Knowledge of Command Usage In a Spreadsheet Program

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Abstract

Knowledge of how software is actually used by people can assist software developers and internal MIS application development personnel to improve the user-interface of existing software, in creating new user interface styles for existing software packages, and to improve the training for personnel using software packages. This article reports results from a study that examined the use of a popular spreadsheet software by 40 experienced users in their work environment. Of the 505 commands that could be used, 18 (3.6%) accounted for over 80% of the usage. More than 50% of the available commands were never used. Most of the command usage was related to creating, maintaining, and printing spreadsheets.

ACM Categories: H.0., H.1.2, K.6.1

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INTRODUCTION

Individuals in organizations use personal computers on a routine basis. Some of the most popular types of software used are for document preparation, spreadsheet analysis, presentation graphics, database management, and communications. Numerous software companies offering their own version of the various types of programs. Accordingly, executives, managers, professionals, and clerical personnel are faced with ever-increasing functionality and widely divergent user interfaces.

In a similar manner, people in organizations use software applications developed by internal MIS personnel. These applications may be processed on personal computers, minicomputers, or mainframes. The applications prepared by MIS personnel may also provide the users of the applications with a variety of user interfaces.

Schneiderman (1987) discusses several types of user interface styles. Having data available on how a software package is actually used should be particularly helpful if a software developer is considering changing from one type of user interface to another. For example, in the IBM-compatible operating environment, developers now have the ability to develop a graphical user interface in addition to the more conventional menu and command language approaches. Knowing how individuals use the software may help a software developer make the transition from one style of user interface to another.

Furthermore, organizations collectively are spending millions of dollars training people to use personal computer software packages and internally developed software applications. Knowledge of how people actually use a software package should be helpful in designing and providing effective training programs for employees.

As individuals increase the amount of time they spend using software packages and applications, it becomes more important that the interaction between the person and the software be easy, intuitive, and consistent. As noted by McDonald and Schvaneveldt (1988), obtaining objective knowledge on how users utilize software would be helpful for improving software user interfaces (making the product both friendlier and easier) in both current and future products.

One method for obtaining such information is via keystroke protocols (e.g., Card, Moran and Newell, 1983). These protocols provide a record of all keystrokes input by an individual using a software package. Card, et. al., have developed a series of models based on these keystroke protocols. One of these models, the keystroke-level model, was used to obtain time estimates of parameters for items such as mentals (the time it takes to recall a command by a knowledgeable user of the software) and when they occur, keystroke time, and the time it takes to perform homing operations, such as using a mouse or the cursor movement keys. Card, et al., collected their keystroke data in a laboratory environment using prepared exercises.

Schneiderman (1987)notes the importance to software designers of knowing how the software is actually used in the work environment. The process of unobtrusively recording keystrokes in the workplace with a keystroke recorder allows the collection of data that occurs naturally in the workplace that cannot be obtained in a laboratory environment. Such data could be used to determine whether models such as the ones developed by Card, et al., can be extended to actual usage in a work environment. For example, a recently completed paper (Lane, Napier, Batsell and Naman (1990) refines the mental time to recall a command for various experience levels of users.

Interest in the design of user interfaces based on keystrokes collected during the use of software packages has increased. Greenberg and Witten (1988a), Hanson, Kraut and Farber (1984), Kraut, Hansen and Farber (1983), and Peachey, Bund and Colbourn (1982) have completed such studies. These studies, most of which concentrated on the use of UNIX commands, found that the distribution of occurrence for the command sequences can be approximated by using the Zipf distribution (Zipf, 1949).

The Zipf distribution has the properties that a relatively small number of items have a high usage frequency, and a very large number of the items are seldom used. A looser characteristic of this kind of rank distribution is the well known 80/20 rule; that is, 20% of the items in question will account for 80% of the activity or usage.

Operating systems use a command-driven user interface, while spreadsheet software packages typically use a menu-

driven interface. One objective of this study is to determine whether the Zipf distribution can be extended to spreadsheet software to describe frequency of command usage.

The present study illustrates a process for gathering objective data of how people use spreadsheet software in their work environment. In this study Lotus 1-2-3 was examined. Keystrokes were recorded for experienced users from a variety of organizations to determine how the software is used. The information obtained from the analysis of the keystroke data should be useful in enhancing the user interface and design of present and future versions of spreadsheet packages. The resultant impact on the software developer is indicated.

OVERVIEW OF THE SOFTWARE

Schneiderman (1987) categorized user interfaces as follows:

- **Menu selection**—The user chooses from among a set of options displayed on the screen
- **Command language**—The user enters commands directly into the system
- **Direct manipulation**—The user moves the cursor around the screen with a pointing device to manipulate a representation of some action or object.

