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DATA ENTRY TIMES FOR NAVY TACTICAL INFORMATION DISPLAYS.(U)

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DATA ENTRY TIMES FOR NAVY TACTICAL INFORMATION DISPLAYS

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The Menu and Page methods of data entry and display format are candidates for possible use on a cathode ray tube (CRT) display on the Navy Tactical Data System. The Menu method presents all possible category choices at a given level of data hierarchy; the operator enters the number that corresponds to his choice of categories from the displayed "menu" of choices. The Page method displays only a subset of possible choices at each level of the hierarchy. If the desired category does not appear, the operator sequences to the next "page" of categories, until he finds the required category.

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Reaction time measures were used to assess the relative speed of data entry using six different types of problems in each of the two methods. Results showed that although each method took longer for problem types requiring deeper hierarchial structure, there was no difference in the methods themselves. There was a significant practice effect, which was also independent of method. Neither method was preferred by the operators.

It is recommended that the "page" method be pursued since it makes more efficient use of CRT screen area. Further, the method can be improved by organizing the categories so that more frequently occurring items appear on earlier "pages."

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FOREWORD

This research and development was conducted in response to a Navy Decision Coordinating Paper, Personnel Supply Systems (NDCP-Z0107-PN), under subproject Z0107-PN.08, Information Processing in Operational Decision Making, and the sponsorship of the Chief of Naval Operations (OP-01). The objective of the subproject is to apply technologies of decision and information science in the development of management and tactical information systems that are compatible with human decision-making capabilities. The results are intended for use by the Fleet Combat Direction Systems Support Activity (FCDSSA), Operation Requirements Section (Code 27).

Appreciation is extended to CDR H. P. Krienke, LCDR W. L. Schwabe, LT A. L. Maples, and LT J. L. Dick of FCDSSA, Pacific, who provided the NTDS materials; to the Commanding Officer of FCDSSAPAC and CDR H. P. Krienke for allowing FCDSSA personnel to act as "console operators"; and to the "operators" themselves, who so generously gave of their time and provided many helpful comments in support of this project.

DONALD F. PARKER
Commanding Officer

SUMMARY

Problem and Background

The Navy Tactical Data System (NTDS), a centralized computer-driven information system, permits shipboard personnel to both obtain and enter large amounts of tactical information through a console containing plan position indicator and a direct readout (DRO) display. Since the present console's capabilities to receive and display information have been exceeded, plans have been made to replace the DRO portion of the console with an alphanumeric cathode ray tube (CRT) display. Although this device will permit increased flexibility with respect to data display formats, little is known about the actual amounts, types, and location of data that would indeed be facilitating in the NTDS environment.

Objective

The purpose of the present effort was to compare two data entry methods--called the Page and Entry methods--as to speed of data entry and display. Since the methods differ with respect to (1) usage of console data entry buttons, (2) display format on the CRT, and (3) requisite computer software requirements, a decision between the two must be made early in the design process (i.e., before implementing the CRT into the NTDS system). Results from the present study were to aid in making this decision.

Approach

The two candidate data entry methods were simulated on a Tektronix 4051 Graphics System. Twelve operators, all familiar with some aspect of NTDS, participated in a reaction time simulation experiment. The operators used one method in the first part of the experiment, and the other method, in the second part. With each method, operators sought information from each of six information categories. Thus, entry times were examined for significance using a 2 (methods) x 6 (problem types) x 2 (order groups) analysis of variance.

Findings

1. The two methods did not differ with respect to speed of data entry.

2. There was a significant practice effect, resulting in increased speed for the second method tried.

3. The data entry times increased as a function of the number of possible entry sequences.

4. Operators did not have a preference for either method.

Conclusions

Although the two methods did not differ as to operator preference, the Page method makes more efficient use of the CRT screen area.

Recommendations

1. Subject to software constraints, effort should be directed towards developing the Page method.

2. Alternatives should be grouped systematically on pages so that more frequently occurring items appear on earlier pages.

3. To ensure the evaluation of reasonably organized pages, software should include monitors to determine frequency of occurrence of alternatives in operational environments. This will allow reasonably organized pages to be constructed.

4. Expansion of input buffer size should be considered. Although this would increase processing overhead, it would allow the operator to complete an entry task and begin another, rather than have to time share between two (or more) tasks.

CONTENTS

LIST OF FIGURES

INTRODUCTION

Background

The Navy Tactical Data System (NTDS), a centralized computer-driven information system, permits shipboard personnel to enter and retrieve large amounts of tactical data through a console. The console contains a radar video plan position indicator (PPI) and a number of fixed format, projection-controlled, numeric displays called the direct readout (DRO). Since the variety of generic types of data to be entered and retrieved expands constantly, the present console's capabilities to efficiently receive and display data have been exceeded. At present, information that is not on the PPI is displayed numerically on the DRO display. The amount of alphanumeric information that can be displayed, however, is severely limited, as is augmentation of this capability by additional labelling of the readouts. Therefore, the operator must learn the meaning of the numbers in the readout, which change, depending on operating mode and information requested.

To alleviate this problem, the Fleet Combat Direction Systems Support Activities, Atlantic and Pacific Fleets, are engaged in a program to supplement and eventually replace the DRO with an alphanumeric cathode ray tube (CRT) Digital Display Indicator (DDI) (IP-1304/UYA-4). The DDI is far more versatile than the DRO because it can display both alphabetic and numeric information. It provides total formatting flexibility: The amount, type, and location of data to be displayed on the CRT are all controlled by the computer, so that both data acquisition and entry by the operator are facilitated. A further advantage is the DDI's ability to label (tag) the information. Eventually these advantages will be implemented via computer programming rather than computer control. Although the programming is subject to resource constraints imposed by higher priority computer tasks, reasonable flexibility still exists for actual information display.

