WORLD HEALTH ORGANIZATION
**REGIONAL OFFICE FOR EUROPE**

WELTGESUNDHEITSORGANISATION
**REGIONALBÜRO FÜR EUROPA**

ORGANISATION MONDIALE DE LA SANTÉ
**BUREAU RÉGIONAL DE L'EUROPE**

ВСЕМИРНАЯ ОРГАНИЗАЦИЯ ЗДРАВООХРАНЕНИЯ
**ЕВРОПЕЙСКОЕ РЕГИОНАЛЬНОЕ БЮРО**

EUR/ICP/CEH 011
ENGLISH ONLY
UNEDITED

# WORK WITH VISUAL DISPLAY TERMINALS: PSYCHOSOCIAL ASPECTS AND HEALTH

## Report of a WHO Meeting



1990

EUR/HFA target 19

## TARGET 19

### Monitoring, assessment and control of risks in the environment

By 1990, all Member States should have adequate machinery for the monitoring, assessment and control of environmental hazards which pose a threat to human health, including potentially toxic chemicals, radiation, harmful consumer goods and biological agents.

Index:

31504

# Work with Visual Display Terminals: Psychosocial Aspects and Health

## Report on a World Health Organization Meeting

*When health effects related to the use of visual display terminals (VDTs) can be substantiated, complaints are largely associated with poor job and workstation design. Psychosocial aspects of work with VDTs may affect users' health and well-being and include a variety of situations: work demands, work design and organizational problems, workload breakdown control, pacing, social support and isolation, deskilling, management of change and user involvement, task analysis and job design, training, work scheduling, and rest periods. Although various physical aspects may affect the health of VDT users and are, to a large extent, inseparable from psychosocial effects, they have been addressed in a previous report. This report takes the view that, in the prevention of VDT-related health problems, psychosocial factors are at least as important as the physical ergonomics of workstations and the working environment.*

In a seminal paper, one of the first to consider human-computer interaction from the perspective of the user, Licklider[1] coined the term "man (sic)-computer symbiosis." This phrase was intended to encapsulate the then prevalent view that anticipated very close cooperation between the human user and the computer system. For the most part, the physical manifestation of this relationship has been the appearance of the visual display terminal (VDT). During the 1960s, the use of VDTs was largely confined to specialized user groups, but nowadays they are used by an astonishingly heterogeneous group of people for an equally broad range of tasks. Five of the ten fastest growing occupations involve nonmanufacturing applications of computer technology.[2] Forecasts suggest that by the early 1990s, around 40 million working people in the United States alone will be using such devices.[3]

The change to new technology has undoubtedly brought with it enormous benefits both to organizations that implement it and to individual users. In other instances, problems have arisen largely because of inadequate planning and implementation policies, including job redesign, poor design of equipment, and poor working environments. More particularly, the VDT has been rightly or wrongly blamed for health concerns ranging from mild headaches to perinatal mortality.[4]

### The Health Debate

Much of the debate about alleged VDT-related illness has taken place in the popular press; some of the accounts imply that almost every bodily system or organ is a potential target. But there has been genuine concern expressed in the scientific and medical community,[5-7] and most countries have been or are in the process of issuing guidance, developing minimum standards, or enacting legislation on actual or perceived VDT-related health issues. Consensus on some issues exists; whereas others, including the reliability and validity of the data on which their existence is based, are hotly disputed. Are VDTs the cause of the complaints heard apparently from large numbers of workers or, as the physical embodiment of a new system, are they a convenient target for hostility and reaction against fundamental changes introduced into the work process, particularly where such changes are perceived as being threatening to livelihood and status? In many industries, the VDT health debate has been the subject of much discussion, negotiation, and anguish, with the result that there has

---

This report was prepared and finalized for the World Health Organization Regional Office for Europe, Copenhagen, Denmark, by Dr Colin J. MacKay, Health and Safety Executive, United Kingdom, acting as Temporary Adviser to WHO and in his capacity as Rapporteur to the respective meeting. The views expressed in this paper are those of the author and the WHO group of experts and do not necessarily represent the decisions or the stated policy of the World Health Organization or the Health and Safety Executive.

Address correspondence to Medical Division, Health and Safety Executive, Magdalen House, Stanley Precinct, Bootle, Merseyside L20 3QZ, United Kingdom (Dr MacKay) or the World Health Organization, Regional Office for Europe, 8, Scherfigsvej, 2100 Copenhagen, Denmark (Dr Suess)

0096-1736/89/3112-0957$02.00/0

been a proliferation of company-union agreements, some of which have been extremely wide-ranging in their coverage and technically very detailed, others less so. The debate has impinged upon those involved in occupational health in several ways. These include issues only marginally related to mainstream occupational health: for example, being the final arbiter in bargaining contexts, being asked to pronounce on the desirability of screening for VDT users (in the case of eyesight examinations), and grappling with allegations of miscarriage and birth defect, while simultaneously trying to allay users' fears and worries about such effects, legitimate or not.

Because of this concern, the World Health Organization (WHO) Regional Office for Europe commissioned a review of physical health hazards associated with VDTs, which was published in a previous issue of this journal.[8] It has been increasingly recognized that psychosocial variables are important in the context of VDTs, both in terms of impact on users and associated health outcomes, and the previous review recognized the interaction of physical and psychological aspects. To cover these issues, and to complement the earlier one on physical hazards, the WHO Regional Office for Europe commissioned the present additional study. A number of experts were invited to review and comment on the draft study document (Appendix 1). A meeting of a group of experts (Appendix 2) was convened at Streatley-on-Thames, United Kingdom, Sept 22 to 24, 1987, to review, discuss, and finalize this document, also giving consideration to the written comments received. Dr C.J. MacKay acted as Chairman and Dr M.J. Suess as Scientific Secretary.

## Psychosocial Factors at Work

It is now well recognized that the overall reaction to working conditions is influenced by a range of factors, some of which are physical and some psychosocial. The psychosocial environment surrounding the workplace may contribute to the perception of risk and to eventual ill health: thus the overall impact on and reaction of the person must be considered.[9]

Although psychosocial factors related to the workplace are recognized as being crucial in both the causation and prevention of disease and promotion of health,[10,11] compared with physical complaints, comparatively little attention has been paid to this area by those concerned with occupational health. Although there is a shift away from the narrow view of occupational mental health in terms of psychiatric referral and resettlement, there has been little systematic attention to the assessment of occupational psychosocial factors. It is increasingly apparent that, in the context of new working methods and technologies and their impact on individual workers, such factors are important in mediating effects upon health and well-being.

## Health Effects of VDTs: A Model

As far as the user is concerned, access to the system is achieved through the medium of an interface. The interface is any hardware or software feature with which the user may have to interact. As such, the performance of the interface, ie, its usability, influences the perception of the user of the system as a whole, and, if deficient, may impede work performance and generate discomfort. In the past, the health debate has tended to focus more on the technology (the physical manifestations and possible hazardous processes within the device) than the information-handling requirements of the task and the related information- processing limitations of the user, as well as wider organizational aspects. This would seem to be a reflection of perception of risk on the part of users rather than an objective assessment of its size. More recently, however, information-processing aspects, cognitive demands in VDT work, and wider organizational considerations have received greater scrutiny. The present report will, therefore, concentrate upon factors relevant to information-processing requirements of VDT tasks and sociotechnical/psychosocial approaches for delineating stress effects and the impact of new technology.

## Work Demands in VDT Operation: An Illustrative Example

In the majority of offices where VDTs are used, their introduction has been trouble-free and has not generally been associated with problems of fatigue and psychologic stress. However, the following case report is an illustration of the combination of problems which can result when inappropriate work demands are coupled with poor design of the workplace and environment. Word processors had been introduced into a typing pool that handled complicated legal documents. Problems had arisen during the winter months, when excessive heat from the central heating pipes combined with radiant heat from the machines. This led to headaches, dry eyes, dry nose and throat, and skin irritation. Investigation by the United Kingdom Employment Medical Advisory Service (EMAS) revealed numerous ergonomic problems as well as organizational and stress-related ones.

