A RAND NOTE

Cognitive Press in Computer-Mediated Work

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October 1987

RAND

The research described in this report was sponsored by the National Science Foundation.

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Published by The RAND Corporation
1700 Main Street, P.O. Box 2138, Santa Monica, CA 90406-2138

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N-2679-NSF/IRIS

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October 1987

Prepared for
The National Science Foundation

RAND

Institute for
Research on
Interactive Systems

COGNITIVE PRESS IN COMPUTER-MEDIATED WORK

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ABSTRACT

A framework is presented for conceptualizing the adaptation to computer-mediated tasks as a function of cognitive resources and demands in relation to established baseline performance. Information work is inherently cognitive since it involves generation, transformation and transmission of symbolic stimuli. Introduction of computers challenges extant response repertoires, but research suggests that white collar employees cope well with this initial stress. The incremental, cumulative and continuous changes to follow--termed press--can present greater difficulty. The framework suggests two avenues for facilitating adaptation: amplifying users' cognitive resources, and modulating task demands by shaping work technology around users' needs.

1 INTRODUCTION

Stress and adaptation are dynamic constructs that have been applied to explain human responses over a number of event domains--from changes in level of a perceptual stimulus (e.g., Helson, 1964) to large-scale social role changes (e.g., Kahn et al., 1964). Technological changes in the workplace and their consequences for human performance constitute another domain usefully studied by means of these concepts (Bell, Bikson, Rich and Wuchitech, 1976).

It is by now a commonplace observation that the U.S. is becoming an "information society," with ever larger proportions of the workforce manipulating symbols and images rather than objects and materials. The number of white collar employees, which exceeded 55 million in 1985, will top 65 million by 1995 (U.S. Department of Labor, 1983). These people are engaged in the generation, transformation or transmission of information (Bikson, 1987).

The key to the transition is the advance in computer-based technologies Bikson and Eveland, 1986). By 1995, it is likely there will be one computer workstation for every information worker (Roessner, 1984). The view taken here

Reprinted from *Social, Ergonomic and Stress Aspects of Work with Computers*, G. Salvendy, S. L. Sauter, and J. J. Hurrell, Jr. (eds.), pp. 353–364, © 1987 by Elsevier Science Publishers B.V., Amsterdam.

is that continuous innovation in information tools makes the white collar environment a "predisposing" one (Jaco, 1970). That is, it subjects its constituents to a high frequency of stress or press. New tools have this consequence by presenting task demands that fall outside well established work behavior repertoires, an inevitable concommitant of the innovation process.

These demands are inherently cognitive ones. This follows not just because appraising and responding to them theoretically require cognition (e.g., Lazarus, 1974; Osipow and Spokane, 1984) but also because the basic tasks of information work are themselves predominantly cognitive (cf. Karasek, 1981). This paper outlines a conceptual framework for understanding cognitive stress and press in the transition to computer-mediated work, applying it to to data gathered in recent RAND research (Bikson, 1987). Implications for facilitating adaptation to continued advance in electronic tools are discussed.

2 CONCEPTUAL FRAMEWORK: COGNITIVE STRESS, PRESS, AND ADAPTATION

2.1 Overview

The conceptual framework presented here was developed for a more general study of adaptation to rapid technological change (Bell, Bikson, Rich and Wuchitech, 1976). It draws on the research tradition initiated by Seyle (1956), emphasizing contributions from perception psychology (Helson, 1964) as well as from clinical and social-psychological research (e.g., McGrath, 1970; Lowenthal and Chiriboga, 1973). The figure below summarizes this composite approach.

