Chapter 5

Office Automation and the Quality of Worklife

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This chapter is concerned with the individual in the office and the way in which office automation affects the individual's quality of worklife. A traditional definition of the quality of worklife is "the degree to which members of a work organization are able to satisfy important personal needs through their experiences in the organization."[1] The relationship of the worker to the office environment affects health, well-being, and productivity. Office automation changes the physical and psychosocial dimensions of the workplace and the work process.

Of the many characteristics of the office, no one factor is the sole determinant of quality of worklife, especially not technology; but technology can change the social processes involved in producing an output or the way a person does a set of tasks. This chapter considers stress, office and workstation design, the human-computer interface and the way these relate to an individual's health, well-being, and productivity.

The discussion is two-pronged; one emphasis is on how new office technologies affect the quality of work life; the second is on public policy. It focuses on factors that contribute to organizational effectiveness by improving work quality and quantity, reducing turnover and absenteeism, and ultimately indirect labor costs.[2]

An emerging policy debate concerns the risk of illness and disease in office environments. The evidence for the potential risks associated with new office technologies is inconclusive. However, heightened public concern and recent workers compensation awards for VDT-related illnesses indicate that a comprehensive and systematic examination of all office environment exposures[3] should be carried out to determine whether new office technologies are indeed increasing a worker's risk for illness or disease.

A systems approach to examining the applications of office technologies indicates that there are many ways in which office automation is related to the quality of a person's worklife. Figure 5-1 shows the general framework used in the analysis. The core relationships are between the organization, the technology, and the individual. The VDT is part of the human-computer interface. The individual's personality or characteristics can mitigate the effects of office automation. For example, some workers enjoy and are more productive in a highly controlled office environment, while others seek to maximize their own control over the environment.

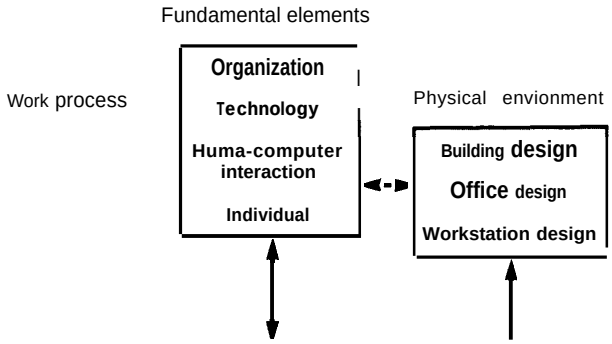
The arrows in the figure do not represent causal relationships, but rather indicate patterns of association. Ultimately, these patterns may be found to be causal, but at present the scientific evidence is not sufficient to determine causality. In some cases, the effect of office automation may be contingent on another factor, for example, the workers' response to some other characteristic of the office.

[1] J. Richard Hackman and J. Lloyd Suttle, *Improving Life at Work: Behavioral Science Approaches to organizational Change* (Santa Monica, CA: Goodyear Publishing Co., 1977), p. 4.

[2] Supporting arguments for these contentions are found in Franklin D. Becker, *Workspace: Creating Environments in Organizations* (New York: Praeger Publishers, 1981); Thomas G. Cummings and Edmond S. Molloy (eds.), *Improving Productivity and the Quality of Work Life* (New York: Praeger Publishers, 1977); Arthur Rubin, *The Automated Office—An Environment for Productive Work, or an Information Factory?: A Report on the State-of-the-Art* (Washington, DC: U.S. Department of Commerce, National Bureau of Standards, 1983). The obsrvations in these materials are based on studies in both blue-collar and white-collar settings and organizations of many sizes.

[3] The concept of exposure in public health refers to the conditions of the (work) environment that lead to the development of illness or disease. For example, a person who smokes cigarettes exposes his her body to cigarette smoke. This can lead to the development of lung cancer. In this chapter. exposures to be discussed are the working conditions created by office automation.

Figure 5.1 .—Characteristics of the Office Setting That Can Contribute to an Individual's Quality of Worklife



The subjects discussed in this chapter are:

- stress, and the quality of worklife;
- health, illness, and disease; and
- interventions, including office and workstation design and labor-management relations.

A discussion of labor-management relations ends this chapter because many of the problems cited in chapters 4 and 5 can potentially be solved or alleviated through some form of worker involvement in the decisionmaking process, such as collective bargaining.

SECTION I: STRESS AND THE QUALITY OF WORKLIFE

Stress is a term often used in both conversation and scientific debate to describe troublesome experiences in daily life, ranging from the illness of one's child to an acrimonious session with the boss. Some stress is routine, the daily hassles of work. But, typically, events that precipitate stress responses alter or intensify daily routines and roles of worklife.[5] Characteristics of office automation that lead to changes in the work role can thereby produce stress responses in the worker.[5]

Work-related stress is the psychological or biological response to conditions in the work environment. Stressors are the conditions that cause stress.[6] Stress can be either good or bad, but "good" stress is usually called "challenge." Office automation, by changing the conditions of work, can elicit psychological and biological responses; i.e., produce stress.

Psychological stress responses to working conditions include challenge, boredom, anxiety, mental fatigue, depression, satisfaction or dissatisfaction, and feelings of security or insecurity. Biological responses can include chronic or periodic arousal,[7] muscle fatigue, headaches, and psychosomatic symptoms. This list is not exclusive. Any of these can occur among office workers. Office automation offers the organization a unique opportunity to create working conditions that challenge the individual worker and at the same time decrease the frequency of adverse stress responses. [a]

[5] Leonard 1. Pearlin, "Role Strains and Personal Stress," *Psychosocial Stress: Trends* in *Theory and* Research (New York: Academic Press, 1984).

A worker's role is defined organizationally by the job he/she occupies.

[6] This model of stressor and stress response is a common model used and was originally developed by Hans Seyle and Walter Cannon in the 1920s and 1930s. For a good overview of this model of stress see, Hans Seyle, *The Stress of Life (New* York: McGraw-Hill Publishing Co., 1956).

[7] Chronic arousal refers to neural, hormonal, and immunological responses to external stimuli. In many instances the term neurohormonal arousal is used to refer to these distinct stress responses to indicate the controlling role played by the brain in initiating them.

[a] "Traditional stress models emphasize that stress responses follow a U-shaped curve. Too little environmental stimulation leads to underload and stress responses such as boredom. Too

A stress response sometimes comes from anticipation of an event as much as from the event itself. The anticipation of a computer going "down,' for example, can produce stress responses. New technologies often lead to new and conflicting expectations.

The term "technostress" has been used to describe consequences of office automation:

> Technostress is a modern disease of adaptation caused by an inability' to cope with new' computer technologies in a healthy' manner-. It manifests itself in two distinct but related **ways:** in the struggle to accept computer technology, and in the more specialized form of overidentification with the computer.[9]

The stress response is not technologically determined, although the word "technostress" conveys that impression. Many conditions that produce a stress response in the automated office are not the result of the new technology, and solutions to the problems can not often be achievecl through modifications in the technology. The consequences are contingent on how an organization implements new office technologies. Most office workers look forward to working on computer systems that automate manual tasks they would rather not do.[10]

Table 5-1 shows a list of conditions that produce stress. These stressors are not unique to office work: they are also found, for example, in factory work. In fact, some people talk about the office becoming the factory of the future.

much stimulation leads to overload and responses such as muscle fatigue. Somewhere in between is the ideal amount of environmental stimulation that leads to a challenging response. There is no standard data for determining normal responses, since no consensus exists on how either the environmental stimuli or the stress response is to be measured.

[9] Craig Brod, *Technostress: The Human Costs of the Computer Revolution* (Reading, MA: Addison-Wesley Publishing, 1984).

[10] The distinction must be made between satisfaction with the job and satisfaction with the technology. Many workers see the new technology as providing them with new skills and opportunities. It can also confer higher status. Others will argue that there is a "honeymoon effect" and, after a short-time period the worker becomes dissatisfied. However, this may be due more to characteristics of the job than the technology. Tora K. Bikson and B.A. Gutek, *Advanced Office Systems: An Empirical Look at Utilization and Satisfaction*, N-1970-NSF-Rand (Santa Monica, CA: Rand Corp., 1983).

Table 5-1 .—Working Conditions Likely to Produce Stress Responses in Offices

Working conditions in all offices:
- *Increased* workload coupled with: a) limited job control, expanded job control
- Repetitive task(s) in the job
- Machine pacing of work
- Lack of time for training to acquire new skills
- Competing roles at work
- Lack of career opportunities in the organization

Working conditions in automated offices:
- Electronic monitoring as a form of supervision and employee monitoring
- Electronic monitoring as a form of task feedback
- Higher expectations for speed of work coupled with computer system response delays
- Office work dependence on computer system and system delays
- The computer mediation of work and/or the problems with the human computer dialog
- Social isolation with the primary interaction the computer
- Increased social contact and social participation via computer networks

SOURCE: Office of Technology Assessment

These conditions have always been felt in offices; new technologies can intensify them. They can also ameliorate them. Typically, the adverse conditions occur together and especially affect lower level jobs. Most have been associated with low job satisfaction or with illness, Each can be alleviated with work redesign strategies, contributing to better employee health and attitudes toward work.

Table 5-1 also shows a list of office conditions characteristic of office automation that produce stress that may permeate all levels of the organization.

Sources of Stress

Factors that bring about stress include increased workload, decreased control over work, repetitive work, machine pacing, inadequate training, ambiguity in role, consciousness of limited career opportunities, computer monitoring of work, unattainable expectations for speed, the abstraction inherent in computer-mediated work, and increased social isolation.

Workload and Control

Office automation can increase the number of tasks a person has to complete; increase the

complexity of the tasks; speed up the pace; or increase the amount of information needed to complete a task.[11] Even the change to an on-line system from a batch processing system can increase workload.[12]

These increases may or may not be transient. The ability to modify work strategies is a co--ponent of the worker's control over the job. [13] If the worker has the ability to modify his/her work strategies, the adverse stress responses can be buffered and transient. When the worker has little control, the adverse stress responses tend to persist. Workload and job control in conjunction affect attitudes about the job, the organization, and the worker's health.

Computer-based communication networks have been shown to lead to increased workload by making the transmittal of documents easier and thus more frequent. This leads to the professional having to sift through many memos to find the relevant one; the case of information overload. This also may be a transient effect that will disappear as the organization learns to utilize the system effectively.

A primary motive for office automation is increased productivity, but many stress responses lead instead to increased absenteeism and turnover (especially under good economic conditions when jobs are plentiful). These responses have also been associated with decreases in performance and even with some instances of sabotage.[14] To alleviate these problems, attempts are typically made to exert greater organizational control over what the worker does. This can be achieved more easily through office automation. Greater organizational control tends to increase the problems of repetitive or machine paced jobs; offering workers even less control and resulting in a vicious circle. The productivity of the worker is stabilized below optimal performance level.

Two patterns appear to be developing. The key difference is the level of control. When control is decreased, either through embedding decisions in the system, electronic monitoring, social isolation, or change in the job (e.g., the development of a single repetitive task), the interaction between increased workload and decreased control leads to adverse stress responses. Alternatively, when the increase in workload is associated with better opportunities to arrange the work, this can produce positive stress responses, or challenge, for employees.

Repetitive Tasks

Office automation can result in repetitive tasks, which lead to increased anxiety, boredom, and dissatisfaction with work. The introduction of a word processor or microcomputer can, however, also reduce the repetitiveness of tasks—for example, the secretary makes a few corrections rather than retyping a page.

Taking breaks from the monotonous repetition provides psychological relief, but sometimes a need for breaks is overridden by the pressure of work. "

Machine Pacing

When control over when to do a task is determined by the computer system, tasks are said to be machine paced.[16] When data entry or other tasks are machine paced, the office begins to mimic the factory assembly line. Machine pacing both increases the workload and decreases control. It can lead to anxiety, de-

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"W'orklo~d is the level of demands the job places on the worker. Technological change can lead to decreases in the amount of time spent at a particular task. However, many studies have documented that workload more often increases with office automation: Jon Turner, *Computers in Bank Clerical Functions: Implications for Productivity and the Quality of Life*, Ph.D. dissertation, Columbia University, 1980; Michael J. Smith, et al., "'An In\'estimation of Health Complaints and Job Stress in Video Display Operations, " *Human Factors*, vol. 23, No. 4, 1981, pp. 387-400; Rob Kling, *The Impacts of Computing on the Work of Managers, Data Analysts, and Clerks*, Working Paper, Public Policy Research Organization, University of California, Irvine, 1978.

[12] Jon A. Turner, *Computer Mediated Work: The Interplay Between Technology and Structured Jobs–Claims Representatives in the Social Security Administration*, Working Paper, Department of Computer Applications and Information Systems, New York University, 1985.

'Control is the ability of the employee to arrange work in terms of speed, task priority, and ways of performing the task.

"Ilrod, op. cit.; see also Gavriel Salvendy and M.J. Smith (eds.), *Machine Pacing and Occupational Stress* (London: Taylor & Francis, Ltd., 1981).

[14] Brod, op. cit., p. 43.

[16] A task is said to be machine paced when the worker has no control over the initiation of the work cycle or the duration of the work cycle. Typically, machine pacing is associated with short-cycle repetitive tasks.

pression, boredom, dissatisfaction, frequent health complaints and, decreased productivity with increases in error rates. [17] It also can allow higher pay because of an increased rate of production.

Training

The employee is sometimes expected to learn how to use new equipment with very little time allocated for training. Management expectations about productivity gains rise quickly, so the worker is faced with simultaneously maintaining the prior level of productivity, acquiring and mastering the new skills, and demonstrating productivity increases. He/she can be caught in a circle of expectations and increased workload demands, and may never learn to use the system effectively. Without the time to develop skills, the worker has limited opportunities for moves up the career ladder. The daily frustration over lack of time to learn may lead to psychosomatic complaints, as well as anxiety, depression, and dissatisfaction.

Competing Roles

Formal recognition of the responsibilities of managers, technicians, professionals, and clerical staff serves to differentiate their work roles, also recognizing interdependencies among members of the office group. [18] Role ambiguity results from the rebundling of tasks through office automation. The professional can do word processing and the secretary can do statistical analysis. Who does what is a key management decision. Without role differentiation it is unclear who is responsible for particular problems.

Conflicting roles can develop when employees are expected to perform tasks that are not part of their job description or are not recognized or given social, monetary, or organizational rewards. With computer-based messaging systems, managers and professionals have to answer the phone, a task that the secretary may have done in the past. [19] One major source of role conflict for women is conflict between home and work roles.

Either ambiguous or conflicting work roles lead to uncertainty in responsibility and performance and to anxiety, dissatisfaction, and insecurity.

Lack of Career Opportunities

Lack of career opportunities can create feelings of job insecurity and belief that one will be replaced by the computer. These feelings are exacerbated by the impression of limited job mobility. Traditionally a worker came into an organization, learned skills, and moved up the job ladder. Today companies more often hire people from outside with the skills needed. As career opportunities become less apparent the employee can become frustrated.

Electronic Monitoring

Electronic monitoring can take two forms—supervision and feedback. This can be illustrated by the example of an information system that stores data on keystrokes and errors. One form of supervision has the computer system examine the worker's performance and send the supervisor a message about her performance compared with prior records and organizational standards. The worker has no responsibility for when the monitoring occurs or how the information is used. [20] Another form, job feedback, lets the employee use the infor-

Salvendy and Smith, op. cit. See also: E. N. Corlett and J. Richardson (eds.), *Stress, Work Design, and Productivity* (New York: John Wiley & Sons, 1981); and Robert Caplan, et al., *Job Demands and Workers Health*, USDHEW (NIOSH) 75-160 (Washington, I)(': U. S. (Government Printing office, 197>1.

'B. (i, F. Cohen, ' 'organizational F-actors Affecting Stress in the Clerical Worker," *human Aspects in Office Automation, 13,(;.* F. Cohen (cd.) (Amsterdam: Elsevier Science Publishers, 1984), pp. 33-42.

'H. C. Amick and J. Damron, "Considerations in Defining office Automation: A Case Study of the Eastern Africa Region of the World Bank," *Proceedings of the First i) SA-Japan Conference on Human-Computer Interaction, Honolulu, Hawaii*, Gavriel Salvendy (cd.) (Amsterdam: Elsevier Science Publishers, 1984), pp. 439-.! 45,

'This example also points out the problem of separating these factors from other stress factors. In this situation. the worker is not only being monitored but also may be machine paced and has no control over the task or the job.

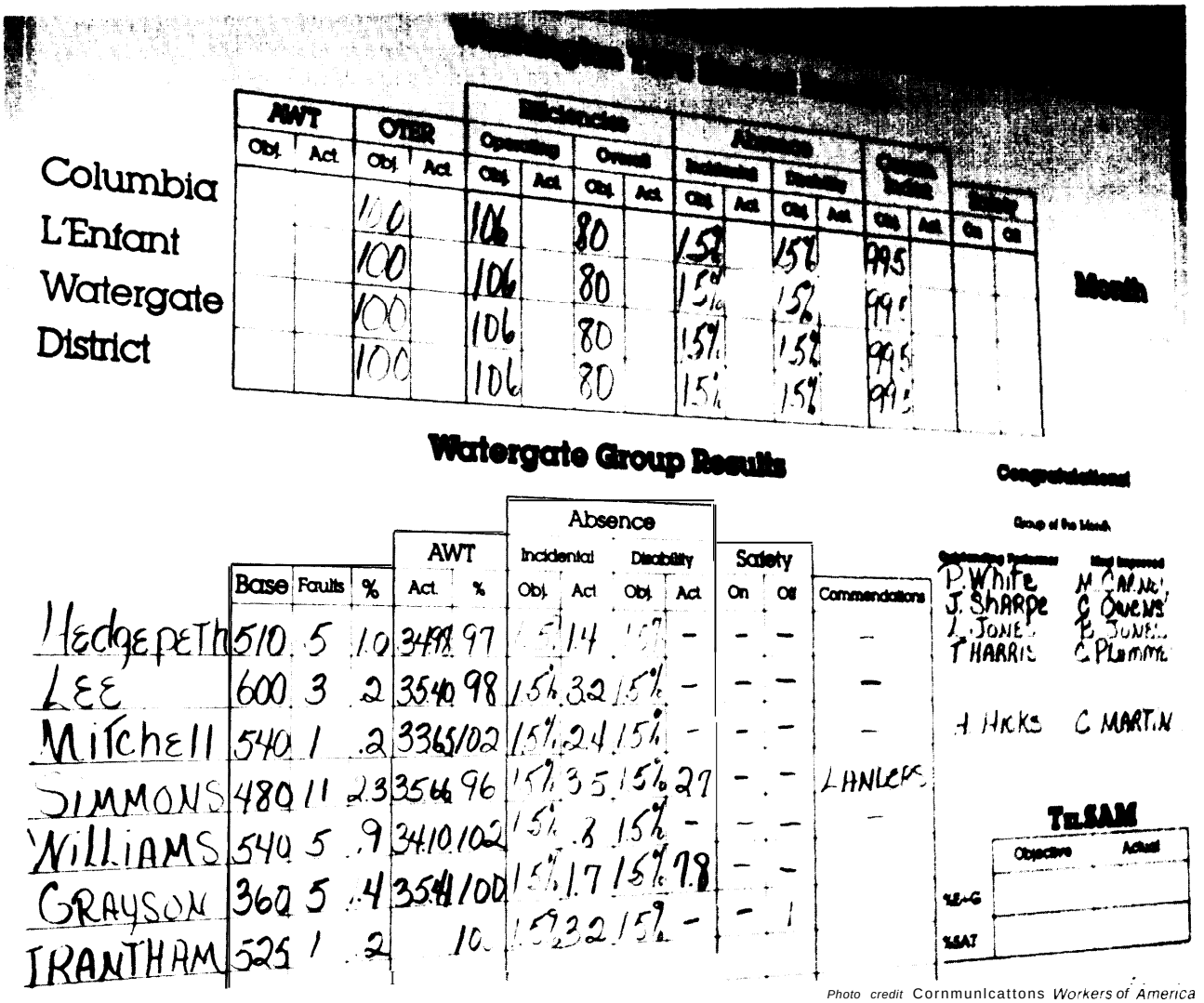

Photo credit Cornmunlcattons Workers of America

In the communications industry, workers can be continuously monitored. These charts show the monitoring of employees by the Average Work Time System. Every call is timed and the total volume of calls handled per day by all workers is then used to calculate an average number of calls for a given period of time. An AWT figure of 100 means that the operator's performance was average

mation to find out, for example, how many files were completed in a given period of time, and modify her performance accordingly. The first often produces adverse stress response and the latter positive challenge.

