ERRORS IN COMPUTERIZED OFFICE WORK: DIFFERENCES BETWEEN NOVICE AND EXPERT USERS*

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Abstract: This paper deals with errors by novices and experts when interacting with the computer in normal office work. Three criteria are discussed to determine the level of expertise: a) total length of time that the user has worked computers, b) number of programs known, and c) length of daily work-time with the computer. In contrast to widespread assumptions, experts did not make less errors than novices (except knowledge errors). On the other hand, experts spent less time handling the errors than novices. A cluster analysis produced groups of Occasional-, Frequent-, Beginning- and General Users in the work force.

INTRODUCTION

In the last decade office environment has been affected more and more by a spread of computers. At the same time more and more employees are required to interact with them on a daily basis. Depending on the experience of the individual user the interaction with this kind of technology affects different kinds of problems.

Different studies used different empirical definitions of experts and novices. Some compared undergraduates with teachers (Adelson, 1984) or students with few programming courses versus those with more than that (Bateson, Alexander & Murphy, 1987; Soloway, Adelson & Ehrlich, 1988). Vihmalo and Vihmalo (1988) compared students who had taken a Cobol-programming course (novices), professional programmers who had used some programming language other than Cobol (non-Cobol-experts) and professional programmers who had used Cobol for at least two years (Cobol-experts). Finally, Barfield (1986) and Shneiderman (1976) used four levels of expertise: naive, novice, intermediate and expert users.

All in all, there are usually two (strongly overlapping) criteria used for the differentiation between novices and experts: knowledge (e.g., comparing students and teachers) and the time spent working with a particular system (e.g., students with a few vs. those with many courses). In general, there is a lack of investigations in the actual work place as well as little use of multiple criteria to differentiate different levels of expertise. Therefore, we investigated errors by novices and experts when interacting with the computer in normal office work discuss various criteria to determine the level of expertise.

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AN ACTION ORIENTED ERROR TAXONOMY

To distinguish errors from novices and experts, it is useful to differentiate specific error classes. A taxonomy was developed for this purpose (Zapf, Brodbeck & Prümper, 1989). For this paper (for a more detailed discussion see: Zapf, Brodbeck, Frese, Peters & Prümper, 1990) we make the distinction between *usability problems* (errors and problems that result from a mismatch between the user and the computer) and *functionality problems* (mismatch between computer system and the task).

Usability problems can occur on higher or lower levels of cognitive action regulation. High level errors occur because of inadequate development of goals and plans. Since the plans are complex or because the conditions of when to use a subplan are not specified, a part of the action may not be done at the right time. Additionally, there may be difficulties in interpreting feedback by the system. Lower level errors occur when performing well-known actions, e.g., executing the correct action in the wrong situation or overlooking some sign or signal. Furthermore, at this level stereotypical, routinized and automatic movement sequences are regulated without conscious attention, e.g. typing errors or incorrect movements with the mouse.

Additionally, there is the knowledge base for regulation which provides the material used to regulate actions. Errors may appear here because of information deficits or misconceived information, for example, not knowing a particular command.

Functionality problems imply that one is not able to do a work task adequately because the computer program is limited.

METHOD

- *Subjects:* In a field study on errors in human computer interaction, 174 clerical workers from 12 different companies were both observed and answered questionnaires. Average age was 31 years ranging from 16 to 60 years and 72.9% were female.
- *Procedure:* The subjects were observed doing their normal work with the computer. The observation period lasted for two hours. Each error was shortly described. Based on these descriptions, errors were rated by two re-raters as to where the error falls into a taxonomy (15 categories which were reduced to four for this paper). Only those errors the re-raters agreed upon were included (N = 1306, kappa = 0.73).
- *Error handling time*: The time it takes to correct or to give up correcting an error after it has been detected.
- *Expertise:* As an *a priori* classification of expertise the following three criteria were considered: a) total length of time that the user has worked with computers (computer expertise), b) number of programs known (program expertise), and c) length of daily work-time with the computer (daily work-time expertise). The novice/expert cut-off point for computer expertise was one year, for program expertise one program and for daily work-time expertise more or less than 50%.

