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Printed Tutorial Instructions: Effects of Text Format and Screen Pictographs on Human-Computer Task Performance

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Abstract

The effects of two printed instruction variables on computer task performance are examined. In written tutorial instructions, illustrative screen pictographs were either present or absent, and text was either in a paragraph or list format. Analysis of errors, help requests, and completion time showed that best performance was produced by subjects using list-format instructions containing pictographs. Implications for improving computer instruction manuals are discussed.

Introduction

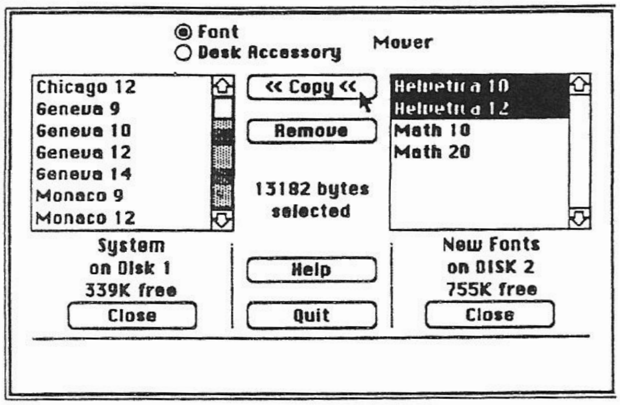
In the last few years human-computer interaction has been one of the dominant interests in Human Factors. Most of the efforts in this area have been focused on computer usability issues (e.g., better screen displays, input devices). One aspect of computer usability that has not received as much attention as it deserves is computer documentation.

The importance of good computer documentation is obvious to most users. Without adequate docu-men-tation, computers are virtually unusable. However, computer documentation tends to be poorly designed and written.

Much of the research on computer documen-tation has dealt with comparing the usability of on-line versus printed documentation (e.g., Hansen, Doring, & Whitlock, 1978; Muter, Latremouile, Treurniet, & Beam, 1982; Wright & Lickorish, 1983). Research examing specific factors of printed computer documentation has been sparse. Carroll, Smith-Kerker, Ford, and Mazur-Rimetz (1987-1988) have shown that learning a text editor using print instructions can be enhanced by removing unnecessary verbiage. Foss, Rosson, & Smith (1982) have shown that modifying the textual content of standard computer documentation can lead to substantial improvements on computer task performance. These studies show computer documentation can be improved, but many kinds of printed instruction variables have yet to be explored. The purpose of the present research is to systematically investigate the effects of two printed instruction variables on computer task performance. We examine whether performance on a computer tutorial task is affected by the presence of embedded screen pictographs (pictures of the computer screen). We also examine whether the presentation of the text in either list or paragraph formats affects performance.

Although no research has specifically investigated the effects of screen pictographs in computer instructions, other kinds of spatial displays in instructional material have been examined. For example, Brooke and Duncan (1980) and Schneiderman et al. (1977) failed to observe performance differences when comparing purely verbal instructions to instructions with visual-spatial components (e.g., flow charts). However, Booher (1975) and Thomas and Gould (1975) showed facilitated task performance for spatial format instructions over verbal format instructions. Why the addition of visual displays facilitated performance in some cases and not others is not clear. In the present research another means of displaying visual-spatial information, screen pictographs, is examined. An example screen pictograph is shown in Figure 1.

Figure 1. Example of computer screen pictograph.



A large body of theory and research in cognitive psychology suggests that the addition of descriptive visual-spatial displays should facilitate performance over verbal description alone. For example, Paivio's (1971) Dual-Code theory predicts that providing information in both a verbal and a visual form would be more beneficial than instructions in the written verbal form only. Thus, it is hypothesized that the addition of illustrative pictographs will facilitate task performance over instructions with words alone. Alternatively, a different prediction can also be made: The screen pictographs could degrade performance because their inclusion increases the length of the instructions which could heighten processing time.

