A Study of File Manipulation by Novices Using Commands vs. Direct Manipulation

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Abstract

There are three basic interactive styles of control in human interfaces with computers: command, menu, and direct manipulation. In the past few years, these three styles have become the subject of many studies. However, few comparisons have been done between interfaces that use direct manipulation and command styles. This experiment compares file manipulation operations on the Apple Macintosh, which has a direct manipulation interface, with the IBM PC with MS-DOS, which has the command interface. After a brief training period, novices accomplished file manipulation tasks more rapidly, with fewer errors and greater satisfaction with the Apple Macintosh. Problems arising for both versions are discussed and suggestions for improvements are made.

1 Command Interfaces (Textual)

Command interfaces require the user to communicate with the computer by typing a formal language with specific syntax. The user is required to learn and memorize the commands and the sequences needed for an operation.

Command interfaces create a feeling of indirectness, because the interface is an implied intermediary between the user and the world of action, i.e., the user is constantly describing the actions. As a result, the user may make mistakes due to:

1. the confusion of the syntax of the language with English,
2. inconsistency in the language,
3. arbitrary syntax (commands made of punctuations),
4. errors made when typing the commands, and,

5. mismatch between the user's intention in the task domain with the computer concepts or syntax.

Therefore, a possible route to increasing user's understanding of the computer is to make the relationship between the command and action should be made more immediate and direct.

1.1 Direct Manipulation

Many people form pictures or patterns of tasks in their mind. These people may more easily understand, learn, and memorize when they can visualize objects and actions. In direct manipulation the visual representation should match the way people think about the problem. Direct manipulation interfaces have these characteristics [Shneiderman, 1987, 1983]:

1. continuous representation of the objects and actions of interest,

2. physical actions (movement and selection by mouse, joystick, touch screen, etc.) or labeled button presses instead of complex syntax,

3. rapid, incremental, reversible actions whose impact on the objects of interest is immediately visible, and,

4. layered or spiral approach to learning that permits usage with minimal knowledge.

A central goal of the direct manipulation designs is to give the user a sense of directness, that is, an impression or a feeling of close contact with the objects and actions of interest. There are two aspects of directness. One of the aspects is the distance between what the user intends to do and what the system can do. The shorter the distance the stronger the feeling of directness. By short distance, we mean that the translation of the user's thoughts into the actions, required by the system, is straightforward and the system output is easily translated in terms of the user's goals. Therefore, distance emphasizes that directness is not a characteristic of just the interface, but rather a characteristic of the linkage between what the user intends to do and the way in which his/her goal is achieved through the interface [Norman, 1984].

The other aspect of directness, engagement, involves the feeling that the user is acting directly on the objects. Engagement gives the user a feeling of control over the objects in the task domain. Here, the user performs actions on the objects of interest, and the system shows the actions that are performed on the objects. When these aspects are included in an interface, they may make the user's learning process easier, since little effort is needed to get from intention to action and from output to interpretation. Hence, the goal is that the user should learn the task domain instead of the computer system. Thus, a good direct manipulation interface eliminates the visibility of the computer system and its interface from the user, i.e., it should appear to the user that the task domain is manipulated directly.

Systems that have applied direct manipulation include the Xerox Star, the Apple Macintosh, and many application software products such as spread sheets, desk top managers, drawing tools and so forth.

1.2 Comparisons Between the Features of the Macintosh and the IBM PC

Our intention was to determine the ease of use for novices of the Macintosh file commands and the IBM PC with MS-DOS. The Macintosh uses several direct manipulation concepts:

i. files and commands on the Macintosh are visible on the screen in forms of icons and menus,

ii. selections of objects and actions on those objects on the Macintosh are generally performed via a mouse mechanism as opposed to the conventional keyboard approach,

iii. it is easier to learn Macintosh commands because it taps analogical reasoning on the part of the user.

Most conventional computers are made to serve people with good knowledge of computers, preferably programmers. Macintosh was designed for people with no computer background and for a group identified as “knowledge workers” — anyone who creates reports, budgets, or memos. IBM PC with MS-DOS can be most effectively operated by people with a good knowledge of computers. It is widely available and a reliable computer for accounting, moderate sized data-base management, and many other tasks.

“Macintosh is often viewed as friendly and IBM PC as intimidating by the first-time computer users” [Burns and Veint, 1985]. The “user-friendliness” aspect of a system centers on the kind of help the system provides and the ease with which the user can cause the effects they wish to cause. The system should be able to help the user find out what went right or wrong and what can be done next.