Problem

The problem addressed here concerns methods of entering and displaying information on the DDI. The keyboard of the present NTDS console includes 18 variable action buttons (VABs), three rows of six buttons each. The functions of the VABs change as the operating mode of a console changes and as a request for action or information is processed. As VAB functions change, so do the labels, indicating to the operator the current function of the VAB.

In principal, it is a straightforward matter to indicate the functions of the VABs on a DDI because of its programmable flexibility. In practice, however, the VAB function must interact logically with the operating mode or method selected to enter and display data. Two methods--called the Page and Menu methods--have been selected as candidates for implementation into the NTDS. Since these methods differ with respect to (1) usage of VABs, (2) display format on the DDI, and (3) computer software requirements, a decision must be made between them early in the design process.

Purpose

The purpose of the present effort was to compare the Page and Menu methods as to speed of data entry and display for various simulated NTDS situations. Results will be used in deciding which method should be incorporated in the system.

APPROACH

Data Entry and Display Methods

The information representing the accumulated knowledge of each sensor contact, or track, that appears on the Plan Position Indicator (PPI) lends itself naturally to an hierarchical data structure. To illustrate, consider the informational aspects of a track taken from the present investigation, which is presented as Figure 1. The hierarchical nature of this information is manifest in the natural presentation of Figure 1 as an outline broken down under three levels, indicated by Roman numerals (I, II, etc.), capital letters (A, B, etc.), and Arabic numerals (1, 2, etc.). Information linked to the second level categorizes the information under the first level, and that linked to the third level further categorizes the information. The number of levels that could be included in such data structures is, of course, arbitrary; that is, Figure 1 could be further broken down to include levels indicated by small letters, Arabic numerals enclosed by parentheses, etc. The point is that the data are naturally represented as a discrete, hierarchial, qualitative structure that can be easily represented by computers. The issue of concern here is how the information should be displayed on the Digital Display Indicator (DDI). Although this device is freely formatted, its display ability is limited to 16 lines and 64 columns of information. Thus, it is necessary to determine how much of this total area the Page and Menu methods would use for information display.

Since this is best conveyed by direct example, the following paragraphs describe how the hierarchical data structure illustrated by Figure 1 is displayed by an operator using the two methods. In each case, let us suppose that the operator is required to enter identification and amplification (ID AMP) information on a particular sensor contact or track, that this track is assumed to be friendly (ASSUMD FRND), and that it is further defined as a helicopter (HELO) (I-D-8).

Page Method

In the Page method, the bottom line (of the 16 available) of the DDI is devoted to supplying alphabetic labels for the top row of six VABs on the NTDS keyboard. Thus, for the above example, the operator using the Page method would initially see the display shown in Figure 2.a. Note that there are six labels--five that represent the first five alternatives in the first hierarchial level of Figure 1 and a sixth marked (PAGE). As indicated above, each label, from left to right, represents the function of the corresponding button in the first row of VABs on the console. Since there are six alternatives in the first level of Figure 1, the sixth, SELECT SEQ, does not appear in the initial display. If this action were required by the operator using the Page method, he would have to push the PAGE button to make SELECT SEQ available. Each group of five (or less, as in this case) labels is called a "page." Continued paging will either present the next five (or less) labels, or, when the list of labels is exhausted, go back and present the first five labels (page 1).

Since, in the present example, the operator wants to enter identifying and amplifying information, he pushes the left-hand button in Figure 2.a, marked ID AMP. This causes the first five alternatives under ID AMP to appear on the DDI, as shown in Figure 2.b, along with a history of entries made so far (in this case, only ID AMP). It also causes the functions of the top row of six VABs to change. Thus, if the operator were to push the left-hand button at this point, the track would be tagged as UNKNOWN. However, since he wants to tag it as "assumed friendly" (which appears on the DDI, since it is the fourth alternative), he pushes the fourth button. This causes the first five alternatives under ASSMD FRND to appear, as shown in Figure 2.c and, again, a history of entries made.

I. ID AMP

A. UNKNOWN

1. CV	6. SURF SUB
2. CG/DG	7. SIGINT
3. FPB	8. HELO
4. AMPHIB	9. BOMBER
5. NON-MIL	10. FIGHTER

B. HOSTILE

1. CV
2. CG/DG

.
.
.

10. FIGHTER

C. ASSMD ENMY

1. CV
2. CG/DG

.
.
.

10. FIGHTER

D. ASSMD FRND

1. CV
2. CG/DG

.
.
.

10. FIGHTER

E. FRIEND

1. CV
2. CG/DG

.
.
.

10. FIGHTER

II. MISSION

A. AAW	F. STRK	K. RECCE
B. ASW	G. EW	L. CAP
C. NGFS	H. AFW	M. LOG
D. UNREP	I. AMPHIB	N. TANK
E. SAR	J. RTB	O. TRNG

Figure 1. Example of hierarchical data structure.

III. LETTER (organized for Page Method)

A. ABCDE
1. A
2. B
3. C
4. D
5. E

B. FGHIJ
1. F
2. G
3. H
4. I
5. J

C. KLMNO . . . F. Z
1. K
2. L
3. M
4. N
5. O

III. LETTER (organized for Menu method)

A. A
B. B
C. C
.
.
.
Z. Z

IV. MISSILE INV[a]

A. CONV
1. REAR ASPT
2. ALL ASPT
3. MULT INT
4. GUIDED A/G
5. UNGUID A/G

B. NUC
1. REAR ASPT
2. ALL ASPT
3. MULT INT
4. GUIDED A/G
5. UNGUID A/G

V. CALLUP[b]

A. TN
B. EVENT NR
C. SIDE NR
D. SPEC PT NR
E. TACAN STA
F. MODE 1
G. MODE 2
H. MODE 3

VI. SELECT SEQ

A. AIR
B. SURFACE
C. SUBSURF
D. TNKR ACFT
E. INTCPTRS
F. HOSTILES
G. UNKNOWNS
H. ENGAGED
I. HELOS
J. ASW ACFT
K. ESM BRNGS
L. SONOBUOYS

---

[a]Completion of a MISSILE INV action required entering a single-digit number specifying the number of missiles.