We also examined another variable that might affect tutorial instruction quality: the format of the written text. Some text-format variables have already been investigated. For example, Trollip and Sales (1986) have found that left-justified text is better than fill-justified text. The research of Gould, Alfaro, Barnes, Finn, Grischkowsky, and Minuto (1987) suggests that an important factor for the difficulty of reading computer text versus printed text is letter resolution differences. No research has examined the effects of paragraph/prose versus list/outline formatted text in computer documentation, but there has been some related research in non-computer instructional domains. For example, Hartley (1978, 1980) demonstrated that vertical spacing of text facilitates reading comprehension. Frase and Schwartz (1979) suggest that list-format instructions facilitate performance because the material is presented in meaningful chunks. Lists might also facilitate performance because the information is presented in sequenced steps making the instructions easier to follow and to relocate one's place when returning to the instructions from the computer task. For these reasons it was hypothesized that list-format instructions would produce better computer task performance than paragraph-format instructions.

We were also interested in whether the presence of pictographs interacts with text format. It was hypothesized that the addition of pictographs would benefit performance to a greater extent when embedded in list-format instructions than in paragraph-format instructions because in a list format they are more proximal to the associated descriptive text than in the paragraph format.

Experiment 1

Method

Subjects. Thirty-two male and female University of Richmond undergraduates participated for research credit in introductory psychology courses. Only subjects with no experience on the Macintosh computer participated. Eight subjects were randomly assigned to each of four conditions.

Apparatus and Materials. The instructions used in the present research was a tutuorial that directed subjects through a series of specific steps on a Macintosh computer and the system application program, Font/DA Mover. This program changes the fonts (type styles and type sizes) and desk accessories available in the Macintosh system. It was used because moving fonts would likely be unfamiliar task for subjects with no prior experience on the Macintosh, including subjects who might have had some experience on other computer systems.

Subjects were provided with one of four sets of instructions for which the text format and the presence vs. absence of pictographs was orthogonally manipulated. This produced four instruction conditions: paragraph-no pictographs, paragraph-pictographs, list-no pictographs, and list-pictographs.

The paragraph-format instructions were in pros sentence style with indentations at paragraphs. Th list-format instructions had nearly the identical semantic content as the paragraph-format instructions except that each element was numbered and indented separately, and listed vertically down the instructions. The instructions containing computer-screen pictographs were identical to the instructions lacking them except that pictographs were inserted at locations near the corresponding textual instructions. The pictographs were depictions of the computer screen seen at that point in the verbal text. Screen pictographs are easily produced on the Macintosh by simultaneously pressing the Shift-Command-3 keys on the keyboard which "dumps" the current screen to disk in the form of a MacPaint document. The same pictographs were used in both the list and paragraph conditions. There were ten distinct steps in the first task, three in the second task, and nine in the third task. In the pictograph conditions there were ten pictographs for the first task, three pictographs in the second task, and eight pictographs in the third task. The pictographs were centered and placed below the corresponding text.

The first task required the installation of two font sizes into the system file of one disk from the system file of another disk. The second task required the removal of five font sizes from a system disk. The third task required creation of a new font file and the installation of seven fonts into the newly created file.

Procedure. Initially, the experimenter gave a five-minute introduction on the direct-manipulation features of the Macintosh computer interface including how to point, drag, select, and scroll by using sections of the tutorial disk "Your Apple Tour of the Macintosh Plus." To motivate the subjects, they were shown a set of different font styles and were told that they would be performing were the basic procedures needed to use and manage fonts. They were told to perform the instructed tasks as quickly and as accurately as possible. They were explicitly told that if they had any trouble with the tasks that they should reread the instructions. If they still had problems after this they could ask the experimenter for assistance. When subjects asked for help, the experimenter gave brief, direct verbal answers to the subject's questions. Lastly, subjects were told that upon completing one task that they should immediately start the next task and continue until all three tasks were completed. Subjects were then given one of the four sets of printed instructions.

The experimenter remained in the room with subjects while they performed the tasks. The experimenter recorded the total number of errors (failures to comply with the directions), the total number of times subjects asked the experimenter's assistance, the time needed to successfully complete each of the three separate tasks, and the total time to complete all three tasks. Subjects were not allowed to access the on-line "Help" instructions within Font/DA Mover.

