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THE EFFECTS OF TASK STRUCTURE AND SOCIAL SUPPORT ON USERS' ERRORS AND ERROR HANDLING

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Abstract:The relationship of four organizational variables - job complexity, job discretion, social climate, and the organization of the computer advisory service - with number and type of errors and use of support facilities was studied in a field observational study. 198 subjects from 12 different public and private companies in the southern part of the Federal Republic of Germany (secretaries, typists, specialists, low level managers) were observed for 2 hours while they used computers during their work. They also filled out a questionnaire (N=232). There were a number of small but significant and practically important relationships, e.g. errors pertaining to conscious strategies happened more often in more complex jobs. Perceived support by supervisors and co-workers was related to whether these people were asked in case of an error. Decentralized advisory services were preferred and used more often by users than centralized services.

1.Introduction

User errors play a prominent role in the literature on human-computer interaction (e.g., Card, Moran & Newell, 1983; Lewis & Norman, 1986; Shneiderman, 1987). This is not surprising. Errors have been used to establish bench-mark tests for systems (Roberts & Moran, 1983). Errors are stressful and because of errors people sometimes give up using computers. Moreover, errors are economically costly; errors usually take more time to correct than it does to work slowly.

Although errors have a prominent place in the field of human-computer interaction, errors are usually not observed at the work place but in the laboratory. While laboratory studies are very useful, larger impact factors like organizational variables cannot be observed. Therefore, the results are often taken to mean that only the human factors area is important without reference to the larger organizational setting. In our study, we have observed users in their usual work situation with office software. Organizations have an impact on particular work settings by determining the concrete task structure and the social climate. Therefore, these two sets of variables and their relationship with how users deal with errors were studied.

The influence of task structure variables and social support is interesting for theoretical and practical reasons (cf. Frese, Ulich & Dzida, 1987 for an overview on this issue). Theoretically, it is interesting to know whether or not high level organizational variables can have an impact on low level errors and error handling. Practically, showing some kind of correlation means that an exclusive concern with the human factors side is not sufficient to reduce errors or error handling time but that the role of organizational variables has to be taken seriously as well.

Traditionally, the two most important task structure variables have been (1) job complexity and (2) job discretion (or control at work). The two social climate factors studied here were (3) social support by supervisors and co-workers. An additional organizational factor important for our field is (4) the organization of the computer advisory service because it influences error handling.

1) *Job complexity*: The organization of work determines which tasks have to be done by each individual worker. The complexity of each particular work task influences which errors appear and how they are dealt with. For example, jobs with highly complex tasks may show more errors (at least errors involving the more complex tasks).

2) *Job discretion*: A high level of job discretion implies that the workers can decide many issues at work, e.g. the timing, sequencing and the content of plans and goals at work (Frese, 1987). Does the discretion level at the work place have an impact on errors and error handling? The discretion level has been shown to reduce stress at work (Karasek, 1979; Semmer & Frese, 1989) and to increase the transfer of computer skills from training to work (v. Papstein & Frese, 1988). Similarly, it might also increase certain errors and decrease the emotional impact of errors. While there are similarities between job complexity and job discretion - and usually high correlations - there are important conceptual and empirical differences (cf. Frese, 1987).

3) *Social climate*: The social climate at work may have an impact on error handling. Aspects of the social climate are social support by supervisors and by co-workers. Social support implies that the supervisor or the co-worker will listen to problems appearing at work, will

give emotional support as well as actual help in dealing with these problems. This may also affect a person's behavior in an error situation. Users who feel that their supervisors support them, will be more likely to ask them for help once they are in an error situation. Similarly, users who feel that their co-workers support them, are also hypothesized to ask co-workers more often in case of an error.

4) *Organization of the computer advisory service*: Most larger organization provide some direct support for error handling. Many organizations have a centrally localized computer advisory service. Other organizations have developed a more local decentralized service with local experts (Dutke & Schönpflug, 1987; Scharer, 1983). We hypothesize that the computer advisory service is more often used when it is decentralized because local experts know more about the users' tasks and are more quickly available (less psychological distance).

Error handling is actually quite a complicated concept embracing many variables. There is no error handling without error detection. After error detection, the error has to be localized. Localization may sometimes result from being able to explain the error. The explanation of the error may facilitate error recovery. Error recovery may take different forms, direct corrections like backward operations (e.g. using the backspace key) or repetition of an action (e.g. rewriting a lost letter) or compensatory actions like using a set of procedures to resurrect a file that was erased.