[b]Completion of a CALLUP action required entering a three-digit number to further identify the desired information.

Figure 1. (Continued)

ID AMP : MISSION : LETTER : MISSILE INV : CALLUP : (PAGE)

Figure 2.a. Initial display.

ID AMP

UNKNOWN : HOSTILE : ASSMD ENMY : ASSMD FRND : FRIEND : (PAGE)

Figure 2.b. Display after actuating ID AMP entry.

ID AMP ASSMD FRND

CV : CG/DG : FPB : AMPHIB : NON-MIL : (PAGE)

Figure 2.c. Display after actuating ASSMD FRND entry.

ID AMP ASSMD FRND

SURF SUB : SIGINT : HELO : BOMBER : FIGHTER : (PAGE)

Figure 2.d. Display after actuating (PAGE) entry.

Figure 2. Page method displays.

As indicated above, the track was defined as helicopter (HELO). Since HELO is the eighth alternative under ASSMD FRND, it does not appear in Figure 2.c. Thus, the operator pushes the PAGE button, causing the requisite label to appear, as in Figure 2.d, and the functions of the VABs to again be redefined.

The Page method has a number of advantages. First, reasonably efficient use is made of the screen: only the bottom three lines are needed for VAB definition and the rest may be devoted to different, independent data display. Second, the operator processes a maximum of five labels at any one time, which is a rather light information load, allowing for performance of concurrent tasks. Third, the operator can page or enter data by a single button press.

This method also has some disadvantages. First, the operator must read all five labels to determine whether the correct one is present. Second, if he passes the correct page when paging, he must, in effect, go entirely around the circle before the correct page appears on the screen.

Menu Method

The Menu method differs from the Page method in two respects. First, the six VABs in the top row of the NTDS keyboard are associated with digits 1, 2, 3, 4, and 5 and the word ENTER, instead of directly to labels. The meanings of the buttons in the second row are associated with the digits 6, 7, 8, 9, and 0 and the word CLEAR. Second, all possible alternatives are presented, using as much of the screen as necessary.

Both of these differences are demonstrated in Figure 3.a, which is the initial display seen by the operator using the Menu method. As shown, instead of label → button, as with the Page method, we have label → digit(s) → button(s). Also, the sixth alternative in the first level, SELECT SEQ, which does not appear in the initial display of the Page method (Figure 2.a), does appear in this display. If the operator required this action, he would merely push the button associated with the number of this action, in this case, "6" (the left-hand button in the second row), followed by the button associated with the word ENTER (the right-hand button in the first row).

In the present example, however, the operator wants to enter ID AMP. Thus, he would press the buttons associated with "1" (the left-hand button in the first row) and with ENTER. This would cause the entire "menu" of alternatives under ID AMP to appear on the DDI, as seen in Figure 3.b. At this point, the operator would press the buttons associated with "4," which corresponds to ASMD FRND, and ENTER, causing all 10 alternatives under ASSMD FRND to appear. Thus, the requisite label is guaranteed to appear, provided the entries were correct up to that point. This is in contrast to the Page method, where, as in Figure 2.c, the requisite HELO does not appear, and the operator must "page" to find it.

Method Tradeoffs

The processing tradeoffs between the two methods are now more apparent. In the Menu method, the operator knows the correct alternative is on the screen somewhere; he must find it and enter the corresponding number. In the Page method, the operator knows that the correct alternative may or may not appear. If he finds it among the list, he pushes the proper button; if he does not, he pushes the PAGE button, and the process begins again. Although the Menu method does eliminate the "Is is there?" decision, the operator may have more information to process.

1	ID AMP	3	LETTER	5	CALLUP
2	MISSION	4	MISSILE INV	6	SELECT SEQ

1 : 2 : 3 : 4 : 5 : ENTER

Figure 3.a. Initial display

1	UNKNOWN	3	ASSMD ENMY	5	FRIEND
2	HOSTILE	4	ASSMD FRND		

ID AMP

1 : 2 : 3 : 4 : 5 : ENTER

Figure 3.b. Display after actuating "1."

1	CV	5	NON-MIL	9	BOMBER
2	CG/DG	6	SURF SUB	10	FIGHTER
3	FPB	7	SIGINT		
4	AMPHIB	8	HELO		

ID AMP ASSMD FRND

1 : 2 : 3 : 4 : 5 : ENTER

Figure 3.c. Display after actuating "4."

Figure 3. Menu method displays.

In addition, the actual response entry differs for the two methods. In the Page method, each button is directly linked to a label by virtue of its relative location. Thus, the left-hand label is identified with the left-hand button, etc. In the Menu method, the buttons are always linked to digits, so that the row of buttons functions as part of a numeric keyboard entry. The left-hand button always corresponds to "1," etc.

Simulation

Page and Menu displays, such as those provided by Figures 2 and 3, were simulated using the BASIC computer programming language and implemented on the Center's Tektronix 4051 Graphic System. Figure 4 is an example of the displays used in the experiment. As shown, the only differences between such displays and those illustrated in Figures 2 and 3 were:

1. The action to be entered (e.g., ID AMP) appeared in a rectangle in the lower center of the screen. Each time an entry was made, the information in this rectangle was updated.

2. As digits were keyed, they appeared on the screen above the sixth label. Thus, if the operator made an error before entering a digit(s), he could clear the number entry by striking the CLEAR button.

(ENTRIES SO FAR)	ACTION TO ENTER	(digits)

(LABEL 1) : (LABEL 2) : (LABEL 3) : (LABEL 4) : (LABEL 5) : (LABEL 6)

Figure 4. Example of display viewed by subject, including action to be entered.