The all-female staff worked both mornings and afternoons on the machines, and an attempt was made to enable them to also cope with all other types of work in the office. Considerable pressures were applied to obtain complicated reports at short notice. Two departments used the typing pool. Each department believed it had priority with work allocation. One department in particular was identified as presenting short notice requirements and inadequately revised drafts. The VDT operators were under continuous pressure because of a continuous backlog of work. The word processors were able to cope with 300 lines per hour as opposed to the normal typist's 60 to 70 lines per hour. Just prior to the EMAS visit, the management had agreed that the women should have a break of 10 minutes for every 1 hour spent on the machines.

An automatic record was kept of the running time of each word processor together with the output in lines per hour, which was used for performance monitoring purposes. The workers felt intimidated, were anxious to

CONTENTS

work at maximum speed, and were reluctant to take their entitled break periods.

At one point, the pool was staffed by temporary personnel, and this produced additional pressures on the regular staff. Much of the layout of the documents was complicated, and finished work was often required on short notice. The skills involved could only be learned over a period, and untrained temporary personnel could not cope with the complexities. A new recruitment policy was introduced which delayed the hiring of new typing staff, and this had the effect of exacerbating inadequate staffing levels.

The supervisor had noticed that experienced women did well up to 1 year after training and then suddenly lost confidence in their abilities, needing support for almost every decision, and that complete recovery did not occur.

Six workers reported a variety of complaints. The visual symptoms were eye dryness, with occasional conjunctival infection. In five of the six workers, this was related to change in blink rate and work in low humidity. Excessive tiredness at the end of the working day was present in four of the six operators. In two cases they retired to bed upon arriving home, resulting in family conflicts. Feelings of lack of control or vacant sensations on leaving work were present in three operators. In all cases they reported that their surroundings felt unreal, as though they were walking in a dream. The problems of concentration persisted for 10 to 15 minutes after leaving work. Although the feelings of unreality reported by some of the operators are uncommon, the case described above serves to illustrate problems caused by inappropriate working methods, which appear to be widespread. Poor task and job design often interact with bad ergonomic practice to generate visual and musculoskeletal symptoms and psychological ill health.

## Work Design and Organizational Problems

If the justification for technology is as a "tool" to extend human capabilities, then this requires, among other things, that users perceive themselves to be in control. However, seemingly contrary assumptions are often made that operators are unmotivated, unintelligent, unable to make task-related decisions, and unable to understand aspects of overall system operation.[12] VDTs may be useful tools for professionals, but for clerical users such technology tends to take the meaning out of work.

One of the supposed advantages of a VDT-based system is the capability of the user to interact intelligently with a computer system in ways compatible with human capacities in information processing. Essentially this approach envisages the VDT as an intelligent device working at the behest of the user. However, a cursory task analysis of many existing VDT-based jobs indicates that such jobs contain undesirable features characteristic of some forms of work organization that fail to provide work that fits existing patterns of skill (or where training is inadequate) and in so doing fail to meet the person's need for challenging and interesting work.

A long-term program of work aimed at examining the impact of computerization and psychosocial aspects of the work environment has been described by Bradley.[13,14] A number of the findings from these studies, which have been ongoing since 1974, are relevant here. In general, VDT users were less satisfied with some aspects of the psychosocial work environment, including questions of workplace participation. They reported more frustration, and viewed their work pace as too irregular, too dependent on other people, and too high during certain periods. Work environment aspects regarding work pace, staffing, and the demands for efficiency were the most salient areas in which VDT users expressed a higher level of dissatisfaction. They point to a number of changes in their work environment resulting from computerization: increased demands put on them (the buffer role intensified); more irregular work pace; and increased demands for attentiveness, accuracy, and responsibility at the job.

With the new technology, it has become possible to accelerate the rate at which work has been performed and material processed. At the same time, the number of contacts, such as with customers, has also increased. However, it appears to be highly difficult, if not impossible, to translate this increased speed of performance into an enhanced quality of personal contacts or into more time available to be spent with customers. As the work pace at the terminal speeds up, it tends to set the pace for other functions.

Employees with longer hours of daily terminal use more often believe that they receive too little information, that the possibilities for promotion and individual development and growth in the work are too small, as are the opportunities for training. They also more often feel imprisoned by their work situation, isolated from other people during working hours, and oppressed by the physical demands on their back, muscles, and eyes. On the other hand, those with longer hours of daily terminal use feel more secure at work (greater job security).

The handful of studies undertaken so far on occupational stress factors inherent in some forms of VDT-based work support these general assertions. Some studies have shown high levels of reported psychological distress among VDT operators.[15,16] Others report no significant differences between users and controls.[17] It is most likely that, in most of these studies, VDT work is confounded with undesirable job characteristics. There are also methodological problems inherent in some of the studies which make the interpretation of cause and effect somewhat difficult.[11,18] Methodological issues aside, the problem seems not to be the technology but the nature of work being undertaken.[19] Thus, Gunnarsson and Ostberg[20] showed that monotony experienced during VDT operation was clearly related to perceived feelings of lack of controllability and low levels of variety. Smith et al[21] report that rigid work procedures, high production standards, and constant pressure for performance were reflected in measures of self-reported stress and work demands that were substantially in excess of those established for 23 occupational groups.[2-] Their respondents also complained of negative effects on their mental health as well as musculoskeletal and visual problems. However, their data from other workplaces suggest that perceived flexibility, autonomy, and control over how work is to be carried out act as attenuating factors in the experience of stress. In these operators the greatest problems were those concerned with ambiguity over career development and future job activities.

## Workload and Demand

Two rather different types of problems with workload exist: work overload and work underload. These problems have been identified in other occupational settings previously, and are now being observed in a VDT work context. When the demands on a person at work are not matched to their skill or skill potential, the situation may be stressful.[23-25]

Most researchers have found a positive correlation between workload and intensity of computer use; thus, Turner,[26] investigating mortgage loan servicing workers, found an association between reported work overload with increasing amount of work done on the computer. Kling[27] found that office workers in 42 cities attributed an increase in job pressure to the use of a computer system.

Certain kinds of pressure may be considered a "part of the job," sometimes even the more stimulating part—eg, journalists may accept and enjoy producing articles to meet deadlines. However, for many workers, purely quantitative pressure may be experienced as intolerable. In the San Francisco study,[21] clerical VDT users scored highest, professional users lowest, and non-VDT clerical control subjects intermediate on work pressure scales (Work Environment Scale, ref 28). On scales of workload and dissatisfaction the same order applied (Job Demands Scale, ref 22). The combination of clerical work and VDT use appears to create the worst conditions with respect to work pressure and workload.

## Breakdowns

Breakdowns, interruptions, overloading, and slow response times are problematic. An operator in a state of readiness to accomplish something experiences frustration when the system blocks effective action.[29] Deadlines are seldom relaxed when response times are long or the system is down. During a breakdown, there is the knowledge that sometime in the future work will have to be completed twice as fast to meet unchanged deadlines. It might at first appear that breakdown time could be used to relax or gain relief but if the delay duration is unknown, the operator is actively waiting for a response and so cannot change over to relief activity or rest.[30,31]

Johansson and Aronsson[32] studied physiological and self-reported stress measures in VDT operators and control subjects over a 3-day period. Epinephrine (adrenaline) levels were higher in the mornings and below the baseline in the afternoons for the VDT users, and vice versa for control subjects. Similarly, feelings of fatigue and effort, and a sense of being rushed were greater for the experimental group in the morning, and greater for control subjects in the afternoon. The likely explanation came from interviews. VDT operators were working very fast in the morning to ensure against later breakdown; they could then relax in the afternoons if the system remained functional. Measurements taken while the system was down indicated significantly higher levels of epinephrine, systolic and diastolic blood pressure, and heart rate than in the same workers during normal operation. Breakdown is a constant threat that can have a number of undesirable effects.[33] The undesirable impact of response times and breakdowns has been linked to unpredictability of events[34] or the interruption of a planned piece of work that is in progress.[35] Some recommendations have been given for response times.[36] Studies thus far do not indicate a clear linear relationship between response time and stress effects.[37] A recent review[38] has differentiated between a number of other factors. These include a need for thinking time as the system is responding (which will be task-dependent), user expectations about likely response times, and individual differences in tolerability to varying delays in response.

