards. We are interested in understanding how people interact with computer screens. After answering an initial questionnaire about computers, I will show you how to change information on the screen and then you will make changes to information on the screen. The information you see on the screen will also be printed on sheets of paper. These sheets will show you what changes you are to make by using the keyboard. When you have finished making changes to the information on the screen you will be asked to complete a second questionnaire about computers. Your answers on the questionnaires and your responses on the computer screen will be kept confidential. The entire test session will last about 1 hour. Do you have any questions? If you would like to participate in this study, please read and then sign this consent form. (Hand the consent form to the person)

### **(BACKGROUND INFORMATION)**

Now I would like to ask you a few questions about your experience with computers. (Ask the person the questions on the Background Information sheet and fill in their answers)

### **(FIRST QUESTIONNAIRE)**

Now I would like you to fill out this questionnaire. Please read the instructions at the beginning of the questionnaire.

Do you have any questions about how to fill out the questionnaire? If not, please take a few minutes now to complete the questionnaire. When you are finished please meet me outside. (Leave the person alone in the room)

### **(TRAINING SESSION)**

**(Introduction)** Now I will show you how to use the test equipment and how to use the test materials. After you feel that you understand how to use the equipment and the materials you may practice what you have learned by completing some problems that are similar to the problems you will do in the actual test session.

**(Training)** I will now explain how to use the keyboard to make changes on the screen. (Enter Subject ID#, select correct condition, and begin Demo session)

These are the keys you will use to move to the place on the screen where you want to make a change. The right arrow key moves the cursor to the right on the screen (**demonstrate**); the left arrow key moves the cursor to the left on the screen (**demonstrate**); the down arrow moves the cursor down the screen (**demonstrate**); and the up arrow moves the cursor up the screen. Notice that when you use the right arrow cursor key to move the cursor all the way to the right side of the screen, if you want to then move the cursor down to the next line on the screen you must use the cursor down key (**demonstrate**). There may be times when the information on the sheets of paper is longer than the amount of information that you can see on the screen. When this happens, you should use the down arrow key to allow the computer to show you the rest of the information. Do you have any questions so far?

This notebook contains the sheets of paper with the changes you will make to the information on the screens by using the keyboard. When I tell you to begin, you will open the notebook, turn to the first page to see what change you should make, and then make the change to the information on the screen. After you have made the change on the screen, you should press this key (**point to the DONE key**), which is the DONE key. This key tells the computer that you have finished making the change and are ready to see the next sheet of information on the screen.

Now I will explain how to use the keyboard to make changes to information on the screen. This is the OPTION key (**point to key**). Each time you want to make a change on the screen, you will need to hold down this key **AT THE SAME TIME** that you press another key. I will explain how to do this in a moment.

There are four kinds of changes that you will be asked to make. These changes are **INSERT CHARACTER**, **INSERT WORD**, **DELETE CHARACTER**, and **DELETE WORD**. You can use this cue card (put out the cue card) to help you remember which keys to use to make these changes.

**(Insert letter demo).** I will start by showing you how to insert a letter. If you want to **INSERT** a letter, or **CHARACTER** as it is often called, you first use the cursor keys to get to the place on the screen where you want to make the change. You should put the cursor on the character to the right of the place where you want to insert the new character, in other words, the letter will be inserted to the left of the cursor position. Then you hold down the **OPTION** key while you press the **"INSERT CHAR"** key at the same time. The text will separate and this pointer will appear. Then you type in the character that is written on the sheet in the notebook. The character is inserted at the point where the cursor is positioned. Then you press the **DONE** key.

(Insert word demo). Now I will demonstrate to you how to INSERT a WORD. (Turn to the next page, explain the hand written editing comment, and show how to make the change). If you want to INSERT a WORD you first use the cursor keys, just as before, to get to the place on the screen where you want to make the change. You should put the cursor at the point where you want to insert the new word. Then you hold down the OPTION key and press the "INSERT WORD" key at the same time. Then you type in the word that is written on the sheet in the notebook. The new word will be inserted at the point where the cursor is positioned. Then you press the DONE key.

(Delete word demo). I will now show you how to DELETE a WORD. (Turn to the next page, explain the handwritten editing comment, and show how to make the change). If you want to DELETE a WORD, you must first move the cursor to the place on the screen where you want to make the change. You should put the cursor anywhere within the word you want to delete. Then you must hold down the OPTION key and press the DELETE WORD key at the same time. Then you must press the DONE key.