Actually, all of these different parts of the error handling process are intermingled and it is not necessary that each step has to be done. Sometimes an error is recovered without explanation, sometimes localization is not necessary (e.g. when the system has an UNDO key), sometimes explanation is achieved while the error is localized or recovered, etc.

Additionally, users may react with emotional upset for having made an error, (actually, the emotional upset may develop at any point of the error handling process, e.g. when it turns out to be difficult to diagnose the error).

Not all of these concepts can be differentially observed in a field study of work behavior. Therefore, we shall concentrate on the following aspects of error handling:
- How many errors does a user make (number of errors)?
- How long does it take to handle the error (error handling time)? This is the time after an error is discovered up to the time the user finishes error recovery.
- How much outside support is needed for error handling, e.g. by co-workers, by supervisor, calling up the help system, asking the computer advisory service, etc.? How useful are the support functions judged to be?
- How many negative emotional reactions does the user show, once he or she gets into an error situation?

Organizational variables do not affect all kinds of errors in the same way. We have developed an error taxonomy based on some theories of errors and inefficiencies (Norman, 1981; Semmer & Frese, 1985; Rasmussen, 1987; Reason, 1987) and have shown its usefulness and its construct validation (Zapf, Brodbeck, Frese, Peters & Prümper, 1990). For reasons of space, the whole error taxonomy cannot be presented here. It may suffice to say that organizational issues should have a higher impact on those errors that arise in the conscious and problem oriented approach to a task in which controlled processes and conscious attention dominate, than in more routinized and automatized actions. The most important errors that pertain to the conscious approach are: knowledge errors that appear if the user does not know how to deal with a certain task; thought errors that happen, when the steps for dealing with a task are not planned out well; memory errors, when some part of a conscious plan is forgotten; and judgment errors when the feedback of a system could not be interpreted correctly. The last three - thought, memory, and judgment errors are part of the intellectual level of regulation of action (the concept of different levels of regulation is described in Hacker, 1986 and in Semmer & Frese, 1985, a similar concept is used by Rasmussen, 1987). This means that the problem is consciously and deliberatively tackled. In contrast to the intellectual level of regulation, the lower levels of regulation imply that the actions are routine and need only minimal conscious attention.
Up to this point, only usability problems were described which are a result of a mismatch between the user and the system (Zapf, Brodbeck & Prümper, 1989). There is also a second class - functionality problems - which appear when there is a mismatch between the task and the computer system. The mismatch concept is important in that it suggests that errors can never be blamed on either the system or the human but that errors arise when a mismatch occurs (Rasmussen, 1987). This mismatch may occur between the user and the system (usability problems) or between the system and the task requirements (functionality).

In general, we do not expect the hypothesized relationships between organizational variables and error handling to be very large. This is so because a task structure variable such as complexity does not directly translate into more errors or longer handling time. Rather, there are many intermediate steps: Complexity of the work task implies that one does not only deal with one particular problem area alone but with a wide range of tasks. Each task implies that a different set of commands has to be used. None of these tasks (and commands) will be completely routine because many different tasks have to be done. Therefore, there are more errors on the intellectual level of regulation. These errors are more complex to deal with and therefore demand a longer handling time. Similarly, social support by co-workers should not directly translate into asking co-workers for help in an error situation. First, the co-workers may not know enough about the user's problem. Second, the user may appreciate the emotional support of his or her co-workers but does not necessarily want to ask them for help in a problem with the computer. Third, the co-workers who the user relies on for support may not be readily available for questions when he or she works with the computer. Thus, all the correlations will be low. This does not mean that they will be unimportant. In different areas it was shown that even small correlations translate into important practical effects (Frese, 1985; Funder & Ozer, 1983; Ozer, 1985).

2. METHODS

2.1 Subjects

We observed and gave questionnaires to 259 office workers using computers from 12 different public and private companies in the southern part of the Federal Republic of Germany. The mean age was 31.1 years, 73% were women. They worked as secretaries, typists, specialists and in lower level management. Not all subjects could be observed (N=198). In all, 174 subjects were both observed and responded to the questionnaire. (Details on the sample are given in Zapf et al., 1990). There is an additional reduction of the N in the analyses since a few subjects did not make certain kinds of errors (e.g. no intellectual level errors) and were, therefore, not included.