1.3 Design Issues of Interactive Interfaces

The screen of a Macintosh is a 9-inch black and white, 512 x 342 pixel resolution video display. The number of lines and the number of characters per line depend on the different fonts and font sizes. Along the top of the screen is a menu bar which contains several pull-down menus. These menus include the commands for file-handling, text-editing, desk accessories, etc. The Macintosh screen is an icon-oriented display (i.e., every object (disk or file representation) is depicted by an icon) which continuously displays users’ objects of interest.

Actions on an object (e.g., opening a file) are generally performed by selecting an object and then choosing a command from the pull-down menus. Selecting an object is done by pointing and clicking on the object via a mouse. The results of performing an action on an object are immediately visible to the users (i.e., the user does not have to explicitly issue another command to see the results of an action).

The Macintosh screen also incorporates a windowing mechanism allowing users to "open" one or more windows; however, only one of these opened windows may be active at any given time. The design tries to simulate a real-world working environment. For instance, the "desktop" of a Macintosh is supposed to resemble a typical office with a clock, clipboard, trash can, folders, and files (inside a folder).

The IBM PC screen is an 11-inch green on black, 640 x 200 resolution pixel video display. The display features a 25 x 80 character screen. File manipulations are performed by typing MS-DOS commands. This approach has several disadvantages:

1. most commands are difficult to memorize (thus very error prone),

2. uncertainty of whether or not a certain command did what the user expected (this usually requires the user to display a directory after performing a certain command to see if a file has been deleted, copied, etc.), and

3. inability to scroll the directories backward and forward (which can be found in many graphic oriented screens such as the Macintosh, Xerox Star, etc.).

A mouse gives a user a much higher degree of freedom of movement on the screen than cursor keys. A mouse also replaces special function keys present on the IBM PC keyboard. Its movements are smooth, not jumpy. To operate the mouse, a user rolls it along the desktop in any direction, while the cursor represents these movements on the screen. This interaction allows a user to manipulate texts, documents, etc. For example, a user can dispose of a document by using the mouse pointer to drag the document icon to the graphic representation of a waste basket.

The Macintosh design features have a good reputation for being easy to learn and use. But many experienced users find it annoying to move off the keyboard to use the mouse and tedious to locate menu items in the pull-down menus. The graphic interface and mouse selection provide users with direct manipulation interaction and allow users to operate intuitively, while conventional user interfaces require that a user learn commands and procedures before typing them into the computer.

1.4 Review of the Previous Studies

The July 1985 issue of the PC Magazine described an experimental comparison of the Macintosh and the IBM PC. The study compared the features of IBM PC with Macintosh which were similarly implemented on the two machines, in order to avoid comparing widely different aspects of the programs. For example, two 512K machines were used, a Microsoft mouse was added to the IBM PC to compare with the Macintosh mouse, and a color monitor and graphic card were also added to the IBM PC to run the graphics programs. The standard test simply timed the execution of three common operations: 1) loading file, 2) saving a file, and 3) opening a saved file. The time for performing the above task was approximated to the tenth of a second. In addition, they selected two or more common operations for each application. For instance, a search and replace operation using a word processor and a recalculation using a spreadsheet were timed. Keystrokes on the keyboard and mouse strokes or double clicking on the mouse were counted. Only the computer's execution time was measured, since a variation in operator speed and the time taken to enter a keystroke often made no significant difference.

In the final wrap-up, no conclusion was made as to which machine was more user-friendly. However, they mentioned that even though more software manufacturers began to make the IBM PC more Macintosh-like, the Macintosh still has an advantage over the IBM PC in that its screen designs are built from the inside out, whereas the PC's software packages are a face-lift until a high-resolution screen with built-in processing can be made for the IBM PC. The keyboard of the IBM PC was preferred, since it displayed typed characters far more quickly on the screen, whereas Macintosh's smaller keyboard has an advantage of being portable. The mouse movement was smooth on the Macintosh but did not match all of the advantages of the IBM PC function keys. Macintosh's smaller screen was preferred to that of the IBM PC's, because of its high resolution as opposed to a larger screen with low resolution. One subjective comment was that Macintosh's black and white image was less tiring to read than the darker images of the IBM PC's color monitor. The experimenters also concluded that menu driven software appeared to be slower than the command languages with keyboard macros software. The slowness of menu commands is often a subjective experience, possibly because we don't experience the time passing when actively inputting commands while menu operations force us to be idle.

Others reviewed the Macintosh and the IBM PC:

1. Consumer Reports (January 1985) recommended: "Macintosh is far and away the easiest computer to learn and use that we have yet seen" [Consumer Reports, 1985].