(Delete character demo). I will now demonstrate to you how to DELETE a CHARACTER. (Turn to the next page, explain the handwritten editing comment, and show how to make the change on the screen.) If you want to DELETE a CHARACTER, you must first move the cursor to the place on the screen where you want to make the change. You should put the cursor directly on the character that you want to delete. Then you must hold down the OPTION key and press the DELETE CHAR key at the same time. Then you must press the DONE key.

As I mentioned earlier, you can look at this cue card whenever you need help in remembering how to use the keyboard. Also, if you make a mistake in editing, you can correct it as long as you have not hit the DONE key. For example, if you delete the wrong letter, you can reinsert it using INSERT CHARACTER, and then delete the correct letter using DELETE CHARACTER.

Do you have any questions on how to use the keyboard? Do you have any questions on how to use the notebook and the keyboard together to make changes to information you will see on the screen? If not, you are now ready to practice what you have just learned. I'll be here to answer questions during the PRACTICE session but when you do the actual test session you will be left in the room alone. So please feel free to ask as many questions as you like during the practice session. You may now turn to the PRACTICE section of the workbook and work through the practice problems. (Stay in room and let the subject work the practice session.)  
(TEST SESSION)

VERY GOOD! Now you are ready to begin the actual test session. Please work at your own speed but be as accurate and quick as you can. When you have finished working through the notebook please meet me back in the room where we met. You may turn the page of the notebook to the test section and begin. (leave the room and go around the corner to watch the printer. Before the person has completed all 36 trials, I will go back to the questionnaire room to be ready to meet him or her there.)

**(SECOND QUESTIONNAIRE)**

GREAT! You are almost finished.

Now I would like for you to fill out this questionnaire. Please read the instructions on the first page of the questionnaire.

Do you have any questions on how to fill out Part I of the questionnaire? If not, please read the instructions for Part II of the questionnaire. Do you have any questions on how to fill out the questionnaire?

If not, please take your time and complete the questionnaire now. When you are finished filling out the questionnaire, please meet me outside. (Leave the person alone in the questionnaire room)

Thank you very much for your participation. I have enjoyed having you.



## EDIT FUNCTIONS REFERENCE CARD

<b>Cursor Keys (Arrows)</b>	Used to move through the text. Also used to exit edit mode and enter cursor mode.
<b>Option</b>	Used to enter edit mode, used simultaneously with edit function keys (described below).
<b>Option-Delete Char</b>	Used to delete a single character. Place cursor directly over character to be deleted, then enter <b>Option-Delete Char</b> .
<b>Option-Delete Word</b>	Used to delete a complete word. Place cursor anywhere within word to be deleted, then enter <b>Option-Delete Word</b> .
<b>Option-Insert Char</b>	Used to insert a single character. Characters will be inserted to the immediate <b>left</b> of cursor position. Enter <b>Option-Insert Char</b> , and the insertion symbol will appear, then enter a single character.
<b>Option-Insert Word</b>	Used to insert a single word. Words will be inserted to the immediate <b>left</b> of cursor position. Enter <b>Option-Insert Word</b> , and the insertion symbol will appear, then enter the word to be inserted.
<b>Done</b>	Used to exit the edit mode and continue on to the next message to be edited.

**APPENDIX B**  
**DRAFT PROTOCOL**

## **PROTOCOL**

**TITLE:** User-Computer Interface (UCI) Pilot Study on Line Length and Window Height

**PRINCIPAL INVESTIGATOR:** Maureen M. Larkin

**DIRECTORATE:** Close Combat

**DATE OF INVESTIGATION:** January 1987

### **1.0 BACKGROUND**

Computer interface has become a necessary element of a soldier's job. Much of the new and developing tactical equipment, including weapons, sensors, and communication devices, requires that the user know how to access, and edit, or modify, information resident in a computer. One aspect of this data acquisition and input task concerns the presentation of information on a computer screen. Information acquisition may be affected by the height of the text window and the width, or character string length, of the line. These in turn determine the amount of information presented on a page of text. Human performance data concerning these display elements, in the context of retrieval of text-imbedded data, can have significant implications for computer interface display design. This will particularly be the case where constraints on display size may exist, such as in portable and transportable military hardware. Research that will identify screen design elements associated with text editing performance is required. These data will be valuable in the generation of soldier-computer interface design requirements and criteria, and in the conduct of design trade-off studies.