To simulate the variable action buttons (VABs) on the NTDS console, a template was constructed that allowed the operation of a selected subset (three rows) of the Tektronix System keyboard. Only the first two rows of VABs were simulated; the second row was exposed but inoperative when the system was simulating the Page method.

The third row of the Tektronix keyboard was used to simulate the action of two other functions that provided error recovery capability. First, a button marked BACKUP allowed the operator to return to the next higher level in the hierarchy for a given problem. In effect, this button allowed him to erase the previous entry, unless it was the final entry. He could not back up to a previous problem. For example, if, on an ID AMP problem, the operator using the Page method entered FRIEND instead of ASSMD FRND, he could hit BACKUP and the system would delete the FRIEND entry and again present the alternatives in that level of the hierarchy.

The second button in the third row was marked ESCAPE. If the operator pushed this button, the system would return to the beginning of the given trial. In essence, it performed a multiple backup function in the event (unlikely) that more than one level of entry had occurred before the error was discovered.

Finally, under software control, a one-character input buffer was simulated. Thus, operators could not "stack" keyed inputs except in the case of numeric entries, where the digits can be held in a temporary store and sent as a single number entry when the ENTER button is pushed. Since the Tektronix system allows the stacking of approximately 25 characters, the software algorithm was used to reject any intercharacter entry time less than 100 milliseconds as stacked key strikes; that is, the second of the two characters was ignored.

Procedure

Twelve operators, all familiar with some aspect of the NTDS, participated in the experiment. These operators were seated in front of the Tektronix 4051--six of them were given a set of instructions on how to enter and display data using the Page method; and six, a set using the Menu method (see Appendix A). They were then presented with 30 practice problems--five for each type of problem included in Figure 1 (i.e., ID AMP, MISSION, LETTER, MISSILE INV, CALLUP, and SELECT SEQ)--and were encouraged to ask questions. The practice problems were not randomized with respect to type; rather, all problems of each type appeared successively. Thus, there were five ID AMP problems, followed by five MISSION problems, etc. Feedback in the form of response time and correctness was given after each trial. Also, for a given problem type, the 30 trials equally weighted the target alternatives in groups of five in order to keep the number of trials on each "page" equal. Although this grouping did not pertain to the Menu method, it did keep each target alternative equally weighted.

The practice session was followed by an experimental session, which consisted of 180 problems (30 problems of each type) in a fixed, random order. As with the practice problems, the experimental problems were the same and presented in the same order for both the Page and Menu methods. Feedback was given after each trial, and 2-minute rest periods were provided after every 30 trials. After the experimental sessions, the operators were asked to complete a debriefing questionnaire asking them to give an overall rating of the method they had used, to compare that method with the way analogous entries are presently being made in NTDS, and to provide comments on its good and bad features and suggestions for improvement (see Appendix B).

The operators returned for a second practice and experimental session within a 3-day period. The procedure was the same, except that the operators were given instructions for the method they had not tried in the first session. Also, the questionnaire included an additional question concerning the operator's preference, if any, for either of the two methods.

Dependent Measure

The dependent measure in the present experiment was reaction time. Times were kept separately for each of the six types of problems, and for each stage of the data entry for each problem type.

For the Page method, the response time recorded was that which had elapsed between the end of the screen writing sequence and the actuation of one of the six buttons in the top row. If multiple "pages" were either required or actuated, the times for that level in the problem were accumulated. Screen-write time and response processing time were not counted. For the Menu method, the response time recorded was that which had elapsed between the end of the screen-writing sequence and the actuation of the ENTER button.

Illegal responses were not recorded. They were counted in the total time, however, and the operator was warned of their occurrence by an audible tone.

Analysis

The main dependent measure was the amount of time required to accomplish the action entry. An analysis of variance (ANOVA) was performed using the average (mean) total entry time for the 30 replications of each type of problem (i.e., ID AMP, MISSION, etc.) for each of the two methods. Thus, each subject provided 12 numbers: an average entry time for each of six problem types under each of two methods. The ANOVA would indicate whether or not (1) the different types of problems were similar in difficulty level, or require varying amounts of resources (i.e., time) to accomplish, (2) the display method affected data entry times, and (3) the order in which the methods were tested affected the task. This final aspect is particularly important in assessing performance improvement due to practice from the first to second session, independent of method.

RESULTS

The basic measures of performance (data entry times) were recorded separately for each trial and then averaged across the 30 replications to produce 12 scores for each operator. An alpha level of .01 was chosen for test significance.

Analysis of Variance of Data Entry Times

As shown in Table 1, two significant effects emerged from the analysis of variance (AVOVA) performed on data entry times--one for type of problem (T) (F = 43.3, df = 5, 50, MS = 23.7) and the other, for the interaction of method and group (M x G) (F = 43.0, df = 1, 10, MS = 40.0). No other factors or interactions were significant, including the variable of prime interest, data entry method (M). The means for the Page and Menu methods were 4.2 and 4.3 seconds respectively.

Figure 5 compares operator performance on the six problem types using the two data entry methods. The function for each data entry method is similar, as the number of possible sequences increases for each problem type. Figure 5 presents problem types in order of the number of data entry sequences required, from the fewest (SELECT SEQ) to the most numerous (MISSILE INV). A Tukey multiple-paired comparison test of the problem types showed that SELECT SEQ, MISSION, and LETTER differ significantly from CALLUP and MISSILE INV and that ID AMP differs significantly from LETTER, but none of the other comparisons reach significance. Based on these findings and the quasi-categorical nature of the problem type factor, no other inferences can be made from this data.

The second significant effect was the method x group interaction. This represents a practice effect, revealing that the second method performed was the faster, regardless of whether it was the "Menu" or the "Page" method. This result was confirmed by the summary of responses to the debriefing questionnaire described in the following section.