Pertinent factors in determining breakdown impact include the amount of system status information available; the likelihood that data will be lost; the amount of effort needed to make up for any losses; uncertainty about whether response times are long or the system is down; and concern about customer reaction: if the system is being used to answer enquiries, the wrath of a customer expecting prompt service has to be dealt with.

In a survey by Eason,[39] a major source of dissatisfaction with computer equipment was that it did not allow jobs to be done as well as with a manual system. These problems could be solved at a technological level by a reduction in the frequency and duration of breakdowns. Production planning needs to take breakdowns into account. Overloading could be avoided and capacity reserved for emergency use.

## Control

The concept of control refers to the possibilities for the user to exert influence over the frequencing, timing, and concept of tasks and the conditions under which they are performed.[40] Controllability is important because it has an impact upon the functionality, the usability, and the "user-friendliness" of the system.[41]

Gregory and Nussbaum[42] suggested that increasing the introduction of computers into the office would probably lead to more machine control, tighter supervision, social isolation, and little freedom of movement, as well as probable de-skilling of some users.

A number of writers have reported reduced autonomy following the introduction of computers into the office. Typical findings indicate a higher degree of structure, preprogramming, and formalized working methods following computerization, leading to reduced choice for the individual worker.

Most commentators agree, however, that the decision to reduce autonomy (or more likely that the reduction is just a byproduct of poor work organization) is not an inevitable consequence of computerization.[43] Frese[44] has summarized a number of prerequisites of control. First, that the users have the relevant *knowledge* and *skills* to manipulate the system. Novices (or infrequent users) of a particular system may need considerable guidance by the system, whereas experts want control of the system and the ability to exploit its capabilities.[45] Second, that the systems possess *functionality* so far as it enables, or, preferably, enhances, the user's ability to perform a task. Third, *transparency*, implying that the user can generate a coherent internal model or representation of system functions, and fourth, *predictability* of system performance.

One of the crucial variables in determining stress-related symptoms in VDT operators is linked to the perception of control by the system (or conversely, lack of control by the operator). Such control is evident in a number of ways. First, in some systems the processing power of the machine is exploited to such an extent that it is able to monitor the minute-to-minute keying performance of an operator. In many instances this information is used to determine levels of remuneration via piece-rate payment systems. Not unnaturally, this level of control is often resented, is regarded with suspicion by many operators, and, understandably, is associated with feelings of fatigue and stress. Second, very long response times from the computer, or those that are variable in length (as described earlier) may be seen as an aspect of controllability.

Buchanan and Boddy[46] reported a reduction in typists' control over work scheduling and boundary tasks after the introduction of word processing. In the San Francisco study,[47] clerical VDT workers scored lowest, followed by clerical non-VDT control subjects, and professional VDT workers on scales of involvement and autonomy (Work Environment Scale, ref 28).

Clerical workers reported a sense of being controlled more often. Feelings of loss of individual control in a computerized work environment have also been documented elsewhere.[20,48,49] Lack of control at work may lead to the adoption of passive behavior patterns.

Perception of limited control or responsibility is likely to give rise to stress, especially if combined with heavy workloads.[21,23-25,50,52] If an operator tries to vary work strategy in response to different work loads and either technology or administration resists, then the technical "aid" (the computer) may become a stressor.[51,53,54] Control is best influenced by effective job design, and training flexibility allows a choice of strategy in meeting work demands while keeping stress to a minimum. Without autonomy to alter control strategies, operators are unlikely to learn tasks effectively or be able to build a clear model of overall system function, and ineffective performance will be the net result.[55] Control over the timing of rest breaks is a particularly important means of relieving the effects of repetitive VDT work.

## Task Pacing

Rigid, time-scheduled, machine-paced tasks do not allow adjustment for daily and moment-to-moment variations in effort. Hence, sometimes there will be excess strain and sometimes an underuse of capacity. The National Institute for Occupational Safety and Health[22] compared machine-paced assembly work and machine minding with supervisory and white-collar work. In the former there was more evidence of boredom, job dissatisfaction, and somatic complaints, self-paced assembly workers being intermediate. In a study of sawmill workers, Johannson and Aronsson[32] found that machine-paced work led to increased urinary catecholamine levels. Laville and Teiger[56] reported higher anxiety and incidence of gastritis and sickness in paced assembly workers (75%). Elevation of heart rate has been observed in computer-paced work with short cycle times (57).

## System Monitoring of User Performance

Allied to the notion of reduced control is the concept of electronic monitoring of worker performance. Often performance monitoring is combined with other undesirable job stresses, but monitoring per se may not be wholly negative. There is reason to believe that proper application of job design principles can develop monitoring systems that may benefit both sides in industry.[58] However, because of the way such systems have been introduced, thus far the response to them has been largely hostile. Such hostility is targeted at typical features of current monitoring methods that include the following: second-by-second monitoring, often at the level of individual keystrokes; overemphasis on the quantitative aspects of performance and upon speed; an element of implied pacing to meet targets; lack of information to users as to what information can (or is) being collected and why; the imposition of a form of supervisory style that is manifested as constant negative performance feedback; lack of discretionary control; and performance standards based upon arbitrarily defined performance goals of system capabilities rather than upon well-established data on human performance limitations.

The impact of such characteristics upon users is likely to be severalfold and may include awareness of constant evaluation, fear of reprimand, and consequent nonremunerated overperformance; difficulties in allocating and/or distributing effort, reduced job and/or involvement participation; time pressure and decreased possibilities for social interaction.[58]

Monitoring may be used, therefore, in a negative way, but it can also be applied in a positive sense. If it is used to provide accurate, meaningful feedback in a timely way and is nonevaluative, it provides the basis for enhanced goal-setting and motivation and provides the cues necessary for improvement in performance.[59]

## Social Support and Isolation

The social environment at work and the proximity of other people for communication is important for maintaining job satisfaction and general well-being.[60,61] Under some circumstances social support mechanisms provide a powerful buffering or attenuating effect on the effects of stressful work demands[11] and represent an important effect in terms of stress mitigation. The possibility that social networks will be directed by computing or word-processing systems is a threat.[32] The constraint of being stationary as a VDT may reduce social contact, with less opportunity for moving around and talking to colleagues, thus leading to isolation.[62,63] Isolation may also result from the fact that it is possible to work away from other people. In total, reduction in formal or informal contact will depend very much upon work organization and will be highly task-dependent.[64]

Word processors reduce the amount of communication between operators and authors.[46] In typing pools, isolated communities tend to form, so that the loneliness of the supervisor can be a problem.[65] Butteriss and Clark[66] found that typists resented being pooled and remote from authors.

## Deskilling

The moving toward computerization may involve the radical redesign of traditional office "paper and pencil jobs" typically performed by clerical workers. Jobs may become fragmented, with only the low skill elements remaining. This process has been referred to as "deskilling."