With electronic monitoring for supervision, maximum consistency and reliability in performance are sought. One distinction between traditional work monitoring and electronic monitoring is that the former is intermittent and the latter continual. Continual monitoring places added pressure on the employee to produce at the pace and level established by the machine. This leads to increased anxiety, fatigue, psychosomatic complaints, and job dissatisfaction.[21] The employee, knowing he/she will be expected to perform at a specified

[21] Because the terminal provides the worker with all the necessary information to complete any task, there is no need for the employee to leave the workstation. This constrained posture for extended periods of time is a key element in visual and musculoskeletal problems.

level throughout the day, feels chronic arousal and job dissatisfaction. [22]

Electronic monitoring can also offer challenge and job satisfaction, if it is designed and used as a form of task feedback. Traditionally feedback on performance and product quality is usually notice that an error has been made. Or it is received infrequently (in quarterly or even yearly evaluations by the supervisor), and the worker begins to believe that quality is not a major concern. Quality checks through an on-line work monitoring system can improve the reliability of performance, and increase the responsibility for the product; this can lead to greater job satisfaction and greater commitment of the worker to the organization. [27]

Typically, electronic monitoring has been carried out among support staff and supervisory staff, but as microcomputers and minicomputers are linked with larger mainframe systems, any person can be monitored. One example of productivity y monitoring of professionals is from a loan administrator using a Management Information System (MIS):

> Each employee is watched by the system, ... To be tracked on the system is to be monitored by it on a daily basis with regard to every conceivable item of work which could be performed on the job. The MIS does perform some essential functions in helping to manage the enormous work load, hut often it was looked upon as an excuse for increasing the work load even more. Preparing the daily MIS input sheets at the end of the day is a dreaded duty, done hurriedly before leaving the office. The MIS theoretically tracks everything which the loan administrator performs during the course of the day. The entire job of the loan administrator is dissected into every minute function which might be performed. Each function is assigned a certain time standard for how long it should take to be performed. The system calculates each worker's daily productivity as a percentage figure based on what the employee reported as having done that day. [27]

If a professional, manager, or secretary is making entries into a calendar, then the person's schedule can be examined through access to the files. In one large American company, the Chief Executive Officer plans to use the computer system for just this purpose. " Employees in the networked system can also get more immediate feedback about a project to which they have contributed. This provides them with a broader picture of what the organization is doing, and so leads to increased satisfaction and commitment.

Higher Expectations of Speed

A subtle effect of office automation is the generation of higher expectations of speed. This can lead to a distorted sense of time and distorted expectations about behavior. One characteristic of the computer system is the ability to respond quickly to commands. The manager and the clerical worker alike can develop a new time reference.

> Days, hours, and minutes take on new meaning as time is compressed and accelerated. . . . Jobs that took days before computerization are expected to be done in hours. . . . Software that was once appreciated for its speed, such as VisiCalc, is suddenly viewed as clumsy and S1ow.[26]

The worker begins to notice response delays in the microcomputer or larger computer system. As he/she becomes more proficient, he/she develops a high expectation of speedy responses from the computer at known intervals. When delays occur, the pattern of work is interrupted as the worker is forced to "waste time waiting for the system to respond. This leads to anxiety and dissatisfaction. When the delays persist above a certain time there is an increase in the error rate for keystrokes.

For an example of how prior knowledge of an event can produce a stress response see the work of Marianne Frankenhauser, "Coping With Stress at Work," *International Journal of Health Services*, vol. 11, No. 4, 1 98 1. pp. 491-5 10.

Richard E. Walton, " From Control to Commitment in t he Workplace, *Harvard Business Ret'iew*. vol. 35, No. 2, 1985, pp. 76-~ 1.

'Alan Westin, *Privacy issue.~ in the Monitoring of Employee Work on VDT's in the Office Environment*, contractor report prepared for the Office of Technology Assessment, 1985.

Mark Potts, "GE's Welch Powering Firm Into Global Competitor: Part I," *The Washington Post*, Sept. 23, 1984.

'Brod, op. cit.

This new time reference results in higher expectations of oneself and others. A worker may seek to discover ways of circumventing organizational procedures to get work completed more quickly. Going through channels or doing excessive paperwork becomes a barrier. This also can lead to increased anxiety and tension and feelings of work pressure, or to a desire for social isolation because one would rather work with the computer than with a person–only the terminal can respond quickly enough. This tension requires some form of stress management.

Like the individual, the office can become dependent on the computer system and vulnerable to system delays. This is perhaps largely a transient problem associated with the implementation of a new system, although changes in both software and hardware will continue, and the work process will become more and more dependent on the computer. When the system breaks down the worker looses control over the work and it piles up. Messages cannot be sent to coworkers in other buildings, memos cannot be printed or distributed. A sense of anticipation develops in the worker–when will the system be back up and running? One study in a Swedish insurance company found that when the computer system went down workers responded with increased arousal, higher blood pressure, fatigue, and feelings of being rushed (work pressure)."

Computer Mediation of Work

The computer mediation of work is likely to produce stress responses that vary from boredom and job dissatisfaction to challenge and increased productivity. Three characteristics of computer-mediated work that are likely to produce stress responses are: 1) human judgments being built into the system, 2) the abstraction of work, and 3) the human-computer dialog.

Judgment is fundamental to work, yet a principal goal of automated work can be to reduce judgment and therefore error. Alternatively, automation can be used to create more opportunities for exercising human judgment. The key to the former approach is the substitution of computer algorithms or decision rules for judgment. This necessitates a formalization of skills traditionally obtained through experience. Problems arise when the worker is not provided with new opportunities to exercise judgment.

For example, automated systems may assign priorities to tasks or refer accounts to employees as they complete previous assignments, decisions previously made by supervisors. This is usually done when automating tasks that in any case are very standardized.

The computer mediation of work extends to professionals and management. Attempts have been made to define decisionmaking so that a level of reliability and predictability in judgments can be maintained. The shifting of partial control from the individual to the computer system also is a defense against data contamination that could result from unlimited access to an on-line system.[28] Risk-taking behavior and creativity, especially of professionals and managers, can be constrained when decisions are embedded in the computer system. The meaning and challenge of work disappears and boredom and job dissatisfaction ensue. A constant state of chronic arousal places a biological burden on the worker. The airline pilot or the nurse who monitors a control panel instead of the plane or the patient, can become bored and dissatisfied, feeling that their training is useless if the computer is going to make the decision. 'g Although uncertainty may lead to errors, freedom of choice leads to creative and inspired decisions, which

- Gunn Johansson, "Computer Technology: Stress and Health Relevant Transformations of Psychosocial Work Environments," *Proceedings of the First USA-Japan Conference on Human-Computer Interaction, Honolulu, Hawaii,* Gavriel Salvendy (cd.) (Amsterdam: Elsevier Science Publishers, 1984), pp. 347-354. In this study, VDT operators performed data-entry tasks and were compared to non-VDT operators performing similar tasks.

[28] Shoshanah Zuboff, "New Worlds of Computer-Mediated Work," *Harvard Business Review, vol. 60, 1982,* pp. 142-152, (hereafter referred to as "New Worlds, " 1982).

[29] Shoshanah Zuboff, "Problems of Symbolic Toil: How People Fare With Computer-Mediated Work," *Dissent,* winter 1982, pp. 51-61 (hereafter referred to as "Symbolic Toil, " 1982).

sometimes go against the grain of organizational logic, and it is this logic that is typically programmed into the computer. [30]

Nowhere is the use of computers to approximate human judgments potentially so dramatic as in the area of expert systems. [31] The goal of developing an expert system is to place in the computer the knowledge and decisionmaking processes of the best workers at a particular job. This can enhance a job by providing large amounts of information in a manageable form, allowing a person to ask questions that were difficult to ask before. Expert systems can evaluate decisions and suggest alternative solutions to problems. The system can serve as a learning tool for new workers, who by asking questions and giving answers can simulate experience that may otherwise have taken years to encounter.

Expert systems for use in offices are still in an early phase, but one area already impacted is insurance underwriting." (See box A for an example of the human-computer dialog.)[33] A dilemma the organization faces is that the expert underwriter is expert because of knowledge gained through field experience, and the dynamic nature of the insurance market will demand continual adjustments in the expert system to reflect current patterns. Therefore, the industry will be required to maintain and encourage the traditional pathways for the development of expertise. The extent to which the transfer of human judgment to a computer system produces a stress response in the worker is contingent on how the new job is defined and how the worker uses the system—as a tool to assist in decisionmaking or as the decisionmaker.

In office automation, a key movement is from physical to mental activities; or the abstraction of work.[34] Instead of manipulating physical objects, creating, storing, and distributing forms and documents, in automated offices, one moves symbols with the push of a button. Messages appear on the screen instead of on paper. For the person who is accustomed to being able to see and take part in the process of manipulation, this change can lead to a sense of removal from the work process.[35] As the worker becomes accustomed to the new form of work, this sense of abstraction can diminish.

One characteristic of the abstraction of work may not be as transient; it appears to demand more mental effort, but may not necessarily lead to a more challenging job. The worker may have to give undivided attention to the screen

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Historically, researchers have argued about whether the bureaucratic structure of the organization constrains human behavior by increasing centralized control and explicitly defining the rules by which the tasks should be performed and the job evaluated. These trends can reduce the effectiveness of the organization as well as the employee. The implementation of office automation can allow many of the rules to be embedded in the system. For discussions of this idea see, Max Weber, The *Theory of Social and Economic Organization*, translated by A.M. Anderson and Talcott Parsons (New York: The Free Press, 1947); Richard H. Hall, "The Concept of Bureaucracy: An Empirical Assessment, " *American Journal of Sociology*, vol. 69, No. 1, 1963, pp. 32-40. For a discussion of the impact of office automation on the bureaucracy see Michel Crozier, " I replications for the organization,"' *New Office Technology: Human and organizational Aspects*. H.J. Otway and M. Peltu (eds.) (Great Britain: Ablex Publishing, 1 983), pp. 86-101.

[30] "An expert system consists of a set of 'if-then' rules that express the knowledge and experience of an expert, and the actions one would take when faced with a set of conditions in the domain of [his her] expertise. It also generally has a separate knowledge base that states facts about the domain, to which the program can refer to make inferences and deductions about situations and conditions. For a full description of expert systems and their development see, *Information Technology R&D: Critical Trends and Issues*, U.S. Congress, Office of Technology Assessment, OTA-C IT-268 (Washington, DC: U.S. Government Printing Office, 1985).

Sherrie Shamoon, "AIG 'S Smart Software: The 'Expert' That Thinks Like an Underwriter. ' *Management Technology*, February 19X5, pp. 54-59. Much of the information used in this paragraph was based on interviews with Dennis White, Syntelligence, 1 nc., Sunnyvale, CA, and, Bob Pulka of American International Groups, Inc., New York, NY.

The goal in underwriting is to decide whether a particular case should be insured and the costs of doing it, There' may be over 100 factors to be considered, An expert can cull out the handful of variables that will be of importance in this decision and, based on the set of facts in a particular case. make a decision. I n theory, the expert system makes this expertise available to any underwriter. providing him her with another tool in the decisionmaking process.

[34] Zuboff, "Symbolic Toil, " 1982.

[35] "One interesting consequence of the abstraction of work may be an increase in the amount of paper used to store information at all stages of the production process. Even in a task like typing that is very similar when done on the screen and on the typewriter, the lack of any physical feedback about what has been done in word processing can lead to the printing of many more versions of a document. These physical objects allow the individual to have a sense of accomplishment not otherwise conveyed by seeing that 30,789 bytes of storage are remaining.

Box A.–Expert System Used in Insurance Underwriting: An Example of the Decisionmaking Process

A publishing company in California has decided to insure their data processing facility. They hire insurance agent Smith to find the best possible policy for them. Mr. Smith approaches Ms. Jones of Insurance Company West to develop a policy for the data processing facility housed in a 25-year old brick building.

Ms. Jones goes to the computer terminal and starts a file called Publishing Company Account. She then accesses the expert system to get assistance in defining the parameters of the policy. First, she must enter information about Mr. Smith, the agent. The computer system has a large database of agents the company works with, describing the type of work they do, their reliability and the quality of the information they provide. (This database is updated quarterly by the company to enter information on new agents and update the information on old agents.) The system evaluates Mr. Smith. Uncertainty coefficients are then estimated by the computer system based on information about Mr. Smith. The expert system uses this coefficient to determine the most appropriate questions (prompts) to Ms. Jones. Any equations used in final recommendations by the system take into account the agent's uncertainty coefficient.

Then Ms. Jones enters the basic information about the facility. The computer responds that in California, 20 years ago, reinforcing bars were not mandatory in brick buildings. Therefore, earthquake damage must be excluded from the policy. The system may then prompt Ms. Jones for information about smoking-is it permitted in the data processing facility, and in what rooms? The system prompts Ms. Jones about whether flammable solvents are stored in the room. A value may be assigned to designate the importance of this information. The system then combines this information with other information. It prompts Ms. Jones when necessary, and comes to a decision about the policy just as an expert underwriter would.

SOURCE: Based on an interview with Steve Weyl of Syntelligence, Inc., Santa Monica, CA, 1985.

to perform the same task over and over within the rules defined by the computer system. In the extreme case, the worker monitors information as it comes to the screen, but all judgments are made in the system or by some other person at another location. For workers whose job involved interaction with people, this change can mean a loss of the sense of the meaning of the work.

Computer-mediated work is characterized by a human-computer dialog. The quality of the dialog is important to the quality of working life. The user gets from the software information about the current state of the system, the work, how to proceed or return to an earlier part of the process, the future stages of the production process, and the consequences of further command sequences. If the software does not provide the needed information, there is decreased control over the work, bringing anxiety, and job dissatisfaction.[36] The worker may use the system less and less, or not attempt to fully use the system capabilities; a circle develops leading to further anxiety and less productive use of the new office technologies. A satisfactory human-computer dialog can counter the sense of abstraction, giving the operator a greater sense of control. Thus, transitory problems with office automation may be alleviated with appropriate attention to the human-computer dialog.

When the dialog uses concepts and phrases that match the operator's task vocabulary,[37] this encourages the use of the system and increases the likelihood of greater productivity y.

[36] Jon Turner and Robert A. Karasek, "Software Ergonomics: Effects of Computer Application Design Parameters on operator Tasks Performance and Health," *Ergonomics*, vol. 27, No. 6, 1984, pp. 663-690.

[37] Turner and Karasek, op. cit.

However, as users become more advanced they begin to prefer more formal dialog. [38] Menu driven systems guide the novice user; as the user becomes more knowledgeable, this may become tedious; the user feels held back by the system. This can also produce anxiety, boredom. and job dissatisfaction. More "transitionality in the way that people and computers interact or interface will alleviate this source of stress. [39] In a dialog based on transitionality, the user can designate changes in the human-computer dialog as he/she becomes more proficient.

Social Participation or Isolation

The office is a social environment, and as the technology changes, the social relationships of work may also change. This is important because the social group can be a buffer between the worker and other characteristics of the work environment .4" Communication and social participation in the work process is central to the productivity of the work unit and the maintenance of the organizational culture.

This social network can be particularly important in a dynamic work environment. At times of heavy workload, when peak worker performance is required, the resulting adverse stress responses affect the employees capability to perform. A social environment capable of ameliorating these conditions for the worker is often not considered in evaluating the affects of office automation on the quality of working life. Yet, new office technologies can either create more opportunities for communication and supportive interaction or close off channels.

There is a tendency for workers to spend more and more of the day interacting with a computer terminal. In Japan, researchers have recognized this potential:

> There will be more need for lounges and discussion rooms and the like, to break the routine of stress from the machines. As tasks become more mechanical and isolating, more group activities and worker clubs and incentive systems need to be developed t o keep up team spirit and morale."

The worker may spend so much time at the terminal because he/she is electronically monitored and paced or because there is no need or opportunity to interact with others, resulting in social isolation, which has been shown to be associated with depression, anxiety, job dissatisfaction, muscular fatigue, and psychosomatic symptoms. [42]

When the computer becomes the primary source of interaction in the office, coordination of the work process is transferred from the social to the technological milieu. .4 technological form of communication develops and both work and communication tend to become more formalized. Whether this will adversely impact the quality of worklife is unknown at the present. One of the primarly reasons for social interaction is to communicate value judgments via both verbal and nonverbal means. The content of the communication may be important although not directly pertinent to the work process. For example, the employee may be performing poorly because of circumstances at home, or an illness; when evaluation is based primarily on computer monitoring, supervisors may not recognize these circumstances[43]

Alternatively, increased social contact can be provided via the computer system or via user groups, because computer-based communication can remove both time and distance

[38] Ben Schneiderman, *Software Psychology* (Cambridge: Winthrop Publishers, 1982).

[39] Albert Badre, "Designing Transitionality Into the User-Computer Interface," *Human-Computer Interaction: Proceedings of the First USA-Japan Conference on Human-Computer Interaction, Honolulu, Hawaii,* Gavriel Salvendy (ed.) (Amsterdam: Elsevier Science Publishers, 1984), pp. 27-34.

[42] Benjamin Amick and David Celentano, "Human Factors Epidemiology: An Integrated Approach to the Study of Health Issues in Office Work," *Human Aspects in Office Automation,* B.G.F. Cohen (ed.) (Amsterdam: Elsevier Science Publishers, 1984), pp. 153-166.

[43] Japan Information Processing Development Association, *Research Survey Concerning the Social Effects of Office Automation,* translation by Michael McCaskey, 1984.

[44] James House, *Work Stress and Social Support* (Reading, MA: Addison-Wesley Publishing, 1981).

[45] Workers at a Volvo automobile plant pleaded with management to replace computerized quality control with a human supervisor with whom they could discuss their evaluations and ratings. Brod, op. cit., p. 45.

constraints on communication.[44] This can lead to greater employee involvement and commitment to an organization along with increased job satisfaction.

Strategies for Alleviating Adverse Stress Responses

The strategies for alleviating adverse stress responses simultaneously encourage challenge, or positive stress responses. Three different approaches concentrate on different parts of the model that was shown in figure 5-1 and have different goals. Stress management programs focus on the individual, job redesign programs focus on the job, and sociotechnical programs focus on the work process. No single approach is always adequate. A participatory style of management in the implementation of new office technologies will help to identify the methods appropriate for a successful implementation.

Stress Management

Stress Management refers to stress reduction programs tailored to the needs of the individual,[45] providing training to deal with conditions either at work or home.[46] These programs can include meditation, progressive muscle relaxation and biofeedback, and cognitive/behavioral skills. The advantages of these approaches are that they do not require any changes in the work process, organization, or the physical environment. They assume no fault for the stress responses on the part of either management or the worker, but place on the worker the responsibility of coping with adverse stress responses.