The interaction of method and problem type (M x T) approached significance but fell short when conservative degrees of freedom were applied to adjust the F test for the violation of assumptions of independence inherent in a repeated measures design.

Debriefing Questionnaire

A quantitative summary of responses to the debriefing questionnaire was not attempted since it was not designed to be a measurement instrument. A visual inspection of responses, however, indicated that they were about the same for both methods. For example, when operators were asked to rate the two methods in regard to speed, ease, and accuracy, they indicated that both ranked somewhere between "very" and "somewhat" on all three variables. When asked to compare the two methods with the method presently being used in NTDS consoles, they indicated that both were between "better" and "about the same" as to speed, ease, and accuracy.

The most common good features mentioned were economy, speed of action (i.e., much could be accomplished with few actions), and flexibility in the sense of diversity of data types that could be represented. Most of the comments regarding bad features pertained to the Menu method, the most common being that the screen contained too much information. The most common suggestion for improvement concerned the need to allow stacked inputs; that is, to increase the input buffer size. The buffer size limitation, however, is an overall NTDS system limitation and is not under software control.

Table 1

Analysis of Variance Summary Table

Source	Error	MS	df	F
T	$(S \times T)_{wg}$	23.720	5	43.33*
M	$(S \times M)_{wg}$	0.514	1	0.55
G	S_{wg}	24.100	1	0.90
S		26.670	10	
G x M	$(S \times M)_{wg}$	40.090	1	43.06*
G x T	$(S \times T)_{wg}$	0.525	5	0.96
M x T	$(S \times M \times T)_{wg}$	0.849	5	4.11
$(S \times M)_{wg}$		0.931	10	
$(S \times T)_{wg}$		0.547	50	
G x M x T	$(S \times M \times T)_{wg}$	0.359	5	1.74
$(S \times M \times T)_{wg}$		0.206	50	

Notes.

T = Problem type (ID AMP, MISSION, etc.)
M = Method (Page or Menu)
G = Group (Subjects using Menu method first and those using Page method first).
S_{wg} = Subject within group

*$p < .01$.

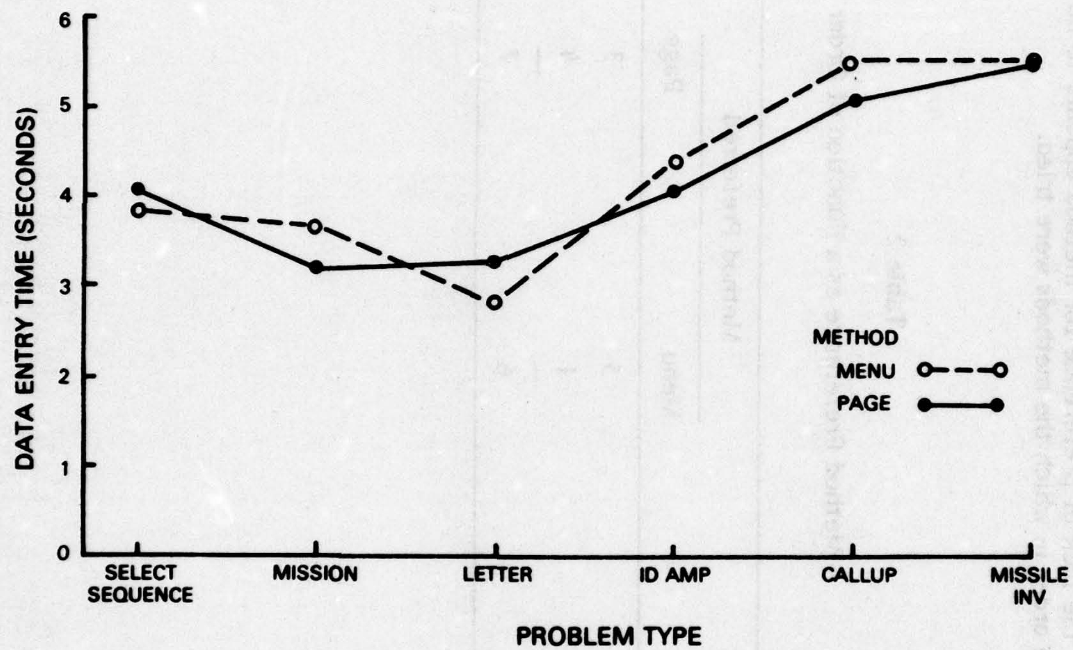

Figure 5. Data Entry Times as a Function of Method and Problem Type.

In the questionnaire administered after the second session, operators were asked to indicate the method they most preferred, if any. Responses to this question are shown in Table 2, which indicates that operators had no clear preference for either method. Since the ANOVA performed on data entry time showed that practice had a significant effect on performance, however, it was felt that performance might be contingent upon which method was used second, particularly if operators realized they performed better (e.g., they were faster) on the second method (whichever one it was), and thus preferred that method. Although data in Table 2 do give some support to preference as a function of order, a Fisher exact probability test yielded a probability value of .163, which is not significant. Thus, the lack of preference for method appears to be a reliable finding and independent of the order in which the methods were tried.

Table 2

Method Preference as a Function of Order

Group	Method Preferred		Total
	Menu	Page	
Menu Second	5	3	8
Page Second	1	4	5
Total	6	7	13

DISCUSSION AND CONCLUSIONS

Results of this study showed that there is no real difference between the Menu and Page methods of data entry. Neither was convincingly superior, even when examined across a variety of problem types. Both showed fluctuations between problem types, which is, for the most part, a result of the change in number of possible data entry sequences as shown by the multiple, paired comparisons. The most striking deviation from this pattern was the LETTER problems within the Menu method. After completing the study, it was decided that LETTER problems were not comparable across the two methods because entry of a letter followed different hierarchial structures in the two methods. In the Menu method, only one level of choice was required after choosing "LETTER"; in the Page method, two subsequent choices were required. Alleviation of this difference would bring the two methods more closely together (Figure 5).