Much repetitive work involves underdemand.[43,44,67] "Deskilling" often occurs in changing jobs to suit technology, resulting in underutilization of skills, knowledge, and abilities.[32,50,68] Among clerical VDT workers, lack of demand on mental abilities is a major contribution to job dissatisfaction.[49] Another related feature of organizational change under such circumstances is that the range of tasks performed in a particular work setting becomes much more uniform.[69,70] Tavistock Institute researchers[60,61] conclude that the use of valued skills and knowledge and involvement in preparatory and auxiliary tasks are significant determinants of the quality of working life. Coburn,[71] studying job incongruence by means of a postal questionnaire sent to more than a thousand men in a variety of jobs, found poor psychological well-being to be associated with both very complex and oversimple work.[72] Complex work, however, was not necessarily disliked.

A study by Cooper and Cox[74] examined mental health and job satisfaction in 166 secretaries working in insurance and banking. A 40-item questionnaire using a six-point Likert type rating scale examined a range of work characteristics, including factors intrinsic to the nature of the job (keeping up with technical changes in equipment), job role factors (job expectations not very clear), and relationships with others. One of the major sources of stress in this particular group stemmed from ambiguity over roles within the present job and concerns over limited career prospects. As the secretaries were becoming more technically trained, their access to various organizational hierarchies was becoming more restrictive.

On a more general level, the pace of technological change, particularly in rapidly developing organizations, is leading to concerns about the relevance of skills acquired today to the jobs of tomorrow.[73]

In a similar study, Billette and Piché[75] studied data entry clerks in two large data pools. In comparison with other occupational groups, these workers had higher rates of psychiatric disturbance as well as a higher usage rate of over-the-counter prescription drugs. The problems were worse in full-time as compared with part-time employees, and were best predicted by work overload and the monotony of work specialization.

## Individual Differences

In predicting impacts it is important to recognize that individual differences between users (and between homogenous user groups) are likely to play an important role. Not only are psychobiological variables (age, sex, personality) important, but differences in cognitive style, learning style, and personal knowledge relevant to interaction with the VDT system[76] must also be considered. Thus far, however, there has been little systematic research. Some of these variables are fixed, others are more or less amenable to change. Clearly, in the system design it may not be practicable to consider individual personalities of users, but because of the flexibility offered by new technology, the goal of providing work individually tailored to meet particular needs, styles, and concepts of users may be more easily achieved.[77] The same argument applies to learning speed and skill development.

## Approaches to Solving Organizational and Job Design Issues

The issues raised above indicate that, as well as physical concerns (eg, hardware, workplace design, and environmental factors), problems can occur due to the nature of the VDT operators' task and role within the organization, as well as individual characteristics of the user. Problems relate to two areas. First, insufficient planning of the job, or planning the job too late in the design process. This often leads to technical constraints of the system defining the precise nature of the operators' role, a process referred to as technical determinism.[78] Second, jobs are often computerized with little regard for which aspects of the old job are satisfying to the operator, and thus should be retained, and which aspects are overdemanding and thus should be phased out or performed in some other fashion. The switch to VDT-based systems provides an opportunity for job enrichment and enlargement. Job flexibility and some control over work allocation should enable the promotion and utilization of individual skills. Although these are ideal outcomes stemming from the introduction of a computer system, they are only achieved by careful and thoughtful planning and implementation and training of user groups.

## Management of Change and User Involvement in the Design Process

Whether change is perceived by workers as being either positive or negative depends very much on the management of the change process itself.[79–81] In relation to the adoption of information technology, there is ample opportunity for fears about health effects of VDTs, unemployment, and future job activities. The result is often indirect measures of resistance or apathy such as reduction of output, keeping information to oneself, working strictly to rules, and unplanned use of the new system.[82–84] The introduction of new technology is sometimes justified on the basis of a need to rationalize office systems, so that streamlined production-line systems are often the result, with the focus upon technology-dependent tasks (word processing, data entry, telephoning). Moreover, the long-term strategy or the long-term repercussions upon users are not always made clear.

There is almost unanimous agreement that, to minimize such problems and ensure system acceptability to users, some degree of participation by them in the design process is necessary. At the most basic level this may mean communication of information concerning future planned change, but more in-depth participation often finds users heavily involved in the design process themselves.

Awareness of new technology can be heightened before it is introduced by giving demonstrations, arranging visits to manufacturers and other sites, and providing opportunities for familiarization. Involving all those likely to be affected by the change in the design process not only promotes better acceptance and commitment, but may also achieve a better system design[85] with user insight into system strengths and weaknesses,[86] with the result that management becomes more familiar with the possible limitations in the proposed system. Involvement must not be illusory, trivial, irrelevant, or superficial. It must be seen as an integral and legitimate part of the workers' job that is reflected in the reward system.

Conflict and resistance are likely to be reduced if an open, exploratory style is adopted by the project team, encouraging collaboration, assistance and questions, looking at the causes of mistakes rather than looking for someone to blame, and looking at how work is actually done rather than the procedures originally laid down.

When new technology and methods are introduced, a gradual changeover, with old and new systems working side by side, is ideal. Training and the opportunity for practice and consolidation of skills are essential. The support of an experienced and patient advisor is important to give people confidence. Adequate and direct feedback about new methods help learning and encourage more rapid adjustment.

Participation has failed in the past for a number of reasons. First, it often occurs too late in the design process and there is too little of it. Second, users are not sufficiently familiar with the proposed technology to make participation effective. Third, users have not had clear expectations about the nature and likely end results of the participative process.

The type and extent of user involvement will depend largely upon local factors such as management styles and organizational structures.[87] However, the path that appears to offer the most advantages and the one most likely to achieve a satisfactory system is the participative approach in which system designers and users of the system, particularly VDT operators themselves, are jointly involved throughout the various phases of planning, design, and implementation. General guidance on the introduction of computer systems is provided by Farrow[88] and Spinas et al.[89] Examples of the participative approach to system design can be found elsewhere.[69,90–92]

## Task Analysis and Job Design

In the design of any system, an analysis of the existing system is crucial, particularly if human factor aspects are to be incorporated into the new system at appropriate points. In the present context it is important to note that during this analysis stage the activities and tasks the worker is carrying out in the precomputerized system need to be determined. In the computerized system, some of these will be allocated to the computer, and some will remain to be carried out by the person. There are a variety of issues including the need to consider abnormal, unexpected, and unusual varieties of activities; data that are ambiguous, uncertain, or unpredictable; processing of data that cannot easily be presented in computer-compatible form; coping with goal conflicts and priorities; novel problems requiring immediate solutions; and the need to interact with others during transactions with the computer, particularly members of the public. The design of the system should ensure that these potentially demanding activities can be performed satisfactorily by designing flexibility into the system (eg, by allowing the operator to perform activities in different sequences) and by designing the software so that the computer acts as a supportive tool for the operator.

Ultimately, job design is a compromise between a number of criteria that place restrictions upon system design: cost, training, organizational flexibility, customer satisfaction and service, as well as user needs and satisfaction. Much has been written about job design both in terms of creating human-oriented jobs and at the same time minimizing stress-related aspects. Some guidelines and draft standards promulgate rather general requirements for good job design; others provide very specific microlevel needs. In integrating the various recommendations, the following general principles apply.

***Job Content***. The job should be mentally challenging but within the capabilities of the individual user. It should be of sufficient complexity to provide commitment to, and interest in, the work itself. This means that jobs should consist of a range of interconnected tasks that require the use of different skills so that an integrated meaningful job is created.

*Skill Utilization.* Job design should incorporate the need to utilize existing skills of users (where practicable) and encourage the development and acquisition of new ones.

*Feedback.* The system should be designed so that appropriate feedback on overall performance provides an aid to learning. On a microlevel system, feedback should be consistent, self-explanatory and should correspond to users' expectations.

*Control Ability.* Job design should incorporate a degree of user discretion into the way work is organized. This may mean deciding upon the content of sub-tasks, on their ordering of priority, the methods for solving them, and overall time frame.