To issue a command in Lotus 1-2-3, the user must go through a hierarchy of menus. Users have a choice of selecting commands from this hierarchy or entering them directly from the keyboard. For example, to insert a single row in a spreadsheet, the user would choose the following options from a hierarchy of menu choices:

Command	Explanation
/	Initiates menu structure
Worksheet	Select Worksheet option from initial menu
Insert	Select Insert option from second menu
Row	Select Row option from third menu
[Enter]	Press the [Enter] key to indicate completion of the command

The alternative approach is for the user to type the keystroke sequence /wir and then press the [Enter] key.

Experienced users quickly learn how to navigate through the hierarchy of menus to enter commands. In most cases, individuals enter commands by selecting the first character of each menu item. Thus, they create for themselves a pseudo-command language that consists of a slash to enter the menu hierarchy and the first letters of the selected menu options.

METHODOLOGY

Subjects

Forty experienced Lotus 1-2-3 users were recruited from eight organizations. The subjects used the software routinely in their daily work. The organizations were large and from a variety of industries—accounting, consumer foods, energy, financial services, medical, and government—with annual revenues exceeding $1 billion.

Equipment

The personal computers used by the subjects were IBM-PCs or IBM-AT compatibles. The subjects used their normal personal computers at work. Information about the personal computers used was also collected. This data was used to adjust the timing information obtained so that appropriate inter-keystroke time comparisons could be made.

Keystroke Information

A keystroke recorder software package was used. The package recorded the subject's keystrokes and elapsed time between keystrokes while they used the program for at least six hours during a two-day period. The subjects completed the tasks normally required in their work day.

Procedure

A research assistant or a designated individual at the organization installed the keystroke recorder software on each computer or network. The files containing the keystrokes were searched and all command sequences were extracted. These files were combined for each subject, even if the use occurred over several noncontiguous time periods during the data collection period. Each participant's data was analyzed to determine the exact command sequences used.

More than 425,000 keystrokes were captured. Analysis of the keystrokes resulted in the identification of 7,212 command sequences. (An example of a command sequence is /wcs for Worksheet,Column Set-Width.) Along with each character in the command sequence, the inter-keystroke time was determined and retained. Differences in processor speed were taken into account in computing the inter-keystroke time.

RESULTS

DEMOGRAPHIC INFORMATION

The demographic information found in Table 1 indicates that the users in this study were very experienced with the software and younger than typical users. The subjects were individuals who prepared spreadsheets or completed analyses for others who reviewed the results.

DISTRIBUTION OF COMMAND USAGE

There are a total of 505 possible commands available in Lotus 1-2-3. Table 2 includes a list of the 27 most frequently used commands and their respective percentage of the total commands. These 27 commands, while constituting only 5.3% of available commands, accounted for 85% of the total commands issued by the subjects. Furthermore, the six most frequently issued commands accounted for 51% of the command sequences that were issued. Not counting the / key, most of these commands required two or three characters. Of the 505 available commands, 207 (41%) were used at least once and 298 (59%) of the commands were never executed.

By categorizing the commands, the actual usage of the commands can be better ascertained (see Table 3). The commands

Table 1. Demographics of Subjects

Item	Subjects	Standard Dev.	Typical User	Standard Dev.
College degree	91%		80%	
Average age	30.6	6.3	37.3	NA
Experience with 1-2-3 (in years)	2.5	1.5	NA	NA

have been categorized as follows: file operations, copying and moving spreadsheet information, changing spreadsheet appearance, printing activities, graphics, and spreadsheet/system operations. (The data within each category appear in descending order by command frequency.)

The file operations in Table 3 account for 19.3% of all commands issued. Users retrieved and saved spreadsheets from files on a disk. Interestingly, there were more file retrieve commands (10%) issued than file save commands (7.7%). Since the number of file save replace (/fsr) commands (5.1%) was about twice the number of file save (/fs) commands (2.6%), experienced users may be more likely to work on existing spreadsheets than they are to create new ones.

Commands to copy and move information on a spreadsheet accounted for 25.9% of the total commands issued. The copy command, which represented 22.3% of the total commands issued, is used to copy labels, data, and formula computations from one or more cells to other locations on the spreadsheet.