RESULTS

The a priori classification of novices and experts

The different operationalizations of novices and experts led to different results (for a more detailed discussion of the results see: Prümper, Zapf, Brodbeck & Frese, 1990). There were no significant differences between Computer Novices and Experts in the total number of errors. Program Experts made even significantly more errors than Novices. On the other hand, there was a significant higher count of errors in Daily Work-Time Novices. The answer to how many errors are made by experts or novices strongly depends on which criterion is used for defining experts and novices.

Table 1:
Average Number of Errors per Computer Hour for Novices and Experts

	Computer Novices n = 51		Computer Experts n = 123	Program Novices n = 95		Program Experts n = 79	Daily Work-Time Novices n = 82		Daily Work-Time Experts n = 91
Errors in the knowledge base of regulation	0.61	*	0.34	0.39		0.45	0.52	*	0.33
Errors on higher level of regulation	0.79		0.81	0.64	*	1.00	0.79		0.82
Errors on lower levels of regulation	2.12		1.89	1.55	***	2.44	2.05		1.88
Functionality problems	0.48	**	1.08	0.58	*	1.29	1.18	*	0.56

Note: *** p<.001; ** p<.01; * p<.05 (one tailed t-test)

Daily Work-Time Novices made significantly more errors on the knowledge base for regulation and Computer Novices made significantly more errors on the knowledge base for regulation. Again, the choice of criterion was important. In contrast to Computer Experts and Daily Work-Time Experts, Program Experts made significantly more errors on the higher level as well as on lower levels of regulation. Thus, learning produced a reduction, as well as an increase of errors depending on the kind of error and the way expertise is operationalized. Apparently, errors in routinized actions were independent of how long one has worked with a computer in general and of how long one has worked with the computer on a daily basis. However, they are dependent on the amount of programs somebody knows.

Computer and Program Experts had significantly more functionality problems than Computer and Program Novices, but Daily Work-Time Novices had significantly more functionality problems than Daily Work-Time Experts. In summary, the overall picture with regard to number of errors depends very much on the specific operationalization of experts and novices.

In contrast, the picture with regard to error handling time is much clearer. In most cases the different novices, regardless of operationalizations, needed a longer time to correct errors. Whenever there was a significant difference, this picture prevailed.

The a posteriori classification of novices and experts

Up to this point, we have been concerned with *a priori* operationalizations of novice and expert status. To find out whether there are natural novice/expert groupings in the work force we performed a cluster analysis with the same three variables computer expertise, program expertise and daily work-time expertise. Four clusters, as described in Table 2 appeared.

Table 2:
Four cluster solution

	Occasional users n=74	Frequent users n=66	Beginning users n=27	General users n=6
Computer expertise	2-3 years	2-3 years	3-6 month	2-3 years
Program expertise	1.9	1.6	1.2	5.2
Daily work-time expertise	20-30%	80-90%	50-60%	40-50%

The most interesting results was that the General Users, in spite of their expert status, made the most errors and that the Frequent Users made the fewest errors in most cases. Beginning Users had the most knowledge problems and Occasional Users the most functionality problems. General Users made significantly more overall errors than Frequent Users. Concerning usability problems, Beginning Users made significantly more errors in the knowledge base for regulation than Frequent Users. General Users made significantly more errors on higher level of regulation than Occasional Users, Frequent Users and Beginning Users.

DISCUSSION

Common sense would assume that the overall number of errors would be higher for novices. This was not the case. Apparently, errors *per se* are not an indication of a novice status. Thus, one has to distinguish different operationalizations of novices and experts. While there were differences in the number of errors depending upon operationalization, the picture for error handling was quite clear and relatively uniform - novices showed significantly longer error handling times than experts. The data fit nicely with our reasoning on the concept of error management (Brodbeck, Zapf, Prümper & Frese, 1990). We think that in both training and software design, the main emphasis has been to reduce the number of errors rather than to facilitate error management. The error management strategy suggests that the goal of software design and training should not be so much to reduce the number of errors *per se*, but to reduce the negative effects of errors. The most important aspects of error management are to know potential errors, to be able to interpret errors, to know strategies to recover from an error, to learn from one's errors, and to develop good strategies of error diagnosis (Frese & Altmann, 1989).

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