Data have not shown conclusively that these programs are cost effective. Their disadvantage is that working conditions are not modified to remove the source of the adverse stress response. In fact, research has shown that to realize the benefits of stress management typically requires extensive and costly training of the worker, not the typical market offering of a two-day seminar. There is no credentialing of the trainers and there are vast differences in the quality of the training. Therefore, although stress management programs are popular, the employer is often faced with having to make a decision about them without sufficient information about the quality of the training and the likely results.

Job Redesign

Job redesign or task redesign are both ways to modify the working conditions to change stress responses. Office automation presents an opportunist y to develop job or task redesign strategies. The central thesis of job design is that through changes in characteristics of a job such as feedback, autonomy, task identity, and skill variety, the internal motivation and thus the performance of a worker is enhanced.

Task redesign focuses specifically on task(s) rather than on a job. The scientific management philosophy is a method of task redesign, which in office automation primarily involves changes at the human-computer interface and the allocation of tasks between the worker and the computer system.

Unlike stress management, job redesign changes the conditions of work. When jobs are designed with little meaning and little responsibility, and the worker has no information about how well he/she is performing, there can be motivational problems.[47] For example, the overrationalization of clerical work results in repetitive jobs, lacking responsibility and offering little scope for personal development.[48]

"In one Swedish study, it was found that 50 percent of the system messages would not have taken place without the system. Cited in Alexia Martin, Office *Automation: Catalyst for Change–Managing the Transition to the Automated Office,* SRI Research Report No. 694 (Stanford, CA: SRI International, 1984).

'Lawrence R. Murphy, "A Comparison of Worksite Relaxation Methods, *Human Aspects in Office Automation,* 13. G.F. Cohen (cd.) (Amsterdam: Elsevier Science Publishers, 1984), pp. 257-265.

" Recently, new software has entered the market that assists the worker in managing stress. One such program is Relax, which uses biofeedback techniques along with muscle relaxation methods for managing stress. See Joseph Hager, "The Stress Manager," *PCjr World,* September 1984, pp. 228-232.

'Richard J. Hackman and Greg Oldham, *Work Redesign* **(Reading, MA: Addison-Wesley** Publishing. 1981).

'"These types of jobs may lead to high labor turnover, absenteeism, and recruitment problems. This leads to inefficiencies through lost time, recruiting and training, and costs asso-

(continud)

Many job redesign programs seek to expand these jobs.[49]

Job redesign, unlike stress management, requires that management recognize a problem, and change working conditions. This could involve relatively high initial costs. Another disadvantage is that job redesign efforts tend to focus on a single class of jobs rather than on the work process; and on internal motivators such as self-esteem rather than external motivators such as career ladders and pay. [50] There may be few opportunities for successful job redesign if an organization has only a limited set of tasks to be done.

Sociotechnical Systems

Sociotechnical systems developed as a counter strategy to the traditionally structured organization. Instead of each worker doing a single task or set of tasks with no clear connection to an end product, workers collaborate to produce a product. Many offices already have small working groups such as the secretary and the manager. However, office automation sometimes changes this, and may dissolve familiar interdependencies.

In sociotechnical work systems, members can share decisionmaking about who is to do what tasks and how they will be executed, with each person capable of doing a variet y of tasks. The pay/reward system can be tied to the skills in order to encourage skills acquisition and career development. There are very few examples of such semiautonomous work groups in white-collar organizations; and those few typically involve lower level staff .5]

The advantage of this approach to stress reduction is that it requires changes not just in the job but in the work process. The principle disadvantage is that changes required at the organizational level and training of workers in group processes such as decisionmaking may be costly. But in addition to reduction of stress there maybe additional benefits such as changes in pay structure to reflect the new skills demanded by computer-mediated work, with the incentive to continue learning, increased sense of job security, and reconfigured job ladders. Continuous electronic monitoring may no longer be needed if the group makes its own decisions about the speed and pace of work, monitoring each other.[52]

ciated with overmanning to deal with absenteeism. For an example of how to measure the impact of behavior on organizations see, Wayne F. Cascio, *Costing Human Resources: The Financial Impact of Behavior in organizations* (Boston, MA: Kent Publishing Co., 1982).

"Iror an example of a job redesign program in white-collar work see, Rodger W. (; ri ffeth, " Moderation of the Effects of Job Enrichment by Participation: A Longitudinal Field Expediment, " *organizational Behavior and human Decision Process*, vol. 35, 1985, pp. 73-93. I n this experiment, desk receptionist jobs were increased in terms of task identity, skill variety, autonomy, and j oh feedback, resulting in increased j oh sat isfaction and self-esteem.

In reviews of job-redesign experiments conducted over the past 20 years, it has been found that a key predictor of maintaining the changes in productivity, quality of work, absenteeism, and turnover was an organizational recognition of t he new tasks and skills a person was using in his her work. Basically, the workers wanted changes in the reward system to reflect the new job. I f these changes did not develop, then many of the problems the job-redesign strategy was intended to resolve returned. John E. Kelly, *Scientific Management, Job Redesign and It 'ork Performance* (New York: Academic Press, 19821.

Recently, there has been a growth in the use of sociotechnical system programs in all levels of the organization. For examples, see Calvin Pava. *Managing New Office Technology: An organizational Strategy* (New York: Free Press, 1983).

-There also can be problems with autonomous groups such as exclusivity and excessive pressure to conform.

SECTION II: OFFICE AUTOMATION AND HEALTH, ILLNESS AND DISEASE

The video display terminal (VDT) is the device most often discussed in relating illness and disease patterns to office automation. It has become a symbol or a scapegoat. But as was depicted in figure 5-1, the VDT is only one part of the work environment. Much of this section will focus on the VDT, since most of the research has done so; but the VDT must

be considered in the context of workstation design, office design, and the task and job."

Occupational health research has traditionally focused on blue-collar work; office work has been considered the least hazardous of occupations. The growth of the white-collar labor force and the ubiquitous applications of the new office technologies demand that this assumption be reexamined. By the year 2000, it is estimated that most white-collar workers will use a terminal. Therefore, office automation requires the attention of public health officials because of the magnitude of the work force at potential risk for any potential illness and disease outcomes.[54]

The list of potential exposures in the office is large and diverse. Table 5-2 showed the list of exposures for workers in all workplaces, many difficult to measure because they occur at low levels.[55] New office technologies must be considered in conjunction with these exposures to understand their full impact. A major problem is the lack of long-term statistics on the illness and disease of office workers. The most comprehensive and thoroughly analyzed national statistics are 25 years old, from the 1960 Health Examination survey." An examination of the medical literature indicates that little valid data exists even on absenteeism and sick leave rates beyond specific industry studies. This makes it impossible to compare historical trends of the morbidity and mortality of office workers with present rates.[57]

Table 5-2.—Exposures in the Office Other Than the Video Display Terminal

Indoor air pollutants:
- Micro-organisms
- Cigarette smoke
- Dust and particulate

Chemical emissions from machines:
- Ozone from photocopiers
- Methyl alcohol from mimeographs
- Ammonia from blueprint machines

Chemicals in paper/office supplies:
- Formaldehyde from carbonless copy paper

Noise from office machines, ventilation systems, and conversation
Static electricity
Low humidity
Inappropriate lighting design:
- Excess lighting
- Insufficient lighting
- Glare

Overcrowding and lack of privacy
Poor ventilation
Awkward and static work postures

NOTE: This list does not include any factors related to either the task, job, or organization which may be associated with stress responses. These are discussed in another section.

SOURCE: Jeanne M. Stellman, Office Automation: A Public Health Perspective on the Potential Acute and Chronic Effect: paper presented at the Office of Technology Assessment Symposium on the Impacts of Office Automation and Computer Mediated Work on the Quality of Work Life, Dec. 10-12, 1984.

1 Health has been defined by the World Health Organization as the state of complete social, psychological, and physical well-being and not the absence of disease. Illness is a subjective state where the individual is aware of dysfunction. Disease is generally a pathological process that creates and ends in an altered physiological or psychological state.

"'Risk is the probability of a disease or an illness free individual developing a specific illness or disease over a specified period of time. It is conditional on that individual not developing an other illness or disease during that period of time.

Photo credit: Michael Smith

The VDT is sometimes placed alongside other technologies (such as the microfiche reader). Some of the symptoms workers report can be traced to the different lighting requirements of different technologies In the workplace

Jeanne M. Stellman, "office Automation: A Public Health Perspective on the Potential Acute and Chronic Effect s," paper presented at the office of Technology Assessment Symposium on the Impacts of office Automation and Computer-Mediated Work on the Quality of Worklife, Dec. 10-12, 1984.

' National Center for health Statistics, *Selected Health Characteristics by Occupation: United States—July 1961 - June 1963,* Vital and Health Statistics, Series 10, No. 21 (Washington, DC: U.S. Government Printing Office, 1965).

'The problem with using industry studies to establish national trends is exemplified by work conducted in the late 1960s on the relationship between social class and coronary heart disease. Industry studies showed a positive relationship between

(continued)

The four major categories of outcomes to be discussed are visual system outcomes, musculoskeletal system outcomes, stress-related outcomes and reproductive outcomes.[58] Causal relationships between some characteristic of the office environment and the outcome are assessed using the standard epidemiological criteria for determining causality, listed in table 5-3. '9 The risk of these outcomes can be reduced by job and task redesign, office design, and workstation design. The question remains open as to whether new office technologies lead to an increased risk of illness and disease.

Table 5-3.—Epidemiological Criteria for Assessing Causality

1, Strong association of factor to outcome
2. A dose-response relations i p between the factor and the outcome
3. Clear temporal relationship between the factor and outcome
4. A consistency of findings across studies
5, A biologically plausible explanation for the observed association

NOTE These criteria do not al I have to he satisfied at one t ime and in one study to suggest a relat ionshi p or lac k of a relati on sh ip between the ne w office technology application and a worker s health For example if no biologically plausible ex planation can be offered for the observed associat ion that may be due to inadequate kn owl edge or measurement techni q ues This makes it very diff c u lt to refute a rel at ionsh ip betw ee n a factor and an out come based 01 a l ac k of biological or biomechanic al evidence

SOURCE A M Lilienfeld and D E Lilienfeld *Foundations of Epidemiology* (Ne w York Oxford University Press, 1980)

Visual System Outcomes

Fifteen years of research has shown that VDT workers report a high prevalence of visual strain, ranging in various studies between 47 and 91 percent of all operators. Comparison to other workers suggests that VDT work is associated with an increase in visual symptoms across most occupations, but especially in those with heavy visual demands. Table 5-4 shows many of the factors that have been associated with asthenopia (visual fatigue) and perception problems in automated offices. Visual symptoms are associated with specific characteristics of the individual, the physical environment and the work process. But based on the current evidence, causal relationships cannot be established between office automation and visual pathologies.

Asthenopia and other acute[60] visual system outcomes reported by VDT workers are listed in table 5-5. A major problem is the lack of correlation between reported visual symptoms and clinically observable signs. Furthermore, there are no national data with which the prevalence rates can be compared. In those studies where visual functions (eye movement, visual acuity, pupil size, blinking, accommodation and vergence) have been objectively measured, no significant differences have been observed between non-VDT and VDT work, or over periods of time at VDT work. Yet some studies have shown that the amount of time spent at

social class and coronary heart disease, The higher the social class the higher the incidence of coronary heart disease (CHD). I n community and national studies, the relationship found was negative: the *lower* the social class the higher the incidence of CH D. one reason for this inconsistency is selection bias. White-collar workers are likely to be kept longer by the organization, and may be more likely to return after serious illness. Thus blue-collar workers are no longer in the industry to be counted, but they are still found in the community, and are counted in community studies. This phenomenon is the "health~' worker effect that over time leads to underestimates of the prevalence of an outcome in industry.

'A nether health outcome whose appearance is associated with office work is dermatitis, There have been too few cases to reliably identify a single cause. Some researchers have hypothesized that this is due to an elect rostatic field that builds up between the terminal and the operator, The unanswered question is why the dermatitis only appears on the face. I t may be that when one cleans off the screen and then touches one's face the dust and fibers collected on the screen are transmitted to the face. I n a recent study, it was found that several dermatological problems occurred in a greater frequency among VDT operators The researchers were unable to determine whether this was due to physical factors such as the electrostatic field, psychological factors, or pure chance. They concluded that working at the VDT may not create but exacerbate dermatological problems. Carola Linden and Jan E. Wahlberg, *Work at Video Display Terminals. An Epidemiological Health Investigat ion of of fice Employees. V. Dermatologic Examination*, National Board of occupational Safet J and Health, Solna, Sweden, 1985.

'P; pidemiology is a comparative discipline concerned with studying and comparing diseases and related phenomena at different time periods, in different places, and among different types of people. M. A braham and David E. Lilienfeld, *Foundations of Epidemiology* (New York: () x ford University Press, 1980). For a more complete discussion of the role of epidemiology i n as sessing workplace exposures see the ( )TA report, *Pre~enting Illness and Injury in the Workplace*, OTA-H-256 (Washington, DC: U S. Government Printing office, 19851.

' 'Acute outcomes are transient and closely associated in time with the exposure. Chronic outcomes are persistent and endu ring and distant ly or i nd i rect ly associated wit h the exposure.

Table 5.4.—individual and Work Environment Factors Associated With Visual System Outcomes

Individual:
Age
Uncorrected refractive errors
Work environment:
Glare on the screen
Flicker and jitter
Resolution of characters
High **contrasts between source document and** screen
Tasks requiring long continuous looks at the screen without a break
Air humidity
High visually demanding task, like data entry and data **acquisition**
Low control jobs where the worker is unable to take a break to relieve the load on the visual system

NOT E: Although the professional who works at the VDT is not as likely to report as many visual problems as people doing data entry acquisition or dialog tasks It is important to recognize they tend to report more symptoms than workers not us I ng [he V DT For a comprehensive revi ew of the l iterature see Ulf Bergqvist, 'Video Display Terminals and Health A Technical and Medical Appraisal of the State of the Art *Scandinavian Journal Of Work Environment and Health* vol 10 Supp 2 1984

SOURCE Off Ice of Technology Assessment

Table 5-5.—Visual System Outcomes: Known Acute or Potentially Chronic[a]

Known acute outcomes:
Asthenopia:[b]
Burning eyes
Itching eyes
Irritated eyes
Perception problems:
Double vision
Blurred vision
Potential chronic outcomes:
Acquired myopia

[a]There are no c-h ron IC outcomes that have been observed i n any c linICalinvest I gations of VDT operators

[b]Asthenopia is a term used to describe visual fatigue or weakness No clear defi n It Ion of visual fati gue is employed in the research and it is someti mes referred to as visual strain

SOURCE Off Ice of Technology Assessment

a terminal is directly proportional to the number of workers reporting symptoms and to the extent of their complaints. That complaints cannot be tied to organic change does not, in other words, mean that they are not "real." There is also evidence that visual problems can influence the development of musculoskeletal symptoms. The acute outcomes in table 5-5 can be reduced with changes in the workplace, such as appropriate lighting levels, computer terminal design, workstation and job redesign, and prescriptions to correct refractive errors.

No existing data shows that working at a VDT can lead to the development of cataracts,[61] but neither has the VDT been thoroughly absolved. While in some industries people have worked at VDTS for years, no study has examined the prevalence of cataracts in such groups of workers. No long-term study has yet shown either clinically observable changes in the eye functions or pathological changes in the eye.

There is evidence that work at a VDT leads to more frequent changes in eye glasses.[62] This has been attributed both to the aging of the workers, and to a greater tendency for VDT workers, as compared to others, to identify minor visual problems. A possible alternative explanation is the development of acquired myopia (nearsightedness), which is characteristic of close visual work such as reading. If working at the VDT is found to increase the chance for acquired myopia, the visual health of a large sector of the population will be affected. As the debate about the effects of VDTs on the visual system of workers continues, there is a growing need for a well-designed longitudinal study to determine whether the acute conditions persist. Since little is known about potential biological or biomechanical mechanisms for the initiation of pathological changes in the visual system attributable to new office technologies, research should also focus here.

Eye exams are recommended by the National Institute for Occupational Safety and Health (N IOSH) before beginning VDT work and periodically thereafter. [63] In many in-

"'National Research Council, *Video Displays, Work and Vision: Panel on the Impact of Video Viewing on Vision of Workers* (Washington, DC: National Academy Press, 1983). However, in a recent workers' compensation case, the worker received an award for incipient cataracts. The workers compensation board found there was a recognizable link between the employee's occupation and disability-see, *Legal Rights for VDT Users* (Cleveland, OH: Working Women Educational Fund, 1985).

"Wlf Bergqvist, "Video Display Terminals and Health: A Technical and Medical Appraisal of the State of the Art, Scan*dinavian Journal of Work, Environment, and Health,* vol. 10, SUpp. **2, 1984.**

' 'J. Donald Millar, Assistant Surgeon General and Director of N IOSH, Statement before the Subcommittee on Health and Safety, Committee on Education and labor, U.S. House of Representatives, May 15, 1984.

stances, visual complaints are in part due to uncorrected refractive errors. Eye examinations would identify and allow correction of this problem. There is no evidence as to how often eye exams should be given for good visual health. They are particularly important for people over 40 years of age, when the visual system begins to change with the onset of presbyopia (farsightedness).

Musculoskeletal System Outcomes

Musculoskeletal disorders rank very high among health problems in the frequency with which they limit activity.[64] Over 10 million people report limitation of activity due to musculoskeletal disorders as compared for example with about 7 million reporting limitation of activity because of circulatory problems. Musculoskeletal disorders are the leading cause of disability of people in their working years. From 1973 to 1983, industry data sources report low back pain as the primary cause in 20 to 25 percent of the yearly workers compensation cases.[65] As the working population ages, the prevalence of musculoskeletal disorders and the potential costs to individuals and society increase.

No recent data are available to provide more accurate estimates of the extent of musculoskeletal disorders in the aging U.S. population, and there is no breakdown of the older data by occupation. Therefore it is difficult to estimate the impact office automation has had on the prevalence of musculoskeletal disorders. A national data collection system is needed to determine the contribution of the workplace to the prevalence of musculoskeletal system outcomes.

NIOSH has identified musculoskeletal disorders of an occupational origin as one of the top ten health problems affecting workers today. Over the past 15 years, they have been one of the major categories of self-reported complaints by VDT workers, a high percentage of whom report pains, stiffness, cramps, and numbness in the back, neck, shoulder, arms, and hands. Comparison with other office workers reveals an association between VDT work and increase in self-reported symptoms in specific types of office work.[66]

Table 5-6 shows factors that have been found to be associated with musculoskeletal system outcomes among VDT operators. Few studies have weighed the relative contribution of each factor.[67] Characteristics of the individual, workstation design, and the work process are associated with the reported symptoms. There is a suggested association between length of time at the VDT and an increased levels of reported musculoskeletal symptoms,[68] but the current scientific evidence is inadequate to demonstrate a causal relationship between any

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"Jennifer L. Kelsey, *Epidemiology?' of Musculoskeletal Disorders*, Monographs in Epidemiology and Biostatistics, vol. 3 (New York: oxford University Press, 1982).

Cited in Charles F. Spakell and William F. McKeon, "Preventing Low Back Pain in I ndustry," *Business and Health*, vol. 2, No. 6, 1985, pp. 16-19. This is supported by unpublished analyses of B 1..S data.

" The data used to make the observat ion are inadequate to make any strong assertion across all jobs where the worker uses the computer terminal.

'For example, see S. L. Sauter, et al., "Job and Health I mplications of VDT Use: Initial Results of the Wisconsin-N 10S1 I Study," *Communications of t he.4 ssociat ion of Computing Machinary*, vol. 26, pp. 28 4-294, 1983.

'"Nl ichael J. Smith, " Ergonomic and Stress Aspects of ( )f - fice Automation," paper presented at t he off ice of Technology Symposium on the Impacts of office Automation and Computer-Mediated Work on the Quality of Worklife, Dec. 1 0-12, 1984.