Although the introduction of new technology provides the opportunity to enhance job content significantly, in many instances such principles have not been used in job design; thus, where simple clerical tasks have been computerized, they invariably retain their monotonous, repetitive, and demotivating features. Moreover, in changing a job to suit the introduction of new technology, an element of "deskilling" is often involved, thus adding substantially to feelings of underutilization of skills developed prior to the introduction of VDTs. In many workers, a considerable amount of time and effort will have been invested in learning and practicing the skills required for the job prior to computerization.

VDT task design must therefore seek to minimize repetitive elements in the operators' task by introducing variability in workload throughout the day, instead of long periods of concentrated work, while ensuring that the load is predictable. This should be coupled with job design features that allow the worker to have some discretion in how work is allocated over work periods and by so doing introduce feelings of personal control and cater to individual differences in the need for brief pauses in work. Thus, in addition to the *quantitative* aspects of the VDT task, the *qualitative* features should also be examined. All too often data entry tasks require only the use of simple psychomotor skills, where only minimal exercise of intellectual abilities is possible. Ideally, the shift should be toward the use of the VDT as a tool for carrying out a much larger job, rather than the VDT user being solely a machine operator.

When the operator's job consists of a variety of tasks, only some of which may be related to VDT operation, minor faults in the ergonomics of the equipment may not be critical. Conversely, when intense and continuous operation is required, the need for optimum workplace and screen characteristics becomes crucial. However, solutions based entirely upon attention to ergonomic factors are not a panacea for low motivation and poor morale; work design and organizational factors are likely to be more important in determining the operator's overall acceptability of the computer.

## Training and Skill Enhancement

The most direct way to influence individual resources is to provide high-quality training. By enabling users both to understand and control the technology at their disposal, it enables them to take full advantage of the flexible and powerful systems at their command. Users who are not well trained often describe themselves as being influenced, even dominated, by the computer rather than the other way round.[93] On a microlevel, training should provide users with a model of how the technology functions, permit development of problem solving strategies, allow for generalization and transfer to new, different, and less structured tasks, and should make transfer between systems to new generations of systems easier. Training goals should be broad and of sufficiently long range to encompass the breadth of work likely to be encountered; providing only novice-level training does not permit users to utilize strong task competencies and judgmental skills in conjunction with VDT tasks. Training should also seek to generate the development of groups of local experts for a given department or organizational grouping[94] and knowledge sharing within work groups.[95]

## Work Scheduling and Rest Pauses

In most tasks, natural breaks or pauses occur as a consequence of the inherent organization of the work. Such informal breaks help to maintain performance by preventing the onset of fatigue. In some VDT work (for example, those data entry tasks requiring continuous and sustained attention and concentration, together with high data entry rates) naturally occurring breaks are less frequent. In situations where this type of task cannot be organized in any other way, and where natural breaks in work do not occur, the introduction of rest pauses should help to maintain attention and concentration. It is difficult to be specific about guidance on the duration of rest pauses. The most satisfactory length of pause can only be determined by consideration of the individual operator's job, since the onset and mainifestations of fatigue will depend upon the nature and mix of cognitive and psychomotor demands imposed by the job.[96-100] Nevertheless, in connection with the provision of rest pauses some general statements can be made.

(1) Some of the symptoms reported by users are often the result of the effort expended to maintain performance in the face of accumulating fatigue. Rest pauses should therefore be arranged so that they are taken prior to the onset of fatigue, not as a recuperative period from it. Rest should be introduced when performance is at a maximum, just before a reduction in productivity. Note that the period of rest is included in working time and does not result in longer hours. The timing of rest is more important than the length of the rest period, although optimal rest period lengths can also be determined for individual jobs. This has not yet been done for VDT work.

(2) Short, frequently occurring pauses appear to be more satisfactory than longer ones taken occasionally. Thus, a 5- to 10-minute break after 50 to 60 minutes would probably be better in this respect than 15 minutes after every 2 hours. Additionally, there is some evidence

to suggest that very short breaks (so-called "micro-pauses") of between 5 and 7 seconds after a few minutes work may also be helpful.

(3) Ideally, the break should be taken away from the VDT workstation.

(4) Rest periods are most effective for work requiring continuous attention than for jobs that are more or less automatic and leave the employee free to daydream, converse with others, or follow similar monotony-reducing strategies.

(5) A number of studies (eg. ref 101) have found that, although fatigue-like complaints about the eyes are not alleviated by mandated formal breaks, they are alleviated by informal breaks, that is, time spent not viewing the screen, which may include time spent performing other work tasks. These findings are consistent with recent work in occupational stress that emphasizes the need to allow individual operators discretion in the way tasks are carried out. Individual control over the nature and pace of work enables effort to be distributed optimally throughout the working day.

(6) On the whole, rest pauses lead to a general improvement in the quality and quantity of output. Beneficial effects are not confined to the period of work following the pause but may also be noticeable before the rest occurs.

(7) Although rigidly specified breaks appear not to have large beneficial effects (see 5, above), totally discretionary arrangements may allow individual users to forgo breaks in favor of a shortened work period. Some prescribed but nevertheless flexible minimum requirements are therefore probably necessary for some types of VDT work.

## Shift Length

Because of concerns not only about fatigue, but also more long-term health effects, some guidelines and policy statements have limited the maximum time allowed at the VDT to 4 hours per day. There is a considerable amount of literature on shift length and health, although only a small proportion of it is concerned with VDT-like tasks. Generally, the results have been mixed and have depended largely upon the outcome measures chosen and the extent to which hours of work are confounded with the nature of the work being undertaken. However, it is reasonable to predict that the longer one works at a particular task the greater the probability of fatigue-like symptoms, and indeed such a statement is well supported by the VDT literature. Overall therefore one may consider different levels of preventive strategy in limiting the impact of VDT work. First, use the VDT as a tool by incorporating good job design principles into system development. Second, where spells of intensive VDT work must be undertaken, mix these with spells of similar duration of nonintensive, non-VDT work. The third and least preferred strategy for continuous text or data entry work is to provide adequate work-rest schedules.

## Conclusions and Recommendations

A critical review of the available literature on psychological health issues leads to the following conclusions.

(1) Psychological factors are at least as important as physical characteristics of workplaces in influencing health and well-being.

(2) The control of psychological risk factors associated with VDT use can best be addressed through primary prevention of VDT job and organizational problems. In this regard, careful introduction of the VDT into the workplace is of utmost importance.

(3) Much has been written on job design in the context of introducing computer systems. However, established knowledge in this area has been largely ignored with respect to control of psychological risk factors in VDT use.

(4) Many variables influence the relationship between psychosocial factors and health outcomes in VDT work. This, combined with the fact that no two situations are exactly the same, makes it inappropriate to set rigid recommendations governing psychosocial conditions in the VDT workplace. In this regard, it is not possible at present to specify the optimum length of a VDT work period.

(5) Some of the literature reviewed demonstrates a lack of attention to methodological and statistical requirements needed to study psychosocial factors in the workplace, making it difficult to draw clear conclusions about possible cause-effect relationships. In particular, the lack was noted of studies concerned with evaluating possible effects of psychosocial interventions in the context of VDT use.

(6) Problems caused by inappropriate design of work involving VDTs can be seen as part of the generic problem area associated with the impact of new technologies, which are increasingly likely to confront occupational health specialists.

The World Health Organization group of experts endorsed the following recommendations. While recognizing that most, if not all, are applicable to any working situation, these recommendations are presented here specifically with respect to work with VDTs.

(1) A thorough analysis of psychosocial impact should be undertaken prior to any final decision on the technical characteristics of a new VDT system.

(2) Sociotechnical changes concerned with introducing VDTs into the workplace should be accompanied by involvement of those affected, at all levels within the organization. Such involvement, where practicable, should be in accordance with the principles of participative design.

