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A CONCEPT OF CONTROL: IMPLICATIONS FOR STRESS AND PERFORMANCE I HUMAN-COMPUTER INTERACTION

MICHAEL FRESE
Dept. of Psychology, Ludwig-Maximilians-Universität, Leopoldst 13, D-8000 München 40, Federal Republic of Germany

ABSTRACT

Control at work has an influence both on stress-effects and performance. A conceptualization is presented that relates to t action process and its implications for stress-effects and perf mance are described. Empirical data shows consistent stress ar performance effects of control over the introductory process of new technology, of control over the training process, and of co trol at work on transfer of training.

1 INTRODUCTION

The issue of control (or decision latitude) has become an im portant topic in stress research (e.g. Frese, 1977, Karasek, 19 Karasek et al., 1981). In this article I would like to pursue t theme of control a little further with regard to stress and per formance in human-computer interaction, presenting first theore cal conceptualization of control, discussing the function of c trol for stress-effects and performance, and presenting some da on the importance of control.

2 THE THEORY OF CONTROL

Experiencing control means to have an impact on the conditic and on one's activities in correspondence with some higher orde goal (Frese, in press).

A person exerts control when she has influence over her acti and over the conditions under which she acts. An action consist of a sequence (this sequence is variable, of course): goal deve opment and goal decision, plan development and decision, execut of the action and use of feedback (Frese & Sabini; 1985, Norman 1986). Having influence means to be able to decide what goals, what plans, what kind of feedback a person is using under what conditions. If the environment does not provide the freedom to

cide, the person does not have any control. This concept is summarized in Table 1. Decision possibilities can appear with regard to sequencing, timeframe, and content. Decision points with regard to sequence may for example mean that people are able to determine which tasks they do first and which one second, in which sequence plans are being formed and executed, or in which sequence they call on signals to inform them of the success of their activities. Timeframe refers to two sets of decision possibilities: First, the decision, when a task is tackled or a plan is performed; second, deciding on how long it will take to work on a task or on a plan. Similarly, the timing of the signal alludes to when it will appear and how long it is displayed. Content refers to the substance of the decisions with regard to task, plan, signal and conditions: What particular task is done, what plan is formed, what kind of signals does one choose to use and what conditions exist for work.

TABLE 1
Aspects of External Control

Action sequence	Decision possibilities		
	Sequence	Timeframe	Content
Tasks (Goals)			
Plans			
Feedback (Signals)			
Conditions			

Four issues are worth emphasizing in this context. First, the decisions must refer to a goal (or in the case of a task, to a superordinate goal). One decides with some goal in mind. As long as something is not related to a goal, non-control does not matter.

Second, freedom to decide has a positive quality only when the decisions do not involve high risks. If all the alternatives involve high risks, then controllability may lead to an aversive situation. This is related to the issue of goal again, because we usually do not develop goals that are very risky.

Third, there is a hierarchy of goals within any one person at any one time (there may be, of course, multiple and conflicting goals). The higher up in this hierarchy a particular goal is, the more important and central the decision become, (e.g. life or career plan decisions). Thus, control and non-control must be weighted by the importance of the goal.

Fourth, aside from the above points about the significance of goals and goal hierarchy, it is important to ask the question, much of the time a person is exposed to non-control or control situations. The theory predicts that exposition time is an important variable (Frese, 1984). If one is constantly under conditi of non-control (little decision making power) even in small matters, there is an impact even if the goals are not very importa The longer, one is exposed to these conditions, the stronger is their impact on experienced control, even if higher order goals (like life goals) are still to be influenced by the individual.

There are certain prerequisites of control: skills, function ity, transparency and predictability:

Skills: The external conditions represent only potential dec sion points with regard to some goal. To realize this potential, one needs to have knowledge and skills as internal requirements

Functionality: It refers to whether a system (e.g. a compute program) allows and enhances the completion of a task. One issu of functionality is, for example, whether the system models rea world tasks. Thus, a statistics program should calculate correc and do what it is supposed to do. A spell program should have enough words in the dictionary. Without functionality there is control, because the decisions are not meaningfully related to goal (task) any more. However, a high functionality does not ne essarily imply, that there are decision points available.