Table 2. Frequently Used Lotus Commands

Command Sequence	Command Description	% of Total Commands
/c	Copy	22.3
/fr	Retrieve a file	10.0
/wcs	Change column width	5.6
/fsr	Save and replace a file	5.1
/re	Erase a range of cells	4.1
/wir	Insert a row(s)	4.0
/m	Move	3.6
/ppa	Align the printer	3.6
/ppg	Print a specified range	3.5
/wdr	Delete a row(s)	3.0
/ppr	Specify a print range	2.9
/fs	Save a worksheet to a file	2.6
/qy	Exit 1-2-3	2.1
/ppq	Exit the print menu	2.1
/rf,	Use comma format	1.9
/rnc	Create a range name	1.9
/gy	View current graph	1.3
/few	Erase a worksheet file	1.0
/ppp	Eject a page	0.6
/wic	Insert a column(s)	0.6
/fd	Change file directory	0.6
/wey	Erase a worksheet	0.5
/s	Use DOS commands	0.5
/wtc	Clear worksheet titles	0.5
/rfp	Use percent format	0.5
/ppoq	Exit print options menu	0.5
/rfc	Use currency format	0.5

Table 3. Categories of Command Usage

File Operations	Command Description	% of Total Commands
/fr	Retrieve a file	10.0
/fsr	Save and replace a file	5.1
/fs	Save a worksheet to a file	2.6
/few	Erase a worksheet file	1.0
/fd	Change file directory	0.6
	TOTAL	19.3
Copy and Move Information		
/c	Copy	22.3
/m	Move	3.6
	TOTAL	25.9
Change Spreadsheet Appearance		
/wcs	Change column width	5.6
/re	Erase a range of cells	4.1
/wir	Insert a row(s)	4.0
/wdr	Delete a row(s)	3.0
/rf,	Use comma format	1.9
/wic	Insert a column(s)	0.6
/rfp	Use percent format	0.5
/rfc	Use currency format	0.5
	TOTAL	20.2
Printing Activities		
/ppa	Align the printer	3.6
/ppg	Print a specified range	3.5
/ppr	Specify a print range	2.9
/ppq	Exit print menu	2.1
/ppp	Eject a page	0.6
/ppoq	Exit print options menu	0.5
	TOTAL	13.2
Graphics		
/qv	View current graph	1.3
	TOTAL	1.3
Spreadsheet/System Operations		
/qy	Exit 1-2-3	2.1
/rnc	Create a range name	1.9
/wey	Erase a worksheet	0.5
/s	Use DOS commands	0.5
	TOTAL	5.0

The move command is used to transfer information from one location to another location on the spreadsheet.

Commands for changing the appearance of a spreadsheet represented 20.2% of the total commands issued. Examples of these commands include altering the format of data, inserting and deleting rows and columns, changing column widths, and erasing cells.

Printing information from a spreadsheet was responsible for 13.2% of the total commands issued. Most of the print commands related to aligning the printer, printing the spreadsheet information, defining ranges of cells to print, and exiting the print command menu.

The remaining categories of commands issued were graphics (viewing a graph) and spreadsheet/system operations (exiting the spreadsheet, erasing a spreadsheet, issuing a DOS command, naming a range).

Fifty-nine percent of the commands available in Lotus 1-2-3 were not used by any of the participants. The main menu options for the version of Lotus used in this study were: Worksheet, Range, Copy, Move, File, Print, Graph, Data, System, and Quit. The Copy, Move and System options do not have additional menus. Table 4 shows the number of commands under each remaining option that were available, but unused.

Table 5 contains data on the usage of the function keys. Some of these operations repeat commands previously set by the user. The function keys were activated 3,655 times.

Macros are sets of keystrokes that can be saved for a spreadsheet and repeated at a later time. For example, a user may create a macro for printing a spreadsheet so that the steps do not have to be manually repeated each time the spreadsheet is printed. Macros were executed 526 times. Only ten of the subjects executed at least ten macros. These individuals executed 386 (73%) of the macros. The remaining 30 subjects executed at least one macro, and as a group they executed 140 (27%) of the macros. The actual keystrokes included in the macros used were not available to examine.

Figure 1 shows the distribution for the command sequences of the 27 most frequently used commands. Subjectively determined points of discontinuity are indicated by changes in the shading of the bars. These results can be approximated using the Zipf distribution. As noted earlier, this distribution has the properties that a relatively small number of items are frequently used. Figure 2 includes the fre-quency distribution for the most frequently used commands. The vertical axis shows the number of commands issued normalized to one for the most fre-quently used command. The horizontal axis shows the rank ordering of the commands. The normalized Zipf function, calculated as $y = 1/x$, is included in Figure 2. The Zipf function appears to provide a plausible model for the observed command usage frequencies.