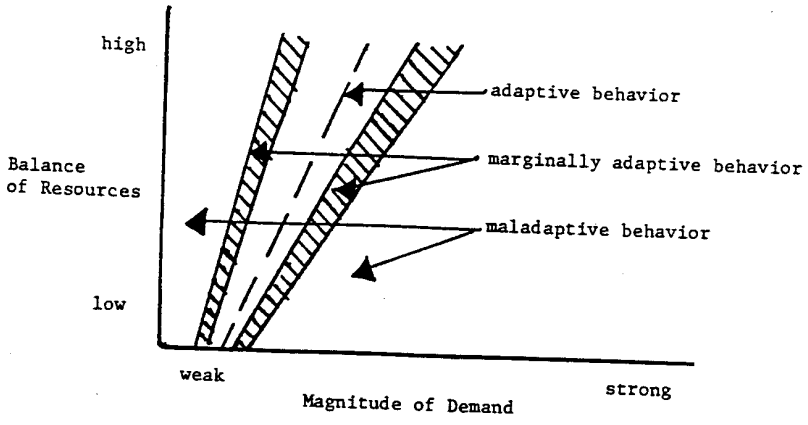

Fig. 1. Framework for conceptualizing adaptation to computer-mediated work.

Outcomes of interactions between people and information work environments are seen as a function of the level of task demands in relation to the task-relevant resources at hand, given cumulative baseline performance (adaptation level). Outcomes, roughly speaking, fall into one of three categories: the central (shaded) area represents greatest congruence between demands and resources, yielding adaptive task behavior and positive affect; striped areas on either side denote marginally adaptive behavior and tolerable affect; and the uncolored region represents maladaptive behavior and negative affect, a function of persistent divergence between task needs and capabilities.

2.2 Resources

In Figure 1, the ordinate represents the available balance of resources relevant to completion of a set of information tasks. Existing literature cites a great number of potentially relevant resources, ranging from genetic predisposition (Sharit and Salvendy, 1982) and personality traits (Brief and Atieh, 1986) to general health and social support (e.g., Williams, Ware and Donald, 1981). Such personal and social characteristics, however, are applicable to coping with all sorts of stress and have no special significance in white collar work.

Of particular relevance for adapting to electronic tools in information work are cognitive resources such as ability, experience, skill, training and learning support (cf. Turner, 1986). The flexibility of the tools provided and their conformability to the tasks at hand further condition adaptation (cf. Turner, 1984). The term "balance" calls attention to the mix of resources in work environments and emphasizes their complementarity (e.g., skill deficits can be compensated by stronger training). Individual variables are de-emphasized, giving more attention to organizational policy influences on task-related resources.

2.3 Demands

The magnitude of task demands (work-related stimuli that present an opportunity or a requirement for a response) appears on the abcissa in Figure 1. Work environments regularly present task demands that are met as a matter of course (see adaptation level, below). However, some task demands differ sufficiently from their predecessors to disrupt or threaten disruption of ongoing work work behavior. Two types of challenges to adaptation are proposed: stress and press.

Stress is the more recent and better-researched construct. By most accounts, stress results from a singular and visible change in the task environment eventuating in demands that fall outside the existing behavior repertoire (e.g., McGrath, 1970; Dohrenwend and Dohrenwend, 1974); current work methods do not generate an adequate response. Initial introduction of computers as information tools in an ongoing work context should--for most employees--be regarded as an instance. It constitutes a "critical work event," borrowing Osipow and Spokane's (1984) phrase (cf. "stressful life event," Holmes and Rahe, 1967). Stressors are taken to be normatively neutral. As occasions for unfreezing of current behavior patterns, such challenges might generate higher-level performance, lower-level performance, or simply different task performance on approximately the same level.

"Press" is a term used originally by Murray (1938) to denote elements in the environment that, together with a need, evoke a response. Like stressors, press are neutral in the sense that their positive or negative character is determined by functional consequences--how they operate to help or hinder the fulfilling of the need; for purposes of this discussion, task demands (getting work done) constitute the need. Unlike stressors, press are likely to be recurrent, chronic and/or cumulative, and individually scarcely noticeable. What is notable about press is not the effect of any one event but the number of events tending in the same direction (cf. aggregate effects of incremental changes in the environment, Studer and Barton, 1974). What makes such merely incremental shifts important is their uniform bias in a particular direction and their summation (Bell, Bikson, Rich and Wuchitech, 1976). In this way press can also eventuate in the disruption of previously viable task responses. Information overload (see Bikson, Quint and Johnson, 1984) is an instance of press. The same might be said of "underload."