Response time frequently is an increasing function of the number of items in a display (Atkinson, Holmgren, & Juola, 1969, Egeth, Atkinson, Gilmore, & Marcus, 1973; Teichner & Mocharnuk, 1974). This type of increase recently was found by Callan, Curran, and Lane (1977) in the context of a visual search task using NTDS alphanumeric information and format. The best explanation of the effect of problem type in this study is that it was a consequence of the number of entry sequences and the number of items displayed on the screen.

The only other significant finding was the practice effect, which was to be expected. Since this effect was similar for both groups, there is no reason to suspect that either method would provide more rapid skill acquisition.

Although, while the two methods did not differ with respect to operator speed or preference, the Page method is preferable because it uses display screen more efficiently and reduces software programming time.

RECOMMENDATIONS

1. Subject to NTDS software constraints, future efforts should be directed toward developing the Page method.

2. Alternative choices should be grouped systematically on pages so that more frequently occurring items appear on earlier pages.

3. To ensure the evaluation of reasonably organized pages, software should include monitors to determine how frequently alternatives occur in operational environments.

4. Consideration should be given to expanding input buffer size. Although this would increase processing overhead, it would allow the operator to complete an entry task and begin another, rather than have to time share between two or more tasks.

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APPENDIX A

INSTRUCTIONS FOR USING THE TWO DATA ENTRY AND DISPLAY METHODS

CRT INTERACTIVE ENTRY
OPERATOR FACILITY COMPARISON TEST

A. GENERAL INSTRUCTIONS--BOTH METHODS

1.0 General

This experiment has been designed to test various methods for performing entry and/or display actions by a Navy Tactical Data System (NTDS) console operator. You will be asked to complete given actions in several different ways. Each action and each method will be explained fully and must be understood before actually attempting the machine entries. You will be given two sets of problems, each set employing a different method. By analyzing time delays and button errors we will be able to objectively identify the best methods for implementing standard operator actions. At the conclusion of each series of runs you will also be given an opportunity to express your opinion of the method just tested. Recommendations for improvements are encouraged.

2.0 Console Description

The experimental mock-up consists of a CRT read-out and a button entry panel. The CRT will display the requested entry display action, some accounting data and the labels assigned to six buttons on the entry panel. These labels can be automatically changed by the computer to reflect new actions assigned to the buttons as each run progresses. Figure 1 illustrates the layout of the CRT. The CRT also displays the current selection made by the operator via the buttons.

The button entry panel contains 14 buttons arranged in two rows of six plus two additional buttons. The meanings attached to the top row of buttons is indicated by the corresponding LABEL entries on the CRT (see Figure 1). These are computer-controlled action buttons. The meaning of this top row is always linked to the CRT.

Each button in the second row of six buttons has a predefined meaning, as indicated on the template above each button to the left of the "/." These are preset action buttons. In one special case, however, they take on a different meaning. Whenever the input request is for a numeric entry, i.e., when the LABELS on the CRT are digits, the second row of six buttons has meaning defined to the right of the "/" on the template, viz., the digitis 6, 7, 8, 9, 0, and "CLEAR." As digits are keyed, they will appear above LABEL 6 (see Figure 1). If an error is made before the number is entered, the number entry can be cleared by striking the "CLEAR" button. These meanings apply only when the computer expects a numeric entry. Use of these buttons is considered an error at all other times.

The two remaining buttons labeled "B" (for Backup) and "E" (for Escape) are on the bottom row. They perform in the following manner. In order to accomplish the ACTION TO ENTER (Figure 1), a sequence of button presses must occur. The "B" and "E" buttons provide two ways to abort the sequence. Pushing the "B" causes the computer to backup one step in the sequence--it erases your previous entry. Pushing the "E" button allows escape from the entire sequence and returns the system to the initial state--it erases all button pushes for the particular problem.

Time:
(IN)CORRECT

(ENTRIES SO FAR)	ACTION TO ENTER	(digits)

(LABEL 1) : (LABEL 2) : (LABEL 3) : (LABEL 4) : (LABEL 5) : (LABEL 6)

Figure 1

3.0 Entering an Action

The action you are required to enter on each trial will appear surrounded by a rectangle as in Figure 1. There are six categories of action requests possible. They are:

ID AMP
MISSION
LETTER
MISSILE INV
CALLUP
SELECT SEQ

These will be discussed in turn. In order to familiarize yourself with the operation of this console, you will be given 30 practice runs (five of each of the above six in order).

Please initiate the practice runs by pushing the Escape ("E") button.

B. INSTRUCTIONS FOR OPERATORS USING MENU METHOD

3.1 First Action: "ID AMP"

The object is to associate a label with a track symbol which will express its identity and amplifying data. The options for "identity" are:

UNKNOWN
HOSTILE
ASSMD ENMY (assumed enemy)
ASSMD FRND (assumed friend)
FRIEND

The options for amplifyng data are:

CV (carrier)
CG/DG (cruiser/destroyer)
FPB (fast patrol boat)
AMPHIB (amphibious)
NON-MIL (non-military)
SURF SUB (surfaced sub)
SIGINT (signal intelligence)
HELO
BOMBER
FIGHTER

Notice the contents of the ACTION TO ENTER rectangle ("ID AMP HOSTILE FPB"). This is the information you are requested to enter. The possible choices for entry at this stage (i.e., the six problem types) are listed as a "menu" on the CRT. The LABEL area contains numbers, implying that the top and bottom rows of buttons have a numeric function. The choice is made by entering the number corresponding to the choice. For ID AMP, then, the left-most button on the top row is pushed. Notice the appearance of the digit "1" above the ENTER label. The number is not given over to the computer until the ENTER button is pushed.