(3) Qualitative aspects of job design should incorporate the following general principles: (i) task variation, including the provision of some non-VDT work, consistent with the equitable distribution of different kinds of work over appropriate time frames (preferably hours and days); (ii) some degree of task complexity, consistent with the skill potential of individual users, and providing some degree of responsibility and opportunity for exercising judgment; (iii) coherent job content, en-

tailing some intrinsic meaning in the tasks performed; (iv) skill development, ensuring that past skills do not become obsolete without the opportunity for learning new ones; (v) feedback on performance, ensuring that it does not create excessive or unrealistic expectations that may result in stress; and (vi) control, implying some possibility of influencing the structure and planning of work tasks and scheduling of breaks.

(4) Qualitative aspects of job and system design should incorporate the following general principles: (i) workload should be realistic, (ii) production planning should take into account likely breakdowns and faults, and (iii) work pace should not be too dependent upon colleagues or the system.

(5) Work with VDTs should not prevent the opportunity for social contact and should be accompanied by some emotional and instrumental support from supervisors and coworkers.

(6) Where variations in tasks cannot be provided, and natural breaks do not occur in continuous VDT work, the number of rest breaks should be increased. The timing and lengths of such breaks depend largely on task requirements and individual susceptability to fatigue.

(7) Insofar as many VDT tasks impose unfamiliar cognitive and other demands and require the acquisition of new skills, particular attention should be paid to providing appropriate training before, during, and after the implementation of the new system. Training should utilize both formal and on-the-job techniques, cover task-specific requirements, and impart a more general understanding of the functional aspects of the whole system.

(8) Investigators should utilize more rigorous research methods to enable cause-effect relationships to be more precisely and reliably delineated. In general, more evaluation research should be performed, including the development of case or demonstration studies, and the generation of data on the effectiveness of psychosocial interventions and guidelines.

## References


1. Licklider JCR. Man-computer symbiosis. *IRE Transactions on Human Factors in Electronics.* 1961;4-11.

2. Silvestri GT, Lukasiewicz M. Occupational employment projections: the 1984–1995 outlook. *Monthly Labor Rev.* 1987;November:42–57.

3. Bezold C, Carlson RJ, Peck JC. *The Future of Work and Health.* Dover, Mass: Auburn House Publishing Co; 1986.

4. *Visual Display Terminals and Workers' Health.* WHO Offset Publication 99. Geneva: World Health Organization; 1987.

5. Lee WR. Working with visual display units. *Br Med J.* 1985;291:989–991.

6. Frank AL. Occupational Medicine. *JAMA.* 1985:254:2333–2334.

7. Pearce BG. *Health Hazards of VDUs?* Chichester: Wiley; 1984.

8. Marriot IA, Stuchly MA. Health aspects of work with visual display terminals. *J Occup Med.* 1986;28:833–848.

9. MacKay CJ, Lucas EG. Occupational aspects of whole-person health care. In: Christie MJ, Mellet PG, eds. *The Psychosomatic Approach: Contemporary Practice of Whole Person Health Care.* Chichester: Wiley; 1986.

10. Kalimo R, El-Batawi MA, Cooper CL, eds. *Psychosocial Factors at Work.* Geneva: World Health Organization; 1987.

11. MacKay CJ, Cooper CL. Occupational stress and health: some current issues. In: Cooper CL, Robertson, IT, eds. *International Review of Industrial and Organisational Psychology.* Chichester: Wiley; 1987.

12. Stellman JM, Klitzman S, Gordon GC, Snow BR. Work environment and the well-being of clerical and VDT workers. *J Occup Behav.* 1987;8:95–102.

13. Bradley G. *Computerization and Working Life from a Psychosocial Point of View.* RAM report 9: Stockholm: University of Stockholm; 1981

14. Bradley G. Psychosocial work environment and use of visual display terminals. In: Knave B, Wideback P-G, eds. *Work with Display Units 86.* Amsterdam: Elsevier Science Publishers; 1987.

15. Elias R, Cail F, Tisserand M, Christmann H. Investigations in operators working with CRT display terminals: relationships between task content and psychophysiological alterations. In: Grandjean E, Vigliani E, eds. *Ergonomic Aspects of Visual Display Terminals.* London: Taylor & Francis; 1982.

16. Ghingirelli L. Collection of subjective opinions on use of VDUs. In: Grandjean E, Vigliani E, eds. *Ergonomic Aspects of Visual Display Terminals.* London: Taylor & Francis; 1982;227–231.

17. Binaghi S, Albonico G, Gelli E, et al. Study on subjective symptomatology of fatigue in VDU operators. In Grandjean E, Vigliani E, eds. *Ergonomic Aspects of Visual Display Terminals.* London: Taylor & Francis; 1982:219–225.

18. Kasl SV. Stress and disease in the workplace. A methodological commentary on the accumulated evidence. In: Cataldo MF, Coates TJ, eds. *Health and Industry. A Behavioural Medicine Perspective.* New York: Wiley; 1986.

19. Sauter SL, Gottlieb MS, Jones KC, et al. Job and health implications of VDT use: initial results of the Wisconsin-NIOSH study. *Communications of the ACM.* 1983;26:285–294.

20. Gunnarsson E, Östberg O. The physical and psychological working environment in a terminal-based computer storage and retrieval system. Report 35; Stockholm: National Board of Occupational Safety and Health; 1977.

21. Smith MJ, Cohen BGF, Stammerjohn LW. An investigation of health complaints and job stress in video display operations. *Hum Factors.* 1981;23:387–400.

22. Caplan RD, Cobb S, French JRP. Job Demands and Worker Health. NIOSH Research Report. HEW publication 75-160. Washington DC, US Dept of Health, Education, and Welfare.

23. Cox T. Repetitive work. In: Cooper CL, Payne R, eds. *Current Concerns in Occupational Stress.* Chichester: Wiley; 1980.

24. Cox T. Repetitive work: Occupational stress and health. In: Cooper CL, Smith MJ, eds. *Job Stress and Blue Collar Work.* Chichester: Wiley; 1985:85–112.

25. Payne R. Demands, supports and constraints and psychological health. In: Mackay CJ, Cox T, eds. *Response to stress: occupational aspects.* Guildford; IPC Science and Technology Press; 1979:85–96.

26. Turner JA. *Computers in Bank Clerical Functions: Implications for Productivity and the Quality of Life.* New York: Columbia University; 1980. PhD dissertation.

27. Kling R. The impacts of computing on the work of managers, data analysts, and clerks. Working Paper. Public Policy Research Organization. Irvine, Calif: University of California; 1978.

28. Insel P, Moos R. *Work Environment Scale—FORMS.* Palo Alto, Calif: Consulting Psychologist Press Inc; 1974.

29. Turner JA, Karasek RA. Software ergonomics: effects of computer application design parameters on operator task performance and health. *Ergonomics.* 1984;27:663–690.

30. Östberg O. Fatigue in clerical work with CRT display terminals. *Gothenburg Psychological Reports.* Vol 4, No 19, University of Gothenburg, Sweden, 1974.

31. Martin J. *Design of Man-Computer Dialogues.* Englewood Cliffs, NJ; Prentice-Hall; 1973.

32. Johansson G, Aronsson G. Stress reactions in computerised administration work. *J Occup Behav.* 1984;5:159–181.

33. Kennedy TGS, Edmonds R. An examination of training problems and naive computer users. Proceedings of the European Computing Congress (Euricomp '74): 1974:411–425.

34. Boucsein W, Greif S, Wittenkamp J. Systemresponsezeiten als Belastungsfaktor bei Bildshirm-Dialogtatigkeiten. *Z. Arbeitswissensch.* 1984;38 113–118

35. Miller RB. Response time in man-computer conversational

interactions. Proceedings of the Spring Joint Computer Conference. Montvale, NJ: AFIPS Press: 1965:267-277.