2.2 Methods

Before observing the subjects, a short job analysis was done to describe the tasks which were performed at the observed work place. This was also necessary for the observers to receive an overview of the tasks they were to observe. Since errors are always defined by the goal, the knowledge of the task structure helped the observers to determine what goals the subjects were trying to achieve. In a second step the subjects were observed doing their normal work with the computer. In some cases, people also did a lot of non-computer tasks. Here it was necessary to ask them to do their computer tasks during the observation period. Since we did not want to make the work situation unrealistic for them, they were also asked to perform their non-computer tasks if this was part of their usual working procedure. The observation period lasted for two hours. The observers had two different protocol sheets. One protocol kept a record on the type of computer task on which the subjects worked on and the amount of time required. This protocol was also used to record all interruptions, either by another person or a telephone. A second protocol was kept for all errors, and the subsequent recovery actions. Here, the observers gave a written prose description of each error. They also responded to a standardized questionnaire on how the subjects handled each error, whether they worked systematically or not; whether they used a manual, help system or asked a colleague; and, what amount of time was needed for error handling.

Observations of number of errors, error handling time, outside support, and negative emotional reactions: The errors were immediately classified in a taxonomy (more on its reliability and validity in Zapf et al., 1990). To increase the validity, only those errors were included in this analysis which could be re-rated consistently by two raters (N=1306). In this article, we are concerned mainly with errors on the intellectual level of regulation. The observers also noted how long it took to handle the error. Due to some regulations in the German industry, we could not use stopwatches to record error handling time; instead the observers made rough time estimates (these estimates were reliable, with a Spearman correlation of .68 for two observers, observing the same subjects). For expository purposes, these estimates were then transformed into a real time scale (the chi^2 tables are difficult to interpret - there are no differences between the correlational treatment used in this article and chi^2). Additionally, it was observed whether or not the subjects required the use of some outside support (using help texts, asking coworkers or supervisors, looking into manuals, asking the computer advisory service and asking others outside the company). The nature of the observation had some impact on the use of supports, e.g. the users tended not to ask the supervisor any questions while we observed, they probably called up the advisory service less often or did not leave their work place to ask a coworkers as often as they might have done otherwise. We, therefore, had the subjects rate the frequency of their use of external support. Additionally, working through an error without external help was included in this list. These external supports were also ranked on two dimensions, preference ("Whenever you encounter a problem or an error which have difficulties to deal with it, which of the following possibilities do you employ first, second, third etc.") and usefulness of information ("Whenever you encounter a problem or an error which you have difficulties to deal with it, which of the following possibilities do you expect to be the best, second best, third best etc. support").

The observers also gave a rough estimate, whether the subjects reacted with anxiety, frustration and anger to errors.

Complexity at work and job discretion were also observed. In another study, the validity and reliability of these variables was shown (Semmer, 1984; Zapf, 1989).

Social support by supervisors and by co-workers is very difficult to observe and they were, therefore, ascertained by a questionnaire. The social support variables have been shown to have good reliability and validity (Frese, 1989).

3. RESULTS AND DISCUSSION

Observed complexity of work was significantly related to the number of errors on the intellectual level of regulation (r=.22, N=176, p<.01), to error handling time for all errors (r=.17, N=168, p<.05) and to a lack of emotional reaction (r=-.20, N=177, p<.01). This is in line with our hypothesis that more complex tasks will lead to more complex errors. Since there are fewer routine actions in a complex job, each error takes longer to correct. On the other hand, errors are less upsetting, probably because jobs of higher complexity usually allow a more leisurely work style than highly supervised non-complex jobs.

Observed job discretion showed similar correlations: r=.14 (N=178, p<.05) with the number of errors on the intellectual level of regulation, r=.28 (N=169, p<.01) with the error handling time, and r=-.16 (N=177, p<.05) with negative emotionality with regard to making errors.

Job discretion and complexity of work tasks are highly correlated as well (r=.72, N=203, p<.01) because more complex jobs usually also allow more leeway in how the job is done.