Table 5-6.—Individual and Work Environment Factors Associated With Musculoskeletal Outcomes

Individual:
Age
Existing musculoskeletal disorders
Visual system characteristics"
Near-s ightedness
Presbyopla
Bi or trl-focal eyewear use during VDT operation
Work environment:[a]
VDT/workstation-user interface"
Keyboard and hand
Body and chair
Eyes and screen
Repetitiveness of task(s)
Length of time spent at task(s)
Extent of physical constraints

[a] These factors will be discussed in more detail in the section on workstation design and the quality of worklife

SOURCE: Office of Technology Assessment

characteristic of the automated office and any musculoskeletal system outcome. [69]

Acute musculoskeletal system outcomes are listed in table 5-7. Back, neck, and shoulder problems are reported more frequently (50 to 80 percent of VDT operators) than arm, wrist, and hand problems (20 to 40 percent of VDT operators). This ranking of self-reported symptoms by site corresponds to a ranking based on a national sample of U.S. adults. [70] Furthermore, in the national sample it was found that the level of self-reported symptoms corresponded to physician-observed abnormalities. There is, however, no evidence from studies of office workers using VDTs display that self-reported outcomes predict clinically recognizable changes in the musculoskeletal system.[71] There is a need for research to clearly identify the relationship between reports of musculoskeletal outcomes by the worker and medically verifiable outcomes.

Based on the current scientific evidence, it is impossible to determine whether the acute outcomes listed in table 5-7 lead to any pathological changes in the musculoskeletal system or to any disability for workers in automated offices. The chronic outcomes reflect potential long-term consequences based on evidence from other occupations and biological and biomechanical evidence. Potential long-term consequences of new applications of office technologies for the musculoskeletal system must be considered. As Kelsey notes:

> [Impairments of the back and spine and arthritis and rheumatism account for the greatest amount of time lost from work. In 1976, it was reported that a reduction of one day per year in the average annual absenteeism rate among the labor force of the United States would increase the gross national product (GNP) by $10,000 million. Accordingly, the GNP would have increased by $19,000 million had musculoskeletal disorders been prevented.[72]

If absenteeism rates can be affected by design of new office technologies, this has far reaching implications for health care costs. Therefore, research should be conducted to determine the relative contribution of office automation to the incidence of the chronic outcomes listed in table 5-7.

"'Although no experiments have been conducted showing a causal relationship between new office applications and musculoskeletal outcomes, there are biologically plausible explanations; for example, the experience of pain and discomfort by the worker who sits at the terminal for extended periods of time in constrained postures. Static loading of muscles results from the efforts of the human body to maintain a fixed posture for extended periods of time. This keeps the muscle in a constant state of contraction instead of a dynamic state of contraction and relaxation. Thus, waste products build up in the muscle and blood is not circulating in the muscle to provide the needed nutrients. This results in cramping and pains. Tichauer has shown that the peritendinitus that occurs in the lower arm of typists is caused by excessive static workload. (E.R. Tichauer, "Biomechanics Sustains Occupational Safety and Health," *Industrial Engineering*, vol. 27, 1976), pp. 46-56.

[70] Linda S. Cunningham and Jennifer L, Kelsey, "Epidemiology of Musculoskeletal Impairments and Associated Disability," *American Journal of Public Health*, vol. 74, No. 6, 1984, pp. 574-579.

Table 5-7.—Musculoskeletal System Outcomes: Acute or Potentially Chronic

Known acute outcomes:
Pain in shoulder
Cramps in arms and legs
Pain in back:
Upper
Lower
Cramps in shoulder and neck muscles (stiff neck)
Soreness, tingling or numbness in wrist and fingers
Potential chronic outcomes:[a]
Cervicobrachial syndrome[b]
Prolapsed lumbar intervertebral disc
Cumulative trauma disorders[c]

[a] The chronic outcomes have not been observed in any Population of Office workers They are potential chronic outcomes based on self. reported acute musculoskeletal outcomes and biological and biomechanical plausibility

[b] Cervicobrachial syndrome is a term used to define a cluster of signs In the shoulder and neck region It is a functional and organic disorder occupationally produced on the basis of muscular and mental fatigue resulting from static and/or repetitive exertion of the arm and hand muscles Chronic pain can result from the compression of nerves in the neck radiating down the arm

[c] Cumulative trauma disorders are a class of musculoskeletal outcomes, that are potentially Important Those in the literature associated with office workers are tenosynovitis and carpal tunnel syndrome Carpal tunnel syndrome is a disorder of the wrist in which the median nerve is compressed against the transverse carpal Ilgament within the carpal tunnel

SOURCE Off Ice of Technology Assessment

'Studies that have attempted to correlate self-reports with medical exams have not demonstrated a clear relationship. For an example see the work of W. Hunting, T. Laubli, and E. Grandjean, "Postural and Visual Loads at VDT Workplace, I, Constrained Postures," *Ergonomics, vol.* 24, No. 12, 1981, pp. 917-931.

[72] Kelsey, 1981, op. cit., p. 7.

Photo credit Communications Workers of America

Workers adjust to their working conditions. Sometimes this can lead to musculoskeletal strain,

The first two, cervicobrachial syndrome and prolapsed lumbar intervertebral discs, can potentially develop among either professionals or clerical workers.[73] They can be related to increased time spent sedentary and in constrained postures, which could be blamed on the job or the design of the office or workstation, but most likely is related to all three. Cumulative trauma disorders are more likely to develop among workers doing highly repetitive keying operations at the VDT for extended periods of time, mostly data-entry clerks who key as much as 12,000 keystrokes per hour. These are the wear and tear disorders. Many of the early warning signs (tingling, numbness, and pain) of these chronic conditions can be alleviated with changes in the working conditions.[74]

There is a relationship between visual system outcomes and musculoskeletal system outcomes. For example, a person who is nearsighted most likely will get a pair of reading glasses that typically allow the person to read clearly at about 33 cm. However for work at the VDT, a person is on average only as close as 50 cm from the screen. The worker then leans forward, and the posture results in mus-

[73] A prolapsed intervertebral disc occurs when the nucleus pulpous of the disc protrudes outside the annulus fibrosis. The disc tends to protrude onto a nerve root causing pain. In the lumbar region this pain radiates down the leg. Kelsey estimates the incidence of prolapsed lumbar intervertebral disc at around 0.1 to **0.5** percent per year (Kelsey, op. cit., 1981, p. 151) in the population of ages between **24** and 64 years.

[74] "Much of the research on the prevention of cumulative trauma disorders is based on redesign of the machines in assembly line operations. See *Preventing Illness and Injury in the Workplace* (op. cit.) for several examples of the prevention projects.

culoskeletal strain. As the pain gets worse through the day, the worker adjusts by moving her body back in the chair, increasing the visual distance, which can lead to visual strain.

NIOSH recommends that a worker take periodic rest breaks every 2 hours when doing work at the VDT to prevent acute asthenopia and musculoskeletal fatigue.[75] This can be enforced through organizational rules, through a job redesign strategy giving the worker a variety of tasks to break up the VDT work, or by allowing the worker the discretion to take breaks when she feels the need. The last is especially advantageous in settings where the work is unpredictable or there is a high worker-to-VDT ratio with competition for terminals, but may demand more flexibility than an organization would normally provide. Sometimes people will not take breaks unless they are required.

Reproductive System Outcomes

Many occupational hazards affect the reproductive system.[76] The concerns about the reproductive hazards of working in an automated office focus primarily on the VDT. Most of the early studies considered only female operators, but both genders should be considered in discussing reproductive system outcomes.

The concern over working at the VDT developed because of reported clusters of spontaneous abortions and birth defects among VDT operators. Table 5-8 shows a list of the work sites where these clusters have been reported. No adequate explanation has been offered for these observed clusters,[77] which include a wide variety of pregnancy outcomes with the majority being spontaneous abortions. The estimated prevalence rate for spontaneous abortions in the general population is between 10 and 20 percent.[78] No site has enough data to show conclusively any association between office automation and any adverse reproductive outcome.[79]

A Finnish study looked at the relationship between occupation and spontaneous abortions, and found that industrial and construction workers had one of the highest ratios (13.01), and clerical and managerial workers one of the lowest estimated ratios for spontaneous abortions (9.91);[80] the lowest ratio was in administrative work (8.16).

Two studies in Sweden and Japan examined the relationship between VDT work and reproductive system outcomes. Little information is available on the Japanese study .8' The Swedish study infers VDT exposure from occupations; the measure of work at a VDT is indirect.[82] Nevertheless, this retrospective

[75] Millar, op. cit.; this recommendation has been challenged in the scientific community.

[76] For a complete listing and a discussion of the potential control technologies see *Reproductive Hazards in the Workplace,* Office of Technology Assessment, Washington, DC, 1985.

[77] '-The argument is made that these clusters are chance occurrences. The rate of spontaneous abortions is not at odds with the normal rate that occurred during the time period of the reported clusters. For a lengthy statistical discussion on this see Bergqvist, op. cit.

[78] In an analysis of the ability of women to recall whether they had a spontaneous abortion or not; one in four cases of spontaneous abortion was not reported. Gestational age of the time of abortion was the major determinant of recall. Allen J. Wilcox and Louise F. Horney, "Accuracy of Spontaneous Abortion Recall," *American Journal of Epidemiology,* vol. 120, No. 5, 1984, pp. 727-733.

[79] There are several methodological problems with examining reproductive hazards in the workplace. First is the problem of selection bias. It is known that a predictor of an adverse pregnancy outcome is prior adverse outcomes. Women who have a full-term pregnancy tend to leave the work force, and therefore women with prior adverse pregnancy outcomes will be over represented (Gosta Axelsson, "Selection Bias in Studies of Spontaneous Abortion Among Occupational Groups," *Journal of Occupational Medicine,* vol. **26, No. 7, 1984,** pp. 525-528).

[80] The ratio is calculated as the number of spontaneous abortions times 100 divided by the number of births. K. Hemminki, M. L. Niemi, I. Saloniemi, H. Vainioh, and E. Hemminki, "Spontaneous Abortion by Occupation and Social Class in Finland," *International Journal of Epidemiology,* vol. **9, No. 2,** pp. 149-153, 1980.

[81] "'Conducted by the General Council of Trade Unions, it has only been reported in "Japanese Miscarriages Blamed on Computer Terminals," *New Scientist,* vol. 106, No. 1457, 1985, p. 7. Among 4,500 women, 250 became pregnant or gave birth after work at the VDT and 91 had problems with pregnancy. There was a reported association between hours per day, work at the VDT, and problems with pregnancy or labor: for more than 6 hours VDT work per day—66 percent had problems; for 3-4 hours VDT work per day–46 percent had problems; for less than 1 hour VDT work per day–25 percent had problems. It is impossible to draw any conclusions from this data since no information on the research design is known.

[82] Bengt Kallen, *An Epidemiologic Study of Work With Dataterminals and Pregnancy (En Epidemiologisk Studie over Arbete med Dataskarm och Graviditet),* translated by Anita Dvorak, research report from the University of Lund, Sweden, 1985. Data reported herein is taken from a second report, Ad

(continued on p.146)

Table 5-8.—Reported Cases of Reproductive System Outcomes in Computer-Mediated Workplaces by Work Site and Job

Company city (date)	Job	Outcomes	
		VDT	Non~VDT
Sears-Roebuck/ Dallas, TX (5/79-6/80)	Financial records processing clerk[a]	2 miscarages 4 full -term[b]	i miscarriages 1 premature birth 8 full-term
Toronto Star/ Toronto, Ontario (5/79-5/80)	Classified ads processing clerks	4 birth defects	3 full-term
Air Canada/ Montreal, Quebec (2/79-4/81)	Part-t i me ticket agents	7 miscarriages 6 full-term	NIA[c]
Defense Department/ Marietta, GA (10/79-10/80)	NIA	3 birth defects 7 miscarriages 5 full-term	NIA
Defense Department/ Marietta, GA (10/80-10/81)	NIA	14 full-term	NIA
Pacific Northwest Bell Telephone/ Reston, WA (7/80-12/81)	N 1A	2 birth defects 1 still born	N 1A
Solicitor General Offices/Ottowa, Ontario (4/79-4/82)	NIA	4 miscarriages 1 premature 2 respiratory diseases	1 full-term
Surrey Memorial HospltallVancouver, British Columbia (1978-82)	Accounting department clerks	3 miscarriages 1 birth defect 1 premature 1 bronchitislful l-term 1 full-term	NIA
Toronto, Old City Hall Ministry of Attorney General (1980-81)	Clerks Secretaries	10 miscarriages 9 full-term	N 1A
United Airlines/ San Francisco, CA (1984)	Airline reservation clerk	23 miscarriages 61 full -term[d]	NIA
Southern Bell Telephone/Atlanta. GA (3/81-9/83)	Telephone operators	7 miscarriages 15 full-term	26 miscarriages 159 full-term
General Telephone/ Alma, Ml (1983-84)	Telephone operators	12 miscarriages 2 still births 3 premature 15 full-term	NIA
Library/ Aarhus, Denmark	NIA	8 miscarriages 2 full-term	NIA
Department of Public Employees/Runcorn, England (1974-82)	Full-time VDT operators	8 miscarriages 4 still births 12 malformations	NIA

[a] Compares on ly full-ti me VDT operators with non-VDT operators who may have worked as much as 6 hours per month at the terminal
[b] Full term refers to the healthy delivery of a newborn after three trimesters These are commonly termed live births
[c] NIA means no information reported
[d] This excludes 23 induced abortions and 9 full-term deliveries of wives of employed men

SOURCE Off Ice of Technology Assessment, compiled from several reports and news sources

study found that women who worked at the VDT were 50 percent more likely to have miscarriages (crude risk ratio was 1.5 with 95 percent confidence limits of 1.1-1.9) than other women of similar age and occupational group. With adjustment for smoking and stress, confidence in the risk ratio being greater than one decreased.[83] For all types of adverse reproductive outcomes, there was a significantly greater risk for those who spent over 40 hours per week at the VDT. This suggests that further investigations are needed that directly measure VDT work and follow a group of men and nonpregnant women to see whether there is an excess of adverse reproductive system outcomes. No epidemiological study has provided reliable data comparing VDT to non-VDT operators.

Two explanations other than chance have been offered for the clusters–stress, and radiation emissions. There is no epidemiological evidence linking stress in office work (either physical or mental) to spontaneous abortions or still births. But while no evidence exists, no research has thoroughly explored the issue.

The greatest interest has been in the impact of radiation[84] and whether radiation from the VDT is the single source exposure. There is no evidence that ionizing radiation above established safe thresholds is being emitted from currently sold terminals.[85] Ionizing radiation from the VDT is not a likely explanation, according to NIOSH, the Federal Drug Administration, and the Government of Canada.[86] The possibility of nonionizing radiation must be considered; but future developments in flat panel display technologies may eventually replace cathode ray tubes as the dominant human-computer interface.

Recent concern has focused on very low frequency radiation, particularly the magnetic pulse generated from the coil of the cathode ray tube. This concern developed because studies in Spain related a magnetic pulse to morphological abnormalities in chicken embryos.[87] The evidence has not been confirmed in any other investigation trying to reproduce the patterns of electromagnetic radiation emitted from a VDT.[88] Currently, there are international efforts to study the effects of pulsed electromagnetic exposure on chick embryo development, but measurement of this and other forms of nonionizing radiation in the field is difficult. Further research should be concerned with the development of reliable instruments for the monitoring of radiation being emitted from VDTS.

Based on current evidence, no long-term risk is associated with very low frequency radiation emitted from the visual display terminal, but continuing evaluation is warranted in light of

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Hans Malker, *Critical Comments on the Report "An Epidemiological Study of Work With Video Screens and Pregnancy Outcomes,"* Memorandum, Swedish National Institute of Occupational Safety and Health, Feb. 2, 1985.

[83] This risk ratio dropped only 10 percent when the effects of smoking and stress were entered into a logistic regression analysis (adjusted risk ratio 1.4 with 95-percent confidence limits of 1.0-1.8). No data was reported on the effects of chemical exposure or heavy lifting on the relationship of work at the VDT and miscarriages. If the relationships persist after adjusting for these potential confounders along with other predictors of miscarriages (e.g., prior spontaneous abortions and parity) then the researchers can make a stronger inference. This will always be limited by the absence of a direct measure of VDT use.

"Three major types of radiation are associated with biological effects. They differ by the energies involved. Ionizing radiation has the most energy and is known to cause cancer and birth defects. Microwaves and radiofrequency nonionizing radiation have been associated with fertility problems and blood abnormalities. Extremely low frequency and electromagnetic nonionizing radiation is the least energetic of the three categories and has not been associated with any adverse biological effects.

[87] William E. Murray, "Video Display Terminals: Radiation Issues," *IEEE Computer Graphics and Applications,* April 1984.

[86] Millar, op. cit.; FDA, *Drug Bulletin*, vol. 14, No. 1, April 1984; Environmental Health Directorate, *Investigation of Radiation Emissions From Video Display Terminals*, Department of National Health and Welfare, Ottawa, Canada, 1983.

[87] This evidence comes from two reports: J.M.R. Delgado, J. Leal, J.L. Monteagudo, and M.G. Garcia, "Embryological Changes Induced by Weak, Extremely Low Frequency Electromagnetic Fields," *Journal of Anatomy,* vol. 134, 1982, pp. 533-551; and A. Ubeda, J. Leal, M.A. Jimenez, and J.M.R. Delgado, "Pulse Shape of Magnetic Fields Influences Chick Embryogenesis," *Journal of Anatomy,* vol. 137, 1983, pp. 513-536.

[88] Arthur W. Guy, *Health Hazards Assessment of Radio Frequency Electromagnetic Fields Emitted By Video Display Terminals,* report prepared for IBM Office of the Director of Health and Safety, 1984; Kjell Hansson Mild, Personal Communications, Swedish National Board of occupational Safety and Health, 1985; S. Maffeo, M.W. Miller, and E. L. Carstensen, "Lack of Effect of Weak Low Frequency Electro-Magnetic Fields on Chick Embryogenesis," *Journal of Anatomy,* vol. 139, No. 4, 1984, pp. 613-168.