Push the "1" button followed by ENTER, and note what happens. The ID AMP appears in the ACTIONS SO FAR area of the CRT, and the menu changes to the five ID options. Pushing the "2" (HOSTILE) followed by ENTER causes the ACTION SO FAR area to be updated, followed by a second change in the menu. The menu now contains the ten possible amplifying data options. Pushing "3" (FPB) followed by ENTER terminates the problem. Notice that the total (elapsed) time and a correctness indicator appear in the upper left corner of the CRT. The time is long, of course, since you are familiarizing yourself with the system. The time should get shorter as you get better.

There is about a 3-second wait between the time you terminate the problem and the time the next one begins.

Please continue with the remaining four ID AMP problems. When the actions request becomes MISSION, continue reading the next section.

3.2 Second Action: "MISSION"

The object is to associate a label with a track symbol which will express its assigned mission. The options for "MISSION" are:

AAW	AMPHIB
ASW	RTB
NGFS	RECCE
UNREP	CAP
SAR	LOG
STRK	TANK
EW	TRNG
AEW	

To obtain MISSION options, push the "2" button followed by ENTER, and continue as before. Continue with the remaining MISSION problems.

3.3 Third Action: "LETTER"

The object is to select one of the 26 letters for display at some undetermined location on the radarscope.

Press the "3" button, followed by ENTER, and notice that the alphabet appears such that a number is assigned to each letter in the menu. Choose and enter the appropriate digits, and then ENTER, as before.

Continue with the remaining LETTER problems.

3.4 Fourth Action: "MISSILE INV"

The object is to enter a specified missile type and quantity as an inventory associated with an undefined air platform. The options for weapon type are:

CONV REAR ASPT	(conventional rear aspect)
CONV ALL ASPT	(conventional all aspect)
CONV MULT INT	(conventional multiple intercept)
CONV GUIDED A/G	(conventional guided air-to-ground)
CONV UNGUID A/G	(conventional unguided air-to-ground)
NUC REAR ASPT	(nuclear rear aspect)
NUC ALL ASPT	(nuclear all aspect)
NUC MULT INT	(nuclear multiple intercept)
NUC GUIDED A/G	(nuclear guided air-to-ground)
NUC UNGUID A/G	(nuclear unguided air-to-ground)

Notice that in the ACTION TO ENTER rectangle, the description of the action is not the order in which the action entry labels appear. Only after the CONV and ALL ASPT actions have been accomplished, can you enter the number of missiles. Note that the numeric entry itself does not require a menu--instead the reminder ENTER NUMBER appears.

Continue with the remaining four problems.

3.5 Fifth Action: "CALLUP"

The object is to enter certain minimum identifying data on a selected track such that the computer can recognize which track is of interest and present to the operator all known data on that track, including current geographic location. (If there is more than one track with the same minimal identifying data, the computer would provide data on all in a sequential manner.) The options for minimum identifying data are:

TN ___
EVENT NR ___
SIDE NR ___
SPEC PT NR ___
TACAN STA ___
MODE 1 ___
MODE 2 ___
MODE 3 ___

Entering the numbers here is the same as on Missile Inventory problems.

Continue with the remaining four problems.

3.6 Sixth Action: "SELECT SEQ"

The object is to enter criteria by which the computer would be directed to call-out certain types of tracks in a sequential manner, all tracks having a specified factor in common. The options for the common factors are:

AIR
SURFACE
SUBSURF
TNKR ACFT
INTCPTRS
HOSTILES
UNKNOWNS
ENGAGED
HELOS
ASW ACFT
ESM BRNGS
SONOBUOYS

Procedure is the same as previously.

4.0 Conclusion

This concludes your practice session. If you have any questions, ask them now.

When the actual session begins, you will be presented with 180 problems, 30 of each type. They will be in a mixed order. After each 30 trials, you will be given a two minute timed rest period. The session will take approximately one hour, including rest periods.

Because our measure of the efficiency of the methods we are examining is reaction time, we need a constant time base for each method. The timing clock does not start until the CRT has concluded its writing on the screen. Therefore, the computer is programmed to ignore all button pushes which occur before the screen is written. Thus, although we wish you to respond as rapidly and accurately as possible, please do not try to get ahead by pre-entering your response. Wait until the screen is written.

Are there any questions before we begin?

C. INSTRUCTIONS FOR OPERATORS USING PAGE METHOD

3.1 First Action: "ID AMP"

The object is to associate a label with a track symbol which will express its identity and amplifying data. The options for "identity" are:

UNKNOWN
HOSTILE
ASSMD ENMY (assumed enemy)
ASSMD FRND (assumed friend)
FRIEND

The options for amplifying data are:

CV (carrier)
CG/DG (cruiser/destroyer)
FPB (fast patrol boat)
AMPHIB (amphibious)
NON-MIL (non-military)
SURF SUB (surfaced sub)
SIGINT (signal intelligence)
HELO
BOMBER
FIGHTER

Notice the contents of the ACTION TO ENTER rectangle ("ID AMP HOSTILE FPB"). This is the information you are requested to enter. Notice the LABEL area on the CRT. The implication is that pushing the left-most button on the top row will initiate an "ID AMP" entry sequence, pushing the next button to the right will initiate a "MISSION" entry sequence, etc.

Note that LABEL 6 on the CRT is "(PAGE)." The concept here is that if there are more than five possible choices at any time (there are six here because there are six categories of action request), the choices are stacked on "pages" as in a book. To examine the next page, simply hit the page button. Of course, in the present problem, this is not necessary, since ID AMP appears. The paging is circular--if you are on the last page and you page again, you will return to the first page.