A looser characteristic of this kind of rank distribution is the well known 80/20 rule. While such results might be expected, the degree to which a relatively small percentage of available commands accounted for most of the command usage by the subjects was not. For example, in this study only 3.6% of the available commands accounted for 80% of the command usage, and 7.9% of the available commands accounted for 90% of the command usage. In comparison, Greenberg and Witten (1988a) and Hansen, et al., (1984) indicated that for UNIX commands, 10% of the available commands accounted for about 90% of the command usage. Operating systems like UNIX use a command type of user interface as opposed to the menu-driven interface in the spreadsheet software. Our results indicate that the Zipf distribution can be extended to describe the frequency of command usage in a menu-driven spreadsheet package.

Table 4. Main Menu Options Underutilized

Main Menu Option	Commands Available	Commands Not Used
Worksheet	120	74
Range	44	24
File	33	16
Print	62	37
Data	62	20
Graph	188	132
Quit	2	0

RESPONSE LATENCY

Figure 3 displays the average keystroke latency for the 31 command sequences executed often enough to provide stable

Table 5. Function Key Usage

Key	Function Operation	Frequency	% Usage
F2	Switch to Edit mode for current entry	2,581	70.6%
F3	Display list of range names	345	9.4%
F5	Move cell point to a particular cell	185	5.1%
F1	Access 1-2-3 Help facility	135	3.7%
F4	Change relative cell to absolute cell or mixed address	112	3.1%
F10	Draw graph on screen using the most recent graph settings	97	2.6%
F6	Move cell pointer to other window on the screen	76	2.1%
F7	Repeat most recent Data Query operation	56	1.5%
AltF2	(AUTHOR-No DESCRIPTION)	33	0.9%
F8	Repeat most recent Data Table operation	21	0.6%
AltF1	Used with other keys to create international characters	14	0.4%
F9	Recalculate worksheet values	0	0.0%