Table 5-9.—U.S. Occupational Exposure Standards

Radiation type	Occupational exposure standard	Source
X-ray ...	2,5 mR/hr	OSHA'
Ultraviolet (near) .,	1,000 microW/cm[a]	ACG I H "
Visible	2.920 fL	ACGIH[h]
Radiofrequency electromagnetic fields, frequency range (MHz)		
0 0 1 - 3	100 mWlcm[b]	ACGIA[b]
1 0 - 1 0 0 , 0 0 0	10 mWlcm[b]	OSHA'

[a]Code of Federal Regulations Title 29 Chapter XVII Part 191096 Ionizi ng Rad ation Occu pat tonal Safety and Health Ad m in strat ion Washington DC 1980
[b]Th reshold Limit for Chemical Substances and Physical Agents in the Work En vironment With I nt ended Changes for 1983 and 1984 American Conference 'or Government Industrial Hygienists Cincinnati OH 1983
[c]Code of Federal Regulations Title 29 Chapter XVII Part 191097 Nonionizi n q Radiation Occupational Safety and Health Administration Washington DC 1980

SOURCE Adapted 'rem Wil I iam E Murray Visual Display Terminals Radiation Issues *IEEE Computer Graph/es and Applications* April 1984

Table 5-10.—International Radiation Protection Association Occupational Exposure Limits to Radiofrequency Electromagnetic Fields

Radiofrequency electromagnetic fields, frequency range (MHz)	Occupational exposure limit (mWlcm[2])
0.1-1 .	10
>1-10. . . .	10/Fa
> 1 0 - 4 0 0 .	1
>400-2,000 .	F"/400
>2,000-300,000	_5

[a]F refers to the frequency in Mfiz thus 10 calculate the specific limit within the range the frequency must be factored in according to the expression

SOURCE International Non Ionizing Radiation Committee of the International Radiation Protection Association Interim Guidelines on Limits of Exposure to Radiofrequency Elect romagnetic Fields in the Frequency From 100 KHZ to 300 GHz *Health Physics* VOI 46 No 4 1984 pp 975984

the large number of people exposed, to see if modified or new standards need to be developed.[89]

Standards shown in table 5-9 reflect the available evidence on the potential effects of chronic exposure at low levels. The American Conference of Government Industrial Hygienists (ACGIH) exposure limit for electromagnetic fields in the frequency range of 0.01-3 MHz is 100 mW/cm^2. This threshold level is 10 times higher than the VDT emissions in the 0.01-100 MHz range measured in a study by the Bureau of Radiological Health of the Environmental Protection Agency.[90] The International Radiation Protection Association (IRPA) standards are 10 times lower for a similar frequency range than standards set by ACGIH (0.01-3 for ACGIH and 0.01-1 for IRPA). Because there are differences in the limits of exposure, the standards should be constantly reexamined in the light of further research. NIOSH is currently conducting a retrospective study to ascertain whether working at a VDT is associated with spontaneous abortions. Similar studies are being conducted by Dr. Irving Selikoff at Mt. Sinai Hospital (in conjunction with 9 to 5, the Working Women's Association), by Dr. Kelley Brix at the University of Michigan and in Sweden, Finland, Canada, and Denmark.

Again, there is no reliable national registry for monitoring the prevalence of reproductive system outcomes as they relate to occupations. The establishment of such a system could help prevent the public fear that has arisen about VDT work.

Metallic shielding has been discussed as one way to avoid any possibility of radiation being absorbed by the operator, especially shielding the flyback transformer. This shielding is relatively inexpensive and is usually provided in newer models to satisfy FCC requirements for reducing electromagnetic interference.'[1]

The government of Sweden has recommended that any pregnant employee have the right to be moved, at full pay, to a job with no exposure until the baby is born. The International Labor Organization recommends that a worker who is considering becoming pregnant be allowed to transfer to another job.[92] However, the risk of reproductive system damage, if it exists, may be just as great for a man as for a woman. Most recently, the Service Employees International Union (SEIU) has negotiated

""A recent report from the U.S. Environmental Protection Agency concluded there were no consistent biological effects at the molecular and subcellular level in laboratory experiments. The report suggested continued revision of general conclusions because of limited knowledge about chronic low-level exposures and the existence of frequency-specific effects and power-density windows. (U.S. Environmental Protection Agency, *Biological Effects of Radiofrequency Radiation*, Joe A. Elder and Daniel F. Cahil (eds.), EPA-60018 -83-026F (Research Triangle Park, NC: Health Effects Research Laboratory, 1984).)

"'Cited in *Reproductive Hazards in the Workplace*, op. cit.
"'Guy, op. cit.
'-International Labor Organization, *Guidelines for VDT's*, Geneva, Switzerland, 1985.

in collective bargaining with Equitable Life Insurance the rights of employees to leave VDT jobs where the believed risk for an adverse pregnancy outcome is high. These measures would at a minimum alleviate fears.

Stress-Related Outcomes

Work-related stress is not new to offices, but recent epidemiological evidence has called attention to the potential long-term consequences of stressful office working conditions. One study of the health records of 22,000 workers in 130 occupations found that clerical workers had the second highest rate of stress-related diseases." Analysis of the Framingham Heart Study data showed that women clerical workers developed coronary heart disease (CHD) at about twice the rate of other women workers and women at home.[94] The workplace factors that predicted the development of CHD among clerical workers were a nonsupportive boss and low-job mobility. Any conclusions about the contribution of the new office technologies to the incidence of disease must thus consider that women clerical workers were already at a greater risk for the development of certain stress-related diseases. The new technology may or may not intensify those characteristics of the work environment that are associated with the elevated risk, increasing one's chances of developing disease; they could also improve working conditions, decreasing the likelihood of disease.

There are no reliable estimates of the costs to the organization or to society of stress-related illnesses, absenteeism, tardiness, employee turnover, decreased quality and quantity of output, unscheduled machine downtime (due to employee tampering) and worker's compensation awards. These outcomes can lead to increased medical care costs and decreased organizational effectiveness.

Stress-related outcomes can be divided into those that are acute and transient[95] and those that are persistent and enduring. Anxiety and depression have been shown to be related to myocardial infarction, angina pectoris, and coronary death.[96] Therefore, correction of working conditions that produce these stress responses can help to prevent stress-related diseases.[97]

As important as are acute conditions, the potential for chronic diseases is the key public health issue. The population potentially at risk in offices is large. If conditions that can lead to chronic illness and disease can be identified, management can use this information to guide implementations.

The biological plausibility of changed working conditions leading to a pathological change in the body has been the subject of debate for decades. Chronic arousal is one currently acceptable biological pathway (see box B for an example of a plausible link to disease). Chronic arousal is a biological adaptation to the environment. When one continues to respond daily to the same stimuli, arousal can become part of the normal biological adaptation to, for example, work—a method of activating the body's resources to meet the demands. This can lead to a form of 'healthy maladaptation, in which the worker completes tasks, but at some biological costs. The eventual cost can be illness due to lowered immunological resistance, or chronic illness that lowers the ability to perform, such as cardiovascular disease or peptic ulcers. The danger is hidden in that the chronic heightened state of arousal does

[94] Michael J. Smith, Michael J. Colligan, and J.S. Hurrell, "A Review of NIOSH Psychological Stress Research–1977," *Occupational Stress: Proceedings of a Conference on Occupational Stress* (Washington, DC: U.S. Government Printing Office, 1977).

[95] Suzanne G. Haynes and Manning Feinleib, "Women, Work and Coronary Heart Disease: Prospective Findings From the Framingham Heart Study," *American Journal of Public Health*, vol. 70, 1980, pp. 133-141.

[96] Stress can contribute to the development of acute visual and musculoskeletal system outcomes. For example, muscle fatigue can be the direct result of a stressful working condition, which can stimulate brain stem activity, which in turn can cause muscle fatigue.

"C. David Jenkins, "Psychosocial and Behavioral Factors," *Prevention of Coronary Heart Disease: Practical Management of the Risk Factors*. Norman M. Kaplan and Jeremiah Stamler (eds.) (Philadelphia: W. B. Saunders, 1983), pp. 98-112.

[97] This type of prevention strategy may be found to be the most cost-effective, since it has the potential to reduce the long-term development of disease. Also, if the working conditions that produce stress responses in workers are modified, this may alter certain behavioral outcomes including smoking, drinking, and overeating—all considered socially acceptable ways to cope with the stresses of life, but primary determinants of premature morbidity and mortality.

Box B.—Chronic Arousal: The Link Between Working Conditions and the Natural History of Disease, The Case of Cardiovascular Disease*

Early theories of stress and disease held that humans instinctively respond to challenging conditions from their environment through activation of pituitary and adrenal gland functions. Walter Cannon in the 1930s showed the importance of the sympathetic adrenal system in the flight-or-fight syndrome. He showed there were limits to how well the system could adapt to stimuli; afterwards bodily harm could result. OnIy in the last 20 years have scientists begun to unravel the complex interrelationship between the brain, immune system, and endocrine system.

There are competing models of this complex system, but several conclusions can be stated. Sympathetic adrenomedullary (SAM) stimulation is accompanied by evaluated blood pressure and heart rate, heightened myocardial oxygen requirements, increased levels of circulating epinephrine (E) and norepinephrine (NE), elevated plasma concentrations of free fatty acids (FFA), and increased plasma renin activity. These can predispose the individual to cardiovascular disease (CVD). The release of the neuroregulator, catecholamine, as a consequence of SAM activity is central to the most prominent theories of stress and CVD. In its efforts to mobilize reserve energy resources, catecholamines hydrolyze triglyceride stores into FFA and glycerol. FFAs are either utilized in the production of energy or taken up by the liver and adipose tissue then resynthesized into triglycerides that are secreted as a component of very low-density lipoproteins (VLDL). VLDLS have been shown to be significant components of the atherosclerotic process. When catecholamines are chronically secreted in great excess of the body's energy requirements to meet the demands of the work environment, the abundance of FFAs can ultimately result in damage to vascular walls caused by circulating VLDLS. Damage to vascular endothelium can also occur as a result of increased arterial blood pressure or turbula.nce caused by SAM hemodynamic responses. Damaged vascular endothelium is more susceptible to atherosclerotic deposits than healthy vessel walls. These processes suggest several possible pathways between the challenges created by working conditions and the development of cardiovascular disease.

[a]This section is based on a summary prepared by Dr. Andrea LaCroix. For a full description see Andrea LaCroix, Occupation *Exposure to High Demand/Low Control Work and Coronary Heart Disease Incidence* in *the Framingham Cohort*, doctoral dissertation, University of North Carolina, Chapel Hill, 1984. A more complete description of the various biological processes can be found in The Institute of Medicine, Research *on Stress and Human Health* (Washington, DC: National Academy Press, 1981).

not necessarily correlate with the worker's attitudes about work. High motivation and satisfaction does not obviate the possibility that a person could be at risk.

Three working conditions have been associated with chronic arousal:

- social isolation or lack of social support;
- lack of control over the timing, speed, and variety of tasks; and
- heavy workload (especially repetitive and machine-paced tasks).

Each of these conditions has also been postulated as likely to arise from office automation. No evidence has shown that all three must occur to elicit deleterious biological responses; however, in some jobs they all occur.

Epidemiological evidence has shown the most consistent links between heart conditions and workload and control. In a 6-year prospective analysis, men with jobs characterized by a heavy workload and limited job control were found to have 1.4 times the normal risk of CVD morbidity.[98] In a case-control study of myocardial infarction and occupational exposures, it was found that hectic work and low control over work tempo and skill variety were associated with myocardial infarction in men under 55.[99] In a study of Swedish workers who had changed jobs, those whose new job had greater control had fewer coronary symptoms

[98]The CHD morbidity measure was a self-report indicator of chest pain, dyspnea, hypertension, and heart weakness. R. Karasek, et al., "Job Decision Latitude, Job Demands, and Cardiovascular Disease: A Prospective Study of Swedish Men," American *Journal of Public Health*, vol. 71, No. 7, 1981, pp. 694-70,5.

[99]L. Alfredsson, et al., "Myocardial Infarction and Psychosocial Work Environment: An Analysis of the Male Swedish Working Force," *Social Science and Medicine*, vol. *16*, 1982, pp. 463-467.

than workers whose new job had less control.[100] In the only American prospective study, women who described their job as having a heavy workload with limited job control had a three-fold greater risk of developing coronary heart disease (CHD) as women reporting a heavy workload but having control over their work. Men did not exhibit the same relationship. At greatest risk were clerical women, who had a 420 percent greater chance of developing CHD (relative risk 5.2 with 95 percent confidence interval of 1.80-15.08). These associations persisted after controlling for the traditional risk factors for CHD. [101]

Based on the available evidence, lower level staff appear to be at greater risk for the development of stress-related diseases. This however need not be true with office automation because the changes in the working conditions can affect all levels of staff. Alternatively, office automation can be implemented so as to add control and encourage more social interaction.

Currently, the evidence for a relationship between stress-related diseases and VDT work is still sparse. A principle problem in drawing conclusions is that the long latency of chronic diseases prevents early recognition. However, in the natural history of disease certain early indicators could be expected such as psychosomatic symptoms (sleeping problems, dizziness, nausea, and stomachache), high blood pressure or angina pectoris.[102] Only preliminary evidence exists for the likelihood of deleterious long. term health effects on office workers, or specifically on VDT workers. Most studies show that support staff who work at a VDT report more psychosomatic symptoms than either other support staff or professionals who work at VDTS. These studies, in general, also show that women report more psychosomatic symptoms, as do people in jobs characterized by little control over pace, a heavy workload, and lack of social support. This is consistent with the general literature on stress-related disease. No study can fully answer the question—what contribution to the risk of disease can be attributed to office automation?

But two recent studies suggest that there is a potential for these psychosomatic symptoms to develop into chronic conditions. In a cross-sectional study of clerical workers in the communications industry, those who worked at the VDT were at about a two-fold greater risk for the development of angina pectoris.[103] This is the first study to demonstrate a relationship between automated office work and a valid precursor of CVD. A second study of Finnish workers found that workers in automated offices were at a 106 percent higher risk (relative risk 2.06, 95 percent confidence interval 1.43-2.69) for one or more chronic illnesses.[104] These projects point to the need to examine the potential effects of office automation to determine under what conditions a worker is likely to be at a greater risk for the development of a chronic disease.

[100] R. Karasek and B. Garden, *Managing Job Stress*, Working Paper, Columbia University, Department of Industrial Engineering and Operations Research, 1984.

[101] LaCroix, op. cit.

[102] These can also be explained by other factors such as situations outside of work or biological predisposition. Research efforts should in the future attempt to differentiate between the risks associated with work and those associated with leisure. Also, physical and psychosocial working conditions can produce similar adverse stress responses and should be differentiated in future research.

[103] The analysis of angina was restricted to a sample of 650 women. There were no significant differences between respondents and a 10-percent sample of nonrespondents. For a full description of the results of the study along with the limitations of the study see, Suzanne Haynes and Andrea LaCroix (University of North Carolina at Chapel Hill), "A Cross-Sectional Study of the Health of VDT Operators in the Telephone Industry, " unpublished manuscript, 1985. The measure of angina used was the Rose Angina Questionnaire. Several studies have shown that this self-report measure is as valid and reliable a predictor of angina pectoris as a physical exam by a physician. (Lawrence M. Friedman, et al., "Assessment of Angina Pectoris After Myocardial Infarction: Comparison of 'Rose Questionnaire' With Physician Judgment in the Beta- Blocker Heart Attack Trial, " *American Journal of Epidemiology*, vol. 121, NO. 4, 1985, pp. 555-563.)

[104] The ratio reported is after adjustment for age, sex, baseline health status, health risk factors and baseline systolic blood pressure. The risk did not change when ergonomic strain, job strain and social support from the supervisor were taken into account. There was a 21-percent increase in the risk when the control over the pace of work was taken into consideration. Again, the unanswered question is whether the job was characterized by low control prior to automation or whether working conditions were exacerbated by the automation of the work process? The chronic illness measure was composed primarily of heart disease (70 percent) with cases of cancer, chronic musculoskeletal disorders, and gastrointestinal diseases. These results are preliminary and further analysis is currently being carried out. For a description of the study see Mary Haan, "Health Effects of Automated Office Work, ' paper presented at the Office of Technology Assessment Symposium on The Impacts of Office Automation and Computer-Mediated Work on the Quality of Worklife, December 10-12, 1984.

Since the evidence relating working conditions in automated offices to stress-related diseases is still limited, it may be thought premature to begin job and organizational redesign strategies. The major dilemma facing managers is whether it is more cost effective to wait and make job and organizational changes later, or to use the new technologies to usher in job and organizational changes. The major dilemma facing public health officials is that by the time the population of VDT users has worked long enough to manifest chronic outcomes there will be few people to use as controls, since most office workers will be working at the VDT.

SECTION 111: INTERVENTIONS

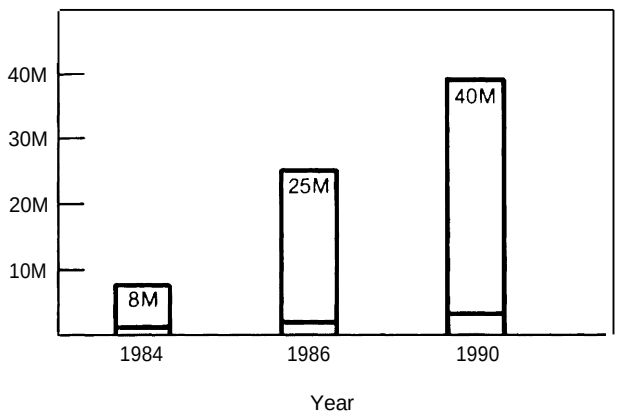
Office Design and Workstation Design

More and more organizations consider the design of the office, building, and workstation as integral parts of the new technology. These characteristics of office environments can contribute to quality of worklife both directly, and indirectly by ameliorating stressful working conditions,

Office Design

The introduction of new office technologies into a building can affect the way the building performs—the distribution of office space, heating, ventilation and air conditioning, power and wiring, and acoustics. [105] Running of cables through offices can be the cause of falls. Office design can balance the impersonality of some computerized office tasks. However, new buildings will only accommodate about 5 percent of the computer terminals installed between now and 1990 (see figure 5-2). The single greatest area of impact will be the retrofitting of older buildings to accommodate new technologies. Retrofitting can be as simple as putting in a new lighting system or as complex as complete rebuilding of the internal structure of the building. When new office technologies are haphazardly introduced without considering the extra demands placed on the building, new health and performance problems can develop or old ones can be amplified.

Figure 5-2.—The Proportion of VDTS Installed in New Office Space Compared to Existing Space, 1984-90



Most video display units will be installed in existing office space. Even if every person in new office construction in the United States had a VDU, only about 5 percent of the VDUs would be in new buildings. Therefore, accommodating them is mainly a retrofit job. (Assuming approximately 200 gross square feet for each workstation with a VDU, then if the height of each bar represents the total space occupied by workstations with VDUs, the shaded part of each bar represents the cumulative total of VDUs in new office space.)

SOURCE Michael Bell, Harbinger Group Inc 1985

Office Space

Office automation allows the redesign of workspace to accommodate private and shared

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It has been estimated that only 2 percent of the costs of conducting business in an office building over 40 years are devoted to building design. Six percent goes to operation and maintenance and 9.2 percent to labor. Therefore, improvements in the quality of worklife through building design offers a potential cost-effective lever for organizations. This estimate is based on 1971 dollars, but the differences in scale still exist today, see Francis T. Ventre, *Documentation and Assessment of the GSA PBS Building Systems Program: Final Report and Recommendations,* NBSIR *83-2777,* General Services Administration, Washington, DC, 1983. This general ratio of costs has been reproduced in another 7 year study of office design and its impact on the quality of work (Michael Brill, presentation at Conexion '85, Atlanta, GA, Nov. 6-9, 1985).

work. Allocation of space is always a critical factor in offices; it signifies status and organizational commitment to the worker. It provides some control over interruptions and privacy and encourages or discourages social interaction, factors associated with job satis " faction and performance.

A personal computer and attachments take about 12.5 square feet of office space, which increases individual workspace needs. [106] With the cost of office real estate rising, new technology is sometimes being crammed into inappropriate spaces that can lead to shifts in status, and awkward work postures associated with visual and musculoskeletal strain. Noise levels can be distracting, especially for workers in an open plan office,[107] and devices such as acoustical printer covers may be needed to reduce noise levels. Changes in office layout may be necessary to reduce the isolating effects of computer work.

Air quality is a major problem in modern offices. Heating and cooling problems can be exacerbated by office equipment that generates heat, and by changes in lighting that are made to accommodate VDT users.[108] Hot spots caused by concentrations of office equipment can change the way the building distributes air, heat, and cooling, and make indoor air pollution and thermal discomfort worse. It is recommended that in refitting a building for extensive office automation, the building be remodeled as a set of microzones composed of comparable offices with localized control of the heating, cooling, and ventilation system.

Workstation Design

The workstation includes the table or desk holding the terminal, the chair, and the equipment that an operator users. In many offices these have not changed, and the microcomputer merely replaces, or even sits next to, the typewriter. Yet several characteristics of the VDT[109] differ from conventional office technologies and impose different physical demands on the worker:

- The terminal is self-luminous.
- There is a transient display on the screen, whereas the display in printed text is constant.
- VDTs usually have highly specular curved glass surfaces that reflect light.
- Information is presented in a vertical plane as compared to the horizontal plane of paper or the angled plane of the typewriter.