2.4 Adaptation

People at work have learned response repertoires for dealing with a range of day-to-day task demands. The impact of an individual event is in large part determined by how similar it is to other environmental events. The broken diagonal line in Figure 1 represents the theoretical mean adaptation level for a person as a function of varying amounts of task-relevant demands and resources; the shaded area around it is a zone of normal deviation. Defined by approximate congruence between resources and demands made on them, activities within this region do not represent changes from baseline performance (cf. homeostasis, as in Osipow and Spokane, 1984).

Threshold-level events occur within the striped regions in Figure 1, at the bounds of adaptive behavior. Such events tax extant performance limits but available resources are sufficiently congruent with the demands to allow marginally adaptive responses to emerge. New behaviors, in turn, shift the adaptive performance zone to include areas previously outside the response repertoire and a new adaptation level results. In this way performance gains can be achieved as part of a developmental process--neither stress nor press is a necessary condition for positive change.

When task demands and available resources are seriously discrepant (in Figure 1, when their intersection lies outside the adaptation threshold), an adaptation problem arises; the existing response repertoire will not meet a recognized need. Such events induce "arousal," "disturbance," and the like (Berlyne, 1960, Lazarus, 1974), motivating attempts at problem-solving. Mastery of events that have caused a "hitch" in performance (Dohrenwend and Dohrenwend, 1974) is experienced with positive affect and boosts the adaptation level. Alternatively, failure to cope with stress or press results over the long term in impaired performance and negative affect (strain).

As Figure 1 illustrates, such maladaptive outcomes are predicted by either a deficiency or an excess of task resources in relation to demands. Deskilling, for example, would be regarded as a change in work environment resulting in an imbalance of the latter sort. This framework also suggests that preventive or ameliorative interventions can occur on either axis: adaptation to new work technologies can be facilitated by careful (re)design of tools, tasks and jobs as well as by an improved resource mix.

3 COMPUTERIZATION OF INFORMATION WORK: STRESS, THEN PRESS

3.1 Initial Stress

A wealth of literature on organizational innovation supports the thesis that the first introduction of a new tool is likely to be stressful in the sense just defined (Bikson, Gutek and Mankin, 1981). When it is a computer-based tool, the focus is usually on the physical workstation, which may well be a misappraisal. That is, the hardware interface is more like a vehicle or agent of change (Keen, 1984). The substance of the change--a change in how symbols are presented and handled--will be reflected in different ways of doing information tasks, bundling tasks into jobs, and distributing jobs among work groups (Bikson and Eveland, 1987).

Data gathered in a cross-sectional study of 55 work units in 26 different private-sector organizations implementing interactive information systems (Bikson, 1987) suggest that even familiar tasks present demands that exceed

capabilities when new electronic tools are first introduced. We inquired about how organizations get basic task needs met during this period.

TABLE 1

WHAT INTERIM MEASURES ARE TAKEN TO HANDLE WORK WHILE USERS ARE LEARNING THE SYSTEM?

	Percent of Groups (n=55)
Send out some of the work	2
Hire temporary workers	6
People work longer hours while learning	19
People fall back on old methods	19
Work is redistributed within the group	21
No interim measures	31

Responses indicated that little attention is given to technological change as it involves task redesign and behavioral adjustment. However, the study also found that employees--even without additional interim resources--are generally willing and able to make the transition to an electronic information environment (Bikson, 1987). Many employees treat it as a positive and exciting challenge (e.g., Bikson, Stasz and Mankin, 1985; Stasz, Bikson and Shapiro, 1985); most report higher satisfaction (Gutek, Sasse and Bikson, 1986), suggesting successful adaptation to the initial stress.