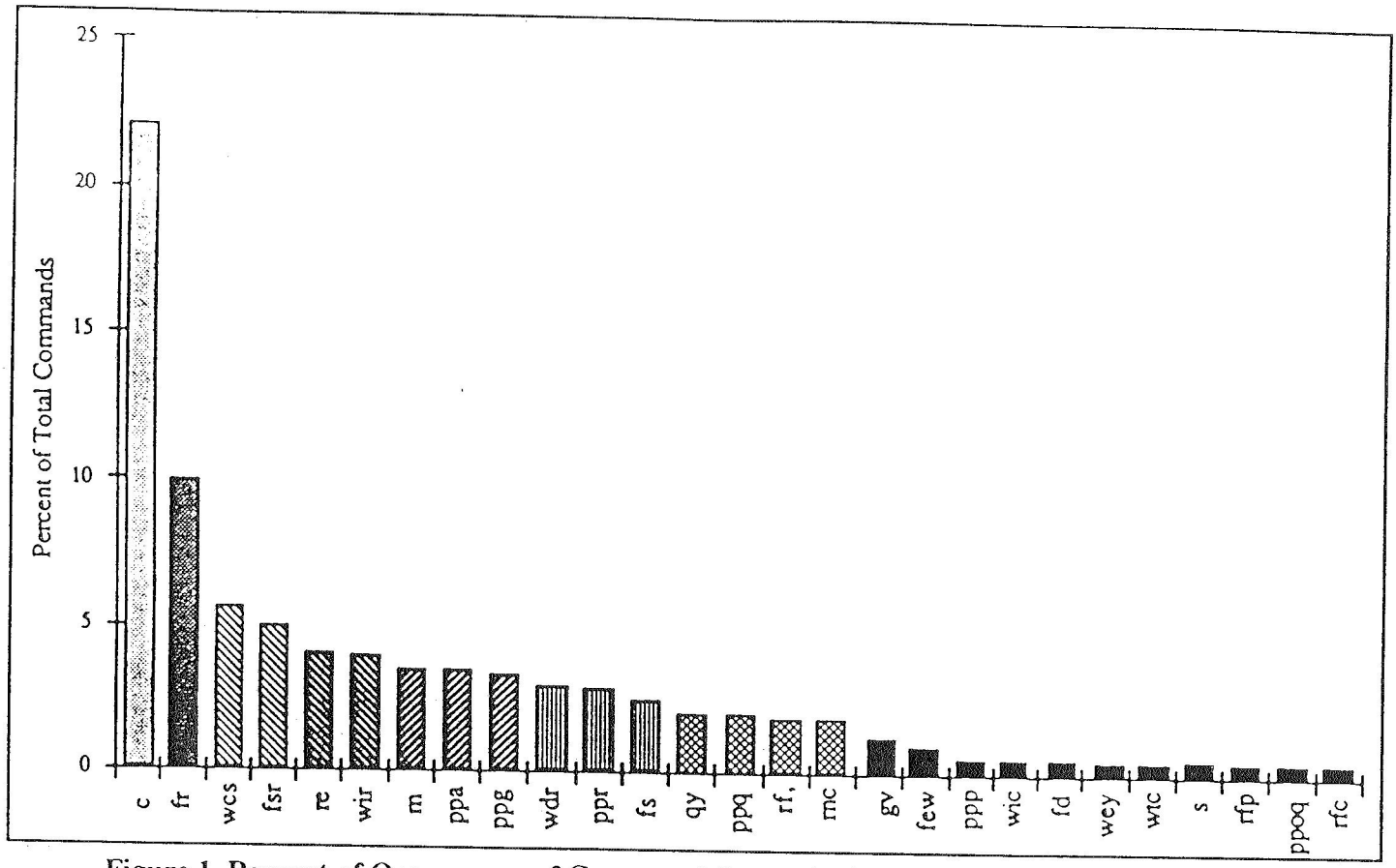

Figure 1. Percent of Occurrence of Command Sequence for the Most Common Command

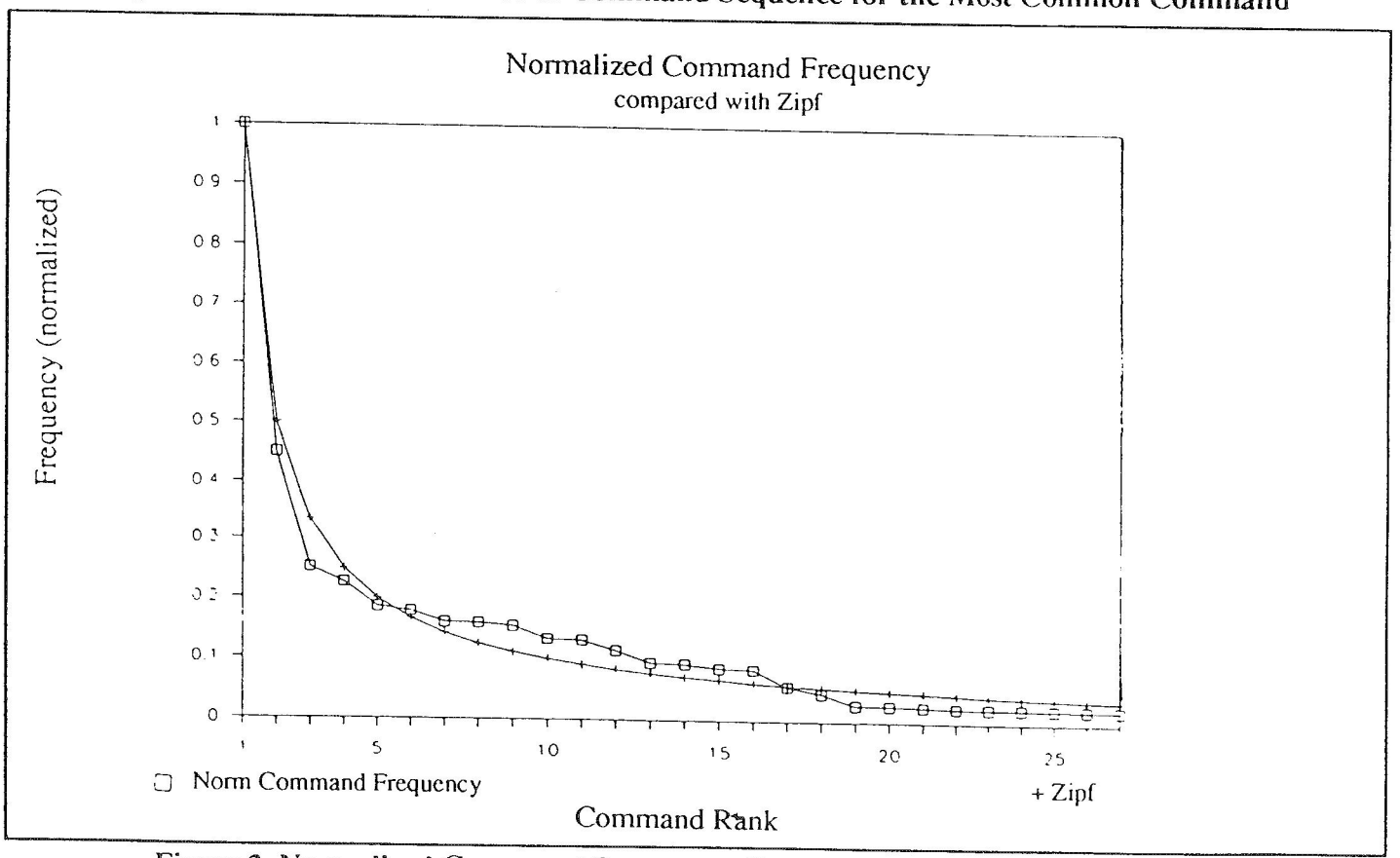

Figure 2. Normalized Command Frequency Compared with the Zipf Distribution

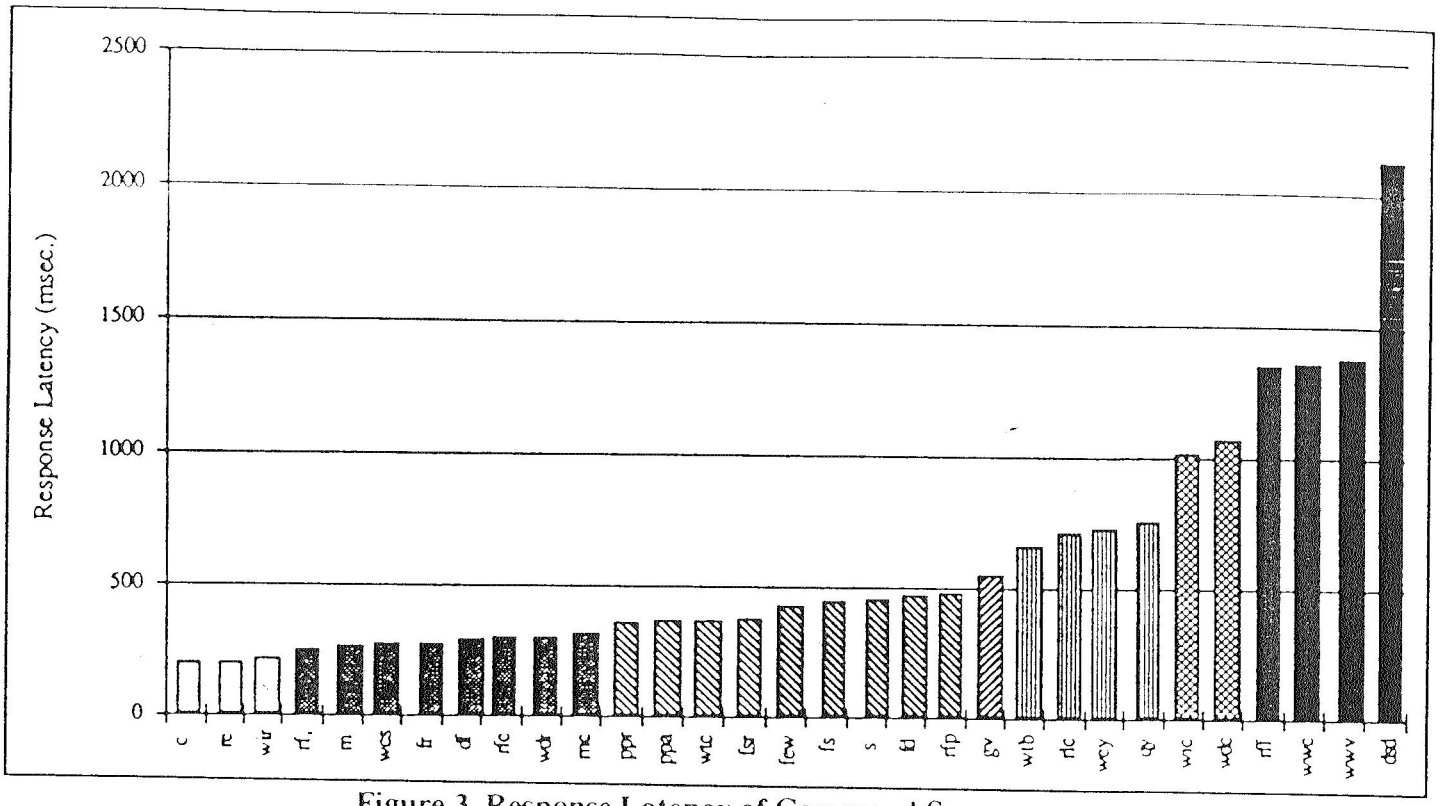

Figure 3. Response Latency of Command Sequences

data. To be included in Figure 3, subjects had to perform the command sequence at least 4 times and at least two subjects had to execute the sequence. The time for the slash key (/) was not included. Some of the original 27 commands (ppg, ppq, ppoq, and few) were not included because they failed to meet the criteria or because they returned to a mid-level menu rather than terminated after completion of the command. Subjectively determined points of discontinuity are again indicated by changes in the shading of the bars.

When response latency times are considered, skewed distributions are expected. To reduce the influence of extreme time values, the average response latency was determined by computing the tri-mean statistic that uses the formula:

$$\frac{Q1 + 2 \times Q2 + Q3}{4}$$

Q1, Q2, and Q3 are the first, second and third quartiles, respectively. Thus, extreme values were not included. The response latency was computed on a per-character basis by computing the tri-mean and dividing by the number of items in the command sequence. For example, the command sequence /re took 203 milliseconds per character for a total time of 406 milliseconds.

In Figure 4 the command sequences on the X-axis are ordered by frequency of use. The Y-axis indicates the average response latency for the commands. The results indicate a close inverse relationship between command frequency and command response latency.

A fear factor may influence the time it takes to enter some commands. Assume a smooth curve that fits the data in Figure 4. Four commands, /fsr, /qy, /wic, and /wdc took longer than might be expected. Issuing a /fsr command results in the stored spreadsheet being replaced by the current spreadsheet. The user may think twice about whether it is appropriate to replace the file or save the spreadsheet with a new name. Use of the /qy command terminates the program. The user may be concerned that the spreadsheet appearing on the screen needs to be saved or that there is some other work that needs to be done. By issuing a /wic or /wdc command, the user inserts or deletes a column in the spreadsheet. Based on debriefings after acquisition of the keystroke data, users indicated that they were concerned about the impact on printing specifications that had been previously defined or whether the deletion of a column might erase a macro.

DISCUSSION

As noted in the introduction, knowledge of how software is actually used by people can assist software developers and internal MIS application development personnel to improve the user interface of existing software, to assist software developers in creating new user interface styles for existing software and to improve the training of personnel using packages.

IMPROVING THE USER INTERFACE OF EXISTING SOFTWARE

Individuals issued 30% more file retrieval commands than file save commands. This result suggests that the user often retrieved several files before the proper spreadsheet was found. The length of file names for Lotus 1-2-3 is restricted to eight characters. This evidence may suggest that developers should

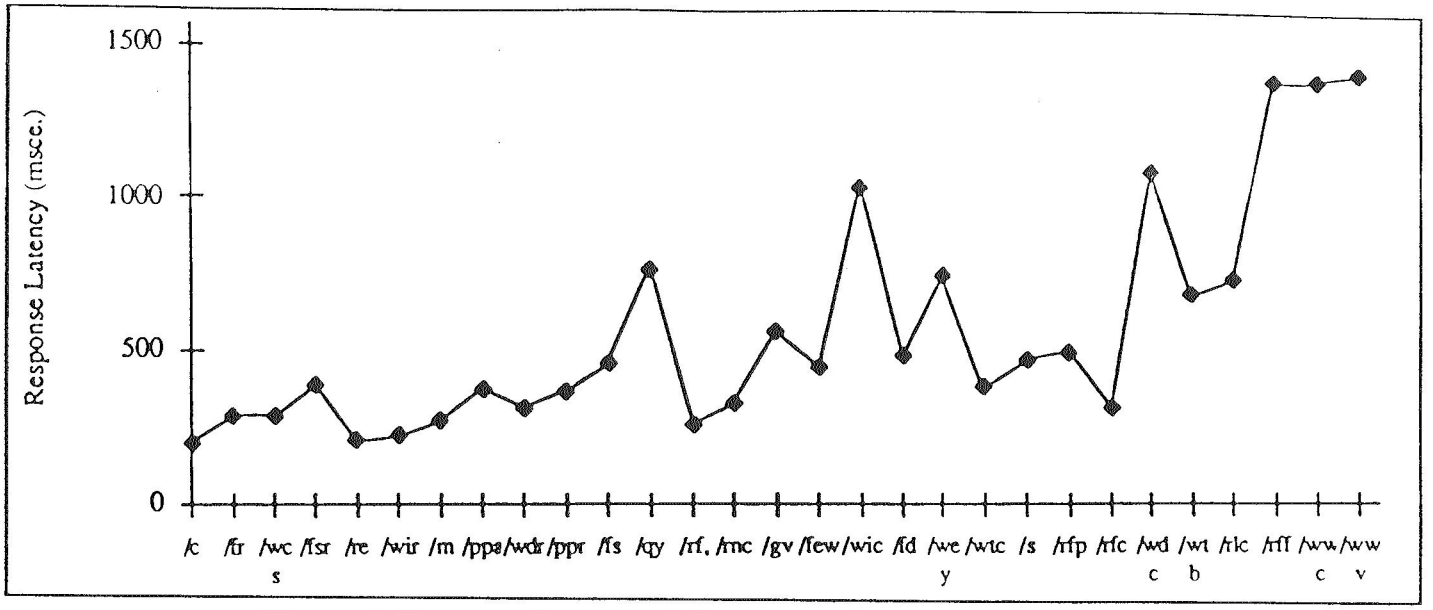

Figure 4. Response Latency of Commands Ordered by Frequency

allow more characters for file names so that users can make names more descriptive. In response to this concern, Lotus Development Corporation included a view command in its most recent release that permits a user to look through a series of spreadsheet files before selecting the spreadsheet to be retrieved.

The subjects completed about seven times as many row operations as they did column operations. This suggests that users need to modify rows more often than columns. Thus, whenever row and column command options appear on the same menu, row operations should appear before column operations. This may be particularly useful for novice or intermittent users.

The relationship between response latency and the frequency of command use is an inverse one; the more often a command is used, the less time it takes to issue that command. Such results could be helpful to software engineers making changes to the user interface; for example, the location of menu items could be changed to improve the efficiency of command selections. The authors are currently completing some experiments investigating menu selection efficiency considerations.

CREATING A NEW USER INTERFACE STYLE FOR EXISTING SOFTWARE

As noted, on some occasions a software developer may want to prepare a new type of user interface for an existing software package. It may be desirable to create a graphical interface for a product that presently has only a menu-driven user interface. By knowing the most frequently used commands, the software developer may be able to include a tool bar or accelerator keys to improve the efficiency of execution.

Software engineers are also concerned with command compatibility as new versions of a software package are developed. Frequency of use and response latency may be helpful in determining how much the existing user interface can be changed without frustrating the experienced user. For example, since virtually none of the worksheet global default commands were ever utilized by the experienced user, software engineers can design the interface for these commands in any way they deem appropriate.

Response latency can be used to indicate the degree to which some commands may be memorized. Such commands should be easy for experienced users to utilize in a new version. As a result of this study, Lotus Development Corporation made sure that the 27 most commonly used commands were keystroke compatible for their graphical user interface in version 1-2-3/G.

TRAINING

Knowing what commands are most used should assist training departments in course development. A review conducted by the authors of typical training courses on 1-2-3 provided by independent computer training companies and training staffs of several major corporations indicates that introductory courses typically cover the process for developing and printing a spreadsheet. Some introductory courses cover the preparation and printing of graphs. Most of the 27 frequently used commands are included in introductory level training courses. After completing such a course, a person can usually prepare individual spreadsheets using the software.

All companies do not require their employees to take a class. Since only a relatively few commands are used by experienced users, the study results indicate that organizations should require new users of a package like 1-2-3 to take a beginning course so they can learn these commands well. Such required training might avoid situations illustrated in this statement from a participant in an introductory Lotus 1-2-3 class, "I learned more in this eight hours of training than I had in three years of using the software."

An intermediate training course often covers topics such as graphs, database capabilities, template creation, and combining information between files. An advanced class usually concentrates on the development and uses of macros. These courses provide methods for further improving an individual's productivity.

The results of the study indicate that the experienced users do not often use spreadsheet commands taught in intermediate and advanced classes. For example, the commands for combining and copying information between spreadsheets accounted for only 12 (or .17%) of the 7,212 commands issued. The low usage of more advanced features could exist because the users' work did not require more advanced commands, or it could be the users were not aware of them.

In discussing the content of training courses with organizations providing such training, the authors determined that fewer people attend intermediate level classes. Even a smaller number attend advanced courses. The results of the current study indicate that many users may simply not be aware of the additional capabilities of the software.

Furthermore, over 50% of the available commands were never used. This result may suggest that organizations should require attendance at intermediate and advanced classes. While individual employees may explore advanced features, organized training classes provide a systematic method of comprehensive coverage of important features. By furnishing such training, an organization may provide employees with the impetus and motivation to use the more advanced capabilities to improve their productivity.

Another advantage of supplying training for employees is that individuals can learn to make better use of the spreadsheet software. Such an argument is applicable to novice and experienced users. By becoming aware of what the software can do, employees may develop applications which benefit the company.

RESEARCH OPPORTUNITIES

The results of this study suggest many opportunities for further research. One such area is the analysis of cyclically and predictability of command usage. The authors are currently completing research on these items as they relate to spreadsheet software usage.

In this study only spreadsheet software was examined, and only Lotus 1-2-3. Research needs to be expanded to include other popular software and applications. The authors are currently collecting data on software packages for document preparation and presentation graphics to determine whether the distributions for command usage and response latency are similar to the results obtained here and for the UNIX operating system.

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