Hit the "ID AMP" button, and note what happens. First, the button labels change to identify options, and the "ID AMP" appears in the ENTRIES SO FAR area (see Figure 1) to aid you in keeping track of where you are. Hitting the "HOSTILE" button causes the button labels to change to amplifying data options, and "ID AMP HOSTILE" appears in the ENTRIES SO FAR area. Pushing the FPB button terminates the problem. Notice that the total (elapsed) time and a correctness indicator appear in the upper left corner of the CRT. The elasped time clock starts only after the screen is written, and is terminated by a button push. Since the clock does not start until the screen is written, any entries made before the writing on the CRT is complete will be ignored. You cannot stack responses. The time is long, of course, since you are familiarizing yourself with the system. The time should get shorter as you get better.

There is about a two second wait between the time you terminate the problem, and the time the next one begins.

Please continue with the remaining four ID AMP problems. When the action request becomes MISSION, continue reading the next section.

3.2 Second Action: "MISSION"

The object is to associate a label with a track symbol which will express its assigned mission. The options for "MISSION" are:

AAW	AMPHIB
ASW	RTB
NGFS	RECCE
UNREP	CAP
SAR	LOG
STRK	TANK
EW	TRNG
AEW	

To obtain mission options, hit the button labeled MISSION. Notice that you must page once to get to STRK. Continue with the remaining MISSION problems.

3.3 Third Action: "LETTER"

The object is to select one of the 26 letters for display at some undetermined location on the radarscope.

Press the button labeled LETTER, and notice that the alphabet appears such that each button is assigned to a group of five letters. Choose the button whose letter group corresponds to the target letter. Accessing the "Z" requires paging.

Continue with the remaining letter problems.

3.4 Fourth Action: "MISSILE INV"

The object is to enter a specified missile type and quantity as an inventory associated with an undefined air platform. The options for weapon type are:

CONV REAR ASPT	(conventional rear aspect)
CONV ALL ASPT	(conventional all aspect)
CONV MULT INT	(conventional multiple intercept)
CONV GUIDED A/G	(conventional guided air-to-ground)
CONV UNGUID A/G	(conventional unguided air-to-ground)
NUC REAR ASPT	(nuclear rear aspect)
NUC ALL ASPT	(nuclear all aspect)
NUC MULT INT	(nuclear multiple intercept)
NUC GUIDED A/G	(nuclear guided air-to-ground)
NUC UNGUID A/G	(nuclear unguided air-to-ground)

Notice that in the ACTION TO ENTER rectangle, the description of the action is not the order in which the action entry labels appear. After pressing CONV and ALL ASPT, there are two important things to note. First, the labels of the first five buttons are now digits 1, 2, 3, 4, and 5. This implies that the second row of six buttons is now active, and will represent digits 6, 7, 8, 9, 0, and the "CLEAR" function.

Second, the sixth button is now labeled "ENTER" instead of "PAGE." As the digits for entry are pressed, they appear on the CRT above the sixth label (ENTER). The computer will not accept anything, however, until the "ENTER" button is pushed, at which point the entire sequence of digits is entered as a single number. Thus, entering the "2" requires pushing the "2" button, then the "ENTER" button. Hitting "ENTER" terminates the problem.

Continue with the remaining four problems.

3.5 Fifth Action: "CALLUP"

The object is to enter certain minimum identifying data on a selected track such that the computer can recognize which track is of interest and present to the operator all known data on that track, including current geographic location. (If there is more than one track with the same minimal identifying data, the computer would provide data on all in a sequential manner.) The options for minimum identifying data are:

TN ___
EVENT NR ___
SIDE NR ___
SPEC PT NR ___
TACAN STA ___
MODE 1 ___
MODE 2 ___
MODE 3 ___

Each of the above eight actions requires a three digit numeric entry. Entering the numbers here is the same as on *Missile Inventory problems. Note that paging is required* to access IFF Mode entry.

Continue with remaining four problems.

3.6 Sixth Action: "SELECT SEQ"

The object is to enter criteria by which the computer would be directed to call-out certain types of tracks in a sequential manner, all tracks having a specified factor in common. The options for the common factors are:

AIR
SURFACE
SUBSURF
TNKR ACFT
INTCPTRS
HOSTILES
UNKNOWNS
ENGAGED
HELOS
ASW ACFT
ESM BRNGS
SONOBUOYS

Notice here that paging is required to obtain the SELECT SEQ initial action. Subsequent procedure is the same as previously.

4.0 Conclusion

This concludes your practice session. If you have any questions ask them now.

When the actual session begins, you will be presented with 180 problems, 30 of each type. They will be in a mixed order. After each 30 trials, you will be given a two minute timed rest period. The session will take approximately one hour, including rest periods.

Because our measure of the efficiency of the methods we are examining is reaction time, we need a constant time base for each method. The timing clock does not start until the CRT has concluded its writing on the screen. Therefore, the computer is programmed to ignore all button pushes which occur before the screen is written. Thus, although we wish you to respond as rapidly and as accurately as possible, please do not try to get ahead by pre-entering your response. Wait until the screen is written.

Are there any questions before we begin?

APPENDIX B

DEBRIEFING QUESTIONNAIRE

DEBRIEFING QUESTIONNAIRE

1. Please give an overall rating of the method you have just used on the following three aspects by checking the appropriate box in each row:

	Very	Somewhat	Not at All
Quick			
Easy			
Accurate			

Please rate this experimental method compared to the way the analogous entries are presently made in NTDS. Thus, if you think that NTDS as it presently exists is on the average just as easy to use, check the middle box in the second row.

	Experimental Better	About the Same	Present NTDS Better
Quick			
Easy			
Accurate			

2. Do you have any comments on this method of presenting information?

   a. Good features -

   b. Bad features -

c. Improvements -

3. Having seen this method, compared with the existing NTDS entry sequences, can you suggest other methods or sequences of interaction that would be easy, quick, and accurate?

4. Which method do you prefer?

First | Indifferent | Second

Note. Item 4 included in questionnaire completed after second session only.

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