36. Cakir A. Short paper towards an ergonomic design of software. *Behav Information Technol.* 1986:5:63.

37. Martin GL. System response time effects on user productivity. *Behav Information Technol.* 1986:5:3–8

38. Shneiderman B. Response time and display rate in human performance with computers. *Comput Surv.* 1984:16:265–272.

39. Eason KD. The manager as a computer user. *Appl Ergonom.* 1974:5:9-14.

40. Parkes KR. Personal control in an occupational context. In: Steptoe A. Appels AD. eds. *Stress, Personal Control and Health.* Chichester: Wiley; in press.

41. Brown JS. From cognitive to social ergonomics and beyond. In: Normal DA. Draper SW. eds. *User Centered Systems Design.* Hillsdale, NJ Erlbaum. 1986.

42. Gregory J, Nussbaum. K. Race against time: automation of the office. *Office: Technology and People* 1982;1:197–201.

43. Ellis P. Office planning and design. The impact of organisational change due to advanced information technology. *Behav Information Technol* 1984:3:221–229.

44. Frese M. A theory of control and complexity: implications for software design and integration of computer systems into the workplace. In: Frese M. Ulich E. and Dzida W. eds. *Psychological Issues of Human Computer Interaction in the Work Place.* Amsterdam: Elsevier Science Publishers: 1988.

45. Frese M. A concept of control: implications for stress and performance in human-computer interaction. In: Salvendy G. Sauter SL. Hurrell JJ. eds. *Social, Ergonomic and Stress Aspects of Work with Computers.* Amsterdam: Elsevier Science Publishers; 1987: 43–50.

46. Buchanan DA, Boddy D. Advanced technology and the quality of working life: the effects of word processing on video typists. *J Occup Psychol.* 1982:55:1–11.

47. Stammerjohn LW, Smith MJ, Cohen BGF. Evaluation of workstation design factors in VDT operations. *Hum Factors.* 1981:23:401–408.

48. Dainoff MJ. Happ A. Crane PC. Visual fatigue and occupational stress in VDT operators. *Hum Factors.* 1981:23:421–438.

49. Cakir A, Hart DJ. Stewart TFM. *Visual Display Terminals.* Chichester: Wiley: 1980.

50. MacKay CJ. Cox T. Occupational stress associated with visual display unit operation. In: Pearce BG. ed. *Health Hazards of VDUs?* Chichester: Wiley; 1984:137–143.

51. Karasek RA. Job demands, job decision latitude and mental strain. implications for job re-design. *Admin Sci Q.* 1979:24:285–308

52. Henry J. Cassel J. Psychological factors in essential hypertension: recent epidemiological and animal experimental evidence. *Am J Epidemiol.* 1979:90:171–200.

53. Speriando J. Variation of operations' strategies and regulating effects on workload. *Ergonomics* 1971;14:571–577.

54. Broadbent DE. The clinical impact of job design. *Br J Clin Psychol.* 1985:24:75–83.

55. Gill C. *Work. Unemployment and the New Technology.* Cambridge: Polity Press: 1985.

56. Laville A. Teiger C. Sante mentale et conditions de travail. *Ther Umsch.* 1976:32:152–156.

57. Kumashiro M. A mechanism of mental stress response on VDT performance. *Visual Funct.* 1983:6: session A.

58. Smith MJ, Pascale C, Miezio K. Electronic monitoring and job stress. In: Salvendy G. Sauter SL, Hurrell JJ, eds. *Social. Ergonomic and Stress Aspects of Work with Computers.* Amsterdam: Elsevier Science Publishers: 1987:33–42.

59. Hackman JR. Oldham GR. Motivation through the design of work: test of a theory. *Organizational Behaviour and Human Performance* 1976:16:250-272.

60. Hill P. *Towards a New Philosophy of Management.* Aldershot. Hants: Gower Press: 1971.

61. Emery FE. Some hypotheses about the ways in which tasks may be more effectively put together to make jobs. Tavistock Institute of Human Relations. 1963. Reprinted In: Hill P, Ed. *Towards a New Philosophy of Management.* Aldershot. Hants: Gower Press. 1971:208–210.

62. Grandjean E. *Ergonomics of VDU's: Review of Present Knowledge.* Zurich Swiss Federal Institute of Technology, Department of Hygiene and Ergonomics; 1980.

63. Salvendy G. ed. *Machine Pacing and Occupational Stress.* London: Taylor & Francis: 1984.

64. Ruch L. The use of word processors: a survey in Switzerland's Federal Government Administration. In: Ulich E. ed. *Computer-Aided Office Work.* Zurich: Swiss Federal Institute of Technology. Chair for Work and Organizational Psychology: 1986:17-23.

65. Stansfield RG. *Typing Pools: A Study on Satisfaction in Work.* Proceedings of the Joint IEA/Ergonomics Society Conference on Job Satisfaction, Slough. Sept 1977:21-24.

66. Butteriss M. Clark A. Giving word processing a new meaning. *Personnel Management.* 1977:9:31–33. 39.

67. Frankenhaeuser M. Gardell B. Underload and overload in working life: outline of a multidisciplinary approach. *J Hum Stress.* 1976:2:35–46.

68. Gallie D. *In Search of the New Working Class: Automation and Social Integration Within the Capitalist Enterprise.* Cambridge: Cambridge University Press; 1978.

69. Spinas P. Bildschirmeinsatz und psycho-soziale Folgen für die Beschäftigten. In: *Arbeit in moderner Technik.* Referate der 26" Fachtagung der Sektion 'Arbeits- und Betriebspsychologie' im BDP, Lübeck: 1984: 503–516.

70. Ulich E, Troy N. Job organization and allocation of functions between man and computer: II—Job organization. In: Klix F. Wandke H. eds. *Man-Computer Interaction Research. MACINTER-1.* Amsterdam: Elsevier Science Publishers: 1986:421–427.

71. Coburn D. Job alienation and well being. *Int J Health Serv.* 1979:9:41–59.

72. Langner TS. A 22 item screening scale of psychiatric symptoms indicating impairment. *J Health Hum Behav.* 1962:3:269–276.

73. Sauter SL. Hurrell JJ. Occupational health and the computer mediation of information work: research needs. In: Salvendy G. Sauter SL. Hurrell JJ. eds. *Social. Ergonomic and Stress Aspects of Work with Computers.* Amsterdam: Elsever Science Publishers; 1987:211–217.

74. Cooper CL. Cox A. Occupational stress among word processor operators. *J Stress Med.* 1985:1:87–93.

75. Billette A, Piché J. Health problems of data entry clerks and related job stressors. *J Occup Med.* 1987:29:942–948.

76. van de Veer G. Tauber MJ. Waern Y. and van Maylwijk B. On the interaction between system and user characteristics. *Behav Information Technol.* 1985:4:289–326.

77. van Maylwijk B. van de Veer G. Waern Y. On the implications of user variability in open systems. *Behav Information Technol.* 1983:2:313–326.

78. Sydow J. Sociotechnical change and perceived work situations: some conceptual propositions and an empirical investigation in different office settings. *Office: Technol People.* 1984:2:121–132.

79. Ulich E. Towards the design of user-oriented dialogue systems. Experiments. In: Ulich E. ed. *Computer-aided Office Work.* Zurich: Swiss Federal Institute of Technology, Chair for Work and Organizational Psychology; 1986:6–9.

80. Sell R. Microelectronics and the quality of working life. Work Research Unit Occasional Paper 17. London: Department of Employment; 1980.

81. Davis A. Cox T. *Management Development-Management of Change. Attitudes to Change.* Nottingham: University of Nottingham; 1986.

82. Baroudi JJ, Olsen MH. Ives B. An empirical study of the impact of user involvement on system usage and information satisfaction. *Communications of the ACM* 1986;29:232–242.

83. Hirschheim RA. Lane FF. Smithson S. Implementing computer-based information systems in organisations: issues and strategies. In: Shackel B. ed. *Human Computer Interaction 84.* Amsterdam: Elsevier Science Publishers; 1985:855–863.