Transparency: Transparency implies that the user can develop internal model of the functions of the system (Maass, 1983). Thus, the system should not confuse the user by giving differen commands to do the same thing under different modes or by givin explanations that are inconsistent or only half true. Under con tions of non-transparency, the user cannot make adequate decisi referring to his goal. Transparency is not identical to control because it is possible to develop a system that is completely transparent, that nevertheless offers only little control (e.g. expert system that perfectly explains why it is doing what, but that does not allow users' decisions).

Predictability: There is some overlap with the concept of transparency. If a system is not predictable, it is most likely not transparent. However, transparency refers to the present, p

dictability to the future. If a system's behavior cannot be foreseen it is not predictable. In the context of predictability, two issues have been discussed: predictability of what (pwhat) and predictability of when (pwhen) (Miller, 1981). Pwhat implies that one knows what happens when a certain command is typed into the machine. Pwhen implies that one knows when a certain command is executed and completed. The relationship between predictability and control is complex. It is possible that a system is predictable but not controllable (e.g. everything is determined by the system but there is a signal that tells what will happen next). It is also possible (although unlikely) to conceive of a system that is controllable but not predictable (e.g. a system in which one does not know what will happen but that allows to change things once they have happened). For practical purposes, lack of predictability make decisions meaningless, because when the states of a system cannot be foreseen, one cannot make adequate decision.

3 CONTROL AND STRESS-EFFECTS AND PERFORMANCE

Control may have a direct influence on the stressors or it may function as a moderator of the relationship between stressors and stress-reactions. The direct effect on stressors is apparent when people can change those working conditions that they find stressful. The moderator effect has been consistently shown in experimental research but also in field studies on the relationship between stress and health. Stressors given under conditions of non-control lead to helplessness and physiological effects (Seligman, 1975; Weiss, 1977). Field studies have shown similarly, that the combination of stress and control can lead to heart attack (Karasek et al., 1981) and psychosomatic complaints (Semmer & Frese, 1987).

Performance effects existed when there was only potential control (Glass & Singer, 1972). In this series of experiments the subjects had a button that could turn off a loud noise (the stressor). In one condition, the subjects were asked not use this button (and all of them complied). This condition produced less performance decrements in various tasks than not having such a control button.

The performance effects because of non-control may be due to the following factors: (1) Helplessness: It leads to passivity and to a reduction of active and exploratory strategies to solve tasks and problems at hand. (2) Reactance effects: In the attempt to regain control, one does not concentrate on the task and may ever actively sabotage those people (or systems) who are seen to be agents responsible for reducing control (Wicklund, 1974). (3) I fusion of responsibility: In non-control situations the person not responsible for the results and, therefore, is less active bring them about. (4) Reduction in learning: When one is not ir control, feedback is not perceived as being brought about by or own actions; therefore, one does not learn from feedback. (5) F ting: When there is control, it is possible to fit the working conditions to one's psychophysiological prerequisites thus maki it easier to work.

4 EMPIRICAL FINDINGS

4.1 Changing technology and control

We were interested whether new (computer) technology would change control at work. Since we had data on German blue collar workers in 1979 (before large scale computer technology was introduced in w.- Germany), we made a second wave of questionnaires the same subjects in 1985. One third of them were now working w new technology. Among these the following groups of people coul be differentiated: (1) Those who worked with the computer but d not have any influence on the programing (N=18), (2) those who some influence on programing (e.g. they collaborated with the programers) (N=17), (3) those who programed themselves (N=10), (4) finally people who worked with robots (N=9). Control at wor was ascertained with a questionnaire on how much influence a worker had on sequencing of tasks, on choice of tasks that he h to do, etc. (Semmer, 1984).