In conventional offices the illuminance has been kept high for reading, with other light sources, such as windows, contributing to the illumination. For VDT work, much lower illumination is best.[110] But the worker often looks back and forth from the VDT to printed text and other equipment, so a compromise is required; task lighting (lamps) can be used for additional illumination where needed. Tradi-

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[105] In one study, "Office Research Into Buildings and Information Technology (ORBIT)" it was found that new information technology only increased the secretaries' space requirements by 50 percent (Duffy, Eley, Giffone, and Worthington—Architects, *ORBIT Report, 1983).*

[106] "It has generally been argued that open space offices are most beneficial to workers doing repetitive and boring tasks; they provide needed social stimulation. Alternatively, people doing creative work require private space. However, this has recently been challenged by researchers who have found that even workers with boring and repetitive jobs prefer private spaces to open spaces and giving it to them increased their job performance (E. Sundstrom, et al., "Privacy at Work: Architectural Correlates of Job Satisfaction and Job Performance, *Academy & Management Journal,* vol. *23, 1980,* pp. 101-1 17).

[107] "wit is generally estimated that a workstation and operator can generate 18.0 Btu/square foot of heat throughout a building. For discussion of these problems see American Society of Heating, Refrigerating, and Air-Conditioning Engineers, *ASHRAE Standard 62-73. Standards for Natural and Mechanical Ventilation (New* York, 1973); *ASHRAE Standard 55-1981. Thermal Environmental Conditions for Human Occupancy (New* York, 1981); *ASHRA Standard 90-75. Energy Conservation in New Building Design (New* York, 1977); and *ANS1/ASHRAE Standard 62-1981. Ventilation for Acceptable Indoor Air Quality (New* York, 1981); also Ventre, op. cit.

[108] "'The discussion of VDTS usually is about the monochromatic raster scan CRT, which is like a television screen with some additional electronics. Other kinds of VDTS that may be much more common in the future are the plasma panel, liquid crystal, and electroluminescent displays. See App. A for descriptions of the technology.

[109] "('The American National Standards Institute recommends a general lighting level of 750-1600 Iux for traditional desktop reading; other groups recommend no more than 200 Iux for rooms where VDTS are used. *American National Standard Practice for Office Lighting, ANSI A132.1 (1973);* AT&T Bell Laboratories, *Video Display Terminals: Preliminary Guidelines for selection, Installation, and Use (1983);* NIOSH, *Potential Health Hazards of Video Display Terminals (1981).*

tional office and office furniture design assumes a depressed line of sight, but the vertical position of the VDT brings windows, ceiling lights, etc., into the line of sight, causing glare. The reflective surface of the screen can also contribute to eye strain.

On a VDT the display is transient and there is a characteristic flicker (assuming that the VDT is a cathode ray tube) which is often imperceptible to the worker, but can probably lead to visual fatigue and asthenopia although it has not been linked to visual performance. [111]

The readability of the screen is also related to the structure of the dot matrix used to create characters, the contrast between the characters and the background, and the viewing distance of the person from the screen. Increases in the size of the matrix have been shown to increase reading performance, [112] but this is not within the control of the user or, generally, the purchaser. The contrast between characters and screen can be controlled by the user, and should be placed for ease of use. The fonts used in VDTS are chosen by engineers for convenience in design, and are less easy to read than print fonts evolved through years of practical experience and user preference. [113] They assume a set viewing distance between viewer and screen, but some people lean back in their chairs and put the keyboard on their lap or in other unlikely places.'" This is especially likely when the worker has such a small table or desk that cannot hold documents as well as the keyboard and screen. Many office furniture designers have evidently not realized that office workers frequently use both paper and a terminal in the same task. The visual and musculoskeletal strain that can result from the wrong viewing distance is best managed by providing fully adjustable equipment so that each user can adapt the workstation design to fit his/her own needs. A tiltable screen and adjustable desktop can solve many problems.

Photo credit Optical Coat/rig Laboratories Inc

One way to control glare and enhance readability is to use a filter

The keyboard is likely to remain the dominant input technology for most office workers;[115] keyboard work has been associated with carpal tunnel syndrome and cervicobrachial syndrome. The physical characteristics of the

[111] If the refresh rate is at least 65 flashes per second, there is no perceptible flicker; VDT refresh rates are about 30-70 Hz. Television set flicker has occasionally been associated with photosensitive epileptogenic seizures, but the refresh rates known to induce such seizures are low, from 8-14 Hz. It is thus highly unlikely that such seizures would be induced by VDT work.

[112] A 14-percent increase in reaction time and a 10-percent decrease in errors was shown in a study by Haubner, et al., *Visual Display Units–Characteristics of Performance,* Commission on International Lighting, 20th sess., 1983, as reported in Bergqvist, op. cit.

[113] 'National Academy of Sciences, op. cit.

"For further discussion see E. Grandjean, W. Hunting, and M. Pidermann, "VDT Workstation Design: Preferred Settings and Their Effects, *Human Factors,* vol. 25, No. 2, 1983, pp. 161-175,

[115] 'The usual QWERTY keyboard dates back to the 1870s, and was recognized as an international standard in 1966 although it has been challenged by the Dvorak keyboard, with a different arrangement of the keys. Some studies indicate the Dvorak would improve typing speed by 25 percent and shorten the time needed to learn to type. It was designed (after World War II) to avoid excessive wrist movement by locating the most commonly struck keys in the center row, possibly reducing musculoskeletal strain, There is currently a resurgence of interest in the Dvorak, but both employers and employees are seemingly unwilling to undertake the retraining that would be necessary to make the change. See Jan Noyes, ' 'The QWERTY Keyboard: A Review, *International Journal of Man-Machine Studies,* vol. 18, 1983, pp. 265-281.

keyboard associated with precursors of these syndromes, such as its height, can be altered. Some keyboards are attached to the terminal and resemble the typing keyboard in height from the table (generally over 40 mm); others are detached and built lower, which has many advantages since a determinant of musculoskeletal symptoms in forearms and wrists is the ability to intermittently rest the arms or wrists on the table.[116] A detachable keyboard can also be arranged for comfort and viewing distance.

Chairs are critical to the comfort of any office worker; and with office automation people tend to spend longer blocks of time in one place. The chair should allow one to change the seated posture without adopting an awkward position; 117 and it should be easily adjustable. To prevent lower back problems, office chairs should have an adjustable lumbar back support and the back rest height should extend beyond the lumbar region to the thoracic region and be adjustable for height, angle, and pressure. The seat should also be adjustable to allow people of different sizes to get about a 90-degree angle between upper body and thighs.

Table height is also important. If used alternately by several workers it should be easily adjustable to accommodate different heights. Desks should not restrain knee and thigh movement, and should have enough space for working documents, screens, and keyboards to be moved around.

One of the most important elements of office design strategy is to make sure that office workers understand why adjusting lighting, furniture, and temperature controls is important, and how to do it.[118] A Finnish study found that if data-entry workers were trained to recognize ergonomic problems and prevention strategies, the level of clinically recognized

Photo credit: Michael Smith

When tables and/or chairs are not adjustable, the user sometimes must assume awkward postures. This woman may eventually develop neck cramps from continually looking down

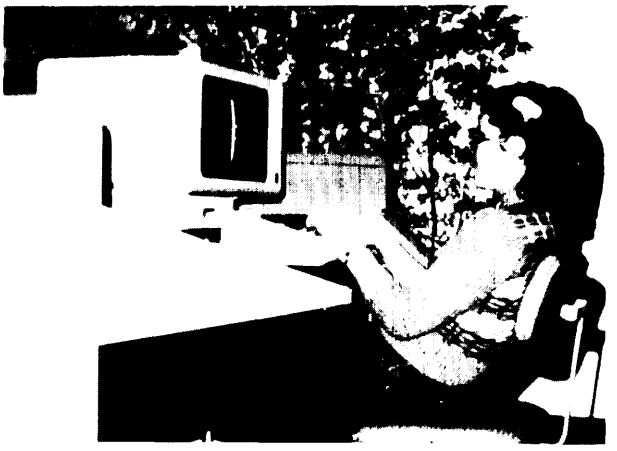

Photo credit Michael Smith

Sometimes the worker finds her own way to sit comfortably

"''Operators may not prefer suggested optimal keyboard heights and their preference may not affect performance. Teresa Burke, "Effects of Keyboard Height on Typist Performance and Preference, " *Proceedings of the Human Factors Society,* 28th Annual Meeting, 1984, pp. 272-276. See also Grandjean, op. cit.

" Most keyboard operators maintain an erect posture for only 2 to 3 minutes at a time. Standards and recommendations are usually based on this position, even though studies show that people prefer leaning slightly forward or slightly backward.

[118]"This has in fact been mandated in the OSHA Act (Sec. 21c), which says that the Department of Health and Human Services must provide for "the establishment and supervision of programs for the education and training of employees and employers in the recognition, avoidance, and prevention of unsafe or unhealthful working conditions,

neck, shoulder, and elbow problems was significantly reduced over a 6 month period.[119]

Public Policy and Quality of Worklife

Public policy interventions must be considered in light of both the scientific evidence and the political and economic climate. Many organizations look to new technologies to provide them with the competitive edge, and some argue that health and safety regulations inhibit the full use of new technologies and further innovations. A report issued by the President's Commission on Industrial Competitiveness recommended that no new health and safety regulations be established; society should not seek to eliminate risk, and risk below minimum levels should be left unregulated, or to industry self-regulation.[120] Executive Order 12291 (1981) provided that except where expressly required by law, the costs of a regulation should not exceed its benefits. This must be considered in discussion of the potential effects of office automation. Cooperative actions by employers and employees, when they are sought in good faith and are successful, are in theory a more cost-effective strategy than regulation because they can be self-enforcing.

Investment tax credits have encouraged the adoption of capital-intensive technology to improve the efficiency and productivity of the work process, yet often working conditions that emerge from this technology adoption produce adverse stress responses.'" Tax policies can also directly affect the way physical characteristics of the office are designed. For example, some experts suggest that technicalities in the way depreciation is allowed have encouraged open plan offices so that partitions separating office spaces can be depreciated. In developing standards or guidelines, current tax codes should be examined to ascertain that they will not act as a barrier to intended change.

Workers' Compensation

Under common law, employers have a duty to exercise reasonable care in protecting their employees from harm in dangerous situations. Remedies under the common law of torts have been proposed for many health and safety problems.'" But in the United States, the laws creating workers' compensation generally make this system the exclusive remedy for employee disability, [123] although in many instances this exclusionary principle has been circumvented by third-party liability suits in which the employee sues the manufacturer of equipment or material (e.g., the thousands of suits against Johns Manville as the producer of asbestos materials).

Workers' compensation does not cover spontaneous abortion, miscarriage or birth defects, since this class of injury does not impair the

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' 'R. Kukkonen, et al., "Prevention of Fatigue Amongst Data Entry operators,'" unpublished manuscript. Using a quasi-experimental design, the researchers were able to demonstrate significant decreases in neck and shoulder symptoms, back symptoms, and clinically defined neck' shoulder tenderness and hardening.

" 'Report of the President's Commission on Industrial Competitiveness, as cited in *The Occupational Health and Safety Newsletter*, vol. 15, No. 5, p. 3, 1985.

'- Michael Beer and James W'. Driscoll, "Strategies for Change, " *Improving Life at I! 'ork*, op. cit. 1977, pp. 364-453.

-"These typically fall into three categories–negligence, product liability, and strict liability. In negligence actions, the employee must demonstrate that the employer was negligent ir. the maintenance or inspection of equipment or did not adequately warn the employee about risks inherent in its use. These actions must be shown to cause proximate harm to the employee and not to be a part of normal dangers inherent in the job. Since it is very difficult to demonstrate a causal link between VDT use and any adverse health outcome, this area of legal action has limited utility. The same analysis can be applied to product liability and strict liability?'. William Presser, *Handbook of the Law of Torts,* 4th ed. (St. Paul: Wrest Publishing, 1971).

"Workers compensation is a broad disability>. insurance program in which awards based on loss of earning power are paid to workers whenever they are injured on the job, Under workers' compensation the employee must establish that the condition arose from employment. (Typically the terms proximate cause, producing cause and contributing cause are used to refer to the relationship between the working conditions and the injury or disease.) Where a claim is upheld, a schedule of payments is set up for the worker based on some formula that determines the extent that the worker is disabled or suffers a decrease in wage-earning capacity. The clear intent of the statute is to compensate all work-related injuries. (This section draws on the work of the National Council on *Compensation* Insurance report, *Emotional Stress in the11'orkplace–,NTeu. Legal Rights in the Eighties, New* York, 1984.) When an injury is found to be covered by a workers' compensation act, it is usually held that the statutory compensation is the exclusive remedy and any recovery at common law (tort law) is barred. (Presser, op. cit.)

worker's earning power.[124] It has allowed for compensation for stress-related diseases and disabilities along with visual and musculoskeletal system injuries. Table 5-11 contains three examples of workers' compensation claims for injury in automated workplaces. The worker must show a causal link between work in an automated office and the injury. Currently, for the VDT operator there is very little direct causal evidence for visual and musculoskeletal injuries and for stress-related injuries. Where an organic cause can be found to explain the injury the claim is easier to interpret. Thus, demonstrating that some characteristic of the automated office environment led to a biological change in the worker is the clearest vehicle for establishing a compensation case. These conditions while impairing the worker's ability to work, may not be medically detectable, so the primary instrument for identifying illness and injury to the office worker is through the reporting of symptoms. Thus, it is difficult to demonstrate proximate cau - sality.

If the condition predated employment or was aggravated by conditions outside the job the claim may be disallowed or the compensation reduced. For the VDT operator who goes home and watches television (also a cathode ray tube~ or has personal problems that produce adverse stress responses, it is difficult to argue that the work was the source of the injury, although workers who spend over 7 hours a day at a terminal may make such an argument effectively. In addition, many chronic debilitating visual and musculoskeletal injuries do not occur suddenly and unexpectedly, so that claims are likely to be awarded only in States that accept gradual developments of an injury over time.

The workers' compensation system was meant to also serve as a preventive measure; forcing employers to pay for injuries and diseases arising from employment should encourage them to develop preventive strategies. Emerging office problems may develop into compensatable disabilities, but the current work force would not benefit from the incentives for prevention created by the rise in compensation claims. Yet today's employee cannot sue the employer in most States through the common law of torts since visual, musculoskeletal, and stress-related conditions are compensable.

Mental Disability.–There has recently been an increase in workers' compensation claims related to mental stress. The California Worker's Compensation Institute found that stress claims doubled from 1980 to 1982, while claims for other disabling work injuries decreased during the same period.[125] Workers' compensation for mental disability arising from employment is greatest among younger workers, as shown in figure 5-3. Mental stress is significant by itself, and may also predict future development of stress-related diseases. If it does, any increase in claims because of office automation could be costly to society. Table 5-12 provides several examples of successful workers' com-

[124] John Parry, Jeanne Dooley, David Rapoport, and John Taylor, "Are VDTS Hazardous to Your Legal Health?" *Mental and Physical Disability Law Reporter,* vol. 8, No. 4, 1984 pp. 342-360. For a more complete discussion of the workers compensation system and its evolution see *Reproductive Hazards in the Workplace,* op cit.; or Peter Barth and H. Allan Hunt, *Workers' Compensation and Work-Related Illnesses and Diseases* (Cambridge: MIT Press, 1980).

[125] California Worker's Compensation Institute, *Bulletin,* Apr. 20, 1983.

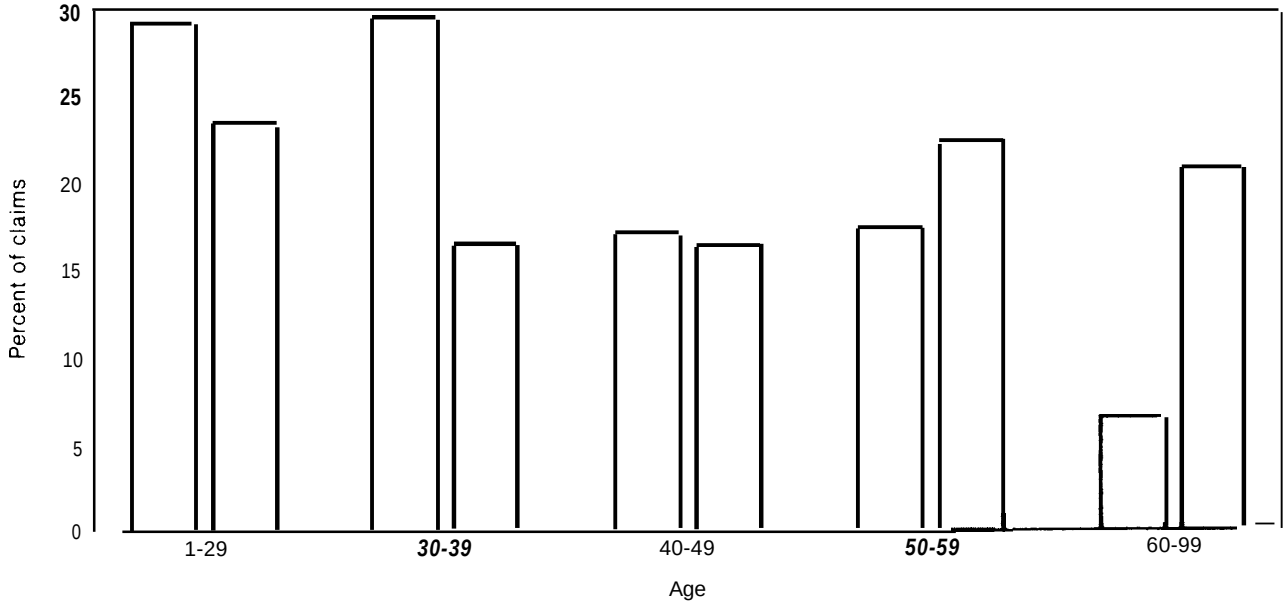
Table 5-11.—Workers' Compensation Claims for Employees Working at Video Display Terminals

Job	Problem	Injury
Word processing	Stress of 6 to 8 hours VDT work per day	Nervous breakdown[a]
Insurance claims processor	Repetitive work at VDT lead to wrist pain	Carpal tunnel syndrome[b]
Word processing	Severe headaches Sensitivity to light Visual pain	Accommodative spasm[a]

[a] Settled prior to judgment
[b] Claim awarded

SOURCE *Legal Rights for VDT* Users (Cleveland OH Working Womens' Educational Fund, 1985)

Figure 5-3.—A Comparison of Workers' Compensation Claims for Mental Stress and Other Occupational Diseases



SOURCE National Council on Compensation Insurance *Emotional Stress in the Workplace— New Legal Rights in the Eighties* (New York 1985)

Table 5-12.— Examples of Mental Stress— Mental Disability Claims for White-Collar Workers

Occupation of clalmant	Alleged work-related mental stress	Alleged mental disability
Advertising manager	Overworked, supervisor requested–ea-rly retirement	Anxiety, depression
Clalms director	Job pressures	Psychiatric illness
Data analyst/control clerk	Inability to perform job duties	Psychological disability
Insurance underwriter	Increase in job duties	Mental breakdown
Secretary	Increase in job duties	Depressive neurosis

SOURCE *Emotional Stress in the Workplace— New Legal Rights In the Eighties* (New York National Council on Compensation Insurance 1984)

pensation claims for mental disability, showing the variability in both the alleged cause and the disability. The workers' compensation system can be considered as an early warning system for the effects of office automation on the mental health of the worker.