Results

Errors, help requests, and completion times were analyzed using separate 2 (text format) X 2 (pictographs) between-subjects ANOVAs. Analysis of errors produced a significant interaction of the text format and pictograph variables, $F(1,28) = 7.54$, $p < .05$. Table 1 shows the mean number of errors as a function of instruction condition. List-pictograph instructions produced the least errors. Comparisons between the means in this table showed a reliable difference between only the list-pictograph and list-no pictograph instructions. The data were also analyzed with respect to the proportion of subjects who made at least one error. The results showed the same pattern as the number of errors analysis.

Table 1. *Mean number of errors as a function of instruction condition.*

	Pictographs	
	Absent	Present
Text Format		
Paragraph	.625	1.125
List	1.625	.25

The help measure showed a significant main effect of the pictograph variable, $F(1, 28) = 5.25$, $p < .05$. More help requests were made by subjects using instructions lacking pictographs (M = 1.0) than by subjects using instructions containing pictographs (M = .25). No subject in the list-pictograph condition requested help. The help data was also examined with respect to the proportion of subjects who made at least one help request. The results were similar to the number of help requests analysis.

Analysis of the total time needed to complete all three tasks yielded a significant interaction of the text format and pictograph variables, $F(1, 28) = 4.97$, $p < .05$. Table 2 shows mean total time (in seconds) as a function of instruction condition. Subjects had the shortest completion time for list-pictograph instructions. Comparisons between the means showed that subjects using the list-no pictograph instructions required significantly more time than subjects using the list-pictograph or the paragraph-no pictograph instructions. Each task's completion time was also analyzed separately. The pattern of means paralleled the results of total completion time analysis.

Table 2. Mean total time (in seconds) as a function of instruction condition.

	Pictographs	
	Absent	Present
Text Format		
Paragraph	551.6	577.6
List	641.4	529.2

Discussion

The presence of pictographs reduced inquiries for help. This result supports the notion that embedding illustrative computer-screen pictographs in instructional text enhances computer task performance. The error and completion time measures showed a more complex pattern of results. They indicate that the presence of pictographs benefits performance when they are embedded in list-format instructions but not when they are embedded in paragraph-format instructions. While the combination of list-pictograph instructions produced the best performance, the list-no pictograph produced the worst performance. In spite of the list- and paragraph-format instructions having the same basic semantic content, list-no pictograph instructions produced signficantly lower performance than the paragraph-no pictograph instructions. Perhaps the appearance of the list led subjects to believe that the task was simple and straightforward, provoking less careful behavior. The data also showed a trend towards reduced performance for the paragraph-pictograph instructions. Reduced performance might be due the less than ideal placement of the pictographs in the continuous prose. To avoid fragmenting the continuous-prose descriptions, the pictographs and the associated verbal text were not always proximally located. This could have caused subjects some confusion and resulted in lowered performance. Performance for these conditions was re-examined in Experiment 2 with a different set of subjects.

Experiment 2

Since subjects in Experiment 1 had no prior experience with the Macintosh interface, task performance might have been affected by the novelty of the situation. Thus, it is not clear whether subjects more experienced with the Macintosh interface would produce a similar pattern of results. So in Experiment 2, the procedures of Experiment 1 were replicated with a group of subjects with somewhat more experience using the Macintosh.

Method

Subjects. Thirty-two male and female upper-level psychology majors at the University of Richmond participated. All subjects had taken at least two undergraduate courses in psychology and had a minimum of six hours experience analyzing data on the Macintosh computer. None of the subjects had any experience with the Font/DA mover before.

Apparatus and Materials. The same apparatus and materials as in Experiment 1 were used.

Procedure. The same procedure as in Experiment 1 was used.

Results

As in Experiment 1, errors, help requests, and completion times were analyzed using separate 2 (text format) X 2 (pictographs) between-subjects ANOVAs. Analysis of the number of errors revealed a significant main effect of the text format, $F(1,28) = 7.99$, $p < .01$. Subjects using the list-format instructions (M = .625) committed significantly less errors than subjects using the paragraph-format instructions (M = 1.75). However, this main effect must be qualified as the ANOVA also yielded a significant interaction, $F(1,28) = 4.83$, $p < .05$. The means can be seen in Table 3. The table show the paragraph-no pictograph produced more errors than the other three conditions which among themselves did not significantly differ.

As in Experiment 1, the error data was analyzed with respect to the proportion of subjects who made at least one error. Only a main effect of text format was found, $F(1,28) = 14.54$, $p < .001$, indicating that signficantly fewer subjects using the list-format instructions (M = .31) made errors compared to those using the paragraph-format instructions (M = .875). However, unlike the number of errors analysis, the interaction of pictographs and text format was not significant.

Table 3. Mean number of errors as a function of instruction condition.

	Pictographs	
	Absent	Present
Text Format		
Paragraph	2.50	1.00
List	.50	.75

Analysis of the number of requests for help showed a significant main effect of pictographs, $F(1,28) = 5.07$, $p < .05$. Subjects using instructions containing pictographs (M = .06) requested less help than did subjects using instructions without pictographs (M = .69). The ANOVA also showed a marginal main effect of text format, $F(1,28) = 3.25$, $p < .09$. Subjects using list-format instructions (M = .125) tended to make less requests for help than subjects using paragraph-format instruction (M = .625). When analyzed with respect to the proportion of subjects who made help requests, the results were similiar to number of error requests analysis. The ANOVA yielded a main effect of pictographs, $F(1,28) = 6.03$, $p < .05$, and text format, $F(1,28) = 6.03$, $p < .05$.

Analysis of total completion time produced a significant main effect of text format, $F(1,28) = 21.56$, $p < .001$. Subjects using the list-format instructions (M = 432.4 s) required significantly less time than subjects who used the paragraph-format instructions (M = 559.7 s). When completion time for each of the tasks are examined separately, all three ANOVAs exhibited a significant main effect of text format. Completion time for Task 2 also yielded a signficant main effect of pictographs. For this task, subjects using instructions with pictographs (M = 40.75 s) required significantly less time than subjects using instructions lacking pictographs (M = 69.25 s), $F(1, 28) = 10.45$, $p < .01$.

Discussion

The list format reduced the number of errors committed and total completion time. The presence of pictographs reduced the number of requests for help. Subjects in the paragraph-no pictographs had more errors than for subjects in any other condition. In general, the results support the notion that printed instructions in list format and containing pictographs produces better computer task performance than instructions in paragraph format and lacking pictographs.

General Discussion

In both experiments, performance on a computer-interaction task varied as function of printed instructions. Overall, the results indicate that list-pictograph instructions facilitate computer task performance.

There are several possible explanations for the better performance from the embedded pictographs. One is that the pictographs provide a redundant visual code which could reduced any misinterpretations of the verbal description. In part, this supports Booher (1975) who found that pictures relevant and redundant to the text facilitated task speed. However, Booher did not find an effect of redundant pictures on measures of accuracy as we did. A second explanation is that the visual code was more directly related to the actual demands of the task than a verbal code. Verbal codes are more symbolic, abstract, and may require additional recoding. A third reason for enhanced performance by the pictographs is that they provide the user with feedback to monitor their progress.

The effect of text format is less clear. Both experiments provide some support for enhanced performance for list-format instructions. Note, however, in Experiment 1 the list-no pictograph condition produced the worst performance. This effect was not replicated in Experiment 2 which showed that, in general, the list format was better than the paragraph format. In addition it is not clear why Experiment 2's more experienced subjects made greater errors in the paragraph-no pictograph condition than Experiment 1's less experienced subjects. A tentative explanation can be offered, however. Experience on the Macintosh might affect the kinds of strategies that subjects engage in. On the one hand, subjects who were unfamiliar with the Macintosh might benefit from having illustrative screen pictographs because they show the novice what to expect. On the other hand, the experienced Macintosh users already possess some knowledge of what to expect and thus did not need the screen pictographs to the extent that the inexperienced users did. Instead, experienced users might need to focus only on keywords in the text to move through the directed steps. We suggest that lists allow one to access keywords more easily than the paragraph format.