Table 2 shows the results; group 3 has the highest control a work, group 4 the lowest. However, this does not test the quest whether or not these blue collar workers gained or lost control because of the introduction of computers. Interestingly, an ana sis of covariance (with earlier control as covariate) showed no gain or loss at all. Apparently, those blue collar workers with high control in their former jobs were also the ones who got th jobs in which they programed themselves or had at least some im pact on programing; similarly those with low control remained i jobs with low control after the introduction of new technology (Frese & Zapf, 1987).

TABLE 2
Different groups of (computer) workers and control at work (means)

no influence (1)	influence on progr. (2)	program themselves (3)	robots (4)
5.09	5.19	6.74	4.30

Control is not only important on the level of work but also on the organizational level (the issue of participation). This is of particular importance when new technology is introduced. We were interested in whether it made a difference for workers to have a "say-so" in the process of introducing new technology. A scale on this issue shows: (1) Those who have high control over technological changes also report that their work situation has improved over the last 6 years ($r=.31$, $p<.05$, $N=53$). (2) Control over technological changes is negatively related to psychological dysfunctioning, with anxiety ($r=-.24$, $p<.05$, $N=56$) and marginally with psychosomatic complaints ($r=-.21$, $p=.06$, $N=55$). (3) There is a high correlation with job satisfaction ($r=.41$, $p<.01$, $N=56$). (4) Finally, people who perceive themselves to have control over technological changes report better social support from their supervisor ($r=.30$, $p<.05$, $N=56$). Thus, to have control over technological changes may have positive effects on workers' psychological functioning, on job satisfaction, on a decrease of anxiety, and on a seeing the job to be better.

4.2 Control in the training process

In an experiment on training we pursued the question of control as well. In one experimental group the training was highly structured and gave a step-by-step procedure with little chance to develop one's own mental model. In the other group, the subjects (all of them complete computer novices) were asked to develop their own hypotheses about the program that they were about to learn and they were encouraged to explore. Thus, the latter group had control over the development of their mental model and had more infleunce over how to proceed in their exploratory behaviors. This group proved to be superior in various performance variables after the training, e.g. they need less time to correct errors when writing a text and a smaller number of keystrokes; they were also better in a transfer task (Frese et al., 1987).

4.3 Control and the transfer from training to everyday work

Finally, we wanted to know, whether control at work helped transfer process. The hypothesis was: Even when people learned lot in the training, they would only apply this knowledge if t had a high level of control at work; otherwise reactance and h lessness effects would decrease their motivation to use the ne system in their everyday work. In a study of engineers, using same scale of control at work as in the studies above, this tu out to be true (v. Papstein, 1987). The correlation between sy knowledge (ascertained at the end of the training) and hours o use of the new system in their work was .66 ($N=14$, $p<.01$) for those with a high level of control at work, while this correla was .03 ($N=11$, n.s.) for those with low control. The difference tween these two correlations is also significant ($p<.05$). If t results can be reproduced in other studies, they suggest that is useless to buy expensive computers and deliver expensive tr ings, if the company does not provide a sufficiently high degr of control to their workers.

5 CONCLUSION

The concept of control developed in this article can be use different levels: It is possible to analyse working conditions with the dimensions of Table 1 (e.g. how much control does a person have over the introductory process, over the timing, or over sequencing of work tasks); it is also useful to analyse computer programs to ascertain whether or not they provide decision points along the lines of Table 1. For example, our re sults show that direct manipulation interfaces lead to superior performance in the long-range training process (Frese, Schulte-Göcking & Altmann, 1987). It may be useful to study whether thi is an effect related to the higher degree of control that direc manipulation provides or whether it relates to other variables.

Control at work has been shown to have an impact on stress-e fects. In a series of studies, we have additionally shown that also has an impact on performance, e.g. in training and in tran fer of training. Our theory and the results suggest that we sho consider the concept of control to be one of the central variab in the use of computers at the work place, in the development o training concepts, and in the design of computer systems.

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