Claims for mental stress and mental disability decrease with increasing age and are greater among women than men. [126] This could be the result of a cohort effect; younger workers are probably more likely to demand rights in the workplace than are older workers. It also corresponds to the trend of increasing automation of the workplace that affects younger workers. Since a majority of the claims have been filed by women (54.2 percent), it may be logical to infer a relationship with the recent technological changes; the workers first affected by office automation in the 1960s and 1970s were predominantly women. [127]

[126] These results are based on a random sampling of claims from 1980 to 1982 in 13 States representing geographic variability. The study is described in National Council on Compensation Insurance, op. cit.

[127] It has been suggested that the highly publicized mental disability claims associated with stress may lead to a greater reporting and filing of similar claims. It may be that the legal recognition of mental disability claims has led to an increase in the number of claims. This is important in mental stress claims because of the universality of stress across all occupations.

Indemnity costs for gradual mental stress claims were less than 60 percent as high as the costs for other occupational diseases per average claim in 1980, but surpassed these claims in 1982. Also, the average medical costs incurred for gradual mental stress claims passed other occupational diseases in 1981.[128] Mental disability awards could become an economic burden for industry.

If workers attribute their adverse stress responses to the VDT and workers compensation claims become a common avenue for compensation, then the system may become overburdened, with the employer becoming a universal insurer. The workers' compensation system is at a crossroads in determining whether a worker who is unable to work because of mental disability is to be treated differently from a worker unable to work due to a physical injury arising out of employment.

There have been relatively few compensation claims specifically related to work at a VDT (about 30), most for physical injury bul: some for mental injury. In one case a VDT operator claimed that the VDT contributed to an already high-pressure atmosphere, leading to three stress reactions during a 7-month period. Her claim was upheld by the New Jersey workers' compensation board.

There seem to be three compensable categories of mental stress. The stress response as a usual condition of the work environment is perhaps the most liberal and far-reaching of the categories. The recognition that gradual accumulation of mental stress is a cause of the mental disability is important since many stress responses in offices result from the incremental or chronic conditions of work rather than from any single acute event. Second, the stress responses can result from a continuing set of unusual conditions in the work environment, for example, an increase in job duties because of new office technologies, Third, the stress reaction can be due to a suds den and unusual event in the work environment, for example, the witnessing of a coworker's heart attack. The only condition under which this could be associated with office automation is if the technological change itself were construed as a traumatic event. Perhaps an acute fear of being exposed to a terminal that purportedly emits hazardous radiation could lead a person to an episode of mental disability. [129]

Fifteen States have no relevant statutory limitations. Seven State courts have concluded that mental disability is to be treated no differently than physical disability if working conditions are the cause of the disability; nine have ruled mental disability is not compensatable. Most of the States that have taken the position that mental disability claims are not compensable have strictly interpreted the statutes defining injury to be of a physical nature. Eight States have adopted the idea of an acute event in employment as proximate cause. They allow mental disability claims when there has been some traumatic event that can be identified as the proximate cause of the disability. Eleven States have upheld the right of the worker to claim a mental disability if the stress exceeds the stress of everyday work. In these States, there have been cautions about limiting the scope of the compensation system to avoid the development of a social health insurance program.

The Federal Government acted first (1908, 1916) to establish workers' compensation for Federal railroad and then for other employees. [130] Since then, the workers' compensation system has evolved at the State level relatively without Federal interventions, although there have been proposals from time to time to create a Federal system. One role the Federal Government might play is to serve as an information clearinghouse for issues of office automa-

[128] National Council on Compensation Insurance, op. cit., p 6.

[129] This is analogous to the idea of a pollutant on the job, where the effects of the pollutant are unknown. The Montana Supreme Court has allowed such a compensation to be awarded to a worker who developed psychological problems on exposure to pollutants at work (*McMahon* v. *The Anaconda Company, No. 81-34* (Montana Supreme Court, Mar. 29, 1984), 8 MPDLR 291).

[130] M.B. Kent, *A History of Occupational Safety and Health in the United States, 1983,* as cited in *Preventing Illness and Injury in the Workplace,* op. cit.

tion and stress responses, to provide States with the most recent scientific evidence for making decisions. Clearly, automation is the dominant change in office work and many mental disability claims in the next two decades are likely to revolve around the effects of the new office technologies.

Standards or Guidelines

Since ergonomic factors in office equipment are important to the health of the American worker and the productivity of American business, there have been proposals that ergonomic standards or guidelines be developed, either by government or other institutions. '3' A recent discussion of regulatory policy pointed out that health and safety regulations should focus on threshold limit values on exposure as oppposed to means for reducing exposure such as design standards.[132] Standards can only be developed with the appropriate measurement techniques.[133] Working conditions that produce adverse stress responses can be measured in many different ways and scientists disagree on which ways are best. Therefore, the development of standards for working conditions that produce psychological and biological stress responses in individuals may be an option to consider only when there are valid and objective measures of the working conditions. [134]

Any standards development process would have to consider issues raised in the recent benzene standard case decided by the U.S. Supreme Court and the noise standard case decided by the U.S. Circuit Court of Appeals in Richmond, Virginia, which exemplify the impact judicial decisions may have on occupational health and safety policy. In the noise case the judges invalidated a standard on the grounds that it might on the basis of medical examiniations require employees to take actions concerning hearing loss caused by nonoccupational factors.[135] While progressive hearing loss can be identified through medical exams, the exams can not distinguish between loss resulting from occupational and nonoccupational sources of noise. The ruling has been reversed by the same court. If upheld, it would have probably severely restricted the development of Federal standards for automated offices where most exposures are chronic and confounded by nonoccupational factors.

The Supreme Court in 1980 upheld an earlier lower court decision striking down the 1978 OSHA benzene standard. They found (5 to 4) that OSHA had not established a threshold limit for benzene posing a significant risk to the worker. The Secretary of Labor must demonstrate that a workplace threatens the worker with a significant risk of harm.[136] Although providing limited guidance as to what significant risk means or how it should be calculated, the Supreme Court decision has demanded a more rigorous scientific treatment of occupational safety and health standards. 37 The setting of standards designed to improve the health and well-being of the office workers would have to take into account this decision.

However, standards can be developed and adopted voluntarily .There are three general types of standards; engineering, informational, and administrative. Engineering standards (which include design standards) establish alternative means of interfacing with the technology or alternative means of building the technology to ensure the health and safety of

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' "In 1981, the Science and Technology Committee of the House of Representatives held hearings, "The Human Factor in Productivity. These hearings are the most recent attempt to gather information about the role of human factors in industrial competitiveness (see, *The Human Factor in Innovation and Productivity,* U.S. House of Representatives, Committee on Science and Technology, Subcommittee on Science, Technology, and Research, 97th Cong., 1st sess., 1981).

"[L]Douglas H. Ginsburg, "Administrative Efforts to Enhance the Opportunities for Self- Regulation," *Labor Law Journal, vol. 3,5,* No. 12, 1984, pp. 731-735.

[133]Becker, op. cit.

' "Edward E. Lawler, "Should the Quality of Work Life be Legislated?" *The Personnel Administrator,* vol. 21, No. 4, 1976, pp. 17-21. See also, Edwin A. Locke, "The Case Against Legislating the Quality of Work Life," *The Personnel Administrator,* vol. 21, No. 4, 1976, pp. 19-21.

' "Reported in the *Occupational Safety and Health Letter,* vol. 15, No. 1, 1985, p. 2.

[135]"Industrial Union Department, *AFL-C1O v. American Petroleum Institute,* 448 U.S. 607 (Supreme Court, July 2, 1980).

For a full discussion of the implications of this decision for OSHA standards setting see, *Preventing Illness and Injury in the Workplace.* op. cit.

the worker. Informational standards include product labeling, instructions for proper use, and other means of transferring information from the employer or manufacturer to the worker. Administrative standards establish organizational policies such as rest breaks. A key policy issue is how to ensure that the standards development process is based on sound scientific evidence. [138]

Design Standards.—The possibility of office and workstation-design standards has received much attention, spurred on by bills introduced into at least 18 State legislatures, and by the development of standards in other countries. The Governor of New Mexico has issued an executive order (No. 85-1 1) mandating ergonomic guidelines for State employees. Such proposals and actions are based on the assumption that there are definable and measurable characteristics of both the office and the workstation that, if modified, will improve health and worker performance. A major issue is whether standards should be voluntary or required-self-regulation or governmental regulation. It is argued that self-regulation is more flexible, and standards can be tailored to meet the specific office automation application. However, a second question is whether many organizations would voluntarily pay the front-end, or retrofitting cost that might be entailed. [139,]

Another issue is that of fairness; standards development committees composed of special interest groups are often suspect. Especially in promulgating mandated standards, balanced groups of consumers, producers and other affected parties may be preferable for the development and enforcement of standards.[140] A major impetus for currently proposed State bills is a concern over the inadequacy of voluntary standards for these reasons. One option at the national level would be to establish a national commission to oversee standards development or to empower the National Bureau of Standards with such duties.[141]

A third problem is that of the appropriate level of specificity for design standards. The level of specificity in State bills varies widely, indicative of the uncertainty as to the most effective way to modify the work environment to accommodate new office technologies.[142] International standards reflect differing approaches, different populations, and different goals. The very specific German standards are meant to standardize the building and production of office equipment, while Swedish standards are more like guidelines to be used in negotiation between the unions and management. Japanese guidelines are not binding and are very general.

Other major issues in standards development are how to define enforcement mechanisms for government standards and how to ensure that the development of standards spurs rather than impedes the development of more protective technology in the future. Standards can be established at either the Federal, State, or organizational level by the use of procurement schedules.[143] California, New Mexico, Massachusetts, and Wisconsin have all developed procurement guidelines for the purchase of workstation equipment in the public sector.

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[138] An examination of the currently proposed office standards for State bills demonstrates problems in the standards development process; general lighting levels vary from 500 lux or less to greater than 700 lux. International standards also do not agree. There is no general national or international consensus on the best way to establish standards for office automation. The lack of consensus may reflect the generally agreed need to maximize flexibility in current design to accommodate a variety of future needs. This need for flexibility is clearly reflected in the mechanisms for controlling glare in proposed State bills, which range from installing indirect lighting; to antiglare filters; to proper placement of the terminals with respect to windows; to task lighting; to screen hoods.

[139] Francis Ventre, "Transforming Environmental Research Into Regulatory Policy, " *Responding to Social Change,* Basil Honikman (cd.) (New York: Halstead Press, 1984).

[140] Ginsburg, op. cit.

[141] Currently, the National Bureau of Standards coordinates within the Federal Government and assists the private sector in the procedures and policy for the development and application of standards; however, they have no enforcement powers.

[142] Currently, the Human Factors Society in conjunction with the American National Standards Institute is developing a set of standards for the physical and perceptual ergonomics of visual display terminal workstations. These standards contend that ergonomics is highly applications dependent and looks only at word processing, data-entry, and data-inquiry tasks.

[143] O. Ostberg, et al., "Ergonomic Procurement Guidelines for Visual Display Units as a Tool for Progressive Change, " *The Proceedings of the Eleventh International Symposium on Human Factors in Telecommunications*, Sept. 9-13, 1985, Cesson-Sevigne, France.

Information Standards.—These might provide the employee and employer with information about, for example, the recommended lighting levels for using a particular display terminal. Rhode Island has just passed a law requiring the State Department of Labor to develop a brochure on VDT use and to hold training sessions throughout the State.

Health and Safety Standards.–They are administrative standards. At the Federal level, an initial policy consideration would be to decide whether they should be developed within a single agency or by several agencies. The former would eliminate replication, while the latter would ensure that all areas are covered. Currently, OSHA, the Consumer Products Safety Commission (CPSC), and the Department of Health and Human Services (DHHS) can develop standards that might be adapted to address new office technologies. For example, the OSHA Health Hazard Communication standard is intended to disseminate information about chemical health hazards and only applies to the manufacturing sector. For OSHA to disseminate information about health and safety issues in office automation under the Health Hazard Communication Standard, that authority might have to be broadened. [144] Alternatively, the recently proposed High Risk Occupational Disease Notification and Prevention Act of 1985 (H.R. 1309), would establish within NIOSH the authority to disseminate information to persons at an elevated risk for the development of disease. Only workers at an elevated risk will receive counseling and medical monitoring. The disadvantage to this approach is that it requires prior knowledge about the development of the disease and the risk to the worker. A broader approach is to provide information to all employers and employees so that the factors associated with health and safety can be discussed before the equipment is installed. This would require input from many sectors of the Federal Government.

Eye examinations, rest breaks, semiannual equipment inspections, and transfers for pregnant VDT operators could be handled through administrative standards. Several countries have standards or guidelines regarding visual exams. [145] Legislation calling for rest breaks has been proposed in several States, and several nations have guidelines or standards with respect to rest breaks.[146] Although Sweden's practice of 15 minute rest breaks after every hour or 2 hours (depending on the work) is often cited, this is not a national standard but results from agreements between labor organizations and management. This will change with the issuance of the *Ordinance Concerning Work With Computer Displays*. [147] This ordinance requires that employees who work more one-half hour consecutively on the VDT on a daily basis, must receive eye exams. In Britain, the Health and Safety Executive recognizes that "the most satisfactory length of pause can only be determined by consideration of the individual operator's job ... , [148] and recommends that natural breaks be built into jobs, with a mix of VDT and non-VDT work; goals are provided to be used in labor-management bargaining.

Guidelines.–The examples above point to the problems of standards development, which is both a scientific and apolitical process. Communications between the scientific and political communities are sometimes lagging and mechanisms for encouraging more dialog are needed.

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[144] "A recent court decision suggested that OSHA expand the scope of the standard to include nonmanufacturing industries, U.S. Court of Appeals, 3rd Circuit, Case No. 83-3554.

[145] Japanese provisional guidelines for VDT work call for a visual exam as part of the preemployment medical exam, with regular eye tests thereafter. West German regulations say that VDT workers should have eye exams every 5 years until age 45 and every 3 years thereafter. In France, two regulations stipulate eye exams and special medical surveillance for VDT users. But Great Britain does not recognize the need for visual standards for VDT usage "which are any different from other clerical work."

[146] "Two Swedish standards call for periodic intermissions without specifying length or frequency?": Japan provisional guidelines call for at least a 10-15 minute break after each hour of VDT work.

[147] "*Ordinance Concerning Work With Computer Displays*, translated by Dr. Olov Ostberg. This ordinance has not gone into effect yet.

[148] "Great Britain, Health and Safety Executive, *Visual Display Units* (London: Her Majesty's Stationary Office, 1983), p. 13.

An alternative to mandated standards is the development of guidelines articulating goals. Both Sweden and Japan have established goals for workstation design. In Japan, these are wholly voluntary; in Sweden the guidelines are presented as the government's position and are used in collective bargaining. Guidelines recognize the variability yin the way office technologies can be implemented. They can be established within the broader context of an institutionalized change process. In some countries this is environmental legislation; 149 for example, the Work Environment Act of Norway (1977) says, "An effort shall be made to avoid monotonous repetitive jobs and jobs which are determined by a machine . . . to such an extent that the worker is prevented from altering his rate of working. " Such acts give those involved in the change process a national policy against which to evaluate their efforts. Such goals and guidelines are only as effective as the commitment on the part of employers and employees to cooperatively achieve them, and on the part of government to monitor and actively encourage their progress.

Research Needs

Congressional hearings have addressed the issue of possible hazards of VDT work,[150] and much has been written on the subject, but workers still wonder if new technology is dangerous. A possible public policy response is to encourage research on various illness and disease outcomes associated with the computer mediation of work, both to answer the questions in the minds of the public and to demonstrate the feasibility y of using new office technologies as both a public health and a productivity tool.

The OSHA Act (section 20) mandates continued research and demonstration projects exploring emerging problems including psychological factors (such as stress) created by new technologies. Office automation is one technological change with such a broad exposure that Congress may wish to insist that the Department of Health and Human Services put high priority on investigating the health and safety issues, demonstrating practices to reduce any potential effects, and disseminating such information.

There is a need for at least three directions in the research. The first is to follow office workers over time to develop risk estimates of the relative contribution of office automation to the natural history of a disease, focusing on those populations at greatest risk today (clerical and technical workers), and also considering the changes in the work of managers and professionals. This field research should be complemented by lab research to test relationships between working conditions and biological processes.

The second is to define the appropriate measures of the physical conditions of work. Field evidence that compares objective measures of the physical environment to subjective measures of the quality of worklife is limited. The tools for measurement must be sharpened and refined to assess the many subtle causes and outcomes characteristic of office work. If it could be demonstrated that subjective measures are valid indicators of the physical environment and discriminate the various health, performance and job attitudes, less costly evaluations of the work environment would be possible.

Third, intervention and field evaluation studies are needed to verify claims that changes in ergonomic or other working conditions can improve worker productivity and reduce health problems. These efforts should focus on high risk groups of office workers or identify high risk working conditions and develop modification strategies.

"[L]"Federal Republic of Germany: The Works Constitution Act of 1972; The Netherlands: Working Environment Act of 1980; Norway: Work Environment Act of 1977 (also known as the Act Respecting Workers' Protection and the Working Environment); Sweden: Working Environment Act of 1974; Denmark: Act Respecting the Working Environment; German Democratic Republic: Labour Code as Amended June 1977, These acts deal with all working conditions, including office automation.

"'U.S. Congress, Committee on Science and Technology, Subcommittee on Investigations and Oversight, *Potential Health Effects of VDT Terminals and Radiofrequency Heaters and Sealers,* 97th Cong., 2d. sess., May 12-13, 1981. U.S. Congress, Committee on Education and Labor, Subcommittee on Health and Safety, *OSHA Oversight: Video Display Terminals in the Workplace,* 98th Cong., 2d sess., 1984.

The Health Promotion and Disease Prevention Amendments of 1984, which establish research centers for disease prevention and health promotion across the country, administered by the Centers for Disease Control. These centers could conduct the research projects mentioned above.

Finally, it is important to know the true extent of the problem. How prevalent are poor working conditions? Section 20(a)(7) of the OSHA Act stipulates that the Department of Health and Human Services conduct industry-wide studies of the effects of chronic low-level exposures on the health of workers. This need for reliable data also points to a need for a centralized data collection system for monitoring the emerging problems. There is now no single source of this data. The current industry and occupational surveillance systems are disparate and difficult to link together. In testimony before Congress the Assistant Surgeon General noted:

> The activities do not provide a comprehensive epidemiologic surveillance of occupational diseases and injuries in the United States . . . Unless our efforts are targeted toward comprehensive data collection and synthesis, the confusion will only grow worse. [151]

The current data collection system at the Bureau of Labor Statistics (BLS) *is* not able to identify the extent of office automation in white-collar occupations. There is a need to develop not only reliable indicators of national trends in morbidity, but also broad national descriptions of those working conditions likely to place the worker at highest risk. The Job Training Partnership Act of 1982, Section 462(b) states: "the Secretary shall maintain descriptions of job duties, training and education requirements, working conditions, and characteristics of occupations. There is a need to further refine the definitions used in the Dictionary of Occupational Titles to reflect the current changes in the workplace. An early warning system could be developed by linking these data sources. [152] This would allow researchers and policy makers to estimate the relative severity of problems among different classes of workers.

Legislation recently introduced into the House of Representatives would establish an early warning system to identify workers at an increased risk for occupational disease (H.R. 1309). This bill could be amended to include language establishing a national morbidity surveillance system for the development of chronic diseases related to technological changes.

Labor-Management Relations and Office Automation

As has been pointed out, one strategy for improving quality of worklife is through standards development, and a second is the setting of goals or objectives, incorporated in public or private sector guidelines. Another way to work toward goal-directed change is through collective bargaining. In Europe, there is much emphasis on involving worker representatives in office automation planning. In some countries there is a national or local work council to which industry supplies information about office automation plans. This creates the framework for monitoring how well organizations are moving toward established goals, minimizing the need for government enforcement. [153] This process of involving workers in technology planning is part of a process called co-determination, a phrase that has gained some popularity in this country.