The social climate at work - social support by supervisors and co-workers - was weakly but significantly related to whether or not supervisors or co-workers were asked for help in an error situation. Social support by co-workers correlated r=.15 (N=222, p<.05) with the frequency of asking co-workers (questionnaire version) and social support by supervisor r=.17 (N=219, p<.01) with the frequency of asking supervisors. Thus, organizational variables can translate into asking for help in a very specific error situation.

The general data on the use of supports are presented in Tables 1 and 2. Table 1 presents the observed and the reported frequencies of supports (reliance on self was always included in addition). Both frequencies showed quite a similar picture. In both cases, co-workers were relied on most often. Co-workers were asked in 60 of 118 cases in which the subjects required any kind of help (sometimes more than one support was used for handling one error; therefore there were 139 uses of support for handling 118 errors). The second most frequently used support was observed to be calls on help texts and exploration of menus. The subjects did not think that they were doing this as often as it was observed. However, the observers also included explorations of menus in this category; thus differences between subjects and observers were to be expected.

Table 1:

<u>Frequency of Use of Supports (Questionnaire and Observations)</u>

	Means (Questionnaire)	Absolute Frequency (Observations)
Without external help	3.68 **	--
Asking a co-worker	3.09 **	60
Looking up in user manual	2.05 ns	15
Use of help/menu facilities	1.93 *	45
Asking user advisory services	1.75 ns	19
Asking superordinates	1.70 **	--
Asking other outside the company	1.11	--

Friedmans Chi^2 511.833,n=214 $p < 0.01$, df = 6

Chi-Square test $Chi^2 = 25{,}68$,n=198 $p < 0.01$, df = 3

Paired t-test for dependent samples
** $p < 0.01$
* $p < 0.05$

Table 2:

<u>Mean Rank Orders for Supports with Regard to Preference and Usability (Questionnaire)</u>

Preference	Usability
1.Asking a co-worker ns	1.Asking a co-worker ns
1.Without external help ns	2.Use of help/menu facilities ns
1.Use of help/menu facilities ***	2.Asking computer advisory service **
4.Looking up in user manual ***	4.Looking up in user manual **
5.Asking computer advisory service ***	4.Without external help ***
6.Asking superordinate ***	6.Asking superordinate ***
7.Asking others outside the company	7.Asking others outside the company

Friedmans Chi^2 386.358, n = 133 $p < 0.01$, df = 6

Friedmans Chi^2 425.252, n = 198 $p < 0.01$, df = 6

Wilcoxons test for single differences
*** $p < 0.01$
** $p < 0.05$

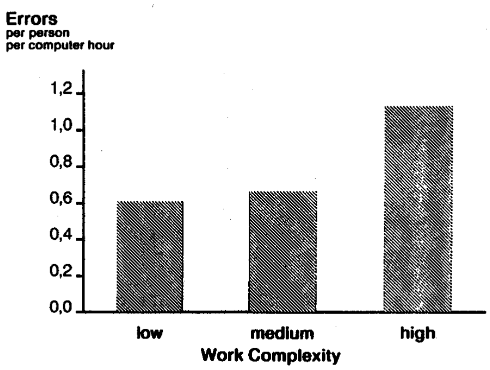
Surprisingly, users thought that they used the manual more often than we observed them doing it. One possible interpretation is that users have great difficulties with manuals and hence still vividly remember how they used the manual. Thus, recall is better and the number of manual use is overrated. Another possible interpretation is that during observation subjects did not want to use the handbooks because they knew that they would have difficulties using them (correspondingly, preference for them is not very high). We did not observe asking supervisors or people outside work.
Table 2 gives an overview on two questions in the questionnaire: How much do you prefer a certain support to solve an error situation and how good is the quality of the information that you receive from these sources of support. All patterns are significant ($p < 0.01$). This Table corroborates the findings reported in Table 1. Asking a