3.2 What About Press?

The subsequent incorporation of computer systems into day-to-day information work is likely to generate press. An impact of small cumulative changes, press is harder to observe. And, if stress measurement presents problems, press must be even more difficult. Nonetheless, it is arguable that events like those grouped under "role ambiguity," "role conflict" and "role loss" are individually small but collectively syndromatic and more properly conceptualized as press than stress (Bell, Bikson, Rich and Wuchitech, 1976). There is considerable evidence of a similar nature for cognitive press in interactive information environments.

For example, employees surveyed in the large-scale field study of computer-based work (n=531) were found to perform more information tasks, and to do them faster and better than before this technology was installed (Gutek, Sasse and Bikson, 1986); their managers tended to concur. As a consequency, performance standards for work had increased in over half of the 55 units studied. By contrast, job descriptions changed in only a third of the sites and pay levels.

in only a fifth. Employees in the main, then, are working harder/faster/better on cognitive tasks to keep up with the same job. As an editorial in Government Computer News (Perry, 1987) put it, now "the impossible takes longer." These appear to be instances of cumulative unidirectional effects of the sort here termed "press."

Accompanying these effects are changes in task variety and skill level. In the sample we studied (Bikson, 1987), a majority of employees and their managers reported that new and higher skills were involved. For some, the result was greater repetition (cf. Turner, 1984) and for others, greater variety. The difference, not surprisingly, is strongly associated with the status of an employee's work unit in the organization (Gutek, Sasse and Bikson, 1986). It is also a reflection of management policy, since organizations can choose whether to enrich or simply enlarge jobs (Bikson, Stasz and Mankin, 1985). Although employees evaluate their jobs and their tools more positively under conditions of greater task variety (Bikson and Gutek, 1983), the amount of cognitive press may not differ--rather, the difference may be in whether accumulating task demands exert press above or below adaptation levels.

Two additional contributors to press in today's electronic information environments should be noted. (1) While it is hard to project the emergence of specific tools at particular times, it is clear that there is no end in sight (Bikson and Evelana, 1986). Consequently skill obsolescence and skill replacement are not just a one-time threat to adaptation; information workers are confronting a demand for continuous change in task behaviors. (2) The need to meet that demand becomes increasingly important as computer systems become part of the infrastructure of white collar work, making the performance of information tasks depend quite directly on acceptance and mastery of the advancing technologies. The conclusion suggested is that most employees find the initial stress of conversion to computer use by and large manageable. It is the host of follow-on changes in information intensive work (cognitive press) that most endanger adaptation.

4 FACILITATING ADAPTATION TO COGNITIVE PRESS

The likelihood of long-term press in periods of rapidly advancing work technologies is corroborated by work unit managers (Bikson, 1987). When asked "how much change will there be in the nature of work for this group over the next 2-3 years," few managers thought the end was in sight. Over 70 percent believed moderate to major changes were yet to occur, even though most of the 55 work groups had been using computer-based tools for over a year. Given this scenario it is important to look at ways of facilitating adaptation to cognitive press. The framework presented here offers two approaches.

4.1 Enhancing Cognitive Resources

The most direct way to enhance workers' cognitive resources is to provide high quality training that enables them to understand and control the technology. An examination of training practices (Bikson and Gutek, 1984), however, suggests that organizations rarely offer the kind of learning that would enable users to take full advantage of their powerful, flexible new tools Rather, what training there is tends to be very concrete in orientation and to emphasize rote performance of sets of pre-defined steps.

In contrast, successful adaptation to changing tools requires a cognitive model of what they are. Providing users a model of how these tools function permits development of problem-solving strategies, allows for generalization and transfer to new, different or less-structured tasks, and makes the transition to the next generation of tools easier (Bikson and Eveland, 1986). Second, organizations should expect to provide long term learning support. White collar workers are better educated than ever before and should be able to make advanced use of information technology; providing only novice-level training does not permit them to deploy their strong task competencies and judgmental skills in conjunction with their tools. Finally, in addition to continuous learning, organizations should find ways of promoting development of local expertise and knowledge-sharing within work groups (Bikson, Stasz and Mankin 1985). Collaborative learning encourages "cognitive bootstrapping" and taps the collective knowledge resources of group members (Brown and Newman, 1985).