While the legal right to be kept informed about technological change has not been ex-

[151] Assistant Surgeon General J. Donald Millar, cited in *Occupational Illness Data Collection: Fragmented, Unreliable, and Seventy Years Behind Communicable Disease Surveillance,* U.S. Congress, Committee on Government Operations, House Report 98-1144 (Washington, DC: U.S. Government Printing Office, 1984).

[152] "For the importance of linking databases to inform policymakers, and current impediments see, *Legal and Administrative Impediments to the Conduct of Epidemiologic Research,* Task Force on Environmental Cancer and Heart and Lung Disease, 1984.

[153] Federal Republic of Germany: Works Constitution Act of 1972; The Netherlands: Works Council Act of 1979; Norway: Work Environment Act of 1977; United Kingdom: Employment Protection Act of 1975; France: Act No. 82-915 of Oct. 28, 1982 and Act No. 82-689 of Aug. 4, 1982; Sweden: Act Representing Co-Determination of Work, 1976. For further detail see *Automation, Work Organization, and Occupational Stress* (Geneva: International Labour organization, 1984).

tended to American workers, the National Labor-Management Relations Act guarantees the right to bargain collectively with management. Thus rather than intervening directly in office automation related quality of worklifc problems, the Federal government can choose to leave this to industry self-regulation, judicial decisions, and labor-management relations, with National Labor Relations Board interventions when they are called for.

Collective bargaining could function as a forum for resolving quality of worklife issues related to office automation. [154] The National Labor Relations Act (NLRA) established collective bargaining to reduce the need for government regulation by providing bargaining power to all parties.'" But the ability to use collective bargaining as an avenue for discussion of stress, health, and ergonomic problems surrounding office automation is limited by the low level of participation of office workers in collective bargaining units.

Fair representation in this process also depends on judicial decisions and National Labor Relations Board (NLRB) decisions about the scope of the law and whether a series of acts and amendments designed to deal primarily with blue-collar occupations applies equally well to white-collar occupations. A complicating factor is that in white-collar work, distinctions between management and labor tend to be blurred. In recent cases over whether a group of workers has the right to organize, the courts have been confronted with problems of determining whether professionals are workers or part of management, and who makes decisions for the employ er.[156] As office automation leads to task bundling, the distinctions between management and workers will blur further. A recent Supreme Court decision reemphasized earlier questioning of the intent of Congress in several sections of NLRA:[157] was the intent to prohibit certain types of collective bargaining over technological change? Current laws may require clarification in this regard.

While some labor contracts contain clauses concerning automation, negotiation about the decision to automate is not construed as mandatory by either NLRB or the courts. However, it is also not clear that management has an absolute right to automate. The employer does have the right to determine equipment needs and the size of the work force, and can change the nature and scope of the business, but only if it does not affect contract terms and conditions of employment. Technology bargaining has become a focus of the collective bargaining process and the extent of employee rights and employer prerogatives is decided on a case-by-case basis by NLRB and the courts.

"'There are other mechanisms through which workers can participate in organizational decisionrnaking about technological change, but they are specific to an organization or industry. There has been, for example, great interest in the Japanese system of quality control circles. One observer notes: "Predecision joint consultation to solve the problems of manpower and employment due to drastic technological changes developed around 1960, and . . . built up to become a basic part of the later Japanese industrial relations. . . . This practice often takes the place of collective bargaining in Japanese industry. Akihiro Ishikawa, "Microelectronics and Japanese Industrial Relations," *Microprocessors, Manpower, and Society,* Malcom Warner (cd.) (New York: St. Martin's Press, 1984).

In Germany, the development of Work Councils at the local shop-floor level came after World War II. These councils are separate from unions in Germany and make many decisions at the local shop-floor level. These alternatives to collective bargaining never developed in the United States to any significant degree.

[155] NLRA gives employees the right to organize and join a union. At least 30 percent of the employees of an organization must petition NLRB to have an election, and to win certification as a bargaining representative the union must win the votes of a majority of the employees. Once the union is certified, the employer is obligated to enter into collective bargaining over wages, hours, and other terms and conditions of employment to develop a contractual agreement, which typically will last 1 to 3 years. NLRB does not oversee specific contract terms, but can be asked to intervene if either party does not act in good faith. Any worker has the right to file an unfair labor practice charge if she believes constraint, coercion, or discrimination has been used.

"'Marina Angel, "Professionals and Unionization, " *Minnesota Law Review,* vol. 166, 1982, pp. 383-457.

[157] In *NLRA v. International Longshoremen Association,* AFL-CIO, et al. (Case No. 84-861, June 27, 1985), the court said "The only question thus to be decided . . . is whether Congress meant, in enacting Sec. 8(b)(4)(B) and 8(e) . . . to prevent this kind of labor-management arrangement designed to forestall possible adverse effects upon workers arising from changing technology. "

The strategy of using collective bargaining for addressing quality of worklife issues related to office automation is limited both by the relatively small number of office workers covered by union agreements and by the nature of the process; both topics are addressed below.

White Collar Unions and Worker Representation

According to BLS statistics, only 19 percent of all U.S. workers belong to labor unions and among office workers the level of unionization is much lower. About 14 percent of clerical workers belong to unions and about 17 percent are in bargaining units covered by union contracts. [158] Professional specialty workers have a higher level of unionization, 23 percent, but this reflects the large number of teachers belonging to unions or professional associations. Only 6 percent of executive, administrative, and managerial workers belong to unions. [159]

Unionization of office workers tends to follow industry lines; in industries where manufacturing workers are highly organized (see table 5-12) they are more likely to belong to unions than in other industries, such as the insurance industry, where office automation has been heavily adopted. The figures show levels of union membership for broad industry categories; the first two rows include most office workers. [160] It has traditionally been difficult for unions to organize office workers, primarily because of their close relationship with management and identification with the middle class. In every occupational category, the number of workers covered by a union or employee association contract decreased slightly from 1983 to 1984 (see figure 5-4).

The influx of women into clerical jobs may have retarded unionization,'" because they were a ready supply of low-paid workers, and have historically been slower to join unions. It has been suggested however that the changes in the office workplace brought on by office automation will increase the level of unionization among clerical workers, in those places where office work is becoming routinized and more like factory work. Alternatively, office automation can improve jobs; if unions can present themselves as mechanisms for ensuring these improvements, they may have greater appeal to office workers.

A policy question to be considered then is whether the Federal Government should take steps to encourage technology-related bargaining in labor-management negotiations, and also encourage other mechanisms to improve the opportunity for office workers to be represented in discussions about office automation.

Technology Bargaining

Traditional subjects for collective bargaining have included wages, fringe benefits, and hours. Increasingly unions are also dealing with questions of health and safety, electronic monitoring, and job security. Technological change is also a major issue, but technology is a difficult subject for collective bargaining. One recent survey found technological change provisions present in fewer than 20 percent of current agreements.[162] Labor organizations can seek to deal with technological change issues by trying to influence: 1) the introduction of new technology per se; 2) the changing nature of the jobs; 3) changes in skills requirements or status; or 4) work force reductions.

The choice of what technology to use (for manufacturing or for office work) has traditionally belonged to management, and many

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'Bargaining units cover all workers whether or not they belong to the union.

'Paul 0, Flaim, "New Data on Union Members and Their I+; arnings," to be published in *Monthly Labor Review*.

" 'Office workers are represented by a large number of unions including the Communications Workers of America, Office and Professional Employees (OPEIU), the Newspaper Guild, the United Food and Commercial Workers, the Service Employees International Union (SEIU), American Federation of Government I+; mployees (A FGE), American Federation of State, County, and Municipal Employees (A FSCME), and others. District 925 is a new nationwide office workers union formed by SE IU and Nine to Five: the National Association of Working Women, in 1981.

"'Roberta Goldberg, *Organizing Women Office Workers: Dissatisfaction, Consciousness, and Action (New* York: Praeger Publishers, 1983).

"-Cited in Kevin Murphy, *Technological Change Clauses in Collective Bargaining Agreements*, Department for Professional Employees, AFL-CIO, Publication #81-2, August 1982, p. 5.

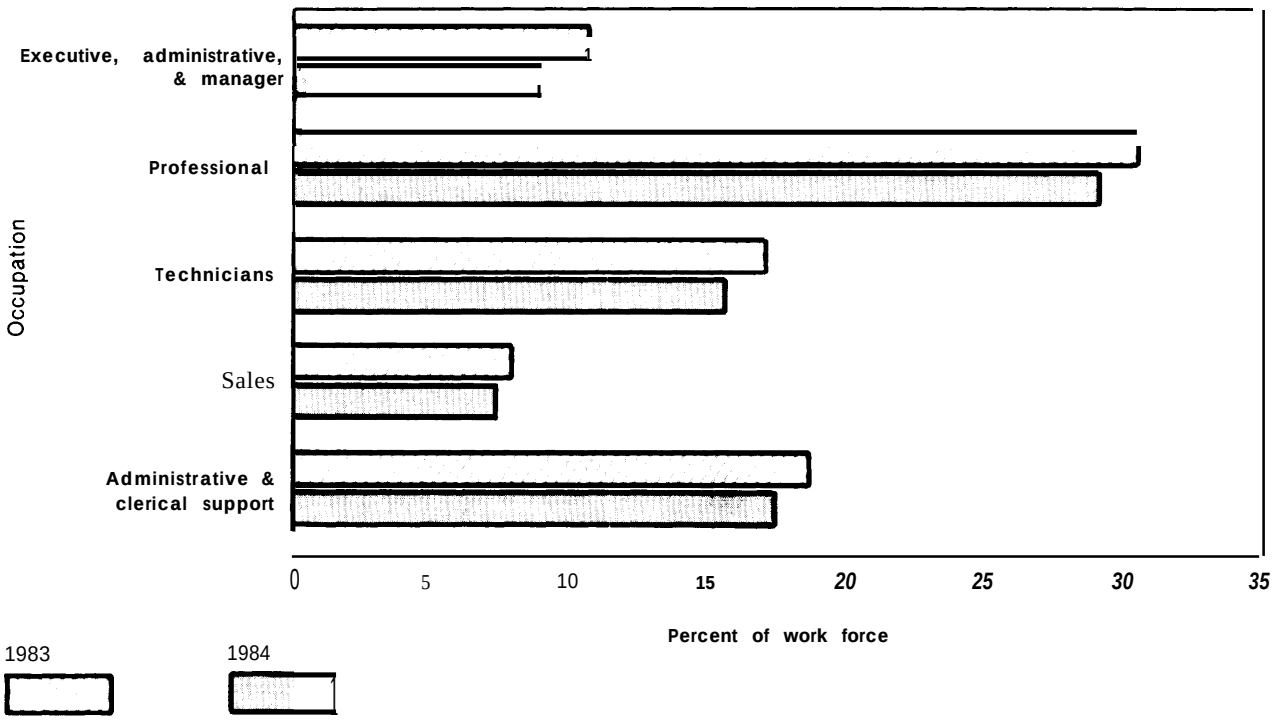
Table 5-13.—Union Membership by Industry and Occupation

Occupation	Industry								
	Total[a]	Mining	Construction	Manufacturing	Transportation, communication, utlities	Trade	Financial ~ insurance, real estate	Service	Government
All occupations	.156	17.9	24.3	26.5	396	82	2,7	72	359
Management/professional specialist	52	1.7	86	40	11 1	18	17	67	381
Technicians/ sales/administrative	80	3.3	2,9	10.4	34.8	6.6	22	5.1	302
Service	87	(b)	(b)	352	490	44	12,4	86	394
Operator/fabricator/ laborer	33.6	32.9	25,7	392	471	204	(b)	11 3	362

[a]The totals include agriculture, forestry, and fishery occupations which are not listed separately. This number includes Private sector union membership, excluding government membership
bThe data do not meet publication standards

SOURCE Larry T Adams, "Changing Employment Patterns of Organized Workers, " *Monthly Labor Review*, February 1985 pp 25-31, uses data from Current Population Survey, Bureau of Labor Statistics

Figure 5-4.—Employed Wage and Salary Workers Covered by a Union or Employee Association Contract in 1983.84



SOURCE. Paul O Flaim, "New Data on Union Members and Their Earnings, " 10 be published in the *Monthly Labor Review*

labor agreements include a "management rights clause' that gives management sole authority over "processes and types of machinery and equipment to be used, types of products to be manufactured, quality of material and workmanship required, selling prices of products . . . [163]

[163] Murphy, op. cit., p. 5.

NLRA does not specifically identify technology as a subject for the bargaining process. There has been no definitive decision on whether or not management has a duty to bargain about implementation of new technology. In the past, the NLRB has:

> . . . shown a willingness to extend the duty to bargain over the introduction of technological change to the decision making stage. The

> courts have tended to restrict the duty, requiring only that the employer bargain with labor over the effects of its unilateral decisions . . . [164]

In recent years, both the NKRB and the Supreme Court have tended to favor management prerogative to effect unilateral change. Yet, a recent Supreme Court decision has partially countered this trend. In a decision regarding the longshoremen, the Supreme Court ruled that:

> Elimination of work in the sense that it is made unnecessary by innovation is not of itself a reason to condemn work preservation agreements . . . ; to the contrary, such elimination provides the very premise for such agreements. [165]

Modified forms of the management rights clause have given the union or the employees right to advance notice of technological change and in some cases the right to consultation in the change. While there is no single blueprint, advance notice and joint consultation seem to be the hallmarks of building a cooperative dialog between labor and management; they reduce opposition and resistance to the change. [166] The Communications Workers of America (CWA), in its agreements with AT&T and the Bell operating companies, has negotiated the right to advanced notice. [167]

Consultation might in rare cases mean participation in the planning and implementation of technological change, but more often it means the right to negotiate about the adjustment mechanisms that will accompany the change, for example, layoffs or retraining.

In Europe, advance notice and the provision of information are usually the first steps in collective bargaining agreements. [168] Advance notice typically means that management must give the workers and their representatives enough time to consult, negotiate, and prepare for the changes. Implementation of the new technology can be made contingent on a collective bargaining agreement. Some agreements specify that the employee be involved in any job redesign.[169]

Close cooperation of unions and management in planning automation systems is rare. The NLRA precludes any person acting in the interest of the employer from being a member of the union. '70 Historically, this has meant that supervisors were excluded. Therefore, if decisions of the planning of technological change are construed to be employer or managerial decisions, union members may be precluded from actively participating in some stages of the decisionmaking.

One policy question for Congress to consider is whether the NLRA needs revision so that the traditional boundaries and relationship between labor and management does not prevent a cooperative planning process.

Cooperative planning is not easy to achieve. Union leaders may be uninformed about technological choices, long-term company, plans or industry conditions. Management decisions may be made at the national headquarters while labor negotiations may take place on a regional basis. Even in Norway, where white-collar unionization is high and where law requires management to inform unions about

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[164] Nicholas A. Ashford, "The Impact of Office Automation on the Quality of Worklife: Policy I replications, paper presented at the Office of Technology Assessment Symposium on the Impacts of Office Automation and Computer- Mediated Work on the Quality of Worklife, Dec. 10-12, 1984, p. 30,

[165] *National Labor Relations Board v. National Longshoremen Assn.*, op. cit.

[166] Steven Deutsch, "Technological Change and Labor-Management Relations," draft report to the Bureau of Labor-Management Relations and Cooperative Programs, Department of Labor, 1985; used with permission.

[167] Dwight B. Davis, "Workplace High Tech Spurs Retraining Efforts," *High Technology*, November 1984, pp. 60-62.

[168] Examples of the collective bargaining agreements are provided in *Automation, Work Organization and Stress*, op. cit., 1984.

[169] For example: "The employees shall, individually or in groups, be given proper information . . about conditions at the workplace that affect their own job . . . The employees shall be given an opportunity to take part in designing their *own* job situations as well as in the work of change and development that affects their jobs. *Agreement on Efficiency and Participation SAF-LO/PTK. Swedish Employer's Confederation* (Stockholm: Andren & Helm, 1982).

[170] Recently, in the case *Yeshiva University v. The NLRB*, the Supreme Court ruled that faculty members were managerial employees and therefore not entitled to organize under the NLRA, see *NLRB v. Yeshiva Univ.*, *444* U.S. *672 (1980).*

industry plans and conditions, actual participation of unions in technological planning is rare. The process of alternating cooperation, conflict, and negotiation requires a large commitment of time and resources from the union. [171]

Several recent labor-management agreements have centered around quality of worklife issues related to VDT use. In late 1984, claims processors at Equitable Life Assurance Company became members of District 925 of SEIU after a 3-year long effort. Points covered in the contract include requirements for detachable keyboards, adjustable chairs, an additional rest break from VDT work, and (in some cases) transfers to non-VDT work for pregnant workers. [172] One strongly worded agreement seeks to prevent the routinization of work through technological change. The contract between District 925 and a legal services organization states that:

> . , . [t]he Employer recognizes that as a general matter the routinization of the secretarial profession through the introduction of new technological changes, such as mag cards, is undesirable, and the Employer has no present intention of doing so.[173]

The problem of electronic monitoring has drawn the attention of at least 30 unions, many of which represent office workers. Several, including the International Federation of Clerical and Technical Employees and the AFL-CIO, have adopted the position that "no VDT monitoring' clauses should be included in contracts, but thus far, no contracts have prohibited monitoring. CWA has won contract language providing that electronic monitoring will be used for training and not for discipline. The SE I U-Equitable contract provides that employees will be given full information about the monitoring system, access to their own records, and the right to file a grievance if they believe their record is inaccurate.1[74]

Some union contracts have focused on new job classifications and higher pay for new skills in office automation. AFSCME contracts with the cities of Los Angeles anci New York require wage increases when word processing systems are introduced. The contract between Equitable and District 925 also modifies the "piece rate" pay system previously used for VDT workers.[175]The CWA contract with AT&T and the Bell operating companies established quality of worklife committees to deal with the retraining issue, and workers are notified in advance when a job will end so they can be retrained. '7' An agreement between OPEIU-and the New York Stock Exchange binds the employer to train displaced employees "for an available job resulting from such technological change or for other jobs which the producer has available. . . ."[177] In some cases, contracts have specified that some form of income maintenance will be available to employees who must be moved to lower paying jobs as a result of automation.[178]

Few unions have been able to negotiate a contract that guarantees no layoffs as a result of technological change, but some contracts have set forth who can be laid off and what severance pay, relocation benefits, or rehiring preference will be given **to** laid-off workers. However, the recent Supreme Court decision in favor of primary work preservation for longshoremen does uphold the right of the employees to keep secure their work:

> When the objective of an agreement and its enforcement is so clearly one of work preservation as is the one involved here, the lawfulness of the agreement under Sees. 8(b)(4)(B) and 8(e) is secure, absent some other evidence of secondary purpose. 179

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[171] U. Briefs, C. Ciborra, and L. Schneider (eds.), *Systems Design For, With and By the Users* (Amsterdam: Nor-th Holland Publishers, 1983).

[172] Stephanie K. Walter, "A VDT Victory at Equitable Life Dents the Anti-Union Armor, *Management Technology,* January 1985, pp. 6-8.

[173] Ibid.

[174] Alan Westin, *Privacy Issues in the Monitoring of Employee Work on VDTS in the Office Environment: Practices, Interests, and Policy Choices,* prepared for Office of Technology Assessment, December 1984, pp. 119-125.

[175] Walter, op. cit.

[176] Davis, op. cit.

[177] Murphy, op. cit., p. 14.

[178] Ibid.

[179] Supreme Court, op. cit., 1985.