A previous study (Larkin, 1986) manipulated window height (number of lines presented per page) and message length to study their effects on text editing performance, using error rates, text locating time, text editing time, and total time on task as dependent measures. In this study, no significant main or interaction effects were found for window height. There were significant effects for message length, both for mean locating time and mean total time.

An extension of the Larkin study is to expand the design in order to examine the effects of line length (in terms of characters per line), window height (lines presented per page), and edit location within a string of text on text editing performance. A pilot study was performed which identified two measures sensitive to the above factors.

The present study will be performed to experimentally assess the implications of line length, window height, and edit location on text editing performance.

## **2.0 OBJECTIVES**

The objective of this investigation is to conduct a study to experimentally compare the effects of line length, window height, and edit location on text editing task performance, using representative military personnel as subjects.

## **3.0 METHODOLOGY**

**Subjects.** Thirty soldiers stationed at Aberdeen Proving Ground, Aberdeen, Maryland will serve as subjects in the experiment.

**Apparatus.** Equipment to be used is as follows:

- a) Apple Macintosh Plus microprocessor running Microsoft BASIC
- b) Modified Macintosh keyboard, with edit function keys and cursor control keys
- c) ImageWriter printer with 20 foot serial cable for data logging
- d) 800 kilobyte disk drive for data and program storage
- e) Text editing software running in Microsoft BASIC (developed specifically for study)
- f) Data capture software for data storage and processing

### **Procedures**

a) Briefing - Each subject will be given an overview of the experiment describing the purpose of the study and the procedures to be employed. Consent forms (enclosure 1) will be completed by each subject prior to data collection.

b) Training - Each subject will receive a description of the editing tasks to be performed (word insertion, character insertion, word deletion, character deletion, cursor movement, and text scrolling). The exact messages to be edited, along with the edit annotations, will be presented to the subject in book form. Use of the edit message book will be explained to each subject. The experimenter will demonstrate each type of editing task, using four demonstration text messages contained in the edit message book. The experimental subject will perform eight practice editing tasks, two for each of:

- word deletion
- word insertion
- character deletion
- character insertion

c) Testing - After training is completed, the experimenter will leave the subject to complete the remaining 36 editing tasks in the book, one for each level of the line length factor (16,

32, and 64 characters per line), the window height factor (1, 4, 8, or 19 lines of text displayed per page), and the edit location factor (edit field located within the first three lines of text, the middle three lines, or the end three lines). Distribution of the tasks (delete word, insert word, etc.) will be randomly distributed throughout the messages. Presentation order will be counterbalanced. As each message is edited, as signified by the subject's depression of a key, the CRT screen will blank. A five second pause will occur, and the message "Press Space Bar to Continue" will appear on the screen. When the space bar is depressed, the next text message will appear on the screen, and the subject will turn to the next page of the text edit message book to identify the text passage to be located and edited. Upon completion of all 36 messages, the CRT screen will blank, and the message "Thank you, this session is over. Please go to test director.", will appear on the screen.

d) Data collection and storage - All data will be automatically captured and stored by the experiment software. Data collected and stored for each message edited is as follows:

- file record number - a random access file structure will be used
- subject identification number - subjects are numerically identified
- counterbalance order
- number of characters/line - 16, 32, or 64
- number of lines/page - 1, 4, 8, or 19
- text message number (each uniquely identified)
- locating time - clock begins upon initial presentation of text, clock stops when edit mode initially entered
- edit time - internal clock starts upon entering edit mode, clock stops upon depression of DONE key
- total time on task - sum of edit and locating time monitored, total of search and edit time
- total keystrokes - total number of keystrokes (cursor movement, edit task, DONE key) for each edit task (this to be tried as a potential covariate of error location in text)
- error assessment - editing correctness is automatically assessed by the experiment software, as follows:
  - performs in-string search for incorrect text, if found, assigns an accuracy value of 0 (zero); also reports line number and character position of incorrect text
  - if not found, performs an in-string search of correct text, if correct text is found, assigns an accuracy value of 1 (one); also reports line number and character position of correct text
  - if neither correct nor incorrect text string is found, incorrect editing is determined, assigns an accuracy value of 0 (zero) also reports line number edited
  - in all cases, the text line edited is printed, as well as the correct and incorrect text strings (e.g., "incorrect string <--> correct string")
- edit line number - the line number of the message text in which the edit field resided