2. Data Decisions (June 1985) claimed that: "There is little question that Macintosh is extremely easy to learn and use. The graphic interface and the mouse selection device provide the user with a very direct method of interaction with the computer which allows a user to operate intuitively" [Data Decisions, June 1985].

3. "the IBM PC is relatively easy to use and powerful computer that enjoys unprecedented hardware and software support from the microcomputer industry" [Sargent and Shoemaker, 1984].

2 Experiment

2.1 Introduction and Hypothesis

This experiment compared the user interfaces of an IBM PC with MS-DOS and an Apple Macintosh. Due to a variety of operations that both systems can handle, we chose to limit our comparisons to the file manipulation "commands" on both systems.

Our hypothesis, is that Macintosh has a more "user-friendly" interface than IBM PC for novices due to the following:

i. files and commands on a Macintosh are visible on the screen in forms of icons and menus,

ii. on a Macintosh, selection of objects and operations are generally performed via a "mouse" mechanism as opposed to the conventional keyboard approach,

iii. it is easier to learn Macintosh commands because it requires minimal knowledge on the part of the user,

iv. it takes less time to perform a task on a Macintosh than on a IBM PC, and,

v. users will make fewer errors in performing commands.

Independent Variables (Computer Type for File Manipulation Commands) :

i. IBM PC with MS-DOS

ii. Macintosh

Dependent Variables:

i. Time taken to perform a specific task

ii. Number of errors made

iii. Subjective satisfaction

2.2 Subjects

Since this experiment was to test for the "user-friendliness" of the interfaces of both systems, we decided to choose people with limited computer background. We sought thirty people with no previous experience in using either the IBM PC or the Macintosh. Eighteen of the subjects were students obtained from the psychology subject pool, and had no computer experience. Twelve subjects were acquired by personal contact. Among the thirty subjects who participated in our experiment, five had used a computer other than the IBM PC and the Macintosh for less than one month. Four subjects had moderate computer experience but no prior exposure to the IBM PC nor the Macintosh.

2.3 Materials

Experimental materials included:

1. a Macintosh (main unit, keyboard, mouse, disk drives, and diskettes),

2. an IBM PC (main unit, keyboard, disk drives, and floppy disks),

3. consent forms,

4. instruction sheets, and,

5. questionnaires.

Subjects were provided with two instruction sheets, one for the IBM PC, the other for the Macintosh. Both instruction sheets showed how to perform file commands such as creating, copying, renaming, and erasing. For the IBM PC, the subjects were instructed step by step on what to do, (for example, looking for the right prompt, typing in the right command and pressing the ENTER key after each command). The following is an example of an instruction for the IBM PC.

Copying a file

To make a duplicate of a file, we have to issue a copy command to the PC.

1. You should see the prompt B> on the screen. Type

   copy first.txt second.txt

   and then press the ENTER key.

2. The PC should return the message:

   1 file(s) copied

   If it does not return the message, then you need to repeat steps 1 and 2.

For the Macintosh, the subjects were also instructed step by step as to what to do. For example, how to use the mouse, how to select an icon, and how to choose commands from the menu bar. The following is an example from the Macintosh instruction sheet:

Copying a file

1. Now on the screen you can see 2 icons: Edit and First.
Position the pointer on the icon First, and click on it.

2. Place the pointer on the word File in the menu bar.

3. Press the mouse button and hold it down while you drag the pointer
to the word Duplicate, then release the mouse button.

4. To the right of First, you will see a copy of it called Copy of First.

The questionnaire consisted of three pages, of which the first page inquired about the subject's background. The rest of the pages contained questions about the different features of both systems. For example :

i. What do you think of IBM' s display? Please explain.

ii. Please explain what you think of the Macintosh's:

a. iconic feature

b. display

iii. If you got error messages, were they helpful in explaining what you did wrong?

IBM PC :
Helpful <- 1 2 3 4 5 6 -> Not helpful

Macintosh :
Helpful <- 1 2 3 4 5 6 -> Not helpful

User's satisfaction questions included:

i. Which machine do you find simpler to use?

IBM PC :
Hardest <- 1 2 3 4 5 6 -> Easiest

Macintosh :
Hardest <- 1 2 3 4 5 6 -> Easiest

ii. Which machine are you more satisfied with?

2.4 Procedures

To make good use of our time, we tried to have two subjects in each one hour session. While one subject worked on the IBM PC, and then the Macintosh, the other subject worked on the Macintosh and later on the IBM PC. A typical session consisted of the phases :

1. Introduction : Subjects were informed of the purposes and procedures of the experiment. They were then asked to sign a consent form. Subjects were then given a demo of each computer. For the Macintosh, the experimenters talked about the display (screen appearance and color, icons and pull down menus, windows), the mouse and its usage, and the keyboard. The demo of the IBM PC provided information on the display (screen appearance and color, cursor, prompts) and the keyboard.

2. Practice : The subjects were allowed to read and practice the tasks in the

instruction sheets twice. The first practice was to familiarize the subjects with both systems and the second practice was to make the subjects memorize the steps. The maximum time permitted for this phase was twenty minutes for each machine. The time taken for each practice was measured.

3. Test : The subjects were asked to perform four tasks without referring to the instruction sheets. These four tasks — creating a file, copying a file, renaming a file, and erasing a file — were chosen by the experimenters. The maximum time permitted for this phase was twenty minutes. The time taken by each subject to perform the four tasks was measured.

4. Evaluation : The subjects were given a questionnaire after they had tried both systems. The questionnaire asked about the subject's views on the tasks described in the instruction sheets and the interfaces of both ma chines.

Whenever subjects took less time to complete a phase, they would start the next phase. During the practice and test phases, they were assisted whenever they had trouble. We took notes on the subjects' behaviors, their performance in using the Macintosh mouse, the commands on both systems, and their comprehension of the commands. We also took notes on the number of errors they made. These errors were 1) not performing the requested tasks (e.g., requested task was to copy a file while the performed task was renaming a file), 2) typing the wrong syntax for the commands on the IBM PC, and 3) confusing the steps on the Macintosh (e.g., instead of dragging the mouse, the subject clicked it).

2.4.1 Administration

A pilot study of eight subjects was conducted over a period of one week. The subjects had no previous experience with computers. Each experiment lasted about an hour. After the pilot study, the instruction sheets and the questionnaire were revised. We also made some changes to the practice and test phases of the experiment.

A series of one-hour experiment were conducted over a period of three weeks with thirty subjects. The subjects signed a consent form and were asked to sit in front of the computers after the computers were set up. The subjects were advised to relax and enjoy the experiment. During the experiment, the experimenter sat beside the subject and assisted him or her whenever they had difficulties. We recorded the time for each practice and the time for the test phase. We also recorded the number of errors made by the subjects.

2.4.2 Grading

In order to measure the satisfaction level, we created an ad hoc scale. First, we added the results of questions 1 and 2 in the questionnaire. Question 1 asks the subjects to indicate, on a scale from 1 to 6, which machine they found simpler to use. Question 2 asks the subjects to indicate, on a scale from 1 to 6, which machine gave them a better understanding of what they did. Next, a score of 1 was added to the average if the subject preferred the IBM PC or the Macintosh. In some cases, where the subject was equally satisfied with both machines or could not make a decision, a score of 0 was added to the average.

3 Results

The mean time for the first practice on the IBM PC was 9.37 minutes, and the mean time for the first practice on the Macintosh was 8.2 minutes. However, the mean time for the second practice of the IBM PC decreased to 5.1 and for the Macintosh the mean time dropped to 4.8. These new values indicated the subjects became familiar with both the typing commands in the IBM PC and in moving the mouse in the Macintosh.

The mean time for the test phases of the IBM PC and the Macintosh were 5.77 minutes and 4.80 minutes respectively, statistically significant by t-test at the $p < 0.10$ level. The mean for the number of errors made on the IBM PC was 2.03, and that of the Macintosh was 0.80 ($p < 0.01$). The mean for the satisfaction levels of the IBM PC and the Macintosh were 3.80 and 5.37 respectively, out of a 7 point scale ($p < 0.01$).

The following tables represent the mean values for the time taken to complete the tasks in the test phase, number of errors made during the test phase, and the satisfaction level on both machines.

Table 1. Mean and Standard Deviation Values for Test Time (in minutes), Number of Errors, and Satisfaction Level for IBM PC and Macintosh.

Out of thirty subjects, eighteen of them preferred the Macintosh, ten preferred the IBM PC, one was undecided, and one liked both machines equally.

4 Discussion

Observations made during the experiment indicated that, almost all of the subjects had a difficult time in using the mouse for the first few minutes. More than twenty of them learned how to use the mouse correctly after nine to ten minutes. Five subjects did have a very difficult time with the mouse the entire time they worked on the Macintosh. Similarly, nine subjects were not familiar with the keyboard and could not type easily.

Half of the subjects had problems in remembering when and how to select, open, or drag a document using the mouse. Another common problem was with renaming a document, somehow the subjects always wanted to do more, rather than simply typing in a word. Forgetting the punctuation, adding unnecessary spaces, and omitting the parameters in such commands as copy and rename were among the common problems the subjects had on the IBM PC. More than half of the subjects had difficulty recalling the steps involved in creating a file on the IBM PC.

The following results were gathered from the subjects' responses to the questionnaire:

1. Four subjects were not happy with the display of the IBM PC, because it was hard for them to know what is happening. The rest of the subjects found the display easy to read and to use and the size of screen and letters appropriate.

2. More than half of the subjects thought the commands on the IBM PC were easy to remember, although it seemed confusing to some of them for the first few times. A number of them found the commands hard to remember and to use.

3. Few subjects voted for typing in the commands. Most of them preferred the use of mouse because they found it to be easier to use, more fun, and faster.

4. The majority of the subjects claimed that the iconic feature of the Macintosh gave them a better understanding of what was happening, since they could see the results of actions immediately. Some subjects thought that the icons were fun, amusing, and even silly.

5. The display on the Macintosh was considered to be clear, easy on the eyes, have an appropriate size of screen and letters, have a good resolution, by a majority of the subjects. A few commented that a larger screen and larger letters would be better. A couple of subjects did not like the display.

6. Many of the subjects rated the pull-down menus as being fast and easy to use because no command memorization and typing was required. A few of the subjects did not like this feature since it looked silly and awkward to them.

7. More than half of the subjects, preferred the black characters on the white background of the Macintosh to the green characters on the black background of the IBM PC. The former was considered to be easier to look at, relaxing to the eyes, and clear. The latter was criticized for being harsh on the eyes, a little fuzzy, and hard to look at. Nevertheless, a few subjects did prefer the latter and believed it made reading easier.

8. The following commands on the IBM PC chosen by majority of the subjects in descending order of difficulty were creating a file, renaming a file, copying a file, listing a file, and erasing a file. A few claimed that none of commands were difficult.

9. The following commands on the Macintosh chosen by majority of the subjects in descending order of difficulty were copying a file, renaming a file, creating a file, removing a file, and erasing a file. A few claimed that none of commands were difficult.

10. Half of the subjects who made errors on the IBM PC found the error messages helpful; the other half claimed that the error messages did not help them find out what they did wrong.

11. A majority of the subjects who made errors on the Macintosh found the error messages helpful in finding what they did wrong. A few did not find these messages helpful.

12. All but three of the subjects thought that the file recovering feature of the Macintosh is a novel idea and it should be implemented in all computers. Most of them commented that discarding something important by mistake is very frustrating and a recovery feature can help a great deal.

5 Conclusion

This study provided some support for the conjecture that Macintosh has a more "user-friendly" interface than the IBM PC with MS-DOS for novices doing file manipulation commands, because:

1. it is easier to learn and use the commands and procedures, as it requires only modest memorization on the part of the users, and,

2. it takes less time for the users to perform tasks on the Macintosh, due to the presence of the mouse and the pull-down menus, which increase the speed of performance and eliminate typing of the commands.

The reason for this may be that Macintosh uses more familiar concepts, whereas IBM PC with MS-DOS uses a language based on computer terminology, which is difficult for most of the users to learn and to retain. For instance, the TRASH icon on the desktop of the Macintosh looks familiar to most users. The users know that trash can is for throwing things away. As a result, users can make a connection between the computer display and objects they are familiar with. Also, the combination of words and illustrations (icons) requires less memorization on the users' part.

Using the mouse can be easier than typing because working with the mouse is very similar to the way people do things. For instance, to turn on a light we must first touch the switch before pushing it (i.e., point to or select the object of interest before per forming an action on it). Working with the mouse may decrease the number of errors, since less typing is involved and thus, fewer typographical errors can be made.

From the subjective responses in the questionnaire, eighteen of the subjects preferred the Macintosh while ten preferred the IBM PC. Overall, Macintosh created a sense of directness, that is, the users felt that they were in control of the system since they were directly manipulating the objects of interest and the actions.

These results should not be used as the sole guide in making purchasing decisions about hardware and software. Many other factors influence such decisions. Rather, these results should serve as a guide to designers in developing future applications and for researchers who are seeking to understand direct manipulation. Furthermore, this experiment dealt only with novices in a learning situation. Additional experiments are necessary to study frequent and expert users, who often prefer and may work more rapidly with command language strategies.

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