co-worker is preferred most often (even preferred to just solving the problem on one's own). Co-workers usually know the task best (e.g. in contrast to a centralized computer advisory center) and they are readily available. As one would suppose, getting along without any external help is most often done and it is also highly preferred. But it is considered not to be the most appropriate possibility to gather information for error coping (ranking on 4th place, Table 2).
Whether or not a supervisor is asked may also depend on how much a user feels to be supported by the supervisor. The Spearman correlations showed that the more social support was given by the superordinate the higher was the ranking of preference of asking the supervisor ($r=.25$, $N=199$, $p<0.01$) and the usefulness ($r=.28$, $N=217$, $p<0.01$). A similar tendency appeared for social supportiveness of co-workers with preference for using co-workers ($r=.16$, $N=222$, $p<0.01$). However, there was no significant relation with respect to usefulness.
The final point of our discussion was a comparison of *centralized versus decentralized computer advisory services*. The computer advisory services were not used very often (Table 1). However, the computer advisory service was actually considered to be an informative support facility (ranking 2 on usefulness), but it was considered significantly less helpful than consulting a co-worker. Why is this so? Qualitative analysis of the interview data showed that the computer advisory service was often centrally organized, technically oriented, not task oriented and it was highly overloaded.
In an additional analysis the subjects were grouped according to whether the advisory service of their department was decentrally or centrally organized. The hypothesis was that those people with a decentralized advisory system would use them more frequently and find them more useful. The average ranking of advisory services differed significantly (Kruskal-Wallis one-way ANOVA). Decentralized advisory services were used more frequently ($chi^2=12.5$, $p<0.01$, $n=129$) and they were ranked higher in preference ($chi^2=9.3$, $p<0.01$, $n=116$) and in the quality of information ($chi^2=15.1$, $p<0.01$, $n=130$) than centralized advisory services.
These data speak for the usefulness of the local experts (Dutke & Schönpflug, 1987; Lang, Auld & Lang, 1982; Scharer, 1983). Local experts combine the advantage of being co-workers with high expertise; they know the tasks and the computer program and can integrate task knowledge with computer knowledge; additionally, they are readily available.

4. OVERALL DISCUSSION

In summary, task structure variables showed significant correlations with number of errors and error handling time. The most important findings concern organizational issues and the use of supports once an error appeared. Social support by co-workers and supervisors influenced who was asked in an error situation. This influence showed up for preferences and the usefulness of the support as well. Finally, it made a difference whether the advisory services of a company were organized centrally or in a decentralized manner. The decentralized computer service was strongly preferred. The results speak for the concept of local experts rather than for a more central advisory system. Although the centralized systems often employ the more knowledgeable experts, they do not know the users' tasks and they are not available enough.

Figure 1: Complexity at work and errors on the intellectual level of regulation



The correlations are by and large small. In so far, this study is suggestive only. However, even small correlations are of practical importance. Figure 1 translates the correlation of .22 between job complexity and number of errors into a different picture; the mean number of errors was calculated for three levels of complexity. It shows that for high complexity mean number of errors is nearly double as high as for low and medium complexity (Scheffé $p<0.05$) - this is clearly an effect size that is important for practical purposes. Furthermore, the data are largely based on observations in an ecologically valid work setting, using computers in normal day to day work.

The data cannot be interpreted causally. While it is unlikely that number of errors and error handling influenced job complexity, job discretion, and social support, it is possible that third variables may have brought forth job complexity and longer error handling times, etc. Nevertheless, the correlational evidence should be taken to mean that there is a relationship between organizational variables and errors.
Although, they were all ascertained by the observers, we are quite confident that the measures on the number of and handling time for errors were not confounded with the measures of job complexity and job discretion. The observers were not aware of this particular hypothesis and a confounding would presuppose that the observers made a count of the errors depending upon the intellectual level of regulation or not (the observers rated each error individually and after the observation answered a set of questions with regard complexity and job discretion).
Note that the errors reported in this study did not directly refer to organizational issues. Actually, we also observed a few additional organizational errors, which we called interaction problems. 2.1% of all errors ($n=28$) were interaction problems. They included, for example, errors using a computer tool that had been changed by another person without indication that this was done. A second example: a user could not start working because the commonly used password of the shared work-station was changed by his co-worker without leaving any message.

Finally, the system manager changed an array of system defaults but the users were not informed properly. Thus, interaction problems directly imply that an implicit or explicit organizational rule was violated or an organizational rule had not be drawn to fit the case.

The data suggest that it is useful to enlarge the picture of software ergonomics to include organizational variables. The human-computer dialogue is clearly also a determinant of the errors and error handling (Peters, Frese & Zapf, 1989) but it may not be the only important factor. The influence of organizational variables on the daily activities with the computers has been underresearched and is usually only paid lip service to. It is necessary to develop a comprehensive concept of how organizational variables enter into each action dealing with the computer and which mechanisms are responsible.

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