A comment should be made regarding the time measure. Completion time is not independent of the error and help measures, and because of this, the time effects are confounded with the time taken to recover from errors and the time involved in making help requests. Note that even if the time measure is not considered, the other two measures are still valid. Note also that the error rate yielded a similar pattern of results as the time measure.

The present research has implications for the design of computer-tutorial documentation, and more generally, for proceduralized instructions. According to our results the most effective method of designing printed computer tutorials is to present the text in list format and to include screen pictographs to illustrate the associated text. Pictographs are apparently more important for inexperienced computer users. Presentation of text so that it is easy to scan for keywords (like in a list) is apparently more important for more experienced computer users.

Whether the effects yielded here can be generalized to other kinds of computer tasks is an empirical question. Both Wright (1980) and Wickens (1984) have pointed out that the effects of instruction depend on the purpose and requirements of the task. Future research should examine the influence of text format and pictographs in other kinds of computer-interaction tasks. In addition more research should be directed on other written instruction factors, for example, ways to highlight important text, and ways to pictorially show dynamic commands.

References

Booher, H. R. (1975). Relative comprehensibility of pictorial information and printed words in proceduralized instructions. *Human Factors, 17,* 266-277.

Brooke, J. B., & Duncan, K. D. (1980). Flow charts versus lists as aides in program debugging. *Ergonomics, 23,* 387-399.

Carroll, J. M., Smith-Kerker, P. L., Ford, J. R., & Mazur-Rimetz, S. A. (1987-1988). The minimal manual. *Human-Computer Interaction, 3,* 123-153.

Foss, D., Rosson, M. B., & Smith, P. (1982). Reducing manual labor: An experimental analysis of learning aids for a text editor. In *Proceedings of Human Factors in Computer Systems.* Washington, DC: Chapter of ACM.

Frase, L. T., & Schwartz, B. J. (1979). Typographical cues that facilitate comprehension. *Journal of Educational Psychology, 71,* 197-206.

Gould, J. D., Alfaro, L., Barnes, V., Finn, R., Grischkowsky, & Minuto, A. (1987). Reading is slower from CRT displays than from paper: attempts to isolate a single-variable explanation. *Human Factors, 29,* 269-299.

Hansen, W. J., Doring, R., & Whitlock, L. R. (1978). Why an examination was slower on-line than on paper. *International Journal of Man-Machine Studies, 10,* 507-519.

Hartley, J. (1978). *Designing Instructional Text.* New York: Nichols Publishing.

Hartley, J. (1980). Space and structure in instructional text. In J. Hartley (Ed.) *Psychology of Written Communication.* New York: Nichols Publishing.

Muter, P., Latremouille, S. A., Treurniet, W. C., & Beam, P. (1982). Extended reading of continuous text on television screens, *Human Factors, 24,* 501-508.

Paivio, A. (1971). *Imagery and Verbal Process.* New York: Hold, Rinehart and Winston.

Schneiderman, B. L., Mayer, R., McKay, D., & Heller, P. (1977). Experimental investigations of the utility of detailed flowcharts in programming. *Communications of the Association for Computing Machinery, 20,* 373-381.

Thomas, J. C., & Gould, J. D. (1975). A psychological study of query by example. In *Proceedings of the National Computer Conference* (pp. 439-445). Arlington, VA: AFIPS Press.

Trollip, S. R., & Sales, G. (1986). Readability of computer-generated fill-justified text. *Human Factors, 28,* 159-163.

Wickens, C. D. (1984). *Engineering Psychology and Human Performance.* Columbus, Ohio: Charles E. Merrill.

Wright, P. (1980). Usability: The criterion for designing written information. In P. A. Kolers, M. E. Wrolstad, & H. Bouma (Eds.), Processing of Visible Language 2. New York: Plenum Press.

Wright, P. (1981). The instructions clearly state...' Can't people read? *Applied Ergonomics, 12,* 131-141.

Wright, P., & Lickorish, A. (1983). Proof-reading texts on screen and paper. *Behaviour and Information Technology, 2,* 227-235.