#### 4.0 EXPERIMENTAL DESIGN

a) **Model**. A completely within subjects design with three independent variables (line length, window height, and edit field location) will be used. The model is a 3 by 3 by 4 by subjects design. Counterbalancing order of presentations will be employed. Thirty subjects will be used. Based on the pilot study, this number of subjects should provide more than adequate statistical power.

b) **Independent variables**. Independent variables for the study will be line length (16,32, and 64 characters per line), window height (1, 4, 8 and 19 lines per page), and edit location (edit field located within the first three lines of text, the middle three lines, or the end three lines).

c) **Dependent variables**. Dependent variables will be edit field locating time and vertical scroll reversals (edit time, total time, and edit errors as secondary DVs?). Based on the Larkin study, no significant effects are predicted for edit time and error rate, so the principal dependent measure will be locating time.

#### 5.0 DATA ANALYSIS

a) **General Models**. Two separate univariate ANOVAs (one for each DV) will be applied to the data.

b) **Post Hoc Tests**. The Bonferroni t statistic for the within subjects case will be used in any comparisons by pairs.

#### 6.0 HUMAN USE

The human-use risks will be no more than those of the everyday activities and duties of the subjects.

## 7.0 REFERENCES

- Baker, C. C., Text Editing Performance as a Function of Line Length, Window Height, and Edit Field Location (DRAFT) Draft technical report prepared for the U. S. Army Human Engineering Laboratory under contract No. DAAA15-86-D-0005, Carlow Associates Incorporated, 1986.
- Kirk, R. E., Experimental Design: Procedures for the Behavioral Sciences, Wadsworth Publishing Company; Belmont California, 1968.
- Larkin, M. M. Text-Editing Performance on a Visual Display Screen as a Function of Window Height and Message Length. U.S. Army Laboratory Command, Human Engineering Laboratory, January 1986.
- Myers, J. L., Fundamental of Experimental Design. Allyn and Bacon, Inc.; Boston Massachusetts, 1979.
- Winer, B. J., Statistical Principles in Experimental Design. McGraw-Hill; New York, New York, 1971.

**APPENDIX C**  
**SUBJECT CONSENT FORM**



## VOLUNTEER AGREEMENT

PROJECT: Computer Screen Research

PRINCIPAL INVESTIGATOR: Maureen Larkin

RESPONSIBLE ORGANIZATION: U. S. Army Human Engineering Laboratory  
Aberdeen, Maryland

**PURPOSE:** This study will investigate people's abilities to use computer screens and keyboards. You will be shown how to change information on the screen and then you will make changes to information on the screen. The information you see on the screen will also be printed on sheets of paper. These sheets will show you what changes you are to make, using the keyboard. You will also be asked to complete two questionnaires regarding your attitudes towards computers. These will be completed before and after you interact with the computer. Your responses on the questionnaires and performance with the computer will be kept confidential. The test session will last about 2 hours.

**CONSENT:** My signature below certifies that this study has been explained to me by Ms. Larkin and that all my questions have been answered satisfactorily. I understand that there are no known physical or mental risks to me because of participating in this study. I voluntarily agree to participate and I understand that I may decline to participate or withdraw from the study at any time without penalty.

SIGNATURE: \_\_\_\_\_ DATE: \_\_\_\_\_

NAME: \_\_\_\_\_

PLEASE PRINT

**APPENDIX D**  
**EDIT FUNCTIONS REFERENCE SHEET**

## EDIT FUNCTIONS REFERENCE CARD

<b>Cursor Keys (Arrows)</b>	Used to move through the text. Also used to exit edit mode and enter cursor mode.
<b>Option</b>	Used to enter edit mode, used simultaneously with edit function keys (described below).
<b>Option-Delete Char</b>	Used to delete a single character. Place cursor directly over character to be deleted, then enter <b>Option-Delete Char</b> .
<b>Option-Delete Word</b>	Used to delete a complete word. Place cursor anywhere within word to be deleted, then enter <b>Option-Delete Word</b> .
<b>Option-Insert Char</b>	Used to insert a single character. Characters will be inserted to the immediate left of cursor position. Enter <b>Option-Insert Char</b> , and the insertion symbol will appear, then enter a single character.
<b>Option-Insert Word</b>	Used to insert a single word. Words will be inserted to the immediate left of cursor position. Enter <b>Option-Insert Word</b> , and the insertion symbol will appear, then enter the word to be inserted.
<b>Done</b>	Used to exit the edit mode and continue on to the next message to be edited.

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