4.2 Alleviating Task Demands

Software design features have received much less attention than hardware properties in research related to effects of computer-mediated work, even though the software interface is most directly linked to the way information tasks are performed. Users' needs to alter their long-practiced work behaviors can be alleviated if the technology meets them half way--that is, if the software is well-adapted to the tasks at hand. Cross-sectional field research in varied task domains (Bikson, 1987) yields two software characteristics that are strongly associated with successful integration of information systems into ongoing work: functionality (or, goodness of fit between applications and job functions); and modifiability (or, extent to which the interface to these functions can be altered and controlled by users). Modifiability deserves emphasis because it allows the same system to serve highly individualized task behaviors and to change with users' changing skills and needs.

Job design features can also significantly influence cognitive press. As evidenced in a number of studies (Turner, 1984; Bikson, Stasz and Mankin, 1985; Bikson and Eveland, 1986), differences in the way tasks are grouped into jobs conditions their effects. For example, rapid pacing or repetition can better be accommodated if they characterize some but not all the tasks in a job. Job redesign thus allows organizations to alter demands that are not readily alleviated at the task level. By intervening at the subtask level (with software design) or the supratask level (with job (re)design), organizations can do much to modulate the cognitive press of computer-based information work.

4.3 Getting It Done

Preceeding paragraphs discuss alternative approaches for facilitating adaptation to electronic information tools, one addressing users' cognitive resources and the other addressing task and job demands. When managers of white collar work groups were asked about what roles organizations should take in helping employees adapt to technological change, they were undecided (see Table 2).

TABLE 2

WHAT IS THE ORGANIZATION'S RESPONSIBILITY?

Response	Percent of Groups
It's not the organization's problem	36.1
It's the organization's problem in the short run	30.5
There is a continuing role for the organization in this area	33.4

Although only a third of managers appear to look beyond the short-term stress of converting to computers, research on implementation suggests that management's commitment to support of technological change is an important ingredient in its long run success (Bikson, Gutek and Mankin, 1981). This does not mean that management should make all the decisions. On the contrary, user participation in decisionmaking is a consistent predictor of successful integration of electronic tools into ongoing work (Bikson, 1987). It is likely that their involvement in this process is the most direct way to link tool and job design to the substantive nature of the work performed (Bikson and Eveland, 1986).

5 COMMENTS

The intent of this presentation has been to take a longer view of human adaptation to new computer-based work tools than is represented by most research. Studies of interactive systems in varied white collar settings suggest that initial introduction of computers is the first in a series of changes in information-intensive work that will continue for years or decades. RAND research finds that coping with the first event is less difficult than many had predicted; managing the succession of events that follow is likely to be harder. The accumulation of cognitive press is less visible, and neither organizations nor individuals are well prepared to cope with it.

Guides to successful adaptation can be drawn from current implementation research. Recommendations include boosting cognitive resources and shaping task demands around human needs rather than technological capability. Potential interventions reviewed above generally involve empowering users (e.g., by making systems more intelligible to and modifiable by them, and by giving them key roles in implementation decisions). Recommendations also reinforce the group or collaborative nature of organized work (e.g., sharing knowledge resources, redistributing tasks). Such approaches to ameliorating cognitive press in technologized environments are consistent with more general research findings about significant mediators of stress and strain (autonomy and social support).

Finally, the presentation emphasizes implications for management policy. Organizations are able to exert considerable influence on the major determinants of stress and press in information work. In a time of rapid technological advance, organizations and individuals need to relinquish the homeostasis model and learn to manage change adaptively.

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