84. Frese M. Human-computer interaction in the office. In: Cooper CL. Robertson IT. eds. *International Review of Industrial and Organizational Psychology.* Chichester: Wiley: 1987:117–165.

85. Thompson L. New office technology: people, work structure and the process of change. Work Research Unit Occasional Paper 34. London: Department of Employment: 1985.

86. Stewart T. Ergonomics of the office. *Ergonomics.* 1985:28:1165–1170.

87. Damodaran L. Simpson R. Wilson P. *Designing Systems for People.* Manchester: National Computing Centre: 1980.

88. Farrow HF. *Computerization Guidelines: Guidelines for Managers. Other Employees and Trade Unions Involved.* Manchester: National Computing Centre; 1979.

89. Spinas P. Troy N. Ulich E. Leitfaden zur Einfuhrung and Gestaltung von Arbeit mit Bildschirmsystemen. (*Guidelines for the introduction and design of work with VDTs*). Munich: CW-Publikationen; 1983.

90. Mumford E. *Values. Technology and Work.* Leiden: Martinus Nijhoff; 1981.

91. Mumford E. *Designing Secretaries: The Participative Design of a Word Processing System.* Manchester: Manchester Business School; 1983.

92. Briefs U. Ciborra C. Schneider L. eds. *Systems Design for, with, and by the Users.* Amsterdam: Elsevier Science Publishers; 1983.

93. Sydow J. Office automation—an organizational perspective. In: Frese M. et al. eds. *Psychological Issues of Human-Computer Interaction in the Workplace.* Amsterdam: North Holland; 1987.

94. Scharer LL. User training: Less is more. *Datamation.* 1983;29:175–182.

95. Bikson TK. Gutek BA. Advanced office systems: an empirical look at use and satisfaction. In: *AFIPS Conference Proceedings.* National Computer Conference: 1983:319–327.

96. Lee KS, Waikar AM. Reduction of physical stress experienced by VDT operators. *Proceedings of the International Scientific Conference: Work with Display Units 86, Part 1.* Stockholm: 1986:507–510.

97. Zwahlen HT. Hartmann AL. Kothari N. How much do rest breaks help to alleviate VDT operator subjective ocular and musculoskeletal discomfort? *Proceedings of the International Scientific Conference: Work with Display Units 86, Part 1.* Stockholm: 1986:503–506.

98. Sundelin G. Hagberg M. Hammarstrom U. The effects of pauses on muscular load and perceived discomfort when working at a VDT word processor. *Proceedings of the International Scientific Conference: Work with Display Units 86. Part 1.* Stockholm; 1986:501–502.

99. Florine R. Cail S. Elias R. Psychophysiological changes in a VDT repetitive task. *Ergonomics.* 1985;28.1455–1461.

100. Horie Y. Aoki M. OhKubo T. A fundamental study on optimum hours with rest pauses for VDT work. Chiba. Japan: College of Industrial Technology. Nitton University.

101. Coe JB. Cuttle K. McClellan WC. et al. *Visual Display Units.* Report W/1/80. Wellington. New Zealand: New Zealand Department of Health; 1980.

## Appendix 1

### List of Reviewers

Dr G. Arendsson, National Board of Occupational Safety and Health, Solna. Sweden.

Dr W. Bachmann, Central Institute of Occupational Medicine, Berlin. German Democratic Republic.

Dr S. Bagnara, Institute of Psychology, National Research Centre, Rome, Italy.

Ms R. Belmont, Office of International Health. Food and Drug Administration, Dept of Health and Human Services. Rockville, Md, USA.

Mr U.O.V. Berquist, National Board of Occupational Safety and Health, Solna, Sweden.

Dr Gunnilla Bradley, Dept of Sociology. University of Stockholm, Sweden.

Dr F. Daniellou. Laboratory of Occupational Ergonomics and Neurophysiology, National Conservatory of Arts and Crafts, Paris, France.

Dr Maria A. Frasquilho, Dept of Mental Health, National School of Public Health, Lisbon, Portugal.

Ms S. Harker, Dept of Human Sciences, University of Technology, Loughborough, United Kingdom.

Dr Frigga Haug, Higher School of Economy and Politics, Hamburg, Federal Republic of Germany.

Dr M. Helander, State University of New York. Buffalo. NY. USA.

Dr G. Johansson. Dept of Psychology. University of Stockholm. Sweden.

Dr R. Kalimo. Institute of Occupational Health. Helsinki. Finland.

Dr B. Knave. National Board of Occupational Safety and Health, Solna. Sweden.

Dr Vera Koycheva. Laboratory of Applied Psychophysiology and Neurophysiology. Institute of Hygiene and Occupational Health. Sofia, Bulgaria.

Dr S. Mateeff. Institute of Physiology, Sofia, Bulgaria.

Dr A O. Navakatikyan. Research Institute for Labour Hygiene and Occupational Diseases. Kiev. USSR.

Dr K. Nishiyama. Dept of Preventive Medicine. Shiga University of Medical Science, Seta, Otsu. Japan.

Dr G. Olsson. Department of Human Work Sciences, Lulea University, Sweden.

Dr O. Ostberg. Department of Industrial Engineering. University of Wisconsin. Madison. Wis, USA.

Mr M. Oxenburgh, Health, Safety and Environment Services, Sydney, Australia.

Dr M. Palacek. Occupational Safety Research Institute, Prague, Czechoslovakia.

Dr F. Pot. Netherlands Institute for Preventative Health Care, Leiden, The Netherlands.

Dr S.L. Sauter, Applied Psychology and Ergonomics Branch. National Institute for Occupational Safety and Health. Cincinnati, Ohio, USA.

Dr Patricia Shipley, Stress Research and Control Centre. Birkbeck College, University of London. United Kingdom.

Mr D.H. Sliney, Laser-Microwave Division, Dept of the Army, US Army Environmental Hygiene Agency, Aberdeen Proving Ground. Aberdeen, Md, USA.

Dr I. Soderberg, Work Psychology Unit, National Board of Occupational Safety and Health, Solna, Sweden.

Dr T.D. Sterling, School of Computing Science, Simon Fraser University, Burnaby, British Columbia, Canada.

Dr Maria A. Stuchly, Non-Ionising Radiation Section. Bureau of Radiation and Medical Devices, Environmental Health Centre, Health and Welfare Canada, Ottawa, Ontario, Canada.

Dr M.J. Suess. Environment and Health, WHO Regional Office for Europe, Copenhagen, Denmark.

Dr J. Sydow, Institute of Management, Free University of Berlin, Berlin (West).

Mr J.C. Villforth, Center for Devices and Radiological Protection, Food and Drug Administration, Dept of Health and Human Services, Rockville, Md, USA.

Dr Gunnela Westlander, National Board of Occupational Safety and Health, Solna, Sweden.

## Appendix 2

### Participants at Review Meeting on the Psychosocial Impact of VDTs, Streatley-on-Thames, Sept 22–24, 1987.

Dr Maria A. Frasquilho. Assistant Professor. Department of Mental Health, National School of Public Health. Lisbon, Portugal.

Dr Vera Koycheva. Head, Laboratory of Applied Psychophysiology and Neurophysiology, Institute of Hygiene and Occupational Health, Sofia, Bulgaria.

Dr Colin MacKay. Principal Psychologist, Medical Division. Health and Safety Executive, Bootle, Merseyside, United Kingdom (Chairman).

Dr Steven L. Sauter, Chief, Motivation and Stress Research Section, Applied Psychology and Ergonomics Branch. Robert A. Taft Laboratories. National Institute for Occupational Safety and Health, Cincinnati. Ohio, USA.

Dr Jorg Sydow, Research Scientist, Institute of Management, Free University of Berlin, Berlin (West).

Dr Michael J. Suess, Regional Officer for Environmental Health Hazards, WHO Regional Office for Europe. Copenhagen, Denmark (Scientific Secretary).