PB84-240449

THE WELL-BEING OF VIDEO DISPLAY TERMINAL USERS

An Exploratory Study

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210-79-0034

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Cincinnati, Ohio 45226

February 1983

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FOREWORD

(to be provided by project officer)

ABSTRACT

This study investigated the well-being and working conditions of a heterogeneous sample of 248 VDT users and 85 non-users. An additional smaller sample of VDT users was assessed for their perceptions of changes in working conditions and health incident to the introduction of VDTs in their jobs. All participants were office workers employed by public agencies of the State of Wisconsin. All but 13 were females. Well-being was measured through the cross-sectional administration of a survey. Working conditions were measured by both survey and objective techniques. All assessments were made in the field. The objectives were (1) to explore whether VDT users are at greater risk for job and health disturbances than their non-user counterparts, and (2) to identify potential causes of strain among VDT users.

No significant differences were found between users and non-users on scales of job dissatisfaction or affective or somatic disturbances. However, incidence rates for most symptoms of eye and musculo-skeletal strain were greater for users than for non-users. The difference for one symptom (burning eyes) was marginally significant. Rates of reporting eye irritation and back/neck/shoulder strain were surprisingly high in both VDT users and non-users. One-fourth to one-third of all participants reported these symptoms as occurring at a frequent or constant rate. VDT users actually reported a significantly lower incidence rate for a limited number of specific symptoms of psychological strain. Unlike the well-being measures, the groups were significantly differentiated on perceptions of working conditions. The VDT users reported less autonomy and skill utilization, less staff/supervisory support, and greater physical environmental problems. Both well-being and working conditions varied in relation to the type of work. Data entry workers had the worst of it. Working conditions tended to be rated less favorably and health disturbances reported more frequently as jobs became less qualified and professional. No differences between VDT users and non-users were observed for job and health effects related to the type of work performed.

Regression analyses showed the predictors of strain to be much the same for VDT users and non-users alike. They involved both job design related factors and physical environmental attributes, as well as worker characteristics. With only one exception, VDT use did not interact with these factors in predicting strain (i.e. differential effects for VDT users and non-users were not witnessed). Only in the prediction of affective disturbances did knowledge of whether or not an individual is a VDT user contribute to the explanation of strain after adjusting for effects of worker characteristics and working conditions. In this case VDT use was associated with improved moods. Extent of daily VDT use or cumulative exposure in months was not an important correlate of strain. The most important worker characteristics influencing strain were age and marital status. Reporting of strains decreased with increasing age and was less pronounced among married workers

for both users and non-users. The effects, however, were modest in comparison to the cumulative effects of work related variables.

In the prediction of eye strain among VDT users, ratings of display and ambient lighting quality were particularly important determinants. So were chair and workstation configuration ratings in the prediction of musculo-skeletal strain. Chair and ambient lighting ratings were also significant correlates of strain among non-users. For both types of strain, corrective eyewear use was also an important predictor among the VDT users. Symptom frequencies were greater for individuals using corrective eyewear, but the effect was most pronounced with monofocal as opposed to multifocal lenses. The eyewear effects were much less pronounced in the control group.

In only one of the prediction models did the explained variance in well-being measures exceed 50 percent. Fifteen to 35 percent was the common range.

For the VDT users whose workplaces were objectively assessed, the simple correlation of measures of workstation illumination with reported eye strain was positive and significant. Use of a detached keyboard and decreased gaze angle were also associated in a simple fashion with less reported musculo-skeletal strain.

While the present study provides no strong evidence of increased strain incident to VDT use, it provides a partial template for understanding the causes of strain in VDT jobs. Although the mechanisms seem much the same for VDT users and non-users alike, the VDT users fare less favorably with respect to certain of the risk factors identified. Further explication and confirmation of a number of the findings needs to be accomplished through longitudinal field work and controlled laboratory research.

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ACKNOWLEDGMENT

We wish to formally cite and extend our appreciation to the many individuals who played essential roles in the conduct of this research.

We are especially grateful to the many officials of the State of Wisconsin who made their officeplaces available for this research. We extend our thanks, too, to the VDT users and office workers of Wisconsin who cooperated as participants in the study.

Michael Smith and Alex Cohen of NIOSH were instrumental in the inception and design of this study. As project officer, Michael Smith provided continuous technical input and guidance throughout the course of the project, as well as valuable editorial comments on drafts of this report.

Major credit is due to William Raynor of the University of Wisconsin Statistical Laboratory for the design of the statistical analyses, and to Karen Jones for the careful conduct of these analyses. Gherry Harding and Mari Palta also contributed to the statistical plan and interpretation of data. Robert Keller, Barbara Lannigan, and Robert Ziegler were responsible for establishing and maintaining the computer data files for these analyses. James Quackenboss was instrumental in the design of the data files and the development of the questionnaire coding schemes, and contributed to the early descriptive data analyses. Bruce Brockman, Heidi Strom, and Jean Werlinger played central roles in the actual coding and transcription of questionnaire data.

Clerical assistance in the preparation of research materials was provided by Louise Vick. We are especially thankful to Greg Rogers who typed the many drafts of this report, and to Larry Chapman for the long hours he spent in proofing the drafts.

Finally, we would like to express our appreciation to Robert Arndt who provided input in the design of the survey, assisted in the evaluation of photographic data, and served as a sounding board for some of our interpretations of the data.

INTRODUCTION

THE RESEARCH PROBLEM

Video display terminals (VDTs) are becoming ubiquitous in office workplaces. The number of VDTs in use in the U.S. for all purposes in 1980 has been estimated at between five and ten million, and the number of operators in excess of seven million (CDC, 1980). In Wisconsin State Government offices where the present research took place, the number of VDTs purchased for replacement and expansion purposes has been increasing at a rate of approximately 50 percent each biennium over the last 10 years. The application of VDT technology is expected to further accelerate through the remainder for this century as business strives for cost-containment and increased productivity in office work, and as the information sector of the economy grows. Giuliano (1982) cites projections that by 1990 between 40 and 50 percent of all American workers will be making daily use of electronic terminal equipment; that nearly 40 million terminals will be installed in offices, factories, and schools; and that home use will involve over 30 million terminals.

In many cases the advent of VDT technology and office automation in general has led to sweeping changes in the way information processing/management work is organized and performed, and in the physical design of workplaces and workstations for this type of work. These changes greatly facilitate the performance of tasks, and research shows that usually the improved capabilities brought about by VDTs are a significant source of satisfaction for workers.

At the same time, however, advances toward automation have created concerns over the potential impact of this technology on the quality of working life and the well-being of workers. Shepard (1971) has drawn a parallel between evolutionary changes toward the automation of office work and prior trends in the mechanization of factory work. Within this framework, some of the concerns over VDT technology can be understood. According to Shephard's scheme, traditional secretaries are the officeplace equivalents of the blue collar craft worker, and production typists, keypunchers, etc., are analogous to factory assembly-line workers, both categories of jobs involving highly mechanized work tasks. One concern with VDT-computer applications in office work, then, is over the attributes of mechanized work (i.e. standardization and simplification of work practices) which have sometimes been judged unfavorable in investigations of industrial work in terms of implications for quality of work life and worker health (e.g. Caplan, Cobb, French, Van Harrison, and Pinneau, 1975; Johansson, Aronsson, and Lindstrom, 1978). Guiliano (1982) describes how electronic information processing may hold the potential for a positive transformation of the dull, fragmented, repetitive, and standardized work that is characteristic of jobs in the "industrial" office. However, it is clear that this potential is not yet fully realized since work in many VDT jobs has advanced little beyond the mechanization stage - as for example, in data entry via VDT.

A second major area of concern, as described by Ostberg (1975), involves potential health related problems (e.g. visual and musculo-skeletal disturbances, and psychological strain) related more directly to the physical and operational ergonomic demands and constraints of VDT technology. These are problems which stem from a poor interface between the user and the physical environment, machine and workstation hardware, and systems software.

A third issue which is not within the scope of the present investigation has been the speculation regarding a potential electromagnetic radiation hazard from VDTs.

The concern over the potential for occupational stress and health problems associated with VDT use has stimulated a substantial number of investigations addressing this subject in recent years. Matula (1981) cited 174 articles and research reports from 1972 through 1980 pertinent to the issue of the well-being of VDT users.

Two types of questions or issues predominate in the literature examining the health implications of VDT use. The first is whether or not VDT users are at greater risk for disturbances of health and well-being than non-users performing similar types of jobs. The second concerns the risk factors in VDT use, i.e. the aspects of VDT work and VDT users which are associated with job and health problems. The current study addresses both of these issues since neither has been adequately resolved.

On the first issue, studies which have compared VDT users with their non-user counterparts on various indices of well-being have produced mixed results. A number of studies suggest increased levels of stress, discomfort, or debility among users (Canadian Labour Congress, 1982; Haider, Kundi, and Weisenbock, 1980; Hunting, Laubli, and Grandjean, 1981; Laubli, Hunting and Grandjean, 1981; Mourant, Lakshamanan and Chantadisai, 1981; Smith, Cohen, Stammerjohn, and Happ, 1981). Others suggest no or few differences (Coe, Cuttle, McClellan, Warden, and Turner, 1980; Starr, Thompson, and Shute, 1983). A number of studies have also shown relatively high frequencies of expressions of various types of job and health disturbances among VDT users (Dainoff, Happ, and Crane 1981; Ghiringhelli, 1980; Gunnarsson and Ostberg, 1977), but contrasts with comparison or control populations are not drawn. Importantly, many of these studies have been rather severely criticized on methodological grounds (Helander, Billingsley, and Shurich, 1983; Starr et al. 1983).

It is important to obtain these types of comparison data as one way of addressing the fundamental question of whether VDT use is stressful or uncommonly so, and how potential stresses and strains of VDT use vary with different types of VDT work. Such information provides the basis for decisions regarding the necessity for additional research or abatement measures.

These types of data and their underlying research methodologies can have fairly severe limitations, however, depending upon the aspirations of the study. Perhaps the most important drawback is that they allow almost no inferences pertinent to the corollary question of the specific causes of differences observed between VDT users and non-users. Some investigators have been critical of prior studies comparing VDT users and non-users, claiming that control groups are inappropriate - that the samples are not well matched in terms of job characteristics and that VDT use as an experimental or treatment variable is not well isolated (e.g. Starr et al., 1983). The assumption underlying such criticism is that "VDT use" can be defined in terms of some fairly narrow attribute of the instrument use itself, and that comparisons of VDT users and non-users can uncover the effects of this attribute. In some cases such as telephone directory assistance via VDT versus hardcopy these assumptions may be largely safe, but such cases are likely in the minority. Even in the Starr et al. (1983) investigation where the jobs of the VDT users and non-users seem distinguished only by the VDT, it is seen that work monitoring practices also separated the two jobs.

Analysis of VDT jobs and their more traditional counterparts seems to suggest that in most cases VDT work cannot be defined in a narrow way. Operationally, VDT use involves much more than simply cathode ray tube viewing or interacting via keyboard. For example, contrasting keypunching with VDT-data entry, significant differences exist with respect to work-station configuration, information display characteristics, ambient noise, and temporal and general process control features of the task related to software determinants. Cakir, Reuter, von Schmude, Ambruster and Shulte (1978) differentiate typing from text processing via VDT on seven major characteristics of the job task alone. Thus even where first impressions suggest that a particular task carried out via VDT is only a limited variant of a similar task performed in a more manual fashion, the two may be differentiated along numerous dimensions, all of which could play a role in affecting the well-being of users.

Such complexity may defy the design of controlled experiments or studies to examine the effects of VDT use construed as a narrow phenomenon embodied simply in the operation of the instrument itself, and generalizations regarding the effects of VDT use from studies so designed. "Paced work" is a good analogy. Salvendy (1981) asserts that comparative studies to investigate the effects of machine pacing versus self-paced work are not desirable because in real world situations these two pacing conditions are confounded by job content. Like paced work, VDT use is similarly a multidimensional phenomenon. Results of simple comparisons of VDT users with non-users are limited to conclusions regarding effects of the complex of conditions separating the VDT and non-VDT jobs. Unfortunately, such studies almost reflexively elicit the inference or perception that group differences observed can be attributed to VDT use narrowly conceived, i.e. the VDT.

A main objective of the present study is to augment the still limited data base addressing the absolute and relative risks of office jobs in which VDTs are utilized. Comparative analyses are carried out to examine the relative intensity or incidence of various strains between users and non-users, and among subgroups of users and non-users from State of Wisconsin Government agencies. Job characteristics of users and non-users are also investigated to assess the impact of VDT use on the nature of office jobs. Evidence of less favorable working conditions among users might indicate increased risk over the long term irrespective of differences in current levels of strain. Where research instruments allow, comparisons are also made with normative data on working conditions from other occupational samples to examine the potential for strain in relation to the workforce at large.

Questions regarding the nature of risk factors in VDT usage are as important, or perhaps more so, than questions regarding the comparative risks of VDT use. This information holds the key for understanding discrepancies among comparative studies reporting varying differences between user and non-user samples in terms of well-being, and can be useful for minimizing stress and strain among users regardless of the comparative risks of VDT use. Nearly all of the studies to date have made some attempt to identify particular origins of stress in VDT work. Some specific ergonomic determinants of musculo-skeletal and eye disturbances are indicated in data provided by Coe et al. (1980) and by European investigators (Cakir et al., 1978; Elias, Cail, Tisserand, and Christmann, 1980; Haider et al., 1980; Hunting et al., 1981; Laubli et al., 1981). User characteristics have been implicated by Cakir et al. (1978), Coe et al. (1980), Ghiringhelli (1980), Rey and Meyer (1980), and by Starr et al. (1983). Salient job content factors have been suggested in research by Cakir et al. (1978), Coe et al. (1980), Johansson and Aronsson (1980), and by Smith et al. (1981). Swedish investigators (Gunnarsson and Ostberg, 1977; Gunnarsson and Soderberg, 1979; 1980) have also provided limited information in all these areas.

Although VDT user and work/workplace design factors have been implicated as stress factors in VDT use, studies thus far have been deficient in sorting-out or prioritizing effects of multiple causal variables within and among these categories. A good example is provided in the report by Ghiringhelli (1980) where the effects of age, extent of daily VDT use, and education cannot be distinguished. Coe et al. (1980) also note the potential for confounding in their results.

A second aim of the present investigation is to improve upon current knowledge regarding the process by which stress and strain are caused in VDT work by examining more systematically, using mainly multiple regression techniques, the relative importance of various job design, physical environmental, and user variables. Our study also asks whether the effects of these variables are any different for non-users.

STATUS OF CURRENT KNOWLEDGE

Current reviews and surveys (Dainoff, 1982; Helander et al., 1983; Matula, 1981) indicate that in the neighborhood of three dozen research studies to date have focussed on the health and comfort of VDT users. However, only a handful have appeared in the regular scientific literature.

The emphasis in prior research is about evenly divided in terms of attention to somatic strains, and to psychological strain and job attitudes incident to VDT work. Findings suggest a pattern of symptomology among VDT users characterized by eye strain (more so by fatigue-irritation than imperception or acuity deficits), together with a lesser degree of musculo-skeletal strain (more so upper torso than arm-hand discomfort), and some indication of mental fatigue, but little job dissatisfaction or explicit psychological strain. Evidence of the exacerbation of these problems in VDT users in comparison to non-users is mixed. Causal factors implicated include physical and ergonomic aspects of the workplace environment and workstation equipment, as well as job content and organizational factors. However, statistical evidence of causal patterns is limited.

Questions have been raised regarding the reliability and meaning of findings thus far, and these concerns cannot be taken lightly. Some investigators have gone so far as to discount to some degree nearly all of the research to date on the basis of methodological shortcomings. Starr et al. (1983) assert that "...nearly all of the studies that have addressed the effects of VDTs on workers have been seriously compromised..." (p. 701), listing basic methodological problems of control including reactive effects from testing, failure to isolate the treatment (VDT use),* and opportunities for systematic bias via selection problems. Starr et al. (1983) are also critical of the fact that judgements have been made regarding the severity of disturbances observed among VDT users in the absence of norms or criteria which define acceptable levels. In a critique of 65 human factors research studies on VDTs, Helander et al. (1983) also conclude that lack of scientific rigor has devalued the meaning of much of this work. They emphasize that many of the studies to date are based upon research methodologies which fail to meet minimal requirements for even quasi-experimental designs and thus have limited internal validity. Much of the existing work consists of field investigations using self-report techniques which are either simply demonstrations (one-shot case studies) or static group comparisons.

Dainoff (1982) asserted that the lack of an "integrated" approach in which different aspects of VDT users, their jobs, and workplaces are systematically examined or manipulated has been a major shortcoming in prior research which precludes a clear and reliable understanding of the risk factors in VDT operation. Although the source of VDT user problems has generally been accepted as multifactorial by prior investigators (e.g. Cakir et al. 1978; Coe et al., 1980; Dainoff, 1982), no studies to date have incorporated designs or analyses which enable a systematic determination of the way in which potential stressors combine additively to affect the comfort of VDT users. Starr et al. (1983) also express concern over failure to investigate potential interactive effects. Ostberg (1977) describes an interaction whereby glare discomfort was rated greater at high task difficulty than low task difficulty, with objective lighting conditions held constant. Likewise, ratings of task difficulty changed with variation in the glare parameter. Smith et al (1981) provide data suggesting that VDT use interacts with job content factors (specifically the professional level of tasks) to contribute to problems experienced by users. Yet, research methodologies which systematically examine for the nonadditive combination of variables or nonlinear effects seem nonexistant. By and large, the analytical schemes employed in the VDT stress research thus far have gone little beyond series of bivariate analyses or comparisons, with limited control (exercised primarily through subgroup analyses) over covariates or potential confounds .

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* However, as discussed previously, such attempts may be an exercise in futility.

In the present study, we sought to overcome some of these methodological shortcomings which are readily amenable to correction.

REVIEW OF BACKGROUND RESEARCH

The results of about two dozen studies which seem to represent the main core of the work addressing the health and job implications of VDT use are described. The review is organized in accordance with the research emphasis which can be generally categorized into three topical areas corresponding to eye or visual function effects, musculo-skeletal effects, and emotional effects/job attitudes. Several studies focus on all three areas. In the interest of brevity, discussion is confined to a synopsis of the main findings, and methodological detail is limited. The reader is referred to Helander et al. (1983) for a more thorough treatment of the methods of this work. Within each section, studies are presented in chronological order of their appearance.

Visuo-ocular Effects

Summary--

Data have been obtained on both subjective reports of eye comfort and visual function, and on various objective indices of ocular and visual status. For the subjective measures, a considerable degree of unanimity exists among the results of different investigations. VDT users tend to give fairly strong affirmative responses to questions regarding the presence of eye fatigue or irritation-like symptoms (asthenopia); e.g. tired, heavy, burning, itching, watery eyes. Users report symptoms such as blurred vision, altered color perception, etc., indicating optical disturbances or imperception to a much lesser extent. In the relatively few studies which have compared VDT users and non-users on subjective indices of ocular discomfort and visual insufficiency, users tend to report higher rates of disturbance. However, evidence of statistically significant differences in incidence rates is mixed.

While some investigations have found effects indicative of alterations in convergence and/or accomodative functioning during VDT use, objective evidence of visual dysfunction incident to VDT use is less consistent and definite than the subjective data.

Although most studies have identified working and viewing conditions which are attributed as the cause(s) of these eye/visual system disturbances (most notably task and ambient lighting, display characteristics, job regimen), only rarely are systematic efforts undertaken to statistically link these conditions with the effects observed.

Review--

Using a worker survey and physical measurement of environmental lighting, Hultgren and Knave (1973) examined the incidence and officeplace geographic pattern of subjectively reported visual disturbances and office lighting conditions for 17 customer assistance VDT users within a single room of an insurance firm. There was no control group. Eleven users complained of "contrast blinding" problems, and 10 users complained of reflection problems. Six users reported eye fatigue with headache, and two reported a sensation of burning eyes. However, there is no indication of the severity or frequency (within users) of these problems. Inspection of a schematic of the office and the location of users with various types of complaints shows a general correspondence of complaints of reflections and contrast blinding with VDT use near south-facing windows. However, the locations of users with the fatigue symptoms did not correspond well with window seating, and the two users with burning eye complaints were not among those with complaints regarding reflections or contrast blinding. Numerous other physical measures of lighting conditions were made, but they were not related in the report in any systematic way to expressions of visual discomfort by the VDT users.

Holler, Kundi, Schmid, Stidl, Thaler, and Winter (1975) subjected 14 experienced VDT users to both 4-hour and 2-hour periods of VDT display viewing-intensive work. Objective pre-post work session data were collected on color perception and visual acuity. No control subjects were employed in this study. Additional information obtained via questionnaire included demographic data, data on normal working and environmental conditions, and data on the experience of headache, fatigue, and various indices of visual system disturbance (flickering before the eyes, burning eyes, changes in color vision, and decreases in acuity). The subjective somatic strain data were obtained both relative to regular VDT work for these individuals, and before and after the experimental work periods.

Inspection of responses to questionnaire somatic disturbance items shows that the most common eye/vision related problem among these individuals relative to their regular VDT jobs was burning eyes. Six of the 14 users reported experiencing burning eyes "sometimes" or "quite often". The reporting pattern was the same for headache. Only two subjects reported changes in color vision, but five reported decreases in acuity. In neither case, however, were these latter effects reported more frequently than "sometimes". Examination of questionnaire data on changes in strain symptoms following the two different work sessions showed that again burning eyes was the effect most reported, although half the subjects reported "somewhat" reduced acuity. On the objective measures, nine of the subjects manifested acuity losses of a myopic nature. This effect was more severe following the longer work session, but appeared to reverse in most cases following a short rest period. Results for color perception changes were inconclusive. No information on the interrelationships among the various research measures was presented, and apparently such analyses were not undertaken.

Gunnarsson and Ostberg (1977) carried out a broad investigation of health complaints and working conditions of VDT users in the Scandinavian Airline System. The study involved both an ergonomic evaluation of various physical environmental parameters and work operations (photographic motion study of work activities, lighting measurements, and viewing distance and angle measurements), and structured interviews seeking information regarding aspects of the physical and organizational working environment. The interviews also sought information on physical discomforts and psychological stresses experienced by users. As in the Holler et al. (1975) investigation, no control group was studied.

Regarding visual system problems, the investigators report that about 75 percent of the interviewed users performing the most terminal intensive work experienced some form of discomfort "daily" or a "few times a week." For all types of symptoms of visual system disturbances, approximately half of the responding users reported "severe" or "very severe" problems. In terms of the specific symptoms, eye fatigue (60% of respondents) and again, burning eyes (48% of respondents) predominated. Only 17 percent of the respondents indicated they experienced double vision, and fewer still "red eyes" or headache. Results of a limited number of bivariate analyses examining visual discomfort in relation to VDT user or task characteristics were also reported. Factors such as screen viewing as opposed to hard copy reading, and refractory deficits appeared to be associated with increased strain. Although a wealth of information was apparently obtained on environmental lighting conditions and on operators' reactions to these conditions (e.g. workplace illumination, screen image intensity adjustability, use of local lighting, reactions to ceiling lights and sunshades, existence of screen reflections, etc.), the report provides no information on how these conditions may have related to the eye/vision problems expressed by users.

One of the most extensive investigations into the well-being of VDT users was carried out by investigators at the Technical University of Berlin (Cakir et al., 1978). The total study sample included 1005 VDT users with diverse tasks and responsibilities, and 16 nonusers, from about 30 different organizations. Not all of the participants were assessed with respect to all the research measures, and it is clear the composite project consisted of a series of separate investigations which share common features, as opposed to a unified study. The research involved: (1) a technical component assessing physical ergonomic aspects of the workplace/equipment and ambient environmental conditions; (2) a physiological component focussing mainly on the visual system; (3) performance assessments indicative of mainly CNS activation/arousal; and (4) a broad battery of tests and surveys assessing affective states, somatic symptomatology, perceived stress, and working conditions. The report provides only select findings from the overall project, and they are presented in a somewhat fragmented, summarized form. The findings are further elaborated in the VDT Manual (Cakir, Hart, and Stewart, 1980) which also alludes to additional studies on control populations. Important data on the research protocol for the much of the work conducted is often not presented or is difficult to extract from the voluminous report. The report actually provides only very limited summary information regarding the incidence of eye/vision disturbances among VDT users, or the relationship between these effects and VDT user or task/display/ambient parameters that would presumably influence visual function or eye comfort.

Levels of up to 85 percent of high speed data acquisition VDT users responded "sometimes true" to a question regarding the experience of excessive eye strain at work. Sixty-eight percent of users with similar tasks but not on an incentive pay schedule responded the same. The rates for programmers, however, were considerably lower, ranging from somewhat less than 50 percent to 64 percent. Group differences in the experience of eye strain were also reflected in the group proportions seeking (but not necessarily receiving) ophthalmologic treatment. Eye strain was also reported more frequently among users wearing monofocal reading glasses than among individuals without vision correction or individuals wearing bifocals. The investigators also describe (but do not present the supportive data) a positive relationship between perceived adverse display characteristics (e.g. poor character recognizability) and reports of eye strain and burning eyes, and a positive relationship between the level of office illumination and these symptoms.

Two investigations by Gunnarsson and Soderberg (1979; 1980) similar to the Gunnarsson and Ostberg (1977) airlines project yielded data showing a similar pattern of eye strain among users. In the 1979 study, 42 older VDT users in the composition department and six VDT users in the sales department of a Swedish newspaper were interviewed to obtain data mainly on visual system discomfort. The incidence of complaints of eye/visual disturbance were close to the rates obtained in the prior airlines study. Sixty-two percent of the VDT composition operators complained of visual fatigue on an "occasional" basis, and 38 percent reported "daily" problems. Only one of the six users in the sales office did not report at least "occasional" problems of this type.

In the 1980 report, 15 VDT users from the sales department and 30 directory assistance users in the Swedish Telecommunications Administration were studied for evidence of eye strain in relation to either a "normal" work session (3.5 - 4.0 hours per day) or an "intensified" (full 6-hour/day) session working at VDTs. This was an experimental manipulation. Measures included an eye strain questionnaire, the near points of convergence and accommodation, and interviews seeking data on eye strain and working conditions. Again, a non-user control group was not examined.

The proportion of study participants reporting symptoms of eye strain was found to increase substantially with intensified work - from 34 percent (normal working procedure) to 63 percent (intensified procedure), and these effects were exacerbated in the sales department and with increasing age. The investigators also suggested an interaction between job type and the intensified work procedure in producing eye strain, but the effect was not examined statistically. Of the symptoms reported, visual fatigue and eye ache/headache were the most frequent, far more so than sore, itching, or bloodshot eyes. Symptoms corresponding to visual imperception were apparently not included in the questionnaire nor sought out in the interview. For the younger workers, near points of both accommodation and convergence were found to regress (i.e. move away) over the course of the day, but generally more so during intensified VDT work. Differences between the two regimens were reported to be statistically significant. These effects would seem contrary to the findings of Holler et al. (1975) who reported a more myopic-type response. The investigators suggested a correspondence between the subjective strain and the optometric findings, noting that convergence shifts were less for the symptom-free group. However, no quantitative data on the strength of the suggested relationship are presented.

In 1980 the results of a number of studies addressing the question of eye strain in VDT users were presented at an international symposium held in Milan, Italy, and have been since published in the proceedings (Grandjean and Vigliani, 1980). In addition, the results of two additional studies, one commissioned by the New Zealand Department of Health (Coe et al., 1980), and the other by investigators from the University of Stockholm (Johansson and Aronsson, 1980) were released in 1980. Several of these studies are distinguished from prior studies by improved methodology, involving both the utilization of control groups and limited analyses to examine relationships of VDT working conditions and user characteristics with strain measures.

In the New Zealand study, 257 VDT users performing either data input, conversational (question and answer), editing, or creative (e.g. programming tasks) tasks were compared with 124 office worker control subjects on survey measures of physical environmental conditions, health problems, biodemographics, job design features, and on a series of objective optometric measures. Objective anthropometric and ergonomic evaluations and lighting measurements were also undertaken, but for the VDT users only. Data evaluation consisted mainly of an extensive set of contingency table analyses through which the investigators sought to identify various determinants of strain.

The study failed to find major differences between the VDT and control group in terms of a cluster of three survey items and responses to an open-ended question, all denoting visual asthenopia (eye fatigue, weakness, pain). Fifty-one percent of the VDT group and 45 percent of the control group reported the experience of asthenopia. In addition, no differences were found between the VDT and control groups on the objective optometric measures. Unfortunately, the questionnaire wording for the asthenopia items allows no inferences regarding frequency or magnitude (within individuals) of the disturbances. Although the two study groups were not significantly differentiated in reports of asthenopia, significant differences were found among the VDT user subgroups. Creative users had a lower incidence of disturbances than users whose tasks were more structured and routine. Also, when these symptoms were separated into fatigue-like effects (heavy, tired, etc., eyes) and irritant-like effects (itchy, gritty, stinging, etc., eyes), the fatigue symptoms were found to be significantly more common among the VDT users. No group differences in terms of any other subjective measures of visual dysfunction or eye discomfort were found, nor was the incidence of visual dysfunction as objectively measured any greater in the VDT group. Of interest however, reports of blurring and asthenopia, particularly irritation, were far more prevalent among full-time users, and among users taking a lower frequency of informal rest breaks. Paradoxically, reports of asthenopia were least frequent among VDT users working under the most intense ambient lighting.

Johansson and Aronsson (1980) investigated 81 VDT users and 14 non-users at a regional office of a large Scandinavian insurance firm to examine the impact of VDTs on users' perceptions of job attributes, on their job attitudes, and on reported strains. The study involved both survey and psychophysiological measurement. The survey component covered biodemographic characteristics of participants, job content, job satisfaction, fatigue, moods, and somatic disturbances within the past year. Data on eye strain were limited. The investigators reported that 58 percent (25 of 43) VDT users with lengthy VDT sessions experienced "eye symptoms" within the past year. But more specific data on the nature, severity, or frequency of these disturbances are not given, nor is a comparison made with non-users. It was also reported that a small group of "favored" individuals (more varied and responsible jobs) were less troubled by unsuitable lighting.

At the Milan symposium, Haider et al. (1980) reported on a study which represented a variation of the previous investigation by Holler et al. (1975). Thirteen VDT users and nine office workers performed VDT and typing tasks respectively for three 4-hour sessions, each session separated by a one week interval. Before, throughout, and following each session, measures of heart rate, psychological state, color perception and acuity (both objective and subjective measures), and perception of an optical illusion (Muller-Lyer) were obtained. Following each session a questionnaire with items denoting visual asthenopia, headache, and musculo-skeletal problems was administered

Results supported the findings of Holler et al. (1975). For the objective visual function measures, significant changes in acuity described as temporary myopia were noted following VDT work, but not following typing. The investigators attributed the effect to accommodative strain. Work breaks moderated the effect considerably. Color contingent after-effects and an increased illusory effect were also observed only for the VDT users. All of the visual disturbances were significantly exacerbated with green as opposed to yellow image foregrounds. No data were presented on changes over the working period on the subjective ratings of visual status, nor was any relationship of these ratings with the objective measures reported. The experience of eye twitching and sore eyes was reported for a majority of VDT users, but data on frequency or intensity and comparisons with non-users were not reported.

A report by Ostberg (1980) at the Milan conference suggests a possible resolution of the apparent discrepancy between the myopia effects reported by both Holler et al. (1975) and Haider et al. (1980), and the regression of the near point of accommodation and convergence observed by Gunnarsson and Soderberg (1979). Using the relatively new technique of laser optometry, Ostberg examined accommodative response during the viewing of targets at various visual depths for a group of air traffic controllers and for a group of VDT users with less taxing visual demands. Both groups exhibited a "hyperopic" accommodative change for near viewing, and a "myopic" effect for distance viewing. The effects were statistically significant for the air traffic controllers. Ostberg also reported that he obtained findings of no such changes among traditional office workers not using VDTs.

Also reporting at the Milan conference, Laubli, Hunting, and Grandjean (1980; results are described more comprehensively in 1981) presented data clearly linking visual discomfort with physical viewing aspects of VDT work. Fifty-three data entry VDT users, 109 conversational users, 55 traditional office workers, and 78 conventional typists were given a medical evaluation which included a vision battery and examination of muscles and joints. Data on forehead and hand skin temperature were also obtained. A questionnaire was used to obtain data on physical symptoms and working conditions. Physical measurements were made of the environmental and VDT display lighting, and of the dimensions of the workstation. Finally, data on working posture were also collected.

Results of a factor analysis of questionnaire vision items showed that 81 percent of the variance in responses was explained by a cluster of items denoting eye irritation (pains, burning, etc.). Items denoting imperception (e.g. blurring) accounted for the remaining 19 percent. Note that this characterization of visuo-ocular symptomatology (i.e. dominated by irritant or fatigue-like effects) is highly consistent with prior findings on the nature of eye/visual disturbances incident to VDT use. Significant differences among groups were found on four questionnaire eye/vision symptom items (fatigue, shooting pain, impairment persisting until sleeping, and impairment before work).

In all cases it appeared that the significance occurred in the comparisons of traditional office workers, who reported the lowest incidence of disturbances, with either the conversational or data entry users (most frequent disturbances). Unfortunately, a posteriori group contrast data are not presented. Conventional typists did not appear to be significantly different on these measures from the entry and conversational groups, although their incidence rates were lower. For the data entry and conversational users, approximately 65 percent reported occasional eye fatigue, and about 25 percent daily fatigue. Clinical optometric data did not predict well the occurrence of subjective symptoms of strain, although there was some tendency for greater blurring and pain in individuals with irritated conjunctivae, with the wearing of corrective lenses, and with low visual acuity. The trend was much the same for VDT users and non-users alike. Visual disturbances correlated significantly with visual field luminance contrasts, but not with the luminance of screen reflections. Finally reports of shooting pain and burning and red eyes were found to be significantly negatively related to the amplitude of oscillation of VDT image luminance. The relationship was not significant, however, for items denoting visual imperception.

VDT users were compared to workers with jobs characterized by strong visual demands (engraving and watch-making) in a field study by Rey and Meyer (1980) also presented at the Milan conference. A control group comprised of clerical workers was also included in the study. Data were collected on general feelings of discomfort, symptoms of visual fatigue at the end of the day, and on other signs of visual asthenopia (burning eyes, ocular pain, etc.). Clinical optometric tests and tests of brightness discrimination, glare resistance, and flicker-fusion thresholds were also administered. Further information on measurement techniques and subsample sizes was not provided.

Age of the participants, VDT use, and VDT task duration were all positively associated with the subjectively expressed eye disturbances. However, only the VDT use and task duration effects were significant. Only age influenced the objective measures of eye defects. About 50 percent more of the VDT users than comparison participants expressed eye complaints, and about the same ratio was observed in users working 6-9 hours versus four or less. Additional laboratory data were presented showing increased blink rates with high as opposed to low screen-background contrast ratios during video display viewing.

At the Milan Conference, Elias et al. (1980) described a relatively high incidence of four types of eye and visual strain symptoms among 89 off-line data acquisition VDT users and 81 dialogue users. In all cases the disturbances were significantly more frequent among the former group (69% vs. 53% prickling; 43% vs. 21% blurring; 82% vs. 69% discomfort glare; 43% vs. 21% acuity weakness). The effects were attributed to repetitive visual adjustment demands related to the very high frequency of visual sweeps between the display and document for the acquisition users. The investigators also suggested a link between users' affective states, as influenced by working conditions in general, and visual functions which are mediated by autonomic mechanisms. This is an important hypothesis few investigators have explicitly considered or explored. Miller and Le Beau (1982) have obtained limited evidence of a myopic-like, dark focus (resting) accommodative change related to induced stress. Also pertinent to this issue, Dainoff et al. (1981) speculated that vision related complaints may represent displaced expressions of distress related to psychosocial stressors in automated office work, and to generalized physical debility among VDT users.

Ghiringhelli (1980) reported at the Milan Conference that eye disturbances were significantly more prevalent among 62 VDT users than a comparison group of 237 non-users. Data were obtained using interview techniques. No description of the comparison group is provided, and description of the research protocol is sparce. About half of the users reported eye irritations at the time of interview and 34 percent reported imperception. Seventy-five percent of users reported some form of vision related disorder. Over 40 percent of users identified both luminance and reflection problems as the source of these problems. Levels of vision-related disturbances in the comparison group were not reported.

In 1981, the results of the first North American field investigations into the well-being of VDT users were reported (Dainoff et al., 1981; Smith et al., 1981). Both were field studies.

The Dainoff et al. (1981) study involved VDT users only. The total sample numbered 121. Most were clerical level users. Data collection involved a formal "funnel-type" interview to examine users' comfort and sentiments regarding their jobs and working conditions, an objective optometric screening, and administration of a mood status and physical symptoms questionnaire. Results showed that one of the most frequently expressed negative responses during the interview concerned visual fatigue (45% of users). Adverse comments regarding lighting, need for vision correction, or eye fatigue were registered by 75 percent of users. The complaints of visual fatigue and lighting problems were significantly positively correlated with estimates of the proportion of time spent in screen viewing ($r = .28$ and $.39$ respectively). Examining changes in the proportion of users reporting various physical symptoms from before to after work, the largest increases observed among 13 symptoms were for eye strain (30%-62%) and blurry vision (14%-39%). However, unlike previous studies in which adverse changes were found in both objective optometric and subjective assessments of visual status (Holler et al., 1975; Gunnarsson and Ostberg, 1977) over a period of VDT viewing, no effects for the objective optometric measures were observed.

The NIOSH investigation of VDT use at four California newspapers and one insurance company was conducted as part of a formal government health hazard evaluation requested by labor unions representing employees at these sites. Radiation, industrial hygiene, ergonomic, and health and job related data were collected by a team of NIOSH scientists. In the health component of the project, Smith et al. (1981) used a broad questionnaire to obtain information on biodemographics, perceived job demands and stressors, disease states, physical symptoms, mood status, and environmental and ergonomic conditions of the workplace from 129 clerical VDT users, 125 professional users, and 157 clerical controls. At the same time, data were collected on objective physical and perceived ergonomic aspects of the workplace and workstations for the VDT users (Stammerjohn, Smith, and Cohen, 1981). However, the methodology did not allow the objective physical data to be associated with the subjective health or job data.

Symptoms of eye/vision related problems were more common than any other symptoms of health disturbance. Ninety-one percent of all clerical users reported the experience of at least "occasional" eye strain, 80 percent reported burning eyes, and 74 percent reported irritated eyes. Symptoms of imperception were less frequently reported: blurred vision - 71%, changes in color perception - 40%. Rates for the clerical controls averaged approximately one-half the rates for the clerical users. Rates for the professional users were somewhat reduced below levels for clerical users, but still significantly elevated above the control level for symptoms other than those denoting imperception. The total number of physical symptoms reported by each user was only modestly related to the extent of daily VDT use ($r = .19$).

In the associated report by Stammerjohn et al. (1981), screen glare, character brightness, and flicker were all reported as problematic by users. At least 75 percent of users rated these conditions as at least "occasionally" bothersome, and 25 percent or more "often bothersome". Furthermore, all three problems were shown to be significantly associated with the number of physical symptoms (not just vision related) reported by users. Importantly, NIOSH investigators were unwilling to implicate physical workplace/station/equipment conditions alone as the source of visual strain, concluding with the speculation (based upon the differential effect observed for professional vis-a-vis clerical users) that job content factors contribute to VDT users' complaints.

A limited number of field studies addressing the subject of eye strain incident to VDT use have been conducted in North America subsequent to the work by Dainoff et al. (1981) and NIOSH investigators.

At the 1981 convention of The American Public Health Association, Sauter, Rohrer, Arndt, and Gottlieb (1981) reported the results of a questionnaire survey of working conditions and of physical and emotional well-being for 63 newspaper professionals (mainly copy editors) who used VDTs for an average of over six hours per day. The control group was comprised of predominantly professional as opposed to clerical office workers. Both groups were from the same newspaper facility. Data were obtained on aspects of job design and demands, social and physical workplace conditions, biodemographics, and aspects of health, comfort, and job satisfaction. Results showed that the two groups were differentiated in a major way only in terms of eye strain symptoms which were characterized by fatigue and irritation as opposed to imperception. Thirty-three percent of users in contrast to 11 percent of non-users reported a "constant experience" of burning eyes. Between 30 and 40 percent of users reported a "frequent" experience of burning, tearing, strained, and heavy eyes, in contrast to 15-20 percent of non-users. These differences were statistically significant. Far fewer reports of blurred vision or color perception problems occurred for either group, and the group differences were less pronounced on these measures. There was no indication that these effects were confounded by other group differences, including workplace lighting conditions which were judged poor by both groups.

At the same meeting Arndt (1981 a,b) reported data showing a significantly higher frequency of eye complaints among telephone directory service operators who used VDTs than among operators who obtained the same information from digital (nixie tube) displays. Both groups performed nearly identical jobs in the same environments. A third group of operators randomly selected from several other facilities and working mainly with hard copy (phone books) reported even fewer complaints. The proportions of the three groups reporting they "often" experienced eye strain were 52 percent, 16 percent, and 8 percent respectively. The proportions reporting burning eyes was reduced by about one-fourth for each group. No significant group differences were observed for indices of visual imperception (blurred vision, focus problems, or color distortions). The reporting of eye strain in the VDT group was very strongly associated with the reporting of direct and indirect (screen) glare (average r of about .60).

Arndt's (1981 a, b) findings stand in contrast to the results of a recent similar and well controlled study by Starr et al. (1983) in which 250 telephone directory assistance operators who used VDTs were compared with 105 control operators who performed identical tasks from hardcopy (phone books). The questionnaire administered solicited information on participant demographics, physical discomforts, and job satisfaction. Although the VDT users reported a significantly greater cumulative number of physical complaints than non-users, with one exception the percentage of VDT users reporting each specific complaint was not significantly greater than the corresponding percentage for the control group. This includes all the items denoting eye and visual disturbances. After adjusting for age (reports of discomfort were more frequent in younger participants) all significant group differences in the incidence of somatic disturbances disappeared.

Smith (1982) briefly commented on certain preliminary findings from a recent NIOSH investigation of 280 VDT users in an east coast newspaper facility. Much the same type of data were obtained as in the NIOSH California study with the exception that ophthalmological examinations were also conducted. Consistent with findings by Dainoff et al. (1981), Smith reported no relationship between the outcome of the ophthalmologic investigation and questionnaire indices of visual disturbances. Additionally, Smith (1982) reported that no relationship was found between either the amount of VDT use in terms of hours per day or years of tenure as a VDT operator and the prevalence of eye abnormalities.

The largest field study addressing the potential health implications of VDT work was conducted by the Canadian Labour Congress (1982). Survey data were obtained from 1742 VDT users and 588 non-user control subjects from 15 sites across Canada. All participants were members of an organized labor union. Four categories of work were represented in the VDT user sample: production line, data entry, conversational-clerical, and professional-technical. The survey solicted information on job characteristics, on aspects of the ambient workplace environment and physical characteristics of the workstation, and on the incidence of various health disturbances (focussing most heavily on eye and musculo-skeletal strain symptoms). Statistical evaluation of the data consisted mainly of contingency table analyses examining symptom incidence rates in relation to VDT use/non-use and to aspects of working conditions.

For all six questionnaire items denoting eye or vision disturbance, the incidence rate for the VDT users exceeded the rate reported by the non-user control subjects by a statistically significant margin. Seventy-seven percent of the users and 56 percent of the non-users reported at least one symptom of eye/vision disturbance as occurring in the three months prior to the survey administration. Rates for the VDT users were highest for reports of burning and aching eyes, marginally lower for imperception symptoms (focussing and blurring problems), and somewhat lower still for grittiness and watery eye sensations. The two groups were most differentiated in the response categories denoting the occurrence of these disturbances once a week and almost daily. Reporting frequencies for each of these disturbances in each time frame were roughly 15-20 percent for the VDT users, and about 10-12 percent for the non-users. Univariate analyses examining the percentage of VDT users experiencing eye problems on an almost daily basis by working conditions indicated an increase in disturbances with increased screen viewing, with increases in the length of work periods, with increases in reported display aberrations (flicker and blurred characters), with reports of poor machine maintenance, with reports of keyboard glare, and with reports of being bothered by dry air. Consistent with observations by Smith et al. (1981), eye disturbances were least prevalent among technical-professional VDT users. It is not clear from the report however, whether all of these effects are statistically signficant.

Finally, two laboratory experiments addressing ocular and visual effects incident to VDT use have been publsihed in this country. Investigators from Oakland University (Mourant et al., 1981) examined ocular kinetics during the performance of a visual search task with either a near VDT or hard-copy display in sequence with a distant display reading task. Outfocus (near to far refocus) and infocus (far to near refocus) times, as well as the blink rate, increased in a progressive fashion over several hours of VDT viewing. The effect was less pronounced with hard-copy viewing, occurring only with long sessions (4 hours). One-hour breaks attentuated the effect considerably. Information processing times were unaffected. However, due to the small sample size, the investigators were reluctant to draw firm conclusions. They indicated however that the data support a local (convergence-accommodative control system) as opposed to central (CNS) effect or mechanism in visual fatigue during VDT viewing.

In a very carefully controlled experiment, Gould and Grischkowsky (1983) had 24 clerk-typists perform proof-reading tasks for six 45-minute work periods via CRT on one day, and via hardcopy with the same regimen on another. Displays for the two conditions were nearly equivalent. Vision measures obtained at the beginning of the day and following each work period consisted of contrast sensitivity and visual acuity and phoria. Eye comfort (feeling of strain, pain, or discomfort) was assessed via questionnaire according to the same schedule. Comfort declined somewhat over the course of the day for both modes of presentation, but there were no differential effects in relation to presentation mode, and the overall decline was very modest. For none of the objective vision function measures was a differential effect of presentation mode found. Neither VDT nor hardcopy presentation mode affected near visual acuity over the course of the day. Lateral phoria varied throughout the day, but again, an interaction of work period with display mode was not observed.

Musculo-skeletal Effects

Summary—
Evidence to date of musculo-skeletal disorders among VDT users has been primarily subjective, involving user complaints of discomfort (mainly fatigue

and pain). Objective or clinical methods for examining neuro-muscular and musculo-skeletal function in VDT users have generally not been applied.

The research shows that the predominant manifestations of musculo-skeletal strain in VDT users are neck, shoulder, and back discomfort. Cakir et al. (1978) refer to this as the "neck-spinal syndrome" caused by poor body posture and incorrect positioning of the spinal column during VDT work. VDT use has also been linked to shoulder, arm, and hand-wrist fatigue and discomfort, but to a lesser extent than neck and back strain. Cakir et al. (1978) refer to this as the "shoulder-arm" syndrome characterized mainly by symptoms of tenosynovitis and attribute it to both improper posture and task manipulative demands.

Judging by the frequency of user complaints of musculo-skeletal discomfort, the problem seems considerably less prevalent or severe than problems of eye strain. There is little evidence of frank musculo-skeletal or neuro-muscular disease, injury, or disability among VDT users. However, on the basis of the limited objective data (reports of medical treatment in two of the studies), there is some indication that such possibilities cannot be completely dismissed. Additionally, Cakir et al. (1978) warn that poor motor habits of VDT users may lead, chronically, to permanent damage, and this may occur in the absence of major signs of discomfort to users.

Research to date is inconclusive regarding a greater prevalence of musculo-skeletal disturbances among VDT users in comparison to their non-user counterparts. However, it appears that VDT use can impose certain physical ergonomic demands which may have musculo-skeletal implications and are somewhat unique to VDT use.

Prior research has also produced extensive subjective and objective data on physical anthropometric and ergonomic conditions in VDT workplaces, but analyses which systematically examine relationships between these conditions and indices of musculo-skeletal disturbances are limited and uncommon.

Review--

Gunnarsson and Ostberg (1977) were among the first to investigate musculo-skeletal disturbances in VDT users and physical workplace/station characteristics which may give rise to these problems. In their study of customer assistance VDT users in the Scandinavian Airline system, 18 users (65%) in one section complained of discomfort either "daily" or "some times" per week. About 18 percent reported severe discomfort at the same rate. The locus of discomfort was primarily the shoulders, back, or neck, with at least 54 percent registering complaints in at least one of these categories. Only two percent of respondents indicated a problem with the arms or wrists. Comparison of full- and part-time users suggested that complaint frequencies were unrelated to the extent of VDT use. Information regarding physical configurations and perceived limitations of VDT workstations were also obtained, but from an alternate section of the airline system. Data indicated few user dissatisfactions, the major exception being limited work surface area. There was also a clear indication that users did not take advantage of the adjustability offered by their workstation equipment and furniture. The report offers no information on relationships between work-place/station physical characteristics and somatic complaints of users. Non-users were not investigated.

Neck and back discomfort were also major complaints among a subsample of 250 VDT users in the study by Cakir et al. (1978). However, reporting rates were shown to vary with a number of factors. Seventy percent of data acquisition users reported it was "sometimes true" that they experienced neck pains. Proportions reporting back thoracic and lumbar pain were 60 and 24 percent respectively. Rates were one-third to one-half lower for clerical and administrative VDT users, and even lower for programmers and editors. The same pattern held for treatment for back pain, with nearly half the acquisition users reporting such care.

Regarding the specific attribution of musculo-skeletal problems, Cakir et al. (1978) and Cakir et al. (1980) listed visual, motor, and temporal task demands, ergonomic aspects of the VDT, length of service at VDT work, and extent of daily VDT use (for tenosynovitis but not back or neck pain) as determinants of musculo-skeletal strain. No age effect was reported. However, data showing such effects are provided for only some of these variables, and apparently no analyses were undertaken to determine their separate effects. Although extensive physical workstation and anthropometric measurements were made, relationships to strains were not drawn. Rather, postural behaviors and physical conditions are summarized relative to ergonomic guidelines, and then health implications of deviations from these prescriptions are merely discussed.

Although supportive data are not presented nor the source clearly identified, Cakir et al. (1980) refer to findings indicating rates of musculo-skeletal strain among office workers using conventional equipment that are as high as those found among VDT users.

Coe et al. (1980) examined reports of musculo-skeletal strain in relation to a number of task variables and anthropometric measures. In terms of identifying the specific causes of musculo-skeletal disturbances, it appeared that the sources were multiple, and as in the Cakir et al. (1978) report, the types of analyses carried out did not completely separate the different potential effects.

Just 11% of the entire VDT sample reported musculo-skeletal discomfort. This is about one-fifth the number that reported eye disturbances. The proportion of individuals with complaints (undifferentiated by locus of complaint), was higher in data input (19%) than in creative (13%), editing (9%), or dialogue (8%) VDT users. Complaints were also more common among users with gaze angles falling outside a 10°-30° range, but there is some confounding of the gaze angle and task-type variables. No relationship between the existence of a detachable keyboard or the presence of near visual acuity defects and musculo-skeletal discomfort was found. A VDT-control group comparison on musculo-skeletal discomfort was not reported.

In terms of musculo-skeletal discomfort expressed as seating problems, a significantly larger proportion of VDT users than non-users (37% vs. 26%) reported discomfort, but no significant differences among types of VDT jobs were observed. Adjustable (height) seating was actually associated with increased seating discomfort, but the heights of most of the adjustable seats were reported to be incorrect relative to existing standards. Seating discomfort was also more prevalent among full-time users, but it seems that this variable is confounded with task type.

Musculo-skeletal complaints ranked third, behind eye/vision problems and fatigue, among complaints by the "lengthy session" VDT users studied by Johansson and Aronsson (1980). Again, neck and shoulder disturbances predominated (10 of 43 users). This is less than half the proportion reporting eye disturbances. Only four users reported arm problems. Data on the frequency or intensity of complaints (within individuals) are not presented, nor were control data presented. Complaints were not evaluated in relationship to working conditions or user characteristics, with the exception that the threshold for the onset of physical problems in VDT work was reported to be less than 1.5 hours for 31 of the 39 users who experienced discomfort in lengthy VDT sessions.

Haider et al. (1980) presented a table showing the experimental inducement of neck and back ache symptoms in experienced VDT users at about the same frequency as eye strain symptoms. Fewer symptoms of arm strain were noted. These data are given only scant attention by the investigators, and thus further interpretation is impossible.

Hunting et al. (1980; data presented in greater detail in 1981) obtained both objective and subjective data on musculo-skeletal disturbances in both VDT users and non-users with differing job requirements, and found important associations of signs and symptoms with both job and workstation characteristics. As in the Coe et al. (1980) report, the overall incidence for experience of musculo-skeletal discomfort on a daily basis was about one-fifth (11% of users or fewer dependent upon the specific complaint) the incidence for eye strain. However, no strong differences existed between the frequencies of neck or shoulder and arm or hand problems. Complaints of daily problems were most common (6%-15%, dependent upon category) among data entry users, and least among traditional office workers (1% or less). Intermediate levels (4%-11%) existed for conversational users and traditional typists, the two groups being undifferentiated in most complaint categories. Medical examinations (palpation of pressure points) rendered the same pattern of results, with 60 percent of data entry users and less than five percent of traditional office workers reporting pain. However, systematic differences of this type were not found in terms of reported "doctor visits" for arm or hand problems (20% average for both the VDT user and non-user groups).

In a series of analyses examining the relationship between working heights and neck, shoulder, and back pain in conversational users, it was found that the more elevated work surfaces were actually associated with a dramatically lower (usually less than half) incidence of impairment. This effect was tentatively attributed to the increased use of hand rests and improved head-neck posture with elevation of the source document and work surface. On the other hand, keyboard height above the desk was positively related to expressions of arm-hand disturbances in both data entry and conversational users, and the effect was exacerbated when hand or forearm supports were seldom used. In general the disturbances were more pronounced on the right side (the predominantly used arm/hand). It should be noted, however, that most of the effects pertaining to working heights failed to reach significance at the .05 level.

At Milan, Ghiringhelli (1980) reported a much lower incidence of musculo-skeletal as opposed to eye disturbances among VDT users. Fewer than 10 percent of the 62 users questioned reported neck or back pain. However, the incidence of pain appeared to increase with tenure in the job, as less than two percent recollected such problems at the time they began their VDT jobs.

In the report by Elias et al. (1980) at Milan, between 40 and 50 percent of the 89 data acquisition users (the group with the high frequency of "looks" between the VDT and source document) reported in the questionnaire that upper and lower back pain and neck pain were experienced. The incidence for the 81 dialogue users (lower frequency of "looks") was reduced by one-third to one-half.

In their open-ended interview, Dainoff et al. (1981) apparently received few or no complaints of musculo-skeletal disturbances from the 121 clerical level VDT users. Only two percent registered complaints regarding the keyboard, and only 12 percent complained about uncomfortable furniture and chair/table heights and dimensions. This compares with rates of about 40 percent for complaints regarding eye strain and lighting conditions. On the other hand, when a subsample of 31 users was evaluated at the beginning and end of normal workdays using a physical symptoms checklist, musculo-skeletal symptoms were clearly represented. However, the increase in the percentages of users reporting musculo-skeletal strain at the end of the day was somewhat less than the increase for reports of eye disturbances (about 10%-23% versus 14%-32% respectively, dependent upon the category). Also, substantial differences in the absolute proportions of users reporting these two categories of strain were observed at both the beginning and end of the day (about 4%-19% for musculoskeletal strain and 39%-62% for eye strain symptoms). Consistent with previous findings, neck and shoulder symptoms tended to be reported and also to increase at a higher rate (about twice) than arm, wrist, or finger problems, with an intermediate effect for back pain.

The percentage of clerical users reporting musculo-skeletal problems in the NIOSH investigation by Smith et al. (1981) seems to be higher than reported by any user group in any other study. Over half of the 25 physical symptoms which were reported significantly more frequently by clerical VDT users than control subjects fell into the musculo-skeletal category. Again, three familiar patterns were evident in the data. First, of the musculo-skeletal symptoms, the most frequently reported was neck-shoulder pain (81%), followed by back pain (78%), ranging to a low for arm-hand problems (33%-49%). Secondly, even these relatively high rates were outstripped by complaints of eye problems (71%-91% dependent upon category). Finally, consistent with findings by Cakir et al. (1978) and by Coe et al. (1980), it appears (actual comparison data not given) that professional users (mainly editors and reporters) experienced fewer musculo-skeletal problems than did clerical users.

In the associated NIOSH report by Stammerjohn et al. (1981), normative data on reactions of users to various design features of their workstations are presented, and linkages between some of these aspects and musculo-skeletal complaints are described. Only generalizations and limited summary data are available on workplace/station physical dimensions and configurations. Users were much less likely to rate the physical configuration of the VDT components as "bothersome" as they were the visual quality of the display. About two-thirds of the users were not bothered at all by screen or keyboard heights, distances or angles. However, musculo-skeletal complaints were shown to be associated with both screen angle and height, but the relationship was described for professional users only. In agreement with findings by Smith et al. (1981) on job content related differences in musculo-skeletal complaints, and in partial agreement with data on chair comfort by Coe et al. (1980), clerical users were found to rate their chairs significantly less comfortable than did professional users or control subjects. However, data on any group differences with regard to objective evaluations of workstation parameters were not provided.

In the investigation of news editors by Sauter et al. (1981), back and neck or shoulder musculo-skeletal complaints were as common (over 85% of participants reported at least "occasional" problems) as they were among the clerical users studied by Smith et al. (1981), and were reported at about the same rate as the most commonly reported eye symptoms. However, the incidence was significantly greater in the VDT group for neck and shoulder symptoms only. For 10 other musculo-skeletal symptoms covering mainly problems in the limbs, no important group differences were found, and the absolute rates were not pronounced. An average of just seven percent of participants reported the "frequent" occurrence of these symptoms. Consistent with results by Stammerjohn et al. (1981), 30 percent of users reported their chairs to be just adequate, and 40 percent reported them to be uncomfortable. However, no difference appeared between users and the control group on these ratings. Over 80% of both groups reported little or no ability to adjust the location of furniture or equipment to improve working comfort. On the physical comfort subscale of the Work Environment Scale (McNair, Lorr, and Droppleman; 1971) the scores for the two groups were undifferentiated. Of responses by VDT users to open-ended questions on desired changes to improve working comfort, physical reconfiguration of the workplace/station was the second largest category (20% of users), with improved lighting ranking first (70%).

Arndt (1982) reported that chair design and comfort complaints were more prevalent among telephone directory assistance VDT users than among operators performing similar tasks from digital (nixie tube) displays, despite the fact that both groups used identical chairs.

In the Starr et al. (1983) questionnaire comparison of 250 directory assistance operators who used VDTs and 105 operators who accessed hard copy, the only health related measure differentiating the two groups was neck discomfort. Sixty-five percent of VDT users versus 48 percent of the non-users reported neck discomfort as occurring at least once in the month prior to the survey. However, when age matched subgroups of 75 operators each were compared, the difference with respect to neck disturbance disappeared. Again, incidence rates among VDT users for shoulder, back, and neck discomfort (48%-65%) were many times the rate for arm or wrist related discomfort (9%-14%). Interestingly, the group differences for the upper torso disturbances averaged about 10% (with the higher frequency consistently found among the users) whereas the average incidence of upper arm and elbow problems was actually higher among the non-users.

Finally, the Canadian Labour Congress (1982) study produced a familiar pattern of findings with respect to musculo-skeletal effects. Disturbances in this category were somewhat less prevalent than eye/vision disturbances. No more than 15 percent of the users reported the daily experience of any of the specified musculo-skeletal strains. Strains in the back, shoulder, and neck were reported more frequently among both users and non-users than strains in the arms, hands/wrists or legs. For the former collection of strains, 40-59 percent of users reported occurrences in the three months prior to survey administration. The corresponding range for the latter strains was 16-31 percent. However, incidence rates were unequivocally greater among VDT users for neck and lower back disturbances only. Interestingly, there existed a tendency for higher incidence rates among the non-users for the leg, hand/wrist, and arm disturbances. When musculo-skeletal disturbances were examined relative to job factors, incidence rates were found to be positively related to reported time spent sitting, and to reported postural discomfort. Interestingly, reported adjustability of the chair and VDT screen angle was not strongly related to reports of musculo-skeletal discomfort. Consistent with observations by Hunting et al. (1981), discomforts of most types were more prevalent among data entry VDT users than among users in other job classifications.

Job Attitudes, Fatigue, and Affective Disturbances

Summary--

The research examining VDT users' perceptions and attitudes regarding their job content and regimen, changes in these conditions brought about by VDT use, and fatigue and emotional effects among VDT users has provided a fairly uniform set of findings.

First, there is little evidence of general job dissatisfaction among VDT users, or increased dissatisfaction incident to VDT use. Neither is there unambiguous evidence of high levels of emotional strain or behavioral or biological manifestations of stress among VDT users in relation to non-users. Yet, some studies suggest that VDT jobs can be mentally fatiguing, and many more have shown that users are irritated by technical difficulties (system failures, slowdown, etc.) which affect performance and which the data suggest can be common with computerized office systems. One study has linked system operational problems with hemodynamic and neuro-endocrine stress reactions.

In terms of perceptions of job content, regimen, or general quality of working life, the findings are mixed. A few studies suggest that in jobs which rank low in terms of variety or worker discretion (i.e. lower level clerical and data processing jobs), the introduction of VDTs is associated with perceptions of further impoverishment of jobs along these dimensions. These studies indicate that with VDT use, such jobs tend to be viewed as more monotonous, routine, controlled, and as involving lower degrees of skill utilization. Perceptions of VDT users with jobs ranking higher in terms of variety and individual discretion (mainly professional-technical users) are not similarly affected.

In terms of task performance effects, for all types of jobs VDTs are generally seen as facilitating the execution of tasks, and in the few studies which have examined perceptions of workload, the evidence seems to weigh in favor of increasing quantitative demands.

Only a very few studies have examined perceptions of job security or opportunities for professional growth incident to VDT use. Results on this topic are mixed.

Review--
In their investigation of the consequences of VDT work in the Scandinavian Airline System, Gunnarsson and Ostberg (1977) carried out a very limited evaluation of VDT users' reactions to their job regimens, and of their perceptions of stress and satisfaction in their work. Thirty-nine customer service VDT users (10 at ticket counters and 29 telephone agents) responded to questions regarding the degree of work variety. Twenty-one of the 29 telephone agents indicated "monotonous" and 5 "far too monotonous". All expressed a need for job enlargement or rotation. Yet, twenty-six expressed satisfaction with the job, but all but seven for reasons other than job content per se. Nine of the 10 counter service representatives, however, reported their work as sufficiently variable. It was reported that long-time employees attribute the job monotony to the progressive transfer of information to the computer, an effect apparently offset by personal contact for counter service users. Only one-third of all users regarded the work pace as unsatisfactory, but it is reported that "many" users desired greater individual control over work pace. Responses to a question regarding job stress were almost evenly distributed among categories of "much", "some", and "none": Extremes in work pace and lack of privacy were attributed as main causes of stress, but it is not clear how the VDTs may have been implicated in the work pace or privacy.

The Cakir et al (1978) Berlin study represents one of the most extensive investigations to date on the relationships among VDT job design, user fatigue, and emotional reactions. Research methods consisted of administration of both survey instruments and behavioral performance tests. The surveys for this aspect of the research included the following: (1) an extensive "work stress" questionnaire tailored for VDT jobs and covering job cognitive, sensory, and motor demands, physical and social environmental conditions, job content and organization, perceived health and functional disorders; (2) two instruments to assess mood or psychic state (a modified version of the "Proper State Scale" by Nitsch [1976] and an adjective checklist); (3) a measure to assess arousal ("General Central Activation" [GCA] scale [Bartenwerfer, 1970]); (4) a personality inventory, (5) a survey of achievement motivation; and (6) a comprehensive job satisfaction survey. Performance tests intended mainly for the assessment of CNS arousal included eye-hand coordination, a vigilance battery, reaction time, and critical flicker-fusion frequency.

The Cakir report contains a separate section by von Schmude (chapter VI) in which the consequences of VDT work in 48 news editors and 57 newsroom information typists (the figures are somewhat at variance with the sample sizes for these groups presented at the introduction to the report) are treated fairly independently. Some of the findings are further elaborated in the VDT Manual (Cakir et al., 1980).

Discussion of the results focussed first on the measure of arousal-activation (GCA) which the investigators treat as a "stress" index, and on fatigue measures from the work stress questionnaire. Of five VDT user groups administered the GCA scale (off-line acquisition, on-line acquisition, supervisor, no paper [a projection screen taking the place of a source document] and programmer), all produced scores less than found in automobile drivers during long trips, crane operators, and most interestingly, keypunch operators or verifiers. The comparisons were with normative data supplied by the scale originator. No comparisons were made with the VDT non-users in the study. Among the five groups studied, the "no paper" group produced the highest mean GCA stress scores (30.1) versus 24.9 - 28.6 for the other groups. However, the intra-group variances are very large. No relationships were observed between age or sex of the user and the GCA stress scores. The lack of a relationship between stress and individual characteristics is supported by data presented later on in the report showing only a tenuous relationship at best between stress indices from the Proper State questionnaire and user personality or motivational disposition. The investigators also stated that the GCA stress scores were less related to the type of equipment used than the activity performed, but go on to say that GCA levels were significantly higher for individuals reporting poor display quality and lower satisfaction with the display quality. Apparently the relationship of GCA scores to somatic complaints was low. Finally, a quadratic relationship was reported with the number of hours of VDT use per day (highest for 4-6 hours).

Unlike GCA stress scores, fatigue as measured on the work stress questionnaire was stated to be linearly related in a positive fashion to number of hours of daily VDT use and also to somatic complaints. This was particularly true for eye/vision complaints in individuals in the no paper group (projection screen display plus VDT display). The indication is that fatigue was also strongly related to job content and activity, with increased levels in jobs rated as boring, monotonous, and strenuous. Finally, fatigue was stated to be strongly related to dissatisfaction with the total job activity.

Results of behavioral performance tests and the Proper States survey assessments administered prior to and following work were also described. Effects were mixed. With the exception of the flicker-fusion test results (showing a significant decrease in fusion frequency following work) all of the objective performance tests indicated no clear functional impairment. However, the Proper State data seemed to clearly demonstrate reduced capabilities with significant post-work impairment on almost all dimensions. It was further reported that recovery times were longer for those workers who performed the most repetitive activities.

As elaborated in the VDT Manual, some of these effects were clearly influenced by job design and content. Impairment on Proper State measures following work was more pronounced in VDT piece workers than hourly paid workers, and the trend in the fatigue findings in general was toward decreasing expressions of fatigue and effort in jobs with increased diversity or complexity. In response to specific questions regarding strong fatigue at work and perceived effort needed to perform the job, the VDT Manual reports lower rates of agreement among programmers and clerical staff than among on-line, off-line, and piece work data acquisition users. The VDT Manual reports the same basic trend in regard to ratings of job monotony, control over work activities by the computer, and occurrence of somatic complaints. A group of workers whose jobs had been "dequalified" from clerical staff to copy typists seemed particularly disadvantaged in that they were more likely to report monotony and extreme fatigue than all the other groups. These effects were reported as significant, but no information on where the significance lies in terms of specific group contrasts was presented.

Data is described by von Schmude (part VI of the Berlin study report) which support and extend the implications from evaluation of the larger sample regarding the influence of job design and content on the well-being of VDT users. In particular, news editors using VDTs were prone to regard their physical workplace positively, were largely satisfied with their work, perceived the fewest physical impairments of all study groups, experienced little fatigue at work, and recovered quickly at the end of the work day. This occurred despite the fact that they reported comparatively high levels of psychic stress at work. It was pointed out, however, that the actual VDT work time of editors was considerably less than that of the other study groups.

What is perhaps most interesting about the von Schmude report is the way in which VDTs were regarded by users to have influenced the jobs of newsroom information typists. The typists responded that with VDTs their work was easier, involved less pressure, was less hectic, and was more interesting. The information typists were only infrequently bothered by technical disturbances. With the exception of the work reported as becoming more interesting, the reactions of editors were less favorable, although not decisively negative on these points. The results for the information typists may seem contrary to expectations based upon data reported previously in the study for individuals with basic clerical and data processing tasks. However, job analysis showed that the work of the information typists involved diverse activities and VDT use was not intensive, usually less than four hours per shift.

In the final section of the Berlin report, users from three different offices which differed in job content and design were compared in terms of perceived fatigue, workload, monotony, work narrowness, and individual responsibility. In one office (B) workers performed narrow repetitive tasks with close supervisory control and hourly pay. Office A was differentiated from B on these dimensions, whereas work in office C was much the same as in B with the exception that users were paid on a piece rate. The results were surprising. While office B workers were dramatically different from office A workers in terms of perceiving more narrow, monotonous, and less meaningful work, the differences between offices A and C on these dimensions were very modest in comparison to the A-B comparison.

A second puzzle presented by the Berlin data is that more professional or qualified workers tended to report high levels of psychic stress, but were clearly favored in terms of health related parameters.

Both of these apparent anomalies seem to point toward self control or discretion in task performance as a potentially important determinant of perceived work quality or user well-being. However, the VDT Manual presents data showing piece workers perceived extreme levels of control by the computer. It would be important to know the levels of computer control of work expressed by workers in office C. Of interest is that data from the Berlin report indicates that the levels of "felt responsibility" in office C were about the same as in office A. It was high in both, but not in office B. Along this line, the job descriptions for the information typists who also seemed relatively favored in terms of well-being and reactions to VDT implementation suggested that they enjoyed a fair degree of self direction in their work.

In the Gunnarsson and Soderberg (1980) study of VDT users in the Swedish Telecommunications Administration, all but three of 45 VDT users who were questioned perceived the introduction of VDTs as facilitating the performance of their jobs. This is similar to the findings among the information typists in the Berlin study and in the airline study by Gunnarsson and Ostberg (1977). The main advantages cited were faster processing times, simplified procedures, reduced physical data handling, and improved customer service. Numerous job dissatisfiers were also mentioned, but it would seem that some of these were not necessarily related to the introduction of the VDT-computer system: heavy load (8 of 15 sales department employees), lower equipment delivery times to customers ("many" employees), monotony of the work (directory assistance employees only). Complaints which were associated with the VDT-computer system per se included lack of control over system design features (about half the employees), and computer technical problems and limitations in data storage.

Coe et al (1980) reported very high levels of job satisfaction in both the VDT user and non-user samples. Over 85 percent of the 257 VDT users and 124 control participants indicated that their work met personal needs with respect to social contact (but less so in the VDT group), work satisfaction, and economic rewards. Major satisfiers cited by both groups were the challenge and content of the job. Surprisingly, job content was the most frequently cited satisfier for data input operators. Among the dissatisfactions cited by the VDT group, VDT contact ranked last, although nearly 60 percent of the group failed to respond to this item. Asked whether they felt "under pressure" from the work performed, 54 percent of the VDT group as opposed to 42 percent of the control group responded affirmatively, a significant difference. Consistent with reports of stress from the Berlin study, more editorial and creative VDT users than data input or dialogue users reported they felt "under pressure" at work. The editors also smoked more, took the fewest breaks, undertook the fewest leisure time activities, and the proportion of editors reporting "pressure headaches" was higher than in any other group (although the input group was close). The investigators noted just a few of the sources of pressure identified by the VDT users (responses to the open-ended question were not tabulated). Among them were key stroke monitoring for data input users, and adaptation to the use of the VDT system for the editors. Cross tabulation or analyses relating satisfaction and work pressure to the extent of VDT use, working conditions, or health measures were not conducted.

For the 80 VDT users and 15 non-users studied by Johansson and Aronsson (1980) at the Skandia insurance company, the physical workplace and job content were positively regarded. Workers reported a high degree of autonomy, limited routine tasks, and moderately challenging jobs. Less than 25 percent of the VDT sample perceived their work as being too monotonous, simple, or demanding in terms of needs for attention. Over 50 percent expressed sufficient skill utilization and influence over work practices. The main negative reaction was an expression of excessive workload (80%). About 75 percent expressed a positive attitude toward the company on dimensions such as personnel policy, transfer opportunities, and the personal meaning of the work. None of the VDT users indicated a desire to revert to the performance of their jobs in the non-VDT mode.

Despite the generally positive atmosphere, questions regarding computerization per se showed employee concern in many areas. About 65 percent of the sample felt they had insufficient influence over the course of company computerization, and nearly 50 percent felt computers impeded the "democratization" of working life. Nearly 40 percent were concerned that their skills may be rendered obsolete.

When asked about the perceived advantages and disadvantages of VDTs, system breakdown, monotony, and job impoverishment were the three most frequently mentioned disadvantages among the 50-60 percent of the participants responding. Rapidity of the system was the dominant advantage listed. Computer or VDT specific aspects of the job were not among the 10 (of 24 possible) factors most highly rated as determinants of job satisfaction.

Reports of difficulty in relaxing during technical breakdowns and excessive dependence upon technical equipment were very prominent (about 50%) among all but those users who worked at VDTs for 10 percent or less of the work day. In attributing the causes of mental strain, of 34 factors rated, work overload, computer breakdown, and breakdown uncertainty ranked 1-3 respectively for users reporting occasional or frequent strain.

Specific changes in working conditions attributed to the implementation of VDTs included slight increases in job difficulty and qualifications needed, in job responsibility and number of routine tasks, and more pronounced increases in mental strain and demands for attention. The greatest change noted, however, was an increased overview of insurance cases handled, a positive feature. A very slight decline in work variety and autonomy was noted. Of interest is that the rated decline in the variety of tasks and increase in the number of routine tasks varied considerably in relation to the specific job task. For example, these perceived changes were far greater in data entry as opposed to customer service jobs. Regarding this effect, in summarizing their results the authors stated the jobs which benefited from computerization consisted mainly of qualified work which calls for experience and allows personal control of the amount of work and work pace. Of further interest is that a portion of the study sample (n=13) reporting the most favorable VDT related changes in working conditions (less routine, greater variety, more influence, greater overview of cases) also reported significantly greater comradery at work, fewer headaches, and less bother by physical environmental stressors (light and noise) than the remainder of the study sample.

In a second part to this study, measures of blood pressure, heart rate, catecholamine (adrenaline and noradrenaline) excretion, and of various mood states were made in 11 individuals who used VDTs for more than 50% of the working day. The same measures were obtained from a reference group of 10 individuals, mainly typists and secretaries, half of whom had very limited daily use of VDTs. Data were collected at various times during two work days, during a day at home, and also during the evenings of these days.

Of primary interest are findings pertinent to catecholamine excretion. Results showed that catecholamine excretion levels in both groups were moderate in relation to other occupational groups studied. During the day, adrenaline excretion was significantly greater at work than at home for the group with heavy VDT use. The effect did not occur for the control group.

Adrenaline levels for the VDT group were also higher than levels for the reference group, both at work and at home. The VDT group also reported significantly greater mental strain at work and mental fatigue after work than the reference group.

Adrenaline excretion over the course of the work day appeared to track workload which was greater for the VDT group in the A.M., and high in both early A.M. and late P.M. for the control group. The authors in turn related workload in the VDT group to computer system functioning in that users attempted to accomplish as much work as possible in the A.M. in anticipation of potential malfunction later. Ratings of perceived effort closely paralleled these trends over the course of the workday.

In view of the complaints of VDT-computer system failures at Skandia, perhaps the most interesting aspect of this part of the study is the evaluation of psychophysiological reactions during temporary breakdowns. When measures obtained on six users during a mid-day breakdown were compared with measures obtained at the same time on workdays with normal system function, significant increases in adrenaline and diastolic blood pressure were observed during the malfunction. These changes were paralleled by a significant increase in reports of irritation and decrease in reports of relaxation.

Most of the research presented at the Milan Conference deals only in a limited way with the perceived quality of working life in VDT jobs and the emotional well-being of VDT users.

Haider et al (1980) showed an interaction between numbers of hours at VDT work and display image character hue in terms of activation (inferred from heart rate). Heart rate decreased steadily over three hours of VDT work in 13 VDT users (a significant main effect seems apparent) with a lower initial and higher final rate with yellow as opposed to green phosphor. Performance increased over the period, but with the same hue related interaction effect. A control group (9 office workers) comparison was not reported on these measures. On the Nitsch (Proper state) questionnaire previously employed by Cakir et al. (1978), results showed a significant change on five factors. Pronounced increases in tiredness and sleepiness after three hours of work are reported for VDT users, but only a modest increase occurs on these dimensions for the control group.

Hunting et al. (1981) compared 54 VDT users engaged in "payment transactions" with 55 individuals performing the same job in the traditional fashion in terms of satisfaction and job content. The apparent rational was to examine the credibility of the hypothesis that somatic complaints among VDT users might represent veiled expressions of dissatisfaction with working conditions. Questionnaire measures of quantitative and qualitative overload, task feedback, variety, cooperation, relationships with colleagues, decision latitude, and utilization of skills were obtained. The VDT group was found to report significantly less variety than the control group, but also less workload. No significant differences were found on the remaining measures, and 70 - 86 percent of both groups reported "satisfied" for the last three measures.

The study by Elias et al. (1980) reported at the Milan Conference, is one of the few to describe high levels of job dissatisfaction among VDT users. Survey findings showed significantly greater job dissatisfaction in 89 off-line data aquisition users than in 81 conversational VDT users (70% vs. 28%). The two groups were also similarly differentiated on four indices of psychosomatic disorders (mean values about 45% vs. 20%), three indices of mood alteration (mean values about 60% vs. 50%), and troubled sleep (about 45% vs. 15%). The investigators attribute these effects to job content differences between the groups. In comparison to the dialogue jobs, the acquisition jobs were more repetitive and short-cycled, involved less personal freedom and decision-making, and required fewer qualifications.

Ghiringhelli (1980) also reported data at the Milan Conference suggesting a rather high incidence of affective disturbances (depressive disorders and anxiety aggravation) among 77 VDT users. The rate approaches that of eye irritation (somewhat less than 50%). However, it appears that the total number of complaints, not the number of users with specific complaints is reported, making interpretation difficult. Data from an extensive control sample were not reported. Of interest is that job content and organizational factors were only infrequently cited by users as causes of health related problems in general. Opinions regarding the VDT work performed were largely negative. Two-thirds of the comments specified problems such as excessive machine dependence, monotony, isolation, and fear of health impairment. Of special interest in view of findings presented below (Starr, et al., 1983), user job and stress related complaints were most frequent among young, educated users who worked on VDTs for less than three hours per day. These three variables were confounded, however.

Evidence of significant acute and chronic fatigue among 52 VDT data entry users was presented by Binaschi, Albonico, Gelli, and Popolo (1980) at the Milan Conference. A multidimensional fatigue scale with a history of application in Japan was used. However, from the discussion it seems that the validity of the instrument is not well-established. Fatigue measures apparently (lack of detail makes interpretation difficult) consisted of the mean number of afflictions or symptoms (three lists of 10 each were presented, with each list denoting a different dimension of fatigue) affecting each participant. Effects observed were more indicative of decreased activation and physical fatigue/discomfort than mental fatigue or concentration problems, and were apparent both over the course of a work day and a work week. The magnitude of changes over time for VDT users was roughly on par with changes observed in a group of 60 city bus drivers, although the absolute magnitude of fatigue seemed greater in the bus drivers. However, the absolute magnitude of fatigue at any occasion did not appear large for either group. Only 10-20 percent of the listed symptoms were selected as pertinent by study participants at the beginning of work periods, and less than 30 percent were selected at post-tests. Of interest, similar daily changes were observed in a group of 54 bank clerks.

In the Dainoff (1981) investigation of 121 VDT users, the familiar pattern of a favorable attitude toward VDT jobs, appreciation of the job facilitative aspects of VDT systems, and complaints with system inefficiencies again appeared. Comments solicited during a structured interview indicated 56 percent of users found their jobs enjoyable, and that a large majority (81%) appreciated the efficiency that the automated office afforded. However, nearly half were troubled by technical problems (interruptions) associated with their VDT systems. Further, when comments pertinent to fatigue, pressure, and mental stress were examined collectively, results showed that well over half the participants were troubled with one or more of these problems at work. Still, the prevalence of these complaints ranked well behind lighting or visual system concerns, and of special interest, the correspondence of stress and fatigue related complaints (together) with the extent of VDT use was negligible. For stress alone the correlation was low but significant ($r = 0.19$).

Among a subsample of the VDT users investigated by Dainoff et al. (1981), mood status (fatigue, vigor, and tension) was measured at the beginning and end of the work day for several days. The instrument used was the Profile of Mood States (McNair et al., 1971) subscale indices of these dimensions. Consistent with findings by Binaschi et al. (1980) significantly increased fatigue was observed at the end of the work day, and so was tension. But unlike the Binaschi et al. (1980) results, no effect related to the work week was observed.

NIOSH research (Smith et al, 1981) presents a much bleaker picture of the quality of working life for VDT users than suggested in research examined thus far. Consistent with the conclusions of Johansson and Aronsson (1980) and with the implications of much of the work reviewed thus far, the study showed that the adverse effects on job quality were pretty much confined to basic clerical jobs.

Regarding perceptions of job content and organization, clerical control subjects reported significantly greater boredom, future ambiguity, workload dissatisfaction, role conflict, and workload (for just one of the two measures used) on Caplan et al. (1975) measures of these dimensions than did either the professional users or clerical controls. Clerical user means on the first three measures were all well above population norms. The clerical users also reported less peer cohesion and autonomy, and greater work pressure and supervisory control than the other two groups on the Work Environment subscales (Insel and Moos, 1974) for these constructs. Again, the scores deviated in an adverse fashion from population norms. In all of these comparisons, values for the professional users were the most favorable, but were generally quite close to values for the clerical controls.

This same general pattern was upheld for 16 additional specific questions pertaining to work tedium and routine, job control and decision latitude, work pace and load demands, the social environment, and career future opportunities. On all of these questions, the most adverse circumstances were reported by the clerical users, and for all but a few cases the most positive reactions came from the professional users.

Of further interest in the NIOSH findings is that despite the presence of a clear indication of impoverished working conditions, the VDT users manifested no similar strong display of psychological strain or emotional debility. The only indication of emotional debility using The Profile of Mood States instrument was increased fatigue among clerical users in comparison to professional users and controls. Evidence of increased mood alterations corresponding to anxiety, depression, vigor, anger, or confusion was not observed among VDT users. From a list of nearly five dozen illness symptoms, emotional strain effects were generally not well represented among the 25 health problems experienced significantly more frequently by clerical users than by controls. The three exceptions were irritability (80% vs. 63%), fatigue (74% vs. 57%), and nervousness (50% vs. 31%). Still, the clerical users were more likely to link personal stresses and problems to their job and career than were the other two groups, but the frequency of reporting these sources was relatively high for professional users as well (about one-third).

With the exception of the Canadian Labour Congress (1982) study, there is little in any of the more recent investigations to suggest a pattern of affective disturbances, excessive fatigue, or dissatisfaction incident to VDT use. However, this work provides some support for prior findings of altered job content/design, and some of the same technical problems associated with VDT use in prior work are identified.

Using many of the same measures employed by Smith et al. (1981), Sauter et al. (1981) turned up almost no evidence of increased emotional disturbances or altered quality of work content and regimen among 63 newspaper professional users. No significant differences from the control group were observed on over three dozen items and scales assessing behavioral, psychological, autonomic, or organic manifestations of stress, nor in reports of use of medication for such problems. Also, the groups did not diverge on reports of job satisfaction, nor was there a trend toward dissatisfaction in either group. Still, consistent with the NIOSH (Smith et al., 1981) findings, the VDT users were more prone to link their personal stresses and tensions to their jobs than was the control group.

Regarding the job content and regimen, no group differences were observed in terms of reported workload, pressure, pace, participation in decision making, autonomy, control by others over work, nor in terms of the social environment. Interestingly, the VDT group reported greater skill utilization. On the other hand, VDT users also reported greater machine influence over their work regimen than did the control group, and two-thirds reported equipment failures that affected their job performance, although the frequency was not high (about 1/week). Interestingly, the same rate was reported by the control group. However, in an open-ended question soliciting comments on needed workplace and practice improvements, "system slowdown" emerged as a major concern for users, ranking third behind desired changes in lighting and workstation design.

Turner and Karasek (1983) presented an extensive theoretical discussion of the implications of computer software and operational characteristics for user well-being and performance effectiveness. Receiving special emphasis in the discussion is how constrained software and system technical problems may result in unpredictability and "exception conditions" (problems difficult for end users alone to easily resolve), how these problems create greater social interdependencies in the performance of tasks, and how these effects can result in increased demands and thus stress.

In their discussion, the authors draw upon research by Turner (1980) of 1001 bank clerks with variable use of a computer system. In Turner's data (only a correlation matrix and limited study details are presented in the Turner and Karasek [1983] report), workload is seen to be positively correlated with intensity of computer use. Workload and task interdependence have a strong positive inter-relationship, and both factors are positively related to mental strain. User autonomy is negatively related to mental strain. Strain in turn is negatively related to job satisfaction. These and other data cited from the literature are used to support the major tenet of the paper: that computer software (application features) alter the task characteristics of jobs, and that both influence user well-being and effectiveness.

In the recent Bell Laboratory study (Starr et al., 1983) of 250 VDT directory assistance operators and 105 hard copy control subjects, the data show moderate to high levels of VDT user satisfaction with five job dimensions denoted by the Job Descriptive Index (Smith, Kendall, and Hulin, 1969: work, pay, promotion opportunity, supervision, and people). Satisfaction scores for the VDT users actually significantly exceeded control group scores for the work, promotion opportunity, and people satisfaction dimensions. The users also reported significantly greater satisfaction in terms of achieving task closure and in terms of opportunity to set the work pace. Questions regarding perceived job security revealed no less optimism among users than controls, with no trend toward a negative outlook in either group.

A recent survey by an advocacy group for office workers (Gregory, 1981) provides limited data supporting the indications in prior work of increased workload demands incident to VDT jobs. In this study respondents selected specified sources of job stress from a survey checklist. About 8000 surveys were distributed, and about 500 VDT users and 800 non-users responded. It was reported that two stress sources were selected more frequently by users than non-users: production quotas (27% vs. 18%) and inadequate rest breaks (18% vs. 15%). Information on how users responded with respect to the many other potential sources of stress cited in the report is not provided.

In the Canadian Labour Congress (1982) investigation, the incidence rates for six symptoms denoting emotional-behavioral debility were significantly higher among the VDT users. Consistent with prior findings, the most prevalent symptom was fatigue, reported to occur on a daily basis by 27 percent of users and 20 percent of non-users. Reporting rates for the remaining symptoms (daily basis) were as follows: irritability, 17%-12%; headache, 15%-11%; sleeplessness, 11%-7%; dizziness, 5%-4%; loss of appetite, 4%-4%. The users were also more prone to report high job pressure (47%-38%), and less job satisfaction (60%-65%). The statistical significance of the latter effects was not reported. Consistent with effects observed for eye and musculo-skeletal symptomotology, these disturbances were least pronounced for professional-technical users. The prevalence of these disturbances also increased with reports of computer monitoring of work, with reports of feeling isolated in the workplace, and with reports of excessive workplace noise.

THE RESEARCH STRATEGY

As explained, one focus of the present investigation is the prevalence of health and job disturbances among VDT users relative to their non-user counterparts. The objective is to further address the uncertainty regarding the extent and nature of health risks incident to VDT use.

To examine this question, a sample of VDT users with jobs and tasks representing a broad spectrum of types of VDT usage are compared on survey data with a heterogeneous sample of office workers. The comparison measures include: 1) an index of job dissatisfaction, 2) a broad array of health-related indices denoting a variety of somatic, behavioral, and affective disturbances, and 3) indices reflecting various attributes of the job and physical environment. Statistical techniques involve mainly univariate analysis of variance and analogous nonparametric tests for the continuous and ordinal data, and contingency table analysis for the categorical data. Comparisons on these measures are also made among subgroups of VDT users and non-users with different types of jobs to determine how potential risks vary with the type of work performed. Further on, these analyses are referred to simply as the "group comparisons".

A second focus of the investigation is the causes of health related disturbances experienced by VDT users, irrespective of whether or not they are differentiated in severity or prevalence from the health problems of non-users. Regarding this second issue, the research emphasis is on some of the major uncertainties, tentative findings, and salient but unexplored questions in prior research. These points of emphasis are as follows:

1) The causes of health and job complaints reported by VDT users seem multifactorial, including content and psychosocial/organizational aspects of the job, physical environmental and ergonomic aspects of the workplace, and characteristics of the users themselves. Yet in attributing the origins of these problems, these variables have not been examined concurrently by others in a controlled fashion.

2) Interactions among causal variables seem indicated (Östberg, 1977; Smith et al., 1981), but have not been investigated. This possibility is supported by prior occupational stress research demonstrating the importance of interaction effects in prediction health outcomes (e.g. House and Wells, 1978; Karasek, 1979).

3) Is is not certain whether there exists a special unique or narrow effect of VDT use that adds to the stress process and which is not experienced in office work where VDTs are not used. That is, after extracting or adjusting for effects related to the physical and organizational climate of VDT jobs, is there an additional additive effect related to VDT usage that does not occur in jobs with similar working conditions but where VDTs are not used? Neither is it certain

as proposed by Smith et al. (1981) whether VDT use interacts with existing working conditions to influence the well-being of workers (i.e. a differential effect of various job demands or stress factors depending upon whether or not VDTs are used).

4) In attributing the causes of health problems and job complaints among VDT users, it appears that causation might be extended even to the effects (disturbances) themselves. The possiblity has been entertained that somatic complaints among VDT users may stem not only from direct external stress to sensory and effector systems, but they may reflect or be exacerbated by psychological strain or dissatisfactions with the job (Dainoff et al., 1981; Hunting et al., 1981). Two mechanisms seem possible. First, some somatic strains might represent veiled expressions of job dissatisfactions. Second, psychosomatic or autonomic processes may provide a causal path from psychological/affective strain to somatic strain. Alternately, job attitudinal change and affective reactions might be expected to occur as a function of perceived health risks or experienced health disturbances in VDT work (as indicated in Ghiringhelli, 1980).

The potential causal factors and pathways indicated above and which we will investigate are illustrated pictorially in the model shown in Figure 1. The model shows that three categories of variables (workplace physical conditions, job design/psychosocial factors and worker characteristics) may each influence the somatic and affective status and the job attitudes of VDT users. To these variables we have added VDT use. Here VDT use represents something unique or additional that is related to VDT-computer system use and is not represented among the other categories of causal variables. As described further on, in the analyses carried out it is a designation of whether a study participant is a VDT user or not. Thus, the independent or causal variables in the present research consist of a set of variables which collectively define some of the major attributes of workers and of VDT jobs and similar types of non-VDT jobs, plus the variable VDT use. If analyses show a significant relationship between VDT use and an outcome measure when controlling for the effects of all other independent variables, it can be surmised that there exists something special about VDT use per se as a stress factor, or at least something about the difference between VDT users and non-users which cannot be attributed to the other independent variables considered.

The model also shows several types of causal pathways. The heavy lines denote main additive effects of the independent variables on each of the well-being dependent variables, and the lighter lines interactions among independent variables. A particular interaction of importance is the interaction of VDT use (i.e. the VDT variable) with each of the other independent variables in predicting well-being indices. This addresses the issue of whether or not VDT use interacts with job content or workplace physical variables to influence the well-being of users as suggested by Smith et al. (1981). Finally, the model depicts causal linkages among the well-being variables themselves.

As presented, the model shown in Figure 1 does not provide a complete picture of the stress process in VDT work. Most importantly, it does not show a causal pathway from the VDT use variable to the job design and workplace

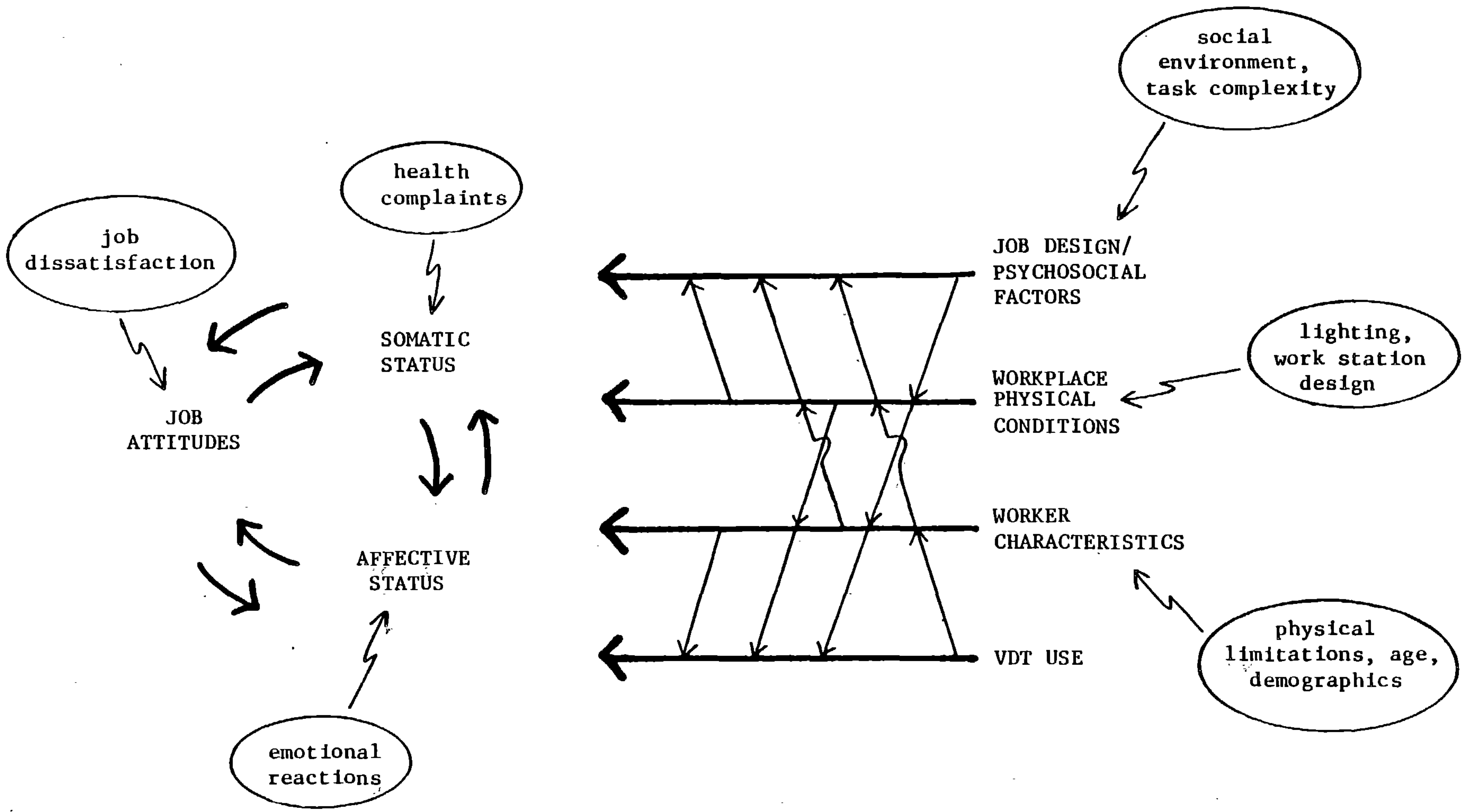


Figure 1. A basic conceptual model of the stress process in office/VDT work.

physical condition variables. Such an effect seems likely, and in the present study can be investigated only through the comparisons of VDT users and non-users in terms of their evaluations of working conditions.

Regarding the presence and strength of various causal processes depicted in this model, the specific research questions of major interest and our approach to their resolution are as follows:

1) What is the relative priority of select worker characteristics, physical workplace factors, job design factors, and the interactions among these variables in predicting the well-being of VDT users?

2) Is there a special unique or additional effect of VDT use as a job stressor?

3) Does VDT use interact with user characteristics or job or physical workplace design factors to affect the way they influence the well-being of users?

4) Do the various dimensions of well-being (i.e. the disturbances themselves) influence one another in addition to the way they are influenced by the three categories of independent variables and VDT use?

To answer these questions, multiple regression procedures are used to analyze the combined data from the user and non-user samples. The basic form of these analyses is expressed in the following general regression equation:

$$\hat{Y} = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_1X_2 + b_6X_1X_3 + \ldots + b_{10}X_3X_4$$

where:

X_1 = individual characteristics
X_2 = job design factors
X_3 = physical environmental factors
X_4 = VDT use/non-use

Simply put, each of the three outcome variables denoting a dimension of well-being is regressed on the three categories of independent variables and the VDT use/non-use variable, and the interactions among these variables. Stepwise procedures are used.

As indicated above, a significant predictive effect of the VDT use variable would suggest an important contribution of VDT use to strain beyond effects attributable to worker characteristics and job and workplace design factors (addressing question 2). A significant VDT use interaction term would denote an effect whereby the influence of the variable it interacts with has a differential effect upon well-being for VDT users and non-users (answering question 3). The relative importance of the other causal variables and of their interactions (question 1) can be assessed by examining their significance levels and the amount of variance they explain in the well-being outcome measures. This procedure, then, helps to overcome some of the methodological limitations of prior research where the different potential effects identified here were not separated and prioritized.

The procedure for investigating question four is somewhat complicated. Separate analyses are carried out in which each outcome well-being variable is entered into the regression equations (as an independent variable) for the prediction of the remaining two well-being measures. That is, there exist three regression analyses, each equivalent in form to the general regression equation shown above. Each analysis has as a criterion outcome variable one of the three well-being measures (Y_1, Y_2, Y_3). In the prediction Y_1 (job dissatisfaction) we add to the set of predictors (independent variables) Y_2 and Y_3 (affective disturbances and somatic disturbances respectively). We also add Y_1 and Y_3 to the independent variables for the prediction of Y_2, and Y_1 and Y_2 to the independent variables for the prediction of Y_3. These three regression equations are then solved simultaneously to determine the influence of the well-being indices upon one another, and the importance of these variables relative to the other independent variables. With this procedure we can systematically examine the entire system of relationships depicted in the model shown in Figure 1.

Clearly, the regression analyses described above can become difficult to manage and accomplish, particularly without a very large sample size, as the number of potential causal variables and well-being dimensions increases. Consider for example, how the number of interaction terms increases with increases in the number of main effect terms. For this reason, in addressing questions 1-4, the variables used are limited in number and broadly conceived. Only three well-being indices are considered. They include a measure of job dissatisfaction, mood disturbance, and a scale of illness symptoms. In addition to a variable denoting whether a participant is a VDT user or not, the independent variables selected include the number of hours spent daily operating a VDT or office machinery, and indices denoting the amount of personal control or discretion an individual exercises in the job, work load demands, social support, physical environmental problems, job/skill future security, and variables denoting the type of job tasks performed. As mentioned, the independent variables also include individual biodemographic characteristics. Because we were interested in assessing the effects of a large number of personal characteristics, a separate set of regression analyses was carried out to sift them down to an important few. These characteristics were then added to the VDT use and job related variables described above.

All of the data for these particular analyses come from survey evaluations of VDT users and non-users.

The rationale for selection of the three well-being dimensions specified is that they represent the major types of effects demonstrated, previously investigated, or theoretically expected in the type of work studied here. Similarly, the independent variables are among the major ones which have been theoretically indicated or empirically demonstrated in prior VDT or occupational stress research to play a role in the promotion or mitigation of stress (Caplan et al., 1975; Cooper and Payne, 1978; Dainoff, 1982; Levi, 1981). Because of the breadth of the conditions denoted by the variables considered here, these regression analyses are referred to as the "general work environment and health analyses".

It is evident that the analyses just described do not address how more specific attributes of the job design and physical environment (e.g. specific

VDT-computer operational, job regimen, or workstation ergonomic/anthropometric factors) influence particular complaints such as expressions of eye strain or musculo-skeletal disturbances among VDT users. For this reason additional analyses are also carried out to examine how these more specific conditions influence specific somatic disturbances in VDT users. Again, multiple regression procedures are used.

In these analyses the health measures of major interest are visuo-ocular disturbances, upper torso musculo-skeletal disturbances, and musculo-skeletal disturbances of mainly the upper extremities. The set of potential causal variables includes fairly specific aspects of the job regimen, specific attributes of the physical environment and workstation, as well as specific worker characteristics (e.g. age and corrective eye-wear use). Selection of causal and outcome variables for these analyses is based upon prior VDT research where associations of these factors with somatic disturbances have been observed (e.g. Cakir et al., 1978; Dainoff et al., 1981; Hunting et al., 1981; Laubli et al., 1981) and upon general knowledge in ergonomics (Grandjean, 1981).

This set of analyses which is referred to as the "specific work environment analyses" has two major components. The first involves the regression prediction of eye and musculo-skeletal strain measures from subjectively (survey) assessed aspects of working conditions and worker characteristics. This is done only for the VDT users. However, the question of whether non-users are affected in a similar way by these types of factors is also addressed here in a limited way. Certain of the independent variables are evaluated, one at a time, and in terms of a differential effect between users and non-users using two-way analysis of variance. This procedure, a departure from the regression technique in the more general work environment analyses, is necessitated because VDT users experience potential stress factors such as glare from a display screen which are not possible for non-users, or for which a comparable phenomenon does not exist among non-users.

The number of predictor variables which were originally considered for these analyses was quite large. In planning the analyses we were able to identify several dozen salient aspects of the job and workplace which might potentially contribute to the somatic complaints of VDT users. Because sample size limitations alone prohibit the evaluation of all these variables in a regression approach, the regressions are restricted to examination of only main effects of a select set of variables deemed most important based upon existing evidence.

In the second component of the specific work environment analyses the influence of ambient environmental conditions, workstation and VDT ergonomic factors, and worker anthropometric parameters that could be <u>objectively</u> measured (e.g. workplace lighting, aspects of the VDT configuration, gaze angle) are examined for their potential influence on reported eye and musculo-skeletal disturbances. These analyses are limited to a subsample of the VDT users whose workplaces could be objectively assessed. The analytical methods involved tests of the simple association between worker/workplace conditions and somatic strains. While multivariable techniques would be appropriate, a relatively small sample size (max. n = 62) and strong correlations among some of the independent variables prevented the application more controlled statistical techniques in these analyses.

DATA COLLECTION

STUDY DESIGN

Many of the major design characteristics of the current study were specified in advance by the NIOSH contract under which this work was performed. They included the basic study design, specific sample requirements, major components of the survey questionnaire instrument, the general analytical scheme, and general procedural aspects of the survey administration. The specific regression techniques employed and the tailoring of the survey content for the evaluation of VDT work was performed at the discretion of the investigators. All aspects of the study protocol and content were evaluated and cleared by NIOSH and by the University of Wisconsin Center for Health Sciences Committee for the Protection of Human Subjects prior to the initiation of the work.

The study consisted of a self-administered questionnaire survey of VDT users and non-users who performed a variety of office functions. Some of the VDT users and their workplaces were also objectively assessed. The survey design was cross-sectional, with all information from each participant collected at one point in time. Although the study design is most appropriately designated as a "static-group comparison" (Campbell and Stanley, 1963), the statistical control via regression techniques over the treatment (VDT use) and other of the independent variables provides important quasi-experimental properties which help circumvent certain limitations intrinsic to this type of design.

Regarding one matter with crucial implications for a survey study on the effects of VDT usage, we emphasize that VDT use was not a labor relations issue for the study population at the time of this survey. Although the population is formally represented by a national labor organization (AFSME), issues related to VDT usage were not included in any ongoing labor negotiations at the time of the study, and the survey administration predated the issuance of materials by AFSME describing bargaining guidelines and directives relative to VDT use.

SAMPLE AND SAMPLING PROCEDURE

Primary Sample

The study actually employed two samples. The primary sample upon which most of the analyses were based consisted of 248 VDT users and 85 non-users for a total of 333 participants. There was one additional participant in the primary sample, but incomplete data on this participant's survey did not enable an unambiguous classification of the individual as a VDT user or non-user, so the case was dropped from all subsequent analyses.

All of the participants were public employees of six State of Wisconsin government agencies. To identify potential participants, a letter (Appendix A) soliciting consent to perform the study on public workers was sent to administrators of six State of Wisconsin agencies and one University of Wisconsin (UW) department overseeing a large segment of UW data processing. These agencies and the UW department were pre-targeted for the study since each maintains extensive and heterogenous data processing operations. In no case was the organization targeted or any participants selected on the basis of existing problems surrounding VDT usage. Affirmative responses were obtained from all solicitations.

In subsequent personal meetings with administrative personnel from each of these facilities, the investigators provided further information on the nature and scope of the study, and sought information on the extent to which sample objectives could be met through the participation of employees from each facility. The main sample objectives were as follows:

(1) A variety in types of VDT usage from each facility was sought. The VDT work of major interest included data or text entry, conversational use such as file maintenance or word processing, general clerical use, and professional-technical or managerial use, including programming. A range of comparable job tasks within each facility was also sought for the control group.

(2) Extensive daily VDT use (>4 hours) was sought for the user group. For the control group, extensive daily office machine use was also sought.

(3) A range of VDT use tenure was sought among the users, with the large majority of users exceeding six months of experience with VDTs.

At the introductory meeting with administrators of the seven targeted facilities, work units which met these objectives were identified and unit managers were briefed on the study. During these meetings it seemed that most of the sample objectives could be attained through the participation of the State government agencies alone. For this reason, and to promote homogeneity of the sample with respect to employment factors, the University site was dropped from consideration prior to actual solicitation of individual participants.

It should be noted that as State of Wisconsin employees, all of the prospective participants, regardless of agency, were subject to equivalent governance in terms of job descriptions, job-career paths and opportunities within State service, and compensation schedules. All of the potential participants were from the immediate Madison (WI) area.

Managers of each of the work units identified were provided a model memorandum (Appendix B) which was subsequently sent to all employees of the units to inform them of the study, and to announce a forthcoming visit by the investigators at which time the purposes of the study would be explained and the participation of employees solicited. The memo indicated in general terms that the study involved an investigation of job demands in office work (VDT use was not specifically mentioned) by investigators from the University of Wisconsin, that further information would be provided in a subsequent visit by the investigators, and stressed in specific terms that participation was voluntary and that participant anonymity with respect to data provided would be assured.

Shortly following the issuance of these memoranda (within two weeks), the project investigators held a short meeting within each unit and formally sought the cooperation of all employees after presenting a more specific description of the nature of the research and the commitment required of participants. At these meetings, the potential participants were informed that the broad objective of the study was to evaluate the impact of new office technology on the job perceptions and well-being of office workers. VDT-computerization was mentioned as an example. However, it was not suggested at these meetings that VDT use posed a potential hazard to health and well-being, and in the very few instances where questions of this nature arose during these meetings, the response was that the outcome of the study would help to resolve any questions regarding both the positive and negative impacts. Following this discussion all employees of these units were individually administered a formal letter of solicitation and consent form (Appendix C) on which they designated their willingness or refusal to participate. Within a few days of each of these employee meetings, the investigators returned and concurrently administered the survey questionnaire on site and collected the objective workplace data.

For most of the VDT users, anonymity was assured by survey data which could identify only the location of a participant's work unit. However, the objective measurements involved photographic assessment of a subset of participants at their workstations which was associated with the survey data for these individuals. They provided release for this purpose (see consent form, Appendix C). Data maintenance procedures assured that subsequent connection of these individuals with specific survey data was near impossible for anyone but the project principal investigators. Photographs and surveys were secured in separate locked files.

Major job and biodemographic characteristics of the study primary sample are described in Tables 1-14. Of special importance, Table 1 shows that of 360 individuals solicited (not including the participant dropped from the analyses), only 27 (8%) declined to participate, and no major discrepancies existed across departments in terms of participation rates. This rather high compliance rate was likely due to the fact that approval was granted (in all but one unit...see measurement protocol section below) to administer the survey during normal working hours. Table 1 also shows that the VDT sample was well distributed across the different agencies. The distribution was less even for the non-users. This could not be avoided due to the status of office automation in the different agencies at the time of the survey.

Evaluation of survey data enabled a somewhat finer stratification of participants according to job tasks than specified in the sample objectives. Brief descriptions of job tasks within each stratum are as follows:

1. DATA ENTRY - Tasks involved the transfer of information from various forms or records to computerized data bases via VDT, or onto cards for computer entry. For VDT users, the operations were mainly key-to-disk.
2. RETRIEVAL AND UPDATE - These were file maintenance tasks which

Table 1. Breakdown of the number of workers solicited, participants, and non-participants by State of Wisconsin agency.

Agency	Total number of workers solicited	Non-participants	Participants		Total sample
			VDT users	Non-users	
Transportation	57	6 (11%)	47	4	51
Natural Resources	79	5 (6%)	13	61	74
Administration	22	1 (5%)	21	0	21
Revenue	79	6 (8%)	68	5	73
Industry, Labor and Human Relations	68	4 (6%)	50	14	64
Health and Social Services	55	5 (9%)	49	1	50
Total Sample	360	27 (8%)	248	85	333

involved both data entry as described above, plus the recall and update or revision of information from various data bases. An example is the entry and updating of motor vehicle registration data. Tasks were predominantly on line, accessing a large computer serving multiple work groups.

3. WORD PROCESSING - For the VDT users the tasks involved preparation of typed documents using various text handling systems. Work was usually from hard copy or machine stored documents. The VDT work was usually on-line accessing a small computer serving about a half-dozen users. This task was accomplished by the control group using typewriters with magnetic storage systems, but not equipped with CRTs.
4. APPLICATION PROCESSING - Tasks involved the evaluation and processing of applications for various types of licenses, consulting previous records in evaluation of these applications, and handling application fees. VDT users were on line, while non-users accessed hard copy records.
5. FISCAL CODING - These jobs involved primarily the evaluation of accounting vouchers and various other monetary records. VDT users were on-line with a large computer, while non-users utilized hard copy.
6. GENERAL CLERICAL/SECRETARIAL - These jobs involved the broad range of tasks normally conducted by the traditional office secretary (general typing, filing etc.).
7. LEAD WORKERS/SUPERVISORS - These jobs involved the supervision (usually first-line) of employees in the other activity categories of the study. While work in these jobs sometimes involved part-time performance of tasks similar to those of the individuals supervised, the jobs are distinguished by the responsibility for the work of others.
8. COMPUTER PROGRAMMING - Main tasks involved composition of computer programs or modifications of programs for work performed by the remainder of the VDT user sample.

The number of study participants within each stratum for the different agencies is shown in Table 2. As seen, several strata from every agency are represented in the study sample. Table 3 shows the number of VDT users and non-users within each stratum.

We wish to emphasize that the discrepancies in frequencies of users and non-users within certain job activity strata does not connote a discrepant or inappropriate comparison group. Some of the tasks performed by VDT users in one activity stratum were subsumed under the jobs of members of another stratum in the non-user group. For example, some of the file maintenance tasks performed by the retrieval and update VDT users are integrated into the jobs of the general clerical/secretarial personnel who do not use VDTs. The number of clerical-secretarial personel is reduced among the VDT users because the clerical jobs have become more specialized with the introduction of VDTs. It is difficult to find a VDT user whose job scope and content is similar to that performed by the traditional office secretary. Similarly, there are today few programmers who do not utilize VDTs, and it is becoming increasingly difficult to find data entry work that is not performed via VDT. The distinctions between the current VDT user and non-user samples in terms of proportions of individuals in the different job activity strata reflect

Table 2. Breakdown of principal job activities of the study sample within State of Wisconsin agency.

	Principal Job Activity							
Agency	Data entry	Retrieval and update	Word processor	Applications processing	Fiscal coding	General clerical/ secretarial	Lead worker/ supervisor	Programmer
Transportation	5	28	0	18	0	0	0	0
Natural Resources	9	0	22	1	10	24	5	3
Administration	9	0	10	0	0	0	2	0
Revenue	46	6	12	0	0	2	6	1
Industry, Labor and Human Relations	20	1	21	0	3	1	6	12
Health and Social Services	24	6	0	0	5	3	5	7

Table 3. Principal job activity for VDT users and non-users.

	Data entry	Retrieval and update	Word processor	Applications processing	Fiscal coding	General clerical/ secretarial	Lead worker/ supervisor	Programmer	Totals
Non-users	12 (14%)	0	25 (29%)	5 (6%)	10 (12%)	27 (32%)	6 (7%)	0	85
VDT users	101 (41%)	41 (17%)	40 (16%)	14 (6%)	8 (3%)	3 (1%)	18 (7%)	23 (9%)	248
Totals	113 (34%)	41 (12%)	65 (20%)	19 (6%)	18 (5%)	30 (9%)	24 (7%)	23 (7%)	333

the change in office work organization that is brought about by the introduction of VDT-computer technology.

Table 4 shows the extent of daily VDT usage within each job activity stratum for the VDT users, and the extent of non-VDT office machine use in each stratum for the comparison group. As seen, the VDT users within the different job activity strata spend about the same number of hours per day in VDT use as do their counterparts in the use of non-VDT office machines. Seventy-three percent of the users spend over 4 hours per day in VDT use (consistent with sample objectives), and 65 percent of the comparison group spends over four hours per day in the use of non-VDT office machines. Differences between VDT users and non-users in terms of proportions of individuals with VDT/office machine use greater and less than four hours per day are nonsignificant.

Table 5 describes the type of VDT equipment utilized by the VDT sample.

Tables 6, 7, 8, and 9 describe different aspects of the employment status of the VDT users and non-users. Table 6 shows the job tenure for the VDT user and non-user samples. Although the VDT users had a shorter mean job tenure, the difference is nonsignificant. Table 7 shows that over 80 percent of the users had more than six months job experience with VDTs (consistent with sample objectives). Table 8 shows that most of the participants within each group were full-time permanent employees, and no significant difference existed between users and non-users with respect to proportions of participants in the different categories of employment status. Similarly, no group differences existed with respect to the number of hours worked per week (Table 9). Most worked a 40-hour week.

Tables 10-14 describe major biodemographic features of the study sample. On none of these measures do even modest differences appear between the users and non-users. Table 10 shows that about half of each group was married, and about a third never married. Table 11 shows that the mean number of dependents for the two groups was nearly the same (about 1.3). Table 12 shows that mean ages differed by only 0.5 year. Table 13 shows that the sample was predominantly white (95% both groups). Table 14 shows that over 50 percent of each group had been formally educated beyond the 12th grade. There were only 13 males in the entire sample, and all were VDT users, mainly programmers ($n = 8$).

In summary then, with the exception of distribution by sex, the two participant groups in the primary sample were nearly equivalence on major biodemographic parameters, and not significantly differentiated on employment factors.

Finally, because health related symptomotology of VDT users vis-a-vis non-users is a primary concern of this study, it is essential that the two groups not be discrepant in terms of medical history which could shape responses on these measures. Table 15 shows that users and non-users were fairly similar in their reporting of prior treatment or diagnosis of 23 different medical conditions within the past five years, and that the overall incidence rates were low. With the exception of increased kidney/bladder disorders among the non-users (corrected Chi-square = 4.18, $p < .05$), no

Table 4. Extent of daily VDT and office machine use by job activity.

	Mean Hours of Office Equipment Use	
Job activity	VDT use	Office machine use (VDT non-users)
Data entry	7.3	6.8
Retrieval and update	6.7	-
Word processor	7.1	7.1
Applications processing	2.2	1.3
Fiscal coding	2.4	4.3
General clerical/secretarial	3.4	3.7
Lead worker/supervisor	2.5	3.8
Programmer	2.4	-
Total sample	5.8	5.1

Test for independence of VDT users/non-users and extent of daily machine use

	VDT users	Non-users
Equipment use 4 hrs/day	68 (27%)	30 (35%)
Equipment use 4 hrs/day	180 (73%)	55 (65%)

Corrected X^2 (1) = 1.32
p = .75

Table 5. VDTs used by the study participants.

Brand Name	Model	Frequency
Entrex	(mainly 121)	101
IBM	(mainly 3278)	79
WANG	Word Processor	11
4 - Phase Systems	Forward 7249	28
AB Dick Shared Logic		5
		24 non-respondents

Table 6. Length of time in current job position for VDT users and non-users.

	Months and Years in Current Position							
	≤6 mos	>6 mos≤1 yr	>1 yr≤2 yr	>2 yr≤3 yr	>3 yr≤5 yr	>5 yr≤8 yr	>8 yr	Totals
Non-users	14 (17%)	11 (13%)	17 (20%)	11 (13%)	12 (15%)	11 (13%)	6 (7%)	82
VDT users	71 (30%)	43 (18%)	49 (20%)	30 (13%)	20 (8%)	12 (5%)	16 (7%)	241
Totals	85 (26%)	54 (17%)	66 (20%)	41 (13%)	32 (10%)	23 (7%)	22 (7%)	323

10 non-respondents

Test (ANOVA) for group differences in time at current position

	Mean months	SD
Non-users	38.26	39.06
VDT users	28.64	39.91

F (1,321) = 3.59
p = .59

Table 7. Length of time of VDT use for the study sample.

Months and Years of VDT Use							
0 mos	>0 mos≤6 mos	>6 mos ≤ 1 yr	>1 yr ≤ 2 yr	>2 yr ≤ 3 yr	>3 yr ≤ 5 yr	>5 yr ≤ 8 yr	>8 yr
85 (non-users)	37 (16%)	43	50	29	32	20	9

$\Sigma(>6 \text{ mos.}) = 183$ (83% of 220 users)

Mean months of VDT use = 29.02

8 non-respondents

Table 8. Employment status of the VDT users and non-users.

	Employment Status				
	Full-time permanent	Full-time temporary	Part-time permanent	Part-time temporary	Totals
Non-users	76 (89%)	4 (5%)	2 (2%)	3 (4%)	85
VDT users	191 (77%)	25 (10%)	24 (10%)	8 (3%)	248
Totals	267 (80%)	29 (9%)	26 (8%)	11 (3%)	333

Test for independence of VDT users/non-users and employment status

$X^2(3) = 7.68$
$p = .053$

Table 9. Number of hours worked per week for VDT users and non-users.

	Mean hours	SD
Non-users	39.26	3.78
VDT users	38.29	5.81

3 non-respondents

Test (ANOVA) for group differences in hours worked per week

F (1,328) = 2.03
p = .16

Table 10. Marital status of VDT users and non-users.

	Marital Status					
	Married	Single	Separated	Divorced	Widowed	Totals
Non-users	43 (51%)	25 (29%)	1 (1%)	14 (17%)	2 (2%)	85
VDT users	130 (53%)	80 (33%)	5 (2%)	26 (11%)	4 (2%)	245
Totals	173 (52%)	105 (32%)	6 (2%)	40 (12%)	6 (2%)	330

3 non-respondents

Test for independence of VDT users/non-users and married/not married status

	Married	Not married
Non-users	43 (51%)	42 (49%)
VDT users	130 (53%)	118 (47%)

Corrected $X^2(1) = .03$
$p = .87$

Table 11. Number of dependents for VDT users and non-users.

	Number of people supported								
	0	1	2	3	4	5	Total	M	SD
Non-users	34 (40%)	22 (26%)	13 (15%)	8 (9%)	6 (7%)	2 (2%)	85	1.26	1.42
VDT users	109 (44%)	45 (18%)	34 (14%)	34 (14%)	10 (4%)	14 (6%)	246	1.32	1.53
Totals	143 (43%)	67 (20%)	47 (14%)	42 (13%)	16 (5%)	16 (5%)	331		

2 non-respondents

Mann-Whitney "U" test for group differences in number of people supported

	Mean rank	
Non-users	166	$z = .00$
VDT users	166	$p = 1.00$

Table 12. Ages of VDT users and non-users.

	Age					
	18 - 24	25 - 34	35 - 44	45 - 54	55 - 64	Totals
Non-users	18 (22%)	33 (39%)	13 (15%)	14 (16%)	7 (8%)	85
VDT users	65 (27%)	79 (33%)	52 (21%)	32 (13%)	14 (6%)	242
Totals	83 (25%)	112 (34%)	65 (20%)	46 (14%)	21 (6%)	327

6 non-respondents

Test (ANOVA) for group differences in age

	Mean age	SD
Non-users	33.05	12.11
VDT users	33.51	11.30

$\underline{F}$ (1,124) = 1.12
$\underline{p}$ = .29

Table 13. Ethnic background of VDT users and non-users.

	Ethnic Background					
	American Indian	Asian	Black	Hispanic	White	Totals
Non-users	0	0	3	1	80	84
VDT users	5	1	4	1	233	244
Totals	5	1	7	2	313	328

5 non-respondents

Test for independence of VDT use/non-use and ethnic background

	Non white	White
Non-users	4 (5%)	80 (95%)
VDT users	11 (5%)	233 (95%)
Totals	15 (5%)	313 (95%)

Corrected $X^2(1) = .04$
$p = .84$

Table 14. Educational attainment of VDT users and non-users.

	Educational Attainment				
	High school graduate or less	High school graduate plus technical training	High school graduate plus some college	College graduate	Totals
Non-users	41 (48%)	22 (26%)	16 (19%)	6 (7%)	85
VDT users	119 (48%)	61 (25%)	45 (18%)	21 (8%)	246
Totals	160 (48%)	83 (25%)	61 (18%)	27 (8%)	331

2 non-respondents

Test for independence of VDT use/non-use and educational attainment

X^2 (3) = .21
p = .98

Table 15. Medical conditions treated or diagnosed in study participants within the past five years.

Medical condition	Users	Non-users
	(% diagnosed or treated)	
Diabetes	1.6	2.4
Cancer	1.6	1.2
Hernia or rupture	2.4	3.5
Tuberculosis	0.0	0.0
Asthma	2.8	5.9
"High" blood pressure	10.2	12.9
Heart disease	1.2	2.4
Arthritis or rheumatism	8.1	9.4
Epilepsy (convulsions or fits)	0.4	0.0
Glaucoma of the eyes	0.8	1.2
Paralysis, tremor, or shaking	0.8	3.5
Kidney or bladder trouble	10.6	20.0
Lung or breathing problems	6.5	8.2
Stroke	0.0	1.2
Anemia	5.7	9.4
Gall bladder, liver problems	4.9	3.5
Thyroid trouble or goiter	2.0	2.4
Insomnia	2.4	7.1
Gastritis	10.7	14.1
Colitis	2.9	4.7
Stomach ulcer	4.5	5.9
Cataracts	0.0	1.2
Mental or psychological problems	4.5	9.4

significant differences existed between groups in terms of proportions responding affirmatively and negatively to each condition.

Secondary Sample

Subsequent to the sampling and survey of the primary sample, managers of some of the work units from which the primary sample was obtained informed us that several new VDT positions had been created in their facilities. They anticipated that we may wish to include the incumbents among the sample from the original survey. According to their reports, most of these individuals had not previously worked at VDT jobs.

This inspired an effort to obtain longitudinal data from these individuals through multiple surveys in order to first gauge the users' immediate health and job reactions to VDTs, and then track changes in these parameters over time. Johansson and Aronsson (1980) had recently published data on worker's assessments of changes in their jobs and well-being incident to VDT use, and we thought this would be a good opportunity to attempt to replicate these observations.

Forty-seven new VDT positions were identified, and the incumbents were solicited according to the procedure described for the primary sample. All participated. At the same time, 45 VDT users with longer job tenure were solicited. The intent was to control for any effects related to potential changes in State of Wisconsin VDT jobs (which could influence job and health perceptions) over the period of time in which we intended to administer the multiple surveys. Eighty-five percent of these individuals were among the users from the primary sample. Table 16 provides the same job and demographic information for these two groups that was provided for the primary sample in Tables 1-14.

The survey instrument we used for the survey of the secondary sample was a modified version of the questionnaire used for the primary sample. The main difference was that it was shortened to facilitate the multiple administrations intended, and items seeking users' appraisals of job and health changes since beginning their VDT jobs (similar to items used by Johansson and Aronsson, 1980) were included (see "Research Measures" section below).

Following the initial survey of each group, the additional surveys we had planned were suspended. The main reasons were that we encountered resistance to further assessment that would have resulted in a considerably reduced sample size, and the ongoing analyses of the data from the primary sample revealed no association of measures of well-being with VDT job tenure.

With one exception, all of the data from this survey of the secondary sample are reported separately; they are not converged with data collected from the primary sample. The single exception is that objective worker and workplace data obtained from the 12 users in the new VDT jobs (only 12 of 47 users and workstations/workplaces were objectively assessed) were combined with the objective data obtained from the primary sample. This combination of data helped improve the sample size for analyses examining the relationship of objectively measured aspects of users and workplaces with reported strains.

Table 16. Characteristics of the secondary sample.

Agency	Existing VDT job users	New VDT job users	Non-participants	Total sample
Transportation	14	11	0	25
Natural Resources	0	19	0	19
Administration	13	0	0	13
Health and Social Services	20	15	0	35
Totals	47	45	0	92

Principal Job Activity	Existing VDT job users	New VDT job users
Data entry	20	7
Retrieval and update	14	12
Work processor	12	19
Applications processing	0	1
Fiscal coding	0	1
General clerical-secretarial	0	2
Lead worker/supervisor	1	3
Programmer	0	0
Extent of Daily VDT Use (hours)		
Mean	6.4	5.9
Standard Deviation	21.2	20.6
Time in Current Position (months)		
Mean	35.9	22.4
Standard deviation	43.5	20.5
2 non-respondents		
Employment Status		
Full-time permanent	43	41
Part-time permanent	4	4

Table 16 continued.

Hours Worked Per Week	Existing VDT job users	New VDT job users
Mean	38.3	39.0
Standard deviation	5.6	7.9
Length of Time VDT Use (months)		
Mean	30.8	15.2
Standard deviation	23.9	19.1
Marital Status		
Married	28	22
Not married	19	23
Number of Dependents		
Mean	1.6	1.5
Standard deviation	1.7	1.3
Age		
Mean	36.5	32.6
Standard deviation	10.8	11.4
Ethnic Background		
White	44	41
Non-white	2	4
1 non-respondent		
Educational Attainment		
High school or less	29	23
High school plus technical training	11	11
High school plus some college	6	10
College graduate	1	1

RESEARCH MEASURES

The questionnaire surveys and the data forms for the objective measurement are reproduced in Appendix D and Appendix E respectively. As shown at the end of Appendix D, the form of the questionnaire administered to the secondary sample was an abridged version of the questionnaire for the primary sample, but with a limited number of items added to assess mainly VDT users' perceptions of job and health changes subsequent to the introduction of VDTs in their jobs. The objective measures were the same for both samples.

The questionnaire sought information on three broad subjects: working conditions and job characteristics, worker biodemographic characteristics, and health and well-being. Some of the questionnaire scales are widely used psychometric instruments for which normative data are available. Nearly the entire content of the questionnaire has had prior application in occupational stress research by NIOSH, and some elements had been applied in prior studies of VDT use (Arndt, 1981a,b; Dainoff et al., 1981; Smith et al., 1981). Much of the questionnaire content was prescribed in advance by NIOSH. However, items were added with NIOSH approval to tailor the content for VDT and office work, and for the types of health and job disturbances identified and suspected for VDT users. The inclusion of these items was based upon prior VDT research, our inspection of VDT facilities in Wisconsin, and general knowledge in the area of VDT ergonomics. Following is a listing of the questionnaire contents organized according to the three broad categories specified:

Working Conditions and Job Characteristics

Job Description--

Information was obtained on job title and classification, tasks performed, equipment used, employment status, job tenure, prior experience, work schedule and temporal characteristics, training, and biodynamic requirements. For the VDT users, separate data specific to VDT use were collected (extent of daily VDT use; modes of VDT use such as dialogue, retrieval, entry; intensity of each mode; temporal aspects: work breaks and interruptions; documents or informational sources used; visual targets; etc.)

Perceived Job Characteristics--

This component of the questionnaire consisted mainly of Form S of the Work Environment Scale (Insel and Moos, 1974) and scales developed and/or refined at the Michigan Institute for Social Research for assessment of working conditions which represent potential stress factors and stress moderators (Caplan et al., 1975). The Caplan et al. (1975) scales included indices of role ambiguity and role conflict, quantitative workload and workload variance, underutilization of abilities, participation, job future ambiguity, and measures of job related social support from supervisors and peers at work, and from spouse/family and friends. Caplan et al. (1975) scales denoting worker personal expectations or needs for some of these conditions were also included. For a discussion of the development, prior application, and reliability of these scales, the reader is referred to Caplan et al. (1975). Subscales of the Work Environment Scale (WES) included the following: job involvement, peer cohesion, staff support, job autonomy, task orientation, work pressure, clarity of expectations, management control, innovation, and physical comfort. Specific items pertaining to perceived performance, needed qualifications for the job, and rationale for job selection were also included. Finally, separate multidimensional measures of job control social environment/support, task performance demands, and job/skill future certainty were computed by the investigators from items within this section of the questionnaire (see "Derived Scales" below).

Workplace Physical Environment--

In addition to the WES physical comfort subscale, items describing the following attributes of the physical environment were included: noise, task and ambient lighting, lighting adjustability, temperature, crowding, fumes and odors, chair comfort and adjustability, adjustability of furniture and equipment, and general quality of the physical environment. From some of these items a multidimensional "environmental problems" measure was computed (see "Derived Scales") below.

For the VDT users, information was also obtained on the manufacturer and model of the VDT, color of image foreground and background, presence of a detachable keyboard, type of work table, and on adjustability of display foreground/background characteristics, of the screen and keyboard distance, height, and orientation, and of task lighting. Ratings of the extent to which most of these parameters were considered bothersome were also obtained. Users also rated the efficiency with which their VDT hardware/software systems could be used, and in open-ended questions provided information on changes both made and desired to improve system efficiency and comfort. Based upon some of these items, multidimensional indices of the adjustability of the workstation physical configuration and workstation lighting, and of disturbance by the workstation configuration, display characteristics, and ambient lighting were computed for the VDT users (see "Derived Scales" below).

Health and Well-being Measures

Job attitudes and the affective and somatic status of participants were assessed. Caplan et al. (1975) scales were used to measure workload dissatisfaction, job dissatisfaction, and boredom. The Profile of Mood States (POMS) developed by McNair, Lorr, and Droppleman (1971) was used to obtain a comprehensive measure of mood disturbance and measures of impairment for six affective states denoted by the POMS subscales (tension-anxiety, depression, anger, vigor, fatigue, and confusion). Also included was an extensive inventory soliciting data on the relative incidence of 59 diverse medical symptoms within the time frame of the year prior to the survey. This inventory was based upon a comprehensive symptom checklist with prior use for health screening in NIOSH investigations. In the present study it was modified to provide further emphasis on the types of disturbances suggested in prior research as associated with VDT use, particularly musculo-skeletal and visuo-ocular strain. An abbreviated version of this inventory was used to collect data on medical symptoms experienced at work. The time frame for the at-work inventory was the month prior to the survey. In addition to information on sleep and vision disturbances obtained via these symptom inventories, data were also obtained on experiences of sleepiness at or after work, and on perceived vision deterioration during the prior year and during the job tenure.

Several indices denoting disturbances of well-being were also computed based upon the items and scales specified above. They included multidimensional measures of job dissatisfaction, mood disturbance, and health disturbance, and the following measures of fairly specific health disturbances: visuo-ocular strain, musculo-skeletal strain of mainly the neck/back/shoulders, musculo-skeletal strain of mainly the arm/hand, and a scale denoting behavioral-autonomic manifestations of psychological stress (see "Derived Scales" below).

Information was also obtained on the prior diagnosis or treatment of over two dozen major health disorders. These data were used primarily to determine the comparability of VDT users and non-users on pre-existing medical conditions which might be reflected in their current symptomotology.

Finally, items were included to obtain information on participants' self-assessment of their overall health, on perceived sources of stress, on sick leaves and hospitalization, on workplace accidents, and on the use of prescription medication and common over-the-counter medication used for symptom relief.

Worker Characteristics

The standard biodemographic data obtained for each participant included the following: age, ethnic background, sex, education, height, weight, marital status, number of children and dependents, living arrangement and salary. Data on the use of corrective eyewear were also obtained.

Personal behavioral-life style data collected included information on coping techniques, recreation activities, time availability for non-work activities, and on tobacco and alcohol, soft drink, and caffeinated beverage use. In addition, the Holmes-Rahe Recent Life Events Scale (Holmes and Rahe, 1967) was administered.

Questionnaire-Derived Scales

Based upon select questionnaire items and scales, 17 additional multidimensional indices of well-being and job attributes were derived. Following below is an annotated description of each of these scales. The acronym accompanying each description is used to denote the measure in data tabulations in the presentation of results.

1. Job Control (JOB CON): Individual freedom and participation with others in determining the way work is to be performed; control over temporal aspects of work; supervisory control over work processes; utilization of personal skills and abilities at work.
2. Social Environment/Support (SOC SUP): Supervisory and peer support at work; family and friend support regarding work matters; social atmosphere at work; support from work peers, supervisors, family and friends regarding personal matters.
3. Job/Task Performance Demands (JOB DEM): Quantitative workload; temporal demands; demands upon attention/concentration.
4. Job/Skill Future Certainty (FUT CER): Certainty regarding career picture, promotion, responsibilities; concern over job loss/replacement by machines.

5. Physical Environmental Problems (ENV PROB): Furniture, space, lighting, and other ambient environmental problems at work.
6. Job Dissatisfaction (JOB DIS): Dissatisfaction with job content, regimen, workload; propensity to take same type of job; perceived stress from job/career; affective disturbances at work.
7. Illness Symptoms (ILL SYM): Broad cross-section of medical symptoms.
8. Mood Disturbance (MD DIS): Tension-anxiety, depression, vigor, fatigue, confusion, anger.
9. Visuo-ocular Strain (VISOC STRN): Eye strain, irritation, and visual imperception (factor analysis did not differentiate items denoting imperception from those indicative of asthenopia as in Laubli et al. [1980]).
10. Musculo-skeletal Manipulative Strain (MANIP STRN): Musculo-skeletal discomfort involving mainly the arms, hands, and wrists.
11. Musculo-skeletal Postural Strain (POST STRN): Neck, back, shoulder, discomfort.
12. Behavioral-autonomic Disturbance (BEH AUT): Behavioral, emotional/motivational, and psychosomatic manifestations of psychological stress.

Calculated for VDT users only

13. Workstation/VDT Physical Adjustability (PHYS ADJ): Extent to which physical characteristics of the workstation furniture and VDT equipment are adjustable.
14. Workstation Lighting Adjustability (LUM ADJ): Extent to which workstation lighting and VDT display characteristics are adjustable.
15. Workstation/VDT Physical Configuration Problems (VDT BOTH): Extent to which height, distance, and orientation of the VDT screen/keyboard are bothersome.
16. VDT Display Problems (DISP BOTH): Extent to which image foreground/background brightness, readability, flicker, and screen glare are bothersome.
17. Environmental Lighting Problems (ENV LUM BOTH): Extent to which ambient lighting quality and quantity are bothersome.

The specific questionnaire items included in each scale are identified in Appendix F.

Several of the scales denoting potential stress factors/moderators (job control, social support, job demands, future certainty) are based largely upon items from similar indices (Caplan et al., 1975, Insel and Moos, 1974) used in prior occupational stress research. Some items have been added to provide emphasis to circumstances that may be encountered in VDT or automated office work (e.g. "possibility of job loss due to machine or computer systems" in the future certainty scale). Other scales within this category (environmental problems, VDT/workstation physical adjustability, lighting adjustability, VDT physical configuration problems, VDT display problems, and environmental lighting problems) were derived based upon the necessity for measures of these conditions as determined by indications in prior research of their potential significance as stress factors in VDT work. Pre-existing scales assessing these types of conditions are not available.

The illness symptoms measure was derived in order to broadly depict the health status of participants for the purpose of predicting this characteristic in the planned analyses. Similarly, the mood disturbance measure was derived in order to depict the general affective status of participants for planned analyses. These two indices are based, respectively, upon the symptom inventories and upon items contained within the POMS. The dissatisfaction measure is an expansion of the Caplan et al. (1975) job dissatisfaction scale (which examines mainly the propensity to accept or recommend the current job) into a more comprehensive index incorporating others dimension of job dissatisfaction and also affective reactions to the job (e.g. "happiness at work"). The visuo-ocular, musculo-skeletal, and behavioral-autonomic strain indices were derived in order to predict these more specific types of health disturbances in planned analyses.

The scale score for each individual for the derived measures was computed as a weighted sum of the constituent item values. Weightings for items in all scales are given in Appendix F. For scales 1-14, the weight of each item is the corresponding coefficient of the first principle component (i.e. eigenvector) of the sample variance-covariance matrix of items.

As indicated above, for scales 1-8 items were first selected for inclusion within each scale based upon their general content relevance to the construct denoted by the scale. For each of these scales, the initially selected items were then factor analyzed (varimax rotation). Items which failed to load strongly on the first factor and were simultaneously judged not to be of central importance for the content validity of the intended construct were then tagged. Using the method of Serlin and Kaiser (1976), some of these tagged items were systematically deleted in order to maximize the internal consistency (reliability) of each scale. Items for the specific health disturbance scales (9-12) were selected from a rotated (varimax) factor analysis of items from the symptom inventories followed by deletion of items from each scale to improve reliability as described above. Items for scales 13 and 14 (the adjustability scales) were selected in the same way. Items within each of these scales were selected from rotated factor analysis of questionnaire items denoting physical adjustability of VDT components and adjustability of task lighting and display characteristics. Items were then deleted to maximize the reliability of each scale.

For all scales 1-14, Table 17 shows the number of specific items within each scale, the reliability coefficient (KR-20) for each scale, and the percent variance explained by the first principal component. As seen, the latter two measures are adequate in all cases, although the internal consistency of the two adjustability scales is somewhat marginal. In plotting the percent variance explained by successive principal components for these factors, a desirable "notch" appears between the first and second components in most cases. The means (across derived scales) for these values are 38 percent, 13 percent, and 9 percent respectively for the first, second, and third eigenvectors. For several of the derived scales 1-14, correlations are shown with other widely used scales denoting similar constructs and upon which the derived scales are in part based (Table 18). As seen, the correlations are all fairly strong.

Table 17. Characteristics of derived scales.

Variable	Number of items	KR-20 (internal consistency/ reliability)	Eigenvalue (first principal component)	% Variance (first principal component)
Job Control	16	.84	4.72	30%
Social Environment/Support	25	.87	6.23	25%
Task Performance Demands	20	.87	5.68	28%
Job/Skill Future Certainty	6	.77	2.77	46%
Physical Environmental Problems	15	.84	4.49	30%
Job Dissatisfaction	23	.92	8.54	37%
Illness Symptoms	51	.95	14.33	28%
Mood Disturbance	58	.98	23.93	41%
Visuo-ocular Strain	6	.87	3.59	60%
Musculo-skeletal Manipulative Strain	7	.78	2.93	42%
Musculo-skeletal Postural Strain	7	.90	4.33	62%
Behavioral-autonomic Strain	14	.90	5.99	43%
Workstation/VDT Physical Adjustability	7	.66	2.31	33%
Workstation Lighting Adjustability	7	.54	1.87	27%

Table 18. The correlation between scores for scales formulated in the present study and scores from analogous scales.

Derived scale	Analog scale	Pearson r
Job Demands	* Combined Quantitative Workload	.92
Social Environment/ Support	* Support from Others at Work	.80
	* Supervisory Support	.77
	† Staff Support	.62
Job Control	* Participation	.80
	† Autonomy	.74
Environmental Problems	† Physical Comfort	.81
Job/Skill Future Certainty	* Future Ambiguity	-.97
Job Dissatisfaction	* Job Dissatisfaction	.73
Mood Disturbance	ʃ Total Mood Disturbance	.99

* Caplan et al. (1975)
† Work Environment Scale (Insel and Moos, 1974)
ʃ Profile of Mood States (McNair et al., 1971)

For measures indicating perceived problems with physical conditions (scales 15-17), scale values were computed directly from item weightings obtained in a varimax rotation of 28 items denoting reactions of VDT users to physical characteristics of the workplace/workstation/VDT. When eight factors were extracted, three factors corresponding to the "problems" constructs denoted in scales 15-17 emerged clearly. The percent variance explained by each of these factors is as follows: workstation/VDT physical configuration problems (20%); VDT display problems (15%); environmental lighting problems (12%). These three scales were computed to be orthogonal to one another based upon our interest in very finely distinguishing their effects in the regression analyses.

In computing scale scores for the derived measures it was necessary to estimate values for a limited number of items to which subjects did not respond. The BMDP (Biomedical Computer Programs P-Series, 1979) PAM regression procedure was used to predict values for missing data based upon values of other items within the same scale was used for this purpose. Data were estimated only for derived scales 1-8. To minimize error due to data estimation, two limitations were imposed. First, no more than two data points were estimated per subject per scale. Second, when only one item value in a scale was estimated its coefficient of determination (R^2) with the scale had to exceed 0.3, and when two item values were estimated the R^2 for each item had to exceed 0.4. We were able to ensure reliability of estimation with these criteria by artificially deleting data for the estimated items from complete data sets, and then estimating these known values using the procedure described above and comparing actual and estimated values. When the above criteria were not met the case was excluded from the sample for the analyses involving these variables. In all, only 57 values (data points) were estimated out of a total of 53,714 data points for the scales 1-8. After estimating these values, complete data on scales 1-8 were available for 186 VDT users and 65 non-users.

Objective Measures

The objective data (obtained for VDT users only) consisted of workplace/station lighting related measures, a measure of screen glare, and measures related to worker anthropometry and to use of keyboards in a detached fashion. These data were obtained in two ways. First, the data on lighting conditions were obtained by on-site determinations using a light meter capable of both luminance and illumination measures. Secondly, information regarding quantity of screen glare, anthropometric parameters, and use of a detached keyboard were obtained by photographic assessment in which slides of the user and workstation and VDT display were evaluated using rear-screen projection. The specific technique for each objective measurement is provided below along with the description of each measure. The acronym accompanying each description is used to denote the measure in tabled data presented further on in the report.

The unit of measurement for illuminance was the "footcandle." The unit of measurement for all luminance determinations was the "foot-Lambert." All lighting measurements were made using a recently calibrated Lite Mate/Spot Mate Photometer System (Photo Research Corp., Burbank, CA). The inaccuracy of this instrument is rated at ± 5%. In all cases of luminance measurement, the reading was taken from the perspective of the operator seated in the natural working position and oriented toward the surface or object from which the value was obtained.

A few of the physical assessments described below (no. 13-16) required dichotomous judgements. In these cases separate photographic assessments were made by three of the project staff with expertise in VDT ergonomics. Where inconsistencies among assessments arose, the two assessments in agreement were recorded for the measured value. The same technique was used for measure nine, number of screen quadrants with glare. The reliability of the measures of anthropometric angles (no. 17 and 18) from slide photographs was confirmed in an independent assessment
($r = .95$).

The objective data were obtained from a total of 62 VDT users (50 from the primary sample and 12 from the secondary sample). A primary criterion for selecting users for objective assessment was the opportunity (determined by the location of the users' workstations in the workplace) to take a side-view photograph of the user and workstation.

Lighting Related Measures--

1. Screen background luminance (SCRN LUM): This measure was obtained from an area of the screen background which was free of a "bounded" diffuse or specular glare. The measurement was made with the VDT turned on, and with contrast and/or brightness adjusted to the normal operational level. An effort was made to take the measure as near center screen as possible.
2. Screen standard luminance (SCRN STD): A measure of the luminance of a white "standard" superimposed upon the screen in a position corresponding to the screen coordinate where the screen background luminance measure was made.
3. Keyboard luminance (KYBD LUM): A measure of keyboard luminance taken in the center of the keyboard.
4. Keyboard standard luminance (KYBD STD): A measure of the luminance of a standard placed in the position and orientation of the keyboard (same coordinate as the keyboard luminance measure).

5a. Background luminance, left (BKGD LUML).
5b. Background luminance, center (BKGD LUMC).
5c. Background luminance, right (BKGD LUMR).
Luminance measurements were made of the visual field approximately 30° to the left and right of the user, and directly in front of the user when positioned at the VDT. The vertical angle of the instrument was 0° (the horizon), at the eye level of the seated operator.

6. Screen illuminance (SCRN ILL): The illumination at the screen was measured with the plane of the the light meter transducer (sensor) positioned in the center of the screen and in the same orientation as the screen surface.
7. Work surface illuminance (WRK SURF ILL): A measure of the illumination at the position of the workstation where the source document was usually situated. Most often, it was a flat tabletop to the right of the VDT user.
8. Keyboard illumination (KYBD ILL): A measurement of illumination at the keyboard, with the meter transducer positioned in the center of the keyboard and in the same orientation as the keyboard gradient.

9. Glare quadrants (GLA QUAD): Slide photographs of the VDT screen taken from the viewing perspective of the seated operator were examined for the presence or absence of either diffuse or specular glare. Scores of 1-4 were assigned according to the number of quadrants of the screen in which any glare was detected.
10. Average background luminance (ABKGD LUM): This measure consisted of the average of the three background luminance values.
11. Screen to background luminance ratio (SB LUMR): The ratio of the value for the screen luminance to the average background luminance value.
12. Screen reflectance (SCRN REF): This was a measure of luminous directional reflectance (i.e. a contrast ratio of the screen background luminance value to the luminance value for the screen standard).

Anthropometry Related Measures--

13. Quality of the frontal plane of the trunk (BACK PLANE): A judgment of whether or not the operator assumed a forward-leaning posture marked by an arched back and drooped shoulders. The judgment was made from a side view photograph of the operator in a normal sitting position. A dichotomous (1, good posture; 0, poor posture) rating was given.
14. Quality of the frontal plane of the neck (NECK PLANE): A judgment of whether the frontal plane of the cervical spine area was a near continuation of the plane of the back, or whether the plane appeared to be excessively inclined or thrust forward and downward. The judgment was made from a side view photograph. Again, the rating was dichotomous (1, good posture; 0, poor posture).
15. Use of a chair back support (BACK SPPT): The measure consisted of a dichotomous (1, yes; 0, no) rating of whether or not the back support of the VDT user's chair was contiguous to the user's back; i.e., an estimate of whether or not the back support was actually being used. The judgement was made from a side view photograph.
16. Use of an adjusted keyboard (KYBD ADJ): A dichotomous (1, yes; 0, no) rating of whether or not the position of the keyboard was separated from the VDT main chassis. A negative score was given for every attached keyboard since separation was impossible by definition, and to each separable keyboard which was positioned in a manner such that for all practical purposes it might just as well have been attached to the mainframe (e.g. contiguous with the VDT main chassis). The judgments were made from close-up photographs of the VDT from the perspective of the operator.
17. Eye-to-screen angle (GAZE ANGLE): The angle of gaze of the subject in viewing the VDT. This is the angle subtended by the horizon at the level of the eye to a line intersecting the eye and the midpoint of the VDT screen. Measures of this angle were made using a protractor on a rear-screen projection of a close-up side angle slide of the operator sitting in a natural working position.
18. Forearm elevation angle (FOREARM ANG). This measure is the angle subtended by the forearm and a verical axis extending upward from the elbow while keying. As with the gaze angle, the measure was made using a protractor on a rear-screen projection of a close-up side view slide of the operator.

MEASUREMENT PROTOCOL AND DATA QUALITY ASSURANCE

For nearly all of the research participants the questionnaires were administered on the job at individual workstations, and collected immediately following completion. Investigators were therefore available to respond to questions arising during completion of the questionnaire. The time required to complete the questionnaire ranged from 45-75 minutes for most of the participants. It was during this on-site period that the photographs and objective workplace measures were obtained. All of the data collection occurred early in the workshift, usually within the first few hours.

At one site management was reluctant to allow administration of the questionnaire during the work period. For these individuals (n = 28 VDT users, primary sample; n = 15 users, secondary sample) questionnaires were completed at home and returned by mail or collected by the investigator at the job site the following day. These individuals received a remuneration of $15.00. Since the remainder of the sample completed the questionnaire during the normal work period, they were not additionally compensated.

Uniformity in data collection methodology was ensured with a standard protocol in which a single investigator oversaw all survey administration measurement activities and made all the objective measures at every job site. The protocol for survey administration and objective measurement was pre-tested and standardized in a preliminary evaluation of a small sample of VDT users and non-users (their data were not included in the study data). This exercise was also used to discover and correct any ambiguities in the survey instrument.

The raw questionnaire data and the objective data were transcribed directly to standard coding forms by trained project staff for later entry to a computer data base. To minimize error, a questionnaire coding rule book was developed by the project investigators to govern the coding process. Efforts were made to have a single staff person code a specific block or section of every questionnaire. In cases where more than one person coded the same block on different questionnaires, the alternates thoroughly re-evaluated each other's work. Throughout the coding process, continual spot checking for coding accuracy by one of the investigators occurred. Approximately one-third of all coded questionnaires were completely re-evaluated to ensure that the established coding rules were observed.

Following professional keypunching and computer entry of coded data, a sample of data sets was randomly selected from the entire file by computer. All of the data in this sample were completely rechecked against the original uncoded questionnaire by a single person, and detected errors were corrected. In the few instances that systematic errors were found, the coding for these items was completely rechecked for every single questionnaire. In all, ten percent of the entire computer questionnaire data base for the project was completely checked against the raw questionnaire. For the objective lighting and anthropometric measurements, 100 percent of the data in computer file was checked against raw data forms. Finally, all calculations required for computed variables were performed by computer.

RESULTS AND DISCUSSION

GROUP COMPARISONS

Aims and Overview of the Analyses

The objective of these analyses is to obtain a broad perspective of the way working conditions and the well-being of workers vary between VDT jobs and their non-VDT counterparts. VDT users and non-users are compared on a variety of measures denoting affective and health disturbances and job attitudes. They are also compared on a range of job characteristics that are indicated in the occupational stress literature to be instrumental in the promotion or mitigation of stress. The primary purpose is to determine whether or not VDT users are at risk, or at increased risk relative to non-users, for disturbances of health and well-being. The answers to these questions are important because they provide the information needed to determine if action geared to the alleviation of these problems is needed and address uncertainties regarding the influence of VDT work as a stressor. However, the absence of a clear increment in strain among VDT users would not necessarily imply that they are at no greater risk than non-users. Evidence of less favorable working conditions among users might indicate greater risk and imminent problems with chronic exposure, particularly if these conditions are identified in analyses presented further on as important risk factors in VDT and office work. The relative potential for strain among VDT users, as judged by the quality of working conditions, is also assessed by comparing users' ratings of working conditions with occupational norms.

The present analyses begin with a comparison of the entire VDT user and non-user samples in terms of their job and workplace perceptions, and in terms of reported strains. Job assessments of both groups are also examined in relation to occupational norms where instruments allow. Next we examine variation in job perceptions and health reports by users and non-users as a function of the type of office work performed. These analyses by job activity were conducted to allow some comparison of the present data with similar contrasts by previous investigators (e.g. Cakir et al., 1978; Coe et al., 1980; Hunting et al., 1981; Laubli et al., 1981; Smith et al., 1981) which showed important effects related to the nature of job tasks. Finally, we examine data (from the secondary sample) on changes new VDT users perceived in terms of working conditions and health status following transition from more traditional office work to their present VDT jobs. These data may be compared to similar data collected by Johansson and Aronsson (1980). They may also serve as a check (albeit limited) on the results of the comparison of the VDT user and non-user samples. It might be argued that longitudinal data may be more appropriate for assessing the risks of VDT use. These "perceived changes" data are the closest we can come to providing a within-subjects assessment that spans the transition from non-VDT to VDT jobs.

Analytical Methods

Comparisons of VDT users with non-users are made on all the scales and subscales in the questionnaire (WES, POMS, Caplan et al., 1975, questionnaire derived scales) denoting working conditions and well-being/strain. The main statistical technique used was one-way analysis of variance (ANOVA). Comparisons of users with non-users were also made on nearly all questionnaire items, but only effects for the symptom inventories and select items denoting working conditions of primary interest are reported here. Test methods involved one-way ANOVA for continuous measures and chi-square tests for independence for nominal data. For reliability, ordinal data were analyzed using both the chi-square and Mann-Whitney U (with correction for ties) tests. In analyzing job and health perceptions in relation to job activity, two-way ANOVA was used (VDT use/non-use by job activity). The results showed no evidence of interactions of VDT use/non-use with job activity. Job activity effects were then examined using one-way ANOVA with VDT users and non-users combined. For a posteriori contrasts following a significant main effect of job activity, the Sheffe test (Kirk, 1968) was used. Although the test is conservative, it is exact with unequal cell sizes. All tests were carried out using SPSS (Statistical Package for the Social Sciences), Release 9 (Hull and Nie, 1981).

The samples for the present analyses fluctuate in relation to the variables examined. For all the scales derived in the present study, the samples consist of exactly 186 VDT users and 65 non-users (i.e. the number of participants without missing data for the items comprising these scales). For the single questionnaire item comparisons, the sample sizes consisted of all of the 248 VDT users and 85 non-users without missing data on these items. For comparisons involving WES, POMS, and Caplan et al. (1975) scales and subscales, the sample sizes also consisted of the entire sample of users and non-users minus those participants with missing data for any of the items comprising these scales. Participants with missing data for comparisons on each of these scales/subscales and single questionnaire items never numbered more than a very small fraction of the total sample sizes, certainly not enough to jeopardize reliability in any case.

Results

Comparison of VDT users and Non-users on Measures Reflecting Well-being--

The bottom of Tables 19 and 20, and the entire contents of Table 21 show the results of univariate comparisons of the VDT user and non-user samples on measures indicating job attitudes, affective disturbances, and somatic disturbances. For comparative purposes, data obtained by NIOSH investigators (Smith et al., 1981) using some of these scales to assess VDT users are presented (Tables 19 and 21), and in Table 19, normative data for the scales used earlier by Caplan et al. (1975) in an investigation of workers from 23 occupations are also presented. In Table 23 we show the proportions of VDT users and non-users reporting specific illness symptoms. The four groupings of symptoms shown in this Table represent the components of the four strain subscales formed from the factor analysis of the questionnaire symptom inventories. The two columns to the left in this table show the proportions of VDT users and non-users reporting the experience of each symptom on at least an "occasional" basis. The two columns to the right show the proportion

Table 19. Group comparisons for Caplan et al. (1975) stressor/moderator and strain scales.

	Current Sample Means		NIOSH	
	VDT Users	Non-Users	Clerical User Means	§ Norms (23 Occupations)
Stress Factors/Moderators				
Role Ambiguity	1.96	1.89	1.79	2.06
Quantitive Workload	3.62	3.68	4.04	3.51
Role Conflict	*1.73	1.96	NA	NA
Workload Variance	2.97	3.05	NA	NA
Job Future Ambiguity	3.16	2.94	3.50	2.70
Underutilization of Abilities	*2.87	2.54	-	2.41
Participation	2.48	2.56	-	2.97
Social Support from Supervisors	*2.69	3.02	-	2.87
Social Support from Others at Work	2.79	2.78	-	3.03
Social Support from Spouse/Family	2.90	2.91	-	NA
Social Support from Friends	3.06	3.02	-	NA
Well-Being Indices				
#Job Dissatisfaction	.05	-.04	-	NA
Workload Dissatisfaction	2.05	2.09	3.17	2.13
Boredom	2.47	2.25	3.36	1.83

(-) Indicates scale value not reported
NA Indicates current sample values were calculated differently from values from the other samples
* $p < .05$ (ANOVA: Current sample group differences)
\# Values indicate standard scores.
§ Median scores for 23 occupational samples (Caplan et al., 1975)

Table 20. Group comparisons for the questionnaire derived scales.

	Current Sample Means	
Stress Factors/Moderators	VDT users	Non-users
Environmental Problems	** 18.87	18.05
Job Control	** 19.33	20.40
Social Support	22.07	22.55
Job Demands	22.71	22.68
Future Certainty	20.49	20.85
Well-Being Indices		
Mood Disturbance	10.30	11.10
Illness Symptoms	9.37	9.47
Job Dissatisfaction	16.27	15.74
Behavioral-autonomic Strain	-5.09	-4.76
Musculo-skeletal Postural Strain	-1.91	-2.13
Musculo-skeletal Manipulative Strain	-4.71	-4.93
Visuo-ocular Strain	-1.99	-2.25

** $p \leq .01$ (ANOVA)

Table 21. Group comparisons for Profile of Mood States (POMS) subscales (occupational norms unavailable).

Subscale	Current Sample Means: VDT users	Current Sample Means: Non-users	NIOSH Clerical User Means
Anxiety-Tension	8.6	9.4	10.2
Depression	7.8	9.5	9.7
Anger	6.7	8.4	8.0
Vigor	16.8	16.8	16.0
Fatigue	7.2	7.5	9.0
Confusion	6.0	6.6	6.2
Total Mood Disturbance	18.9	24.4	-

(-) Indicates scale value not reported

Table 22. Group comparisons for Work Environment Scales (WES).

WES Subscale	Current Sample Means VDT users	Current Sample Means Non-users	NIOSH Clerical Users Means	WES NORMS (44 Occupations)
Job Involvement	1.99	2.21	1.01	2.08
Peer Cohesion	2.22	2.53	1.33	2.73
Staff Support	*2.18	2.62	1.38	2.94
Job Autonomy	**1.77	2.74	1.14	2.69
Task Orientation	2.50	2.68	2.02	2.51
Work Pressure	*2.39	2.04	3.38	1.77
Clarity of Job Expectations	2.34	2.51	1.17	2.33
Management Control over Workers	**2.45	1.90	3.04	2.32
Innovation	1.65	1.65	1.18	2.40
Physical Comfort of Workplace	**1.55	2.31	1.28	2.04

* $p \leq .05$ (ANOVA: Current sample group differences)
** $p \leq .01$

Table 23. Proportions of VDT users and non-users reporting symptoms in four strain categories (Mann-Whitney U test performed on ranks ascribed to reporting frequencies: 1=never, 2=occasionally; 3=frequently; 4=constantly; Chi-square test based upon the four frequency categories).

	Significance	% Reporting Symptom		% Reporting Frequently or Constantly	
Visuo-ocular Strain Scale Symptoms		VDT user	Non-user	VDT user	Non-user
Eyes ache/burn at work	NS	75	64	27	23
Eye strain at work	NS	75	75	24	20
Burning eyes	†	71	56	20	22
Tearing, itching eyes	NS	68	60	19	21
Problems focusing vision	NS	50	45	12	8
Blurred vision	NS	39	41	5	5
Behavioral-autonomic Strain Scale Symptoms					
Periods of depression	*	66	80	14	15
Easy irritability	NS	66	72	10	18
Severe fatigue/exhaustion	NS	62	65	13	19
High levels of tension	** †	60	74	14	22
Difficulty sleeping	NS	60	54	14	13
Upset stomach at work	NS	48	45	8	11
Periods of extreme anxiety	NS	47	47	8	12
Acid indigestion	†	46	53	11	8
Stomach pains	NS	42	46	5	7
Nervous or shaking inside	NS	39	41	7	7
Constipation	NS	34	40	7	11
Nausea or vomiting	NS	29	32	2	1
Trouble digesting food	NS	25	21	3	5
Racing or pounding heart	* ††	14	24	2	1

Table 23 continued.

Musculo-skeletal Postural Strain Scale Symptoms	Significance	% Reporting Symptom: VDT user	% Reporting Symptom: Non-user	% Reporting Frequently or Constantly: VDT user	% Reporting Frequently or Constantly: Non-user
Backache at work	NS	81	72	35	29
Neck/shoulder ache at work	NS	79	79	34	28
Back pain	NS	79	72	27	22
Neck or shoulder pain	NS	78	72	24	19
Shoulder soreness	NS	59	51	12	13
Pressure in neck	NS	52	53	15	11
Radiating neck pain	NS	40	39	10	9
Musculo-skeletal Manipulative Strain Scale Symptoms					
Pain or stiffness in arms/legs	NS	56	52	13	12
Leg cramps	†	46	39	7	4
Swollen muscles or joints	NS	41	42	9	11
Persistent numbness or tingling	NS	28	27	5	4
Hand/finger cramps	NS	26	20	3	6
Stiff or sore wrists	NS	26	16	4	4
Loss of feeling in fingers/ wrists	NS	19	15	2	1

Mann-Whitney U
 * $p \leq .05$
 ** $p \leq .01$

Chi-Square
 † $p \leq .05$
 †† $p \leq .01$

reporting the experience of each symptom at a "frequent" and "constant" rate. We have reported the incidence of these symptoms in this fashion in order to draw attention to the frequent/constant category which we feel denotes the extent to which each disturbance may be of clinical significance. Tests of group differences in the incidence of these symptoms, however, were conducted using all four response categories (never to constantly) as indicated in the legend to Table 23.

The single most impressive feature of the data presented in Tables 19-21 is that for none of the scales denoting job attitudes or affective or somatic disturbances are the VDT users and non-users separated by a statistically significant margin. Similarly, statistically significant differences between users and non-users in reporting specific symptoms of strain are rare (Table 23).

Job attitudes—Looking first at the Caplan et al. (1975) measures of job and workload dissatisfaction (Table 19), a greater mean job dissatisfaction score is seem among VDT users. However, the difference is modest and statistically nonsignificant. The same is true for the boredom scale. The mean boredom score for the current VDT users is higher than for non-users, but the groups are not significantly differentiated. Mean boredom scores for both groups are somewhat higher than the median for the 23 occupations investigated by Caplan et al. (1975), but considerably less than observed for the clerical VDT users workers investigated by Smith et al. (1981). The questionnaire derived scale of job dissatisfaction (Table 20), based in part on the Caplan et al. (1975) dissatisfaction and boredom scales, also suggests a trend toward increased user dissatisfaction, but again the effect is nonsignificant. Workload dissatisfaction was not excessive for the current study sample judging by the Caplan et al. (1975) median. Mean scores of users and non-users were nearly equivalent, and about the same as the median level of workload dissatisfaction for the 23 occupations investigated by Caplan et al. (1975). Like boredom, the workload dissatisfaction mean is seen to be lower than for the clerical VDT users investigated by Smith et al (1981).

These findings are consistent with trends witnessed in the VDT research thus far which suggest that VDT users manifest no greater levels of general job dissatisfaction than their non-user counterparts. The recent investigation of directory assistance operators by Starr et al. (1981) actually indicated a slight increase in satisfaction among VDT users. The Canadian Labour Congress study (1982) showed a tendency toward the opposite effect, but the statistical significance was not reported. Sixty percent of VDT users reported they were satisfied or very satisfied with their jobs, in comparison to 65 percent of the non-users. Coe et al. (1980) also reported that the vast majority of the VDT users and non-users they investigated responded that their jobs met personal needs with respect to job satisfaction. In three other studies of VDT users only, evidence of an unfavorable attitude toward the job in general was not obtained (Dainoff et al., 1981; Gunnarsson and Ostberg, 1977; Johansson and Aronsson, 1980). Users investigated in these studies tended to express fairly high levels of general satisfaction with their jobs. In the Johansson and Aronsson (1980), study for example, none of the VDT users expressed a desire to revert to their pre-VDT work process.

Although collectively the VDT research to date provides little evidence of increased job dissatisfaction incident to VDT use, it is important to point out that VDT work is not without dissatisfactions. In nearly all of the studies cited here, VDT users have noted disadvantageous or dissatisfying aspects of their work. As described in the background literature section of this report, they include mainly increased technical problems, and some studies indicate increased monotony or boredom. However, these effects vary from job to job, and do not seem sufficient to result in a general negative attitude toward VDT jobs.

Affective disturbances--Table 21 shows no significant differences between VDT users and non-users in total mood disturbance scores on the Profile of Mood States instrument, nor on any of the subscales of this instrument. Similarly the questionnaire derived mood disturbance measure (Table 20), which is a reformulation of the Profile of Mood States scores based upon factor analysis of items in this instrument for the present sample, also fails to differentiate VDT users and non-users. If anything, there seems to be some trend toward increased strain among the non-users. Looking at Table 21, it can be seen that for the total mood disturbance measure, and for five of the six subscales, mean scores are actually elevated in the non-user sample.

Thus the present data provide no indication of increased emotional debility in terms of adverse mood effects in the present sample of VDT users. In this regard, the present data compare favorably with the results of Smith et al. (1981). On the six subscales of the Profile of Mood States, Smith et al. (1981) found a significant impairment for VDT users (clericals only) in relation to non-users for only the fatigue index. For only two of the subscales, anxiety-tension and fatigue, were the scores for the clerical users investigated by Smith et al. (1981) much in excess of the non-users in the present sample. The results of Smith et al. (1981) are of particular interest because the remainder of the findings regarding working conditions and health effects in that investigation, some indicating psychological strain, suggested fairly severe levels of adversity among the clerical VDT users. Yet, with one exception (fatigue), these effects were not manifest in similar disturbances on the mood indices.

Few other investigations utilizing psychometric instruments have provided evidence of high levels of affective problems in VDT users in comparison to non-users. In fact, few investigations have utilized such instruments and clearly more work using reliable indices of emotional strain is needed. Cakir et al. (1978) found that scores obtained on the "General Central Activation" scale (Bartenwerfer, 1970) for VDT users were less than scores reported by other investigators for automobile drivers during long trips, foundry crane operators, or keypunch operators or verifiers. It almost seems, though, that this effect might be interpreted as increased strain in terms of activation which may be below optimal levels. However, Cakir et al. (1978) explain the effect as indicative of reduced stress among VDT users. In an experimental study, Haider et al. (1981) reported increased fatigue among VDT users in comparison to control subjects on two scales of the Nitsch (1976) "Proper State" instrument. Significance levels are not reported, but the effect seems pronounced.

Two controlled studies which did not use standard instruments to assess psychological strain have reported conflicting results. Data by Coe et al.

(1980) indicated somewhat greater levels of strain among non-user control subjects, consistent with the present findings. The Canadian Labour Congress (1982) investigation, on the other hand, reports a greater incidence of irritability and fatigue-like symptoms among VDT users.

Other studies have provided evidence of affective disturbances among VDT users (e.g. Dainoff, 1981; Ghiringhelli, 1980; Johansson and Aronsson, 1980), but it cannot be clearly established from this work that the effects are different from effects encountered in non-VDT work.

Collectively, the data thus far seems insufficient to conclude that VDT users are at increased risk for emotional debility. Fatigue is a possible exception, although such an effect is not borne out in the present data.

Somatic disturbances--Table 20 shows no significant differences between VDT users and non-users for scores on the derived scale denoting general illness. Neither are there significant group differences on any of the four specific symptom scales denoting visuo-ocular, musculo-skeletal, and behavioral-autonomic disturbances. However, it is of some interest that the mean scores for visuo-ocular and musculo-skeletal disturbance scales are higher for the VDT users than non-users. A similar nonsignificant trend toward the increased reporting of these types of disturbances was reported by Starr et al. (1983). For the behavioral-autonomic disturbance scale, denoting behavioral and psychosomatic manifestations of stress, an opposite trend is observed. Consistent with the trend seen in scores on scales of mood disturbances, behavioral-autonomic scores are actually higher in the non-users than among the VDT users.

Could these aggregate scales be concealing important group differences with respect to more specific symptomatology which has separated VDT users and non-users in prior research (e.g. burning eyes or neck and back pain as in Smith et al., 1981)? Looking at Table 23, it can be seen that statistically significant differences between users and non-users in the reporting of specific symptoms of strain are rare. Of all the symptoms denoting musculo-skeletal and eye strain, no significant group differences in the incidence of symptoms were observed using the Mann-Whitney U test. In this regard, the present results stand in contrast to findings by Smith et al. (1981) and by the Canadian Labour Congress (1982) in which VDT users and non-users were significantly different in the reported incidence rates for numerous musculo-skeletal disturbances as well as for symptoms denoting both ocular irritation and visual imperception. The results do agree, however, with findings by Starr et al. (1983) showing no differences between VDT users and non-users in the incidence of musculo-skeletal and eye disturbances, although rates for VDT users tend to be systematically greater in both studies.

Using the chi-square test for independence, which is perhaps less appropriate for these types of comparisons (the data are ordinal), the incidence of disturbance was in fact significantly greater among the VDT users for two symptoms, "burning eyes" and "leg cramps". Were it not for the fact that the "burning eyes" effect is highly consistent with effects observed in prior research, it would be tempting to attribute the effect to chance (considering the multiple comparisons). Of all symptoms relating to eye or vision impairment, "burning eyes" was the second most commonly reported symptom among the clerical VDT users investigated by Smith et al. (1981). The overall incidence in that study (80%), is not greatly at variance with the incidence in the current sample of VDT users (71%). As in the present study, in the Smith et al. (1981) investigation the difference in proportions of clerical VDT users and non-users reporting various symptoms of eye or vision disturbance was also no greater for any other symptom in this category. Of all types of eye or vision disturbances, "burning eyes" was the second most commonly experienced on a daily basis, exceeded only by fatigue, among the conversational VDT users investigated by Laubli et al. (1981). The incidence appeared to be significantly greater than in traditional office workers, but not greater than in conventional typists. In the recent Canadian Labour Congress investigation (1982), VDT users reported a significantly greater frequency of "burning eye" problems than users, and the overall incidence was greater for only one other symptom of eye or vision disturbance.

A few more cases of significant group differences in the incidence of specific disturbances are observed for symptoms comprising the behavioral-autonomic strain scale. Consistent with scale scores for this scale, and with trends observed for group differences in moods, the incidence rate for these disturbances is systematically lower among the VDT users. VDT users report significantly less frequent depression, tension, indigestion, and cardiac arousal. These results stand in contrast to findings by Smith et al. (1981) and the Canadian Labour Congress (1982) in which symptomotology of this general type (e.g. irritability, nervousness) was more prevalent among VDT users than non-users.

The incidence of certain specific disturbances not listed in the sets of symptoms in Table 23 was also examined based upon attention drawn to these problems in prior VDT research. Four disturbances of particular interest are listed below, along with incidence rates.

		never	occasionally	frequently	constantly
1. color perception problems	users	90	9	1	0
	non-users	99	0	1	0
2. skin rash, itching, allergic reactions	users	67	26	7	1
	non-users	68	25	6	1
3. headache	users	20	55	23	2
	non-users	21	49	25	5
4. fainting spells or dizziness	users	80	18	2	0
	non-users	75	23	2	0

The color perception symptom was excluded from all symptom scales due to the low variance in this measure. The remaining symptoms were included in the general illness symptoms scale, but factor analysis did not permit their inclusion in any of the four more narrow symptom scales. Of all four symptoms, only the incidence of color perception disturbance separates VDT users and non-users (corrected $X^2 = 6.88$, $p < .01$, when incidence rates were regrouped into never and otherwise). Yet the absolute incidence rate for VDT users is so low, the meaning of the effect in practical terms is somewhat questionable. However, very modest color vision disturbances in VDT users have also been reported by Dainoff et al. (1981), and Ghiringhelli (1981). In Smith et al. (1981), a significant increase in color perception problems in clerical VDT users in comparison to non-users was also reported.

The possibility has been raised that VDT users may be susceptible to dermatologic disorders related to ambient effects of electrostatic fields created by CRTs (Linden and Rolfsen, 1981). Smith et al. (1981) report an increase in the incidence of skin rash among VDT users, but no such effect is observed here. There are alternate mechanisms for dermatologic reactions, including psychosomatic bases. It may be of some interest that despite the fact that the skin rash symptom could not be included in any of the symptom scales based upon the factor analysis of symptoms, it loaded most heavily on the behavioral-autonomic scale. The association of the symptom frequency with behavioral-autonomic strain scale scores is significant (rho = .32, $p < .01$).

Headache is sometimes cited as a consequence of VDT work, but an excess frequency of headache among VDT users is not seen in the present data, nor does this symptom differentiate the VDT users and non-users investigated by Smith et al. (1981), or in Starr et al. (1983). However, more frequent headaches among VDT users were reported in the Canadian Labour Congress investigation (1982), and the absolute incidence in the present investigation seems to warrant clinical concern regardless of relative effects.

Increased fainting/dizziness episodes among VDT users were also reported in the Canadian Labour Congress (1982) and Smith et al. (1981) investigations, but again, no such effect is observed here.

Two aspects of the symptom data presented in Table 23 merit further discussion. First, is it meaningful that VDT users systematically report a greater incidence of eye and musculo-skeletal symptoms than non-users considering the fact that the group differences are statistically nonsignificant? If the different symptoms were independent of one another in terms of incidence rates, which they are not, the effect would be of statistical importance. On the other hand, frequencies for symptoms of musculo-skeletal and eye disturbances are now found to consistently greater among VDT users in four <u>independent</u> studies (the present study plus the investigations by the Canadian Labour Congress, 1982; Smith et al., 1981; and Starr et al., 1983). Such findings would seem unusual from a probability perspective if VDT users were not at greater risk for these types of problems.

The second issue concerns the absolute frequencies of various types of disturbances, regardless of their relative incidence in the VDT user and non-user samples. First, Table 23 shows that consistent with all of the work to date, the present data indicate that eye strain problems in VDT work are manifest in users mainly in terms of asthenopia or ocular irritation as opposed to imperception or functional deficits in vision per se. Also consistent with the prior literature, musculo-skeletal disturbances center mainly on neck/back/shoulder discomfort as opposed to discomfort in the arms and hands. Secondly, the frequency data for eye and musculo-skeletal disturbances presented in Table 23 indicate that the lack of significant group differences in incidence rates does not obviate the need for attention to these problems in VDT users. Table 23 shows that in the neighborhood of 25 percent of VDT users, and also of non-users, are reporting ocular irritation at a frequent or constant rate. The proportions reporting back/neck/shoulder discomfort frequently or constantly is slightly higher. Over a third of the VDT users reported the frequent or constant experience of neck/shoulder and back ache at work. Clearly these rates approach a magnitude which is too high to ignore in terms of their implications for the personal sense of well-being among VDT users, if not their chronic health effects. We hasten to add that the same is true for the non-users.

Comparison of VDT Users and Non-users on Measures Reflecting Working Conditions--

In Tables 19, 20, and 22, the current samples of VDT users and non-users are compared on measures denoting working conditions. A quick overview of these tables shows that in contrast to the well-being measures, VDT users and non-users are differentiated in terms of their perceptions of a number of job attributes. In general, the data indicate a greater prevalence of unsatisfactory staff/supervisory relationships and physical environmental problems, and reduced job autonomy/control among VDT users.

Looking first at the Caplan et al. (1975) indices in Table 19, it is seen that perceived social support from supervisors is diminished and skill underutilization is increased to a significant degree among VDT users in comparison to non-users. Skill underutilization is also in excess of the median for 23 occupations investigated by Caplan et al. (1975) for both groups, but particularly the VDT users, and supervisory support for users only is below the median.

Similar to the effect for the Caplan et al. (1975) supervisory support measure, VDT users report significantly less staff support than do non-users on this Work Environment scale (Table 22). The level is well below the occupational norm, but not nearly so low as reported by clerical users in the Smith et al. (1981) investigation. The current users are also strongly differentiated from non-users on the Work Environment scales of job autonomy, control, and physical comfort. VDT users report less autonomy and physical comfort, and greater external control over their work activities. In addition, the VDT users report significantly greater work pressure than non-users. In all cases, VDT users scores deviate from occupational norms in an adverse direction.

The effects compare quite favorably with results obtained by Smith et al. (1981) in comparing clerical VDT users and controls on the Work Environment scales, although the absolute levels of adversity among the current users are not nearly so great as in the Smith et al. (1981) sample of clerical users. Of the five subscales differentiating the current users and non-users, the clerical users in Smith et al. (1981) were significantly differentiated from control subjects in the same fashion for the autonomy, control, and work pressure subscales. Trends were the same for the staff support and physical comfort scales, but the effects were nonsignificant.

For the derived scales denoting broad physical environmental problems and job control (comprised in part of items contained within analogous Work Environment and Caplan et al., 1975 scales respectively), scores for VDT users were also significantly different from non-user scores (Table 20). VDT users reported less job control and greater environmental problems.

These significant group differences are of interest in that prior occupational stress research suggests they may have implications for the well-being of VDT users. House and Wells (1978) present data suggesting that social support from supervisors may be an important moderator of stresses encountered in the workplace. Turner and Karasek (1982) postulate that the need for social interdependencies adversely influences operator effectiveness and well-being via disruptive effects in task performance. Worse would be the inopportunity to satisfy the needs for increased interdependencies as might result through the reduced supervisory and staff support among VDT users witnessed in the present data. Regarding the potential effects of the reduced control and autonomy observed here among VDT users, Karasek (1979) and Karasek et al. (1981) have provided impressive evidence that these types of circumstances are linked to increased strain among workers as job demands increase. In analyses presented further on it is also shown that the social support, job control, and environmental problems variables which tend to differentiate the present VDT users and non-users (although the social support effect is limited to staff/supervisory support) are important determinants in predicting strain.

Although a number of the job attributes investigated are rated more unfavorably by the VDT users, other job attributes which may hold the potential for stress and strain are rated much the same by the two groups. The difference between VDT users and non-users on the Caplan et al. (1975) measure of role ambiguity was nonsignificant, and scores for both groups are below the occupational norm (Table 19). VDT users actually perceived significantly less role conflict than non-users. On a related Work Environment scale, clarity of expectations, the two groups were not significantly differentiated, and both groups scored close to the occupational norm (Table 22). Other than the supervisory support measure, the two groups were nearly equivalent in ratings of social support on the Caplan et al. (1975) indices as shown in Table 19. Neither were they significantly different on the related Work Environment scale of peer cohesion (Table 22). Although Caplan et al. (1975) participation scores and the related Work Environment subscale job involvement scores are lower for VDT users than non-users (Tables 19 and 22 respectively), consistent with the reduced personal control and autonomy observed among users, the two groups are not significantly differentiated on these participation and involvement measures.

Consistent with findings by Starr et al. (1983), the VDT users seemed no less certain about their job future than non-users (Caplan et al., [1975] job future ambiguity measure, Table 19). They are also not differentiated on the derived scale of future certainty (Table 20) which incorporated a question asking specifically the likelihood of future job displacement due to computerization. The two groups were also not differentiated on this single question ($X^2 = 4.10$, $p = .25$). On the one hand, this effect seems contrary to some prevailing concerns regarding job loss due to VDT-computer automation of office work. The result is also different from findings by Smith et al. (1981) in which clerical users reported greater job future ambiguity than non-users. The null effect in the present study may have been influenced by the fact that all of the VDT users were employees of public agencies, and hence to some degree enjoy greater job security than might exist in the private sector.

Finally, the Caplan et al. (1975) index of quantitative workload shows no greater perceived workload among VDT users than among non-users (Table 19). Levels for both groups are on par with the occupational norm, but less than reported by clerical VDT users in the investigation by Smith et al. (1981). The effect seems anomalous in view of the increased work pressure reported by VDT users on this Work Environment scale (Table 22). VDT users reported greater pressure than non-users, and levels that are in excess of the norm, but again considerably less than reported by clerical users in Smith et al. (1981). However, on the questionnaire derived scale of job demands which incorporates items from both the Caplan et al. (1975) workload and Work Environment pressure measures, as well as select questionnaire items denoting work rates, work quantity, and time pressures, the two groups are not significantly differentiated. The present data, then, provide no unequivocal indication of variation in production demands incident to VDT use. In this sense, they are somewhat at variance with observations by Smith et al. (1981)

of increased scores on both the Caplan et al. (1975) workload scale and the Work Environment pressure scale for clerical VDT users.

Other than the Smith et al. (1981) investigation, there have been few studies which have systematically compared VDT users and non-users in terms of their perceptions of job demands and psychosocial aspects of working conditions. The Canadian Labour Congress investigation (1982) and the Coe et al. (1980) and Starr et al. (1983) investigations are limited in this regard, but the latter study less so. Hunting et al. (1981) briefly describe a comparison of 55 VDT users and 54 non-users, both engaged in banking payment transactions, in terms of work overload, task feedback, task variety, and social cooperation. Results showed significantly decreased qualitative and quantitative overload, and reduced variety among the VDT users. A fairly extensive analysis of job perceptions of VDT users was conducted by Johansson and Aronsson (1980). However, the investigation did not utilize a control group, relying instead on VDT users' perceptions of alterations in their own jobs subsequent to the introduction of VDTs. The results showed a trend toward increased demands incident to VDT use, consistent with Smith et al. (1981), but contrary to Hunting et al. (1981). Task variety and job autonomy were perceived as moderately reduced, consistent with findings by Smith et al. (1981) and by Hunting et al. (1981) for variety.

The limited research to date regarding the impact of VDT use on job demands, content, and psychosocial attributes, and the limited commonality among the results of this work, do not seem sufficient to permit broad generalizations regarding such effects. Perhaps the strongest unifying feature of the research thus far is the tendency toward reduced job control/autonomy with VDT work. Prior work suggests than an important qualifying factor is the nature of the work performed. Smith et al. (1981) showed important differences between clerical VDT users and "professional" users. Almost invariably the professionals judged working conditions to be more favorable than did the clericals, and the indication is that strains were similarly less prevalent. Differences between customer service and data entry workers appear in the investigation by Johansson and Aronsson (1980). Effects differentiated by job type also appear in Cakir et al. (1978), in the Canadian Labour Congress investigation (1982), and in Gunnarsson and Ostberg (1977). In most of this work, effects are most undesirable in lower skilled jobs. In analyses to follow, both reported strains and perceptions of working conditions are examined relative to the types of tasks performed.

Perceptions of the Physical Environment--
As described above, group comparisons on the Work Environment physical comfort scale and the derived environmental problems scale indicated a significantly less favorable perception of physical environmental attributes of workplaces among the VDT users than among the non-users (Tables 22 and 20). Both scales are multi-dimensional, containing items pertinent to space, noise, lighting, fumes, furniture, and general ambience. Of these characteristics, the largest differences in the evaluations of VDT users and non-users were for general workplace ambience and chair comfort. Fifty-two percent of the VDT users rated their workplaces as "just adequate" to "very unpleasant" (response format = very unpleasant, somewhat unpleasant, just adequate, somewhat pleasant, very pleasant). The comparable figure for the non-users was 26 percent. The difference is highly significant (X^2 = 26.23, $p < .01$). In rating the chair, comfort was judged as "just adequate"

to "very uncomfortable" for 53 percent of the users and 23 percent of non-users (same response format as for the workplace environment rating). Again the difference is highly significant ($X^2 = 24.46$, $p < .01$). This effect is important because analyses presented further on show chair perception to be an important determinant in predicting reported musculo-skeletal strains among VDT users. The same is true for non-users, but the lower ratings for the users suggest they are at greater risk.

Although chairs were judged less comfortable by the VDT users, about 90 percent of the VDT users (and non-users as well) reported they could adjust their chairs to preferred heights, and that the present heights were correct. This suggests that characteristics of the VDT users' chairs other than height were instrumental in the higher rates of discomfort they reported. Alternately, preferred and perceived correct settings may have been selected based upon features of the VDT workstations, such as worksurface or keyboard height, and these settings may not have always been appropriate based upon other biomechanical prescriptions for correct chair height. The latter explanation assumes this maladjustment is more likely at VDT workstations.

The VDT users and non-users also differed significantly in their ratings of workplace noise ($X^2 = 10.55$, $p < .05$, 5-point scale with correct in the center and much too high/low at the extremes), but the effect actually favored the users. Seventy-four percent of the non-users as opposed to 58 percent of the VDT users reported that ambient noise levels were too high. However, there were no significant differences in the reported incidence of being bothered by noise from office machines per se, although again the rate was slightly higher among the non-users. Twenty-five percent of the users and 30 percent of non-users reported this type of a disturbance often or fairly often (5-point scale ranging from never-rarely to very often). These results are contrary to findings by the Canadian Labour Congress (1982) where 54 percent of users and 39 percent of non-users reported too much noise (significance not reported).

The VDT users, however, reported a greater incidence of being bothered by odors or fumes ($z = -2.86$, $p < .01$ [Mann-Whitney U test]), but the absolute rates were low (65% of non-users and 46% of users reported rarely-never, same 5-point scale as for the office machine noise). A greater frequency of being bothered by dust ($z = -2.44$, $p < .05$), but not tobacco smoke, was also reported by the users. In the Canadian Labour Congress study, the incidence of smoke problems was greater among VDT users than among non-users (19% vs. 9%), and less for dust problems (17% vs. 24%). The incidence of crowding problems was also reported to be greater among the users than the non-users ($z = -2.48$, $p < .05$). The Canadian Labour Congress (1982) study found no differences between users and non-users on a crowding question.

The final comparison of VDT users and non-users on environmental attributes involves perceptions of ambient lighting. For the present VDT users and non-users, no significant differences were found in ratings of the appropriateness of lighting intensity, nor in reports of being bothered by background lighting. Fifty-seven percent of the users and 67 percent of the non-users reported the lighting was correct, and only 12 percent of the users and 10 percent of the non-users rated the lighting as too intense (5-point scale ranging from much-too-high to much-too-low, correct in the center). In a classification of background lighting as bothersome or not, only about 20 percent of each group responded affirmatively.

This result seems unusual considering that office workplace lighting is often judged to be substandard for VDT users. The Canadian Labour Congress investigation (1982) found an increased incidence of adverse ratings of lighting among VDT users in comparison to non-users. We have no way of knowing whether or not the lighting was objectively any different in the VDT and non-VDT workplaces in the present study, but the survey data would suggest it was much the same. About 80 percent of both users and non-users reported they did not have supplemental lighting, and about 90 percent of each group reported their lighting was nonadjustable. About 25 percent of each group reported that windows represented a main source of lighting and nearly 100 percent of each group also reported fluorescent fixtures represented a main source.

In addition to ratings of the workplace physical environment by both VDT users and non-users, aspects of the VDT were evaluated by the users. Table 24 shows the proportions of VDT users citing various problems with their VDT configuration and video displays. A quick overview of this table shows that a substantial number of VDT users report all types of problems listed. This is of some concern since further on we present analyses which show that perceived problems with the display and VDT/workstation physical configuration are important predictors of reported eye and musculo-skeletal strain respectively. However, although these problems are reported by a relatively large proportion of the VDT users, there are few cases in which the incidence rate is reported as greater than "occasional". In only one case (screen glare) does the proportion reporting the incidence as "often" or more frequently exceed 10 percent.

Looking first at the VDT configuration problems, the data show a strong uniformity in ratings of screen and keyboard heights, angles, and distances. An average of just over 70 percent of the users reported these parameters were never a problem. These data compare favorably with findings in the NIOSH (Stammerjohn et al., 1981) investigation of physical attributes of the workplaces for VDT users studied by Smith et al. (1981). In that study, an average of over sixty percent of VDT users rated the same conditions as not problematic. Also as in the Stammerjohn et al. (1981) report, the present study shows little variation in ratings of these different conditions. In both studies, keyboard distance was the least bothersome, and screen angle and heights tended toward the most bothersome.

It might be expected that these perceptions would vary in relation to opportunities for VDT users to adjust the positioning of their VDTs. Sixty percent of the VDT users reported their VDTs had separable keyboards, and 25 percent reported they worked at specially designed workstations, although we observed none that offered the flexibility of the newer "ergonomic" systems with separate and adjustable supports for the display and keyboard.

To investigate the relationship between the potential for adjustability and reported problems, the correlation of the workstation/VDT physical adjustability scale scores (denoting perceived adjustability of VDT and workstation components) with the scores for the scale denoting problems associated with the positions of these components (VDT/workstation physical

Table 24. Proportion of VDT users citing display and workstation configuration problems.

		Problem Frequency				
Display Problems	(n)	Constantly	Very often	Often	Occasionally	No problem
Screen brightness	242	-	4	3	36	57
Letter brightness	242	-	5	5	34	56
Readability	241	1	5	4	32	58
Screen glare	241	4	8	15	40	33
Screen flicker	240	1	-	5	37	58
VDT Configuration Problems						
Distance to screen	241	1	3	3	23	70
Screen height	240	2	3	4	21	70
Keyboard distance	241	-	2	3	19	76
Screen angle	241	-	3	4	24	70
Keyboard height	241	2	3	5	20	71
Keyboard angle	241	1	2	4	19	75

configuration problems scale) was examined. The results were in line with expectations, but the effect was very modest and statistically nonsignificant ($r = -.10$). This raises the question of whether or not features enabling adjustability are utilized, or utilized effectively. Maladjustment of chair pan heights (in relation to common ergonomic guidelines) among VDT users has been reported by Coe et al. (1980). Further on we describe analyses in which reported musculo-skeletal strains were examined in individuals with separable adjusted keyboards in contrast to individuals with fixed or unadjusted keyboards (the conditions were objectively assessed). The contrast was in fact significant, with increased strain in the latter group. A comparison of VDT users reporting fixed and separable keyboards yielded a difference in the same direction, but the effect was non-significant. The inference is that the capability for adjustment of VDTs and workstation furniture is important, but alone, is insufficient for avoiding problems and subsequent strain in the use of these components.

VDT users' reactions to their displays were less favorable than their perceptions of the VDT/workstation physical configuration. With the exception of glare, 42-44 percent of the VDT users reported they were bothered by display characteristics. This is about 10-15 percent more than were bothered by physical characteristics of the VDT/workstation. A similar effect is seen in Stammerjohn et al. (1981), except there, the difference is much greater. Stammerjohn et al. (1981) report that only about 30-35 percent of VDT users do not cite problems related to the display, somewhat less than half the proportion reporting no physical configuration problems. The most interesting similarity between the two studies, however, is the propensity of users to report glare problems. In both studies, glare problems stand apart from all other display aberrations in terms of the proportions of users citing these problems. Glare is cited about twice as frequently as any other type of display problem in both cases. The rate is about 70 percent in the current study, and 85 percent in Stammerjohn et al. (1981). Another interesting effect observed in both studies is that rates of reporting flicker are quite pronounced. Nearly 70 percent reported flicker in the Stammerjohn (1981) study. Although display unsteadiness was not apparent to us with causal inspection during survey administration, over 40 percent of the VDT users in the current study reported being disturbed by flicker. A similar rate for reporting flicker problems is reported in the recent Canadian Labour Congress (1982) investigation.

Finally, Table 25 summarizes responses to open-ended questions regarding environmental and VDT system changes made and desired by VDT users to improve their comfort and efficiency. The tabled data reflect only the first response (where multiple responses were given) for each user. It is of interest that nearly 60 percent of the users reported deficiencies in their current VDT systems. Looking at the specific types of changes made and desired, the concerns focus most heavily on physical design features of the workstation. Nearly half of the changes made involved physical adjustment of the VDT/workstation. This type of alteration was also the most frequently cited as needed (29%). Within this category, work surface height/angle adjustability was the most cited parameter. This finding reinforces the importance of the current emphasis on high quality ergonomic furniture for VDT use. It is not clear why desired changes in this category outnumber changes desired in display characteristics, considering that display problems were reported by a higher proportion of users.

Table 25. VDT-work system changes made and desired to improve comfort and efficiency (n = 248).

	Number of users		Number of users
No changes made	91 (37%)	No changes desired	21 (8%)
Changes made	69 (28%)	Changes desired	143 (58%)
Non-respondents	88 (35%)	Non-respondents	84 (34%)

	Changes Made		Changes Desired	
Types of changes	Number of users	% Users making changes	Number of users	% Users desiring changes
Display	4	6%	21	15%
-Quality (exclusive of glare)	2		12	
-Screen glare	2		9	
Workstation/VDT adjustability	34	49%	42	29%
-Chair	7		7	
-Keyboard	8		4	
-Work surface height/angle	8		21	
-Other	11		10	
CPU/Software design	9	13%	10	7%
Ambient environment	0	0%	22	15%
-Lighting	-		11	
-Temperature	-		3	
-Other	-		8	
Work space	6	9%	24	17%
Source document design	7	10%	4	3%
Job organization	7	10%	11	8%
Other	2	3%	9	6%

One of the most interesting observations among these data is the large number of changes desired with regard to workspace alone. The apparent deficiency here is greater than for any other single item in Table 25. This observation is important in that it seems relatively little attention has been devoted in the ergonomics/facilities design VDT literature to the subject of workspace needs for VDT users. Some varieties of ergonomically designed, stand-alone VDT support systems may actually reduce workspace available with more conventional office desks.

Job Perceptions and Well-being in Relation to Job Activity

Previous investigations have shown considerable variation in reported strains and appraisals of working conditions among VDT users in relation to the types of tasks they performed (Cakir et al., 1978; Canadian Labour Congress, 1982; Johansson and Aronsson, 1980; Hunting et al., 1981; Laubli et al., 1981; Smith et al., 1981). Similar effects are observed in the present study. Figure 2 shows the variation in mean scores on select indices denoting strains and job perceptions across five job activity classifications for the present sample of VDT users and non-users.

The five job activity groups shown along the abscissa in each panel in Figure 2 result from a reclassification of study participants according to similarities in the tasks they performed. The data entry group represents only data entry workers. The file maintenance group is the combination of users and non-users performing data retrieval and update tasks, word processing, and the processing of license applications. The VDT users in this group are all similar in that their tasks involved fairly intensive conversational use of VDTs. The clerical-secretarial group is the combination of users and non-users with varieties of tasks of the type generally performed by the traditional office secretary. The lead worker group consists of VDT users and non-users who are first-line supervisors, and the programmers are exclusively VDT users performing only computer programming tasks.

One-way analysis of variance was used to examine for overall differences among groups in terms of scores on the job and strain indices. This was followed by a posteriori group contrasts using the Scheffe test when a significant effect was observed. We do not distinguish between VDT users and non-users in these analyses because preliminary analyses using two-way analysis of variance showed no significant job activity by VDT use/non-use interaction effects for any of these job or strain indices.

A quick scan of the variation by job activity group for the job and strain measures in Figure 2 reveals an interesting trend. We have positioned the job activity groups along the abscissa of these plots in an order, proceeding from left to right, reflecting our judgements regarding increases in skill requirements or qualifications incumbent to the different jobs. A fairly uniform effect observed in these plots is that reported strain tends to decrease and working conditions (by subjective appraisal) improve in a similar fashion. Scores for data entry workers are higher than for any other job activity group for the measures of job dissatisfaction (Panel 3), postural strain (Panel 4), manipulative strain (Panel 5), visuo-ocular strain (Panel 6), and boredom (Panel 15). They are lower than for any other group on the indices of job control (Panel 8), future certainty (Panel 11),

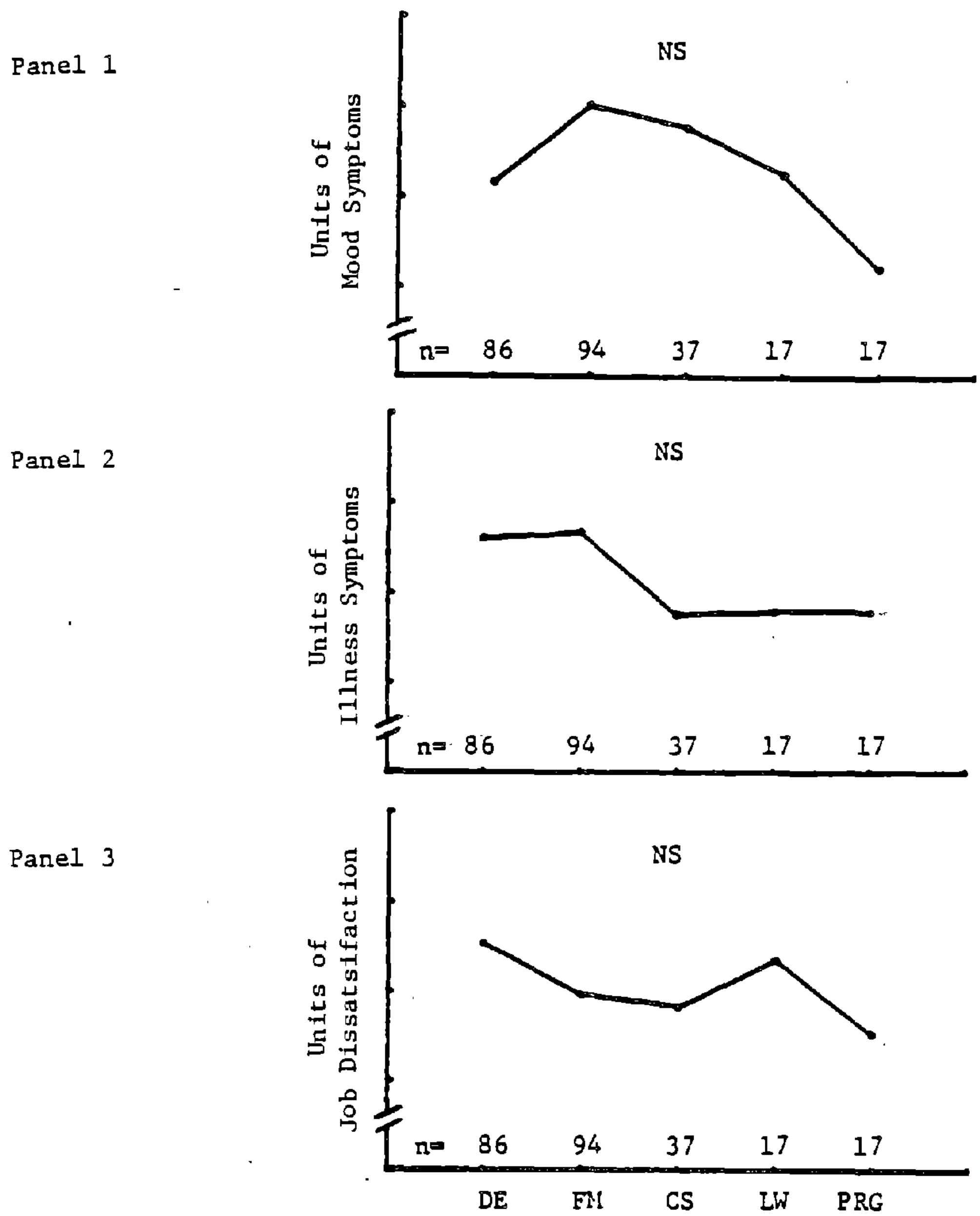


Figure 2. Variation in working conditions and strain in relation to job activity classifications for the study sample (DE=Data entry, FM=File maintenance, CS=Clericial-Secretarial, LW=Lead worker, PRG=Programmer; Sheffe test [Kirk, 1968] used for a posteriori contrasts, $p \leq .05$).

Panel 4

Panel 5

Panel 6

Panel 7

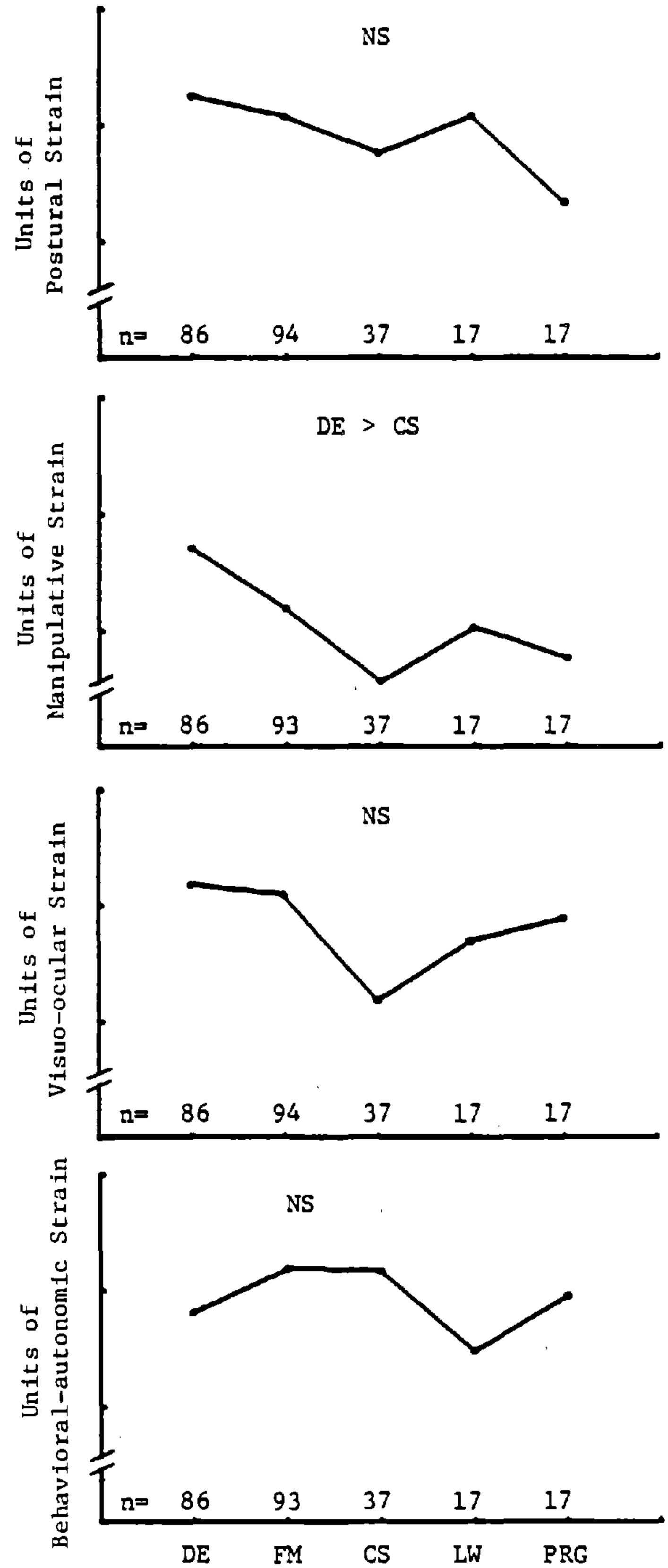


Figure 2 continued.

Panel 8

Panel 9

Panel 10

Panel 11

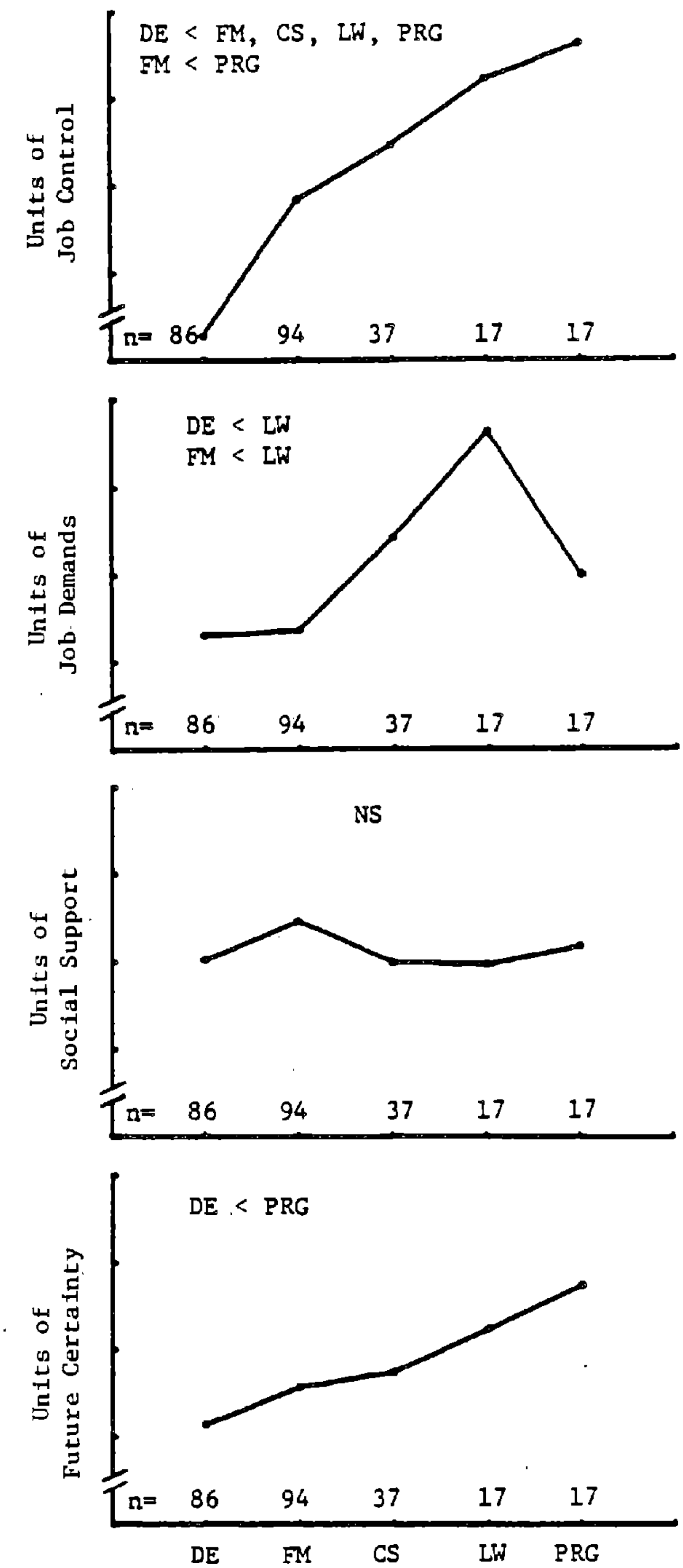
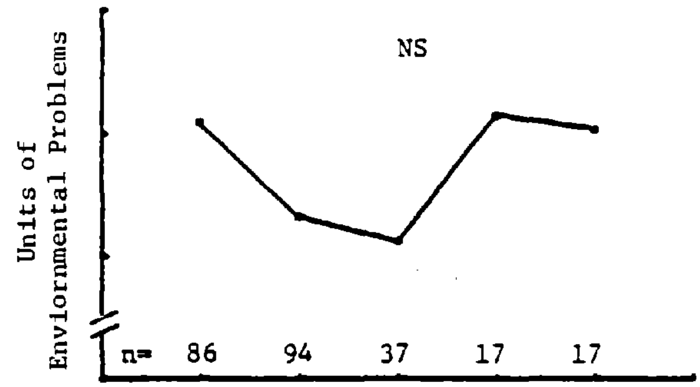
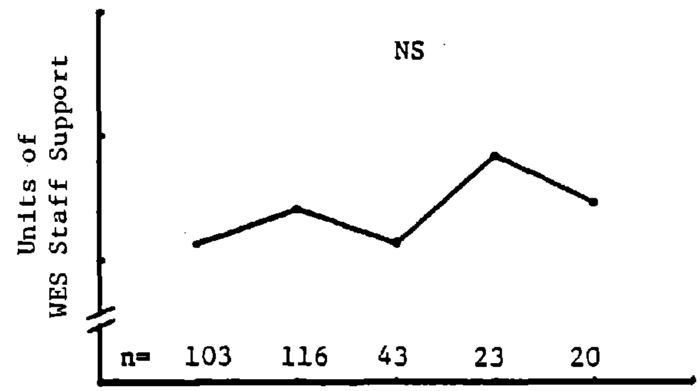


Figure 2 continued.

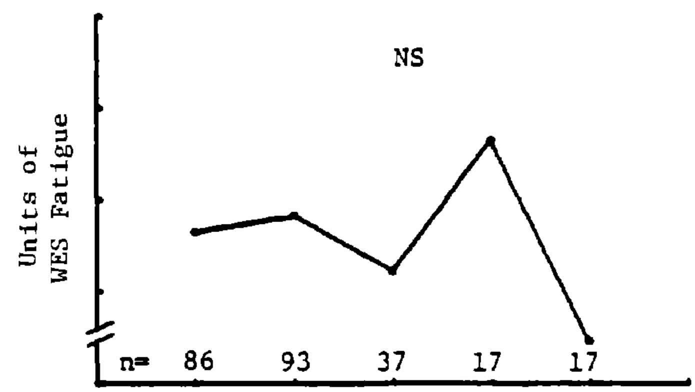
Panel 12



Panel 13



Panel 14



Panel 15

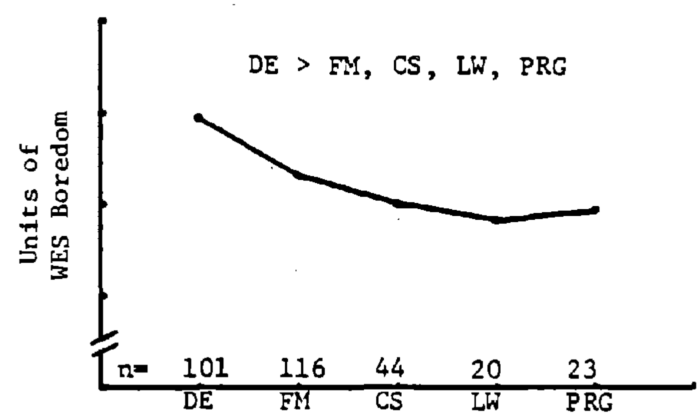


Figure 2 continued.

and on the Work Environment staff support (Panel 13) scale. Scores for the data entry group are also nearly the highest for the environmental problems and illness symptoms measures (Panels 12 and 2 respectively).

Group contrast tests show that data entry workers are significantly differentiated from the clerical-secretarial group in terms of manipulative strain (Panel 5), they report significantly less job control and greater boredom than any other group (Panels 8 and 15), and they perceive significantly less future certainty than programmers (Panel 11). For programmers, the effect is just the reverse. On most of the strain and job measures, levels of adversity are low or the least of any other job activity group, although programmers tend not to be differentiated from other groups at statistically significant levels.

These data tend to be consistent with previous work showing reduced strain and an improved physical and psychosocial job climate with more skilled, professional, or qualified VDT work. Cakir et al. (1980) report six times the level of perceived external control over work in data input typists as in programmers, with clerical workers in an intermediary position. A similar trend was observed for fatigue. Johansson and Aronsson (1980) found reduced levels of reported autonomy and significantly reduced levels of reported task variety among data entry VDT users in comprison to customer service users. Data by Smith et al. (1981) show that working conditions were rated far more favorably and reports of health disturbances were less frequent among professional VDT users than among clerical users. "Creative" VDT users investigated by Coe et al. (1980) reported less eye irritation and fatigue, seating discomfort, and headache than did data input users and conversational VDT users.

It is important to emphasize again that the effects observed here do not seem to be unique to VDT users. For none of the measures where there is a significant job activity effect (manipulative strain, job control, job demands, future certainty, boredom) was there a significant interaction with VDT use/non-use in the two-way analyses conducted to investigate for such effects. Neither were there significant interactions of this type for any of the remaining measures for which main effects of job activity failed to attain significance.

The evaluations of perceived working conditions and reported strains by job activity show two additional effects of interest. First, Figure 2 (Panel 6) shows that data entry workers report a greater incidence (but not significantly so) of eye strain than do individuals in any other job activity group. There is no difference in this trend for the VDT users and the non-users. Yet, the VDT data entry workers report they spend less time looking at the VDT display than does any other group. On a five point scale denoting the extent of time spend viewing various fields (format = never, rarely, sometimes, often, very often), the data entry workers tend to report "sometimes", while the remaining individuals fall in the range of "often" to "very often". The tendency toward increased eye strain among data entry workers seems counter-intuitive considering that beliefs (and some data; e.g. Laubli et al., 1981) indicate the display is a source of eye strain. However, there is some parallel to the present finding in Laubli et al. (1981). They showed that conversational users reported a greater incidence of eye complaints than did data entry workers, but the persistence of visual disturbances was greater for the data entry workers. Although the present data entry workers report more daily VDT use than does any other group (Table 4), hence possibly more absolute time in screen viewing, this explanation is ruled out by analyses presented further on showing that extent of daily VDT use is not strongly correlated with reported eye strain. Neither is the extent of screen viewing. The analyses do show, however, that job control, a condition on which the data entry workers are least favored, is an important predictor of reported eye strain.

The data also show that whereas data entry workers tend, as a rule, to report the greatest incidence of strain and the least favorable working conditions, they also report fewer job demands than does any other job activity group. Figure 2 (Panel 9) shows a trend toward increases in perceived job demands with increased job qualification. The effect is contrary to the observation by Smith et al. (1981) that quantitative workload was judged greater by clerical VDT users than professional users, but fits with findings by Cakir et al. (1978) and Coe et al. (1980) where job pressures tended to be rated greater among editors in comparison to clerical users.

Perceptions of Changes in Working Conditions and Well-being Incident to VDT Use

The survey administered to the secondary sample of VDT users contained a series of 27 items soliciting information on perceived changes in working conditions and the incidence of strain symptoms following the transition to VDT work. Users were asked to respond to these questions only if their prior jobs were similar in nature to their present VDT work. All of the items presented in a similar fashion to the VDT users investigated by Johansson and Aronsson (1980) were included among the present items. Of the 92 VDT users in this sample, 61 responses were recorded for every item, and 62 for some of the items. Table 26 shows the "perceived change" items and the proportions of users responding in different ways to each. The proportions shown for the "decreased" and "increased" categories are the combined proportions from the response categories of "decreased somewhat/decreased a lot" and "increased somewhat/increased a lot" in the actual survey.

Responses to these items compare very favorably to the results obtained by Johansson and Aronsson (1980). They found that users perceived decreased autonomy, increased responsibility, increased demands for attention and concentration, increased mental strain, increased task difficulty, and an increased number of routine tasks. Precisely the same trends are observed in the present data (items 1, 3, 8, 26, 10, and 12 respectively). Responses to items 4-6, indicating improved job effectiveness with VDT use, also compares well with job facilitative effects of VDT use reported by the VDT users in Johansson and Aronsson (1980) and other previous work (e.g. Gunnarsson and Ostberg, 1979). The only difference between the results of the two investigations is that the present data show an increase in the reported variety of tasks (item 12) whereas Johansson and Aronsson (1980) showed a decrease.

The agreement of trends witnessed in these data with trends observed in the previous comparisons of users and non-users is mixed, however. Looking first at the well-being items, eye and musculo-skeletal disturbances are reported to have increased. The actual data show that proportions citing an increase

Table 26. Perceptions of work and health changes incident to VDT use.

Conditions	Decreased	Stayed the same	Increased
	Percentages of Respondents Citing Effects*		
Job design:			
1. Personal freedom in doing your work	33	42	25
2. Freedom to move around	36	39	25
3. Person responsibilities	22	43	35
4. Efficiency in job performance	10	38	52
5. Ability to do job well	7	44	50
6. Ability to do work quickly	8	31	61
7. Feeling rushed	20	44	36
8. Demands for attention/ concentration	16	50	34
9. Amount of work to do	13	44	44
10. Difficulty of the work	18	45	37
11. Variety of tasks	21	31	48
12. Number of routine tasks	11	41	48
13. Problems with supervisors	20	69	11
14. Problems with co-workers	25	69	7
Physical environment:			
15. Workstation lighting problems	8	65	28
16. Chair/desk problems	11	63	26
17. Noise problems	18	55	27
18. Temperature problems	8	51	41
Well-being:			
19. Eye/vision problems	6	39	55
20. Neck/arm problems	3	57	39
21. Finger/wrist problems	8	81	11
22. Back/leg problems	5	65	31
23. Headaches	8	53	39
24. Stomach/digestion problems	10	74	16
25. Fatigue when arriving home	11	33	56
26. Mental strain	18	53	30
27. Job satisfaction	18	26	46

*Some values do not add to 100% due to rounding in these symptoms is usually several fold greater in the "somewhat increased" as opposed to the "increased a lot" category. This is in accordance with the trend observed in the group comparisons of VDT users and non-users. However, the same effect is observed with respect to the job satisfaction item (i.e. increased satisfaction following the introduction of VDTs). If anything, the trend is toward the reverse in the group comparisons.

In surveying perceived changes in working conditions, one very strong and notable similarity with the comparison of users and non-users is observed. The present sample reports a decrease in personal freedom in their jobs (item 1). Of the 33 percent reporting a decrease, most (20 percent of all respondents) reported their freedom decreased a lot. Of all 27 items, in no case did the proportion reporting "increased a lot" or "decreased a lot" exceed the proportion reporting their individual freedom decreased a lot. This compares favorably with the job control/autonomy effects observed in the group comparisons. The same type of effect is observed for the item (no. 2) denoting physical constraint. However, inspecting the items reflecting work demands, some discrepancy with the group comparisons is also seen. The trend is toward an increase in feeling rushed, an increase in demands for concentration, and an increase in work quantity (items 7, 8, 9). The group comparisons showed an increase in the Work Environment work pressure scores for the users, but no such effect was observed for the Caplan et al. (1975) quantitative workload measures or the derived job demands measure.

Looking at items pertaining to the physical environment, the trend toward increased problems is consistent with the increased reporting of environmental problems in the group comparison. However, the reporting of increased lighting problems was not observed in the comparison of VDT users and non-users.

How reliable are these data and the similar type collected by Johansson and Aronsson (1980)? They do support some of the findings from the group comparisons. If these data had resulted form a pretest-posttest design with proper controls over experimental mortality, etc., they would probably be more powerful than the static between-group comparison. But they were not obtained in this fashion, and thus are likely less reliable than the results of the group comparisons and should be interpreted with caution.

Summary and Conclusions

Regarding the health risks of VDT use, the present findings are consistent in several respects with observations in prior comparative studies. There is little evidence that the present VDT users suffer greater somatic disturbance/impairment than their non-VDT counterparts. With the exception the burning eyes symptom, the VDT users did not report significantly greater strain on any of the physical health related measures. Even the burning eyes effect is equivocal. These findings are in agreement with the results of earlier comparative studies by Coe et al. (1980) and Starr et al. (1983), but stand in contrast to observations by Smith et al. (1981) and by the recent Canadian Labour Congress (1982) investigation showing significant differences between VDT users and non-users for indices of both eye and musculo-skeletal strain. However, the findings are consistent with all prior comparisons of VDT users and non-users in that disturbances in these two categories were more frequent among the users. It would seem unreasonable to dismiss this tendency in the research to date as meaningless. The data also provide no evidence of increased affective disturbances or job dissatisfaction among the present VDT users. The effect suggested is actually one of less psychological strain among the users. However, the data do show that certain aspects of working conditions generally believed to be conducive to psychological stress and strain to be less favorable among the VDT users and non-users.

Regarding the character of the eye disturbances reported by the VDT users, the effects are also in agreement with prior findings. The data point to eye discomfort or irritation (i.e. asthenopia) as opposed to imperception or functional problems of vision. Also consistent with the prior research, musculo-skeletal disturbances are more pronounced in the upper torso (neck/back/shoulders) than in the arms and hands.

Although the incidence of eye and musculo-skeletal disturbances is not significantly greater among the VDT users than non-users, it would seem imprudent to ignore some of these problems. One-fourth to one-third of the VDT users (and of the non-users as well) report they frequently or constantly experience eye irritation and back/shoulder/neck strain. The same is true for headache. The medical implications of chronic strain of this type need to be addressed by clinical specialists and possibly further research. Job performance implications would seem likely.

Unlike the null effects for well-being measures, aspects of working conditions were less favorably regarded by VDT users. These effects are fairly consistent with observations by Smith et al. (1980). VDT users reported less job control and staff support, and greater environmental problems than did the non-users. Such effects would seem to point toward the potential for increased strain among VDT users over the long term. Chair comfort was a particular problem for the users. Reports of display problems of all types, but especially glare, were also very prominent. This finding closely parallels effects observed by Stammerjohn et al. (1981). These results add emphasis to the importance of continuing efforts toward ergonomic reforms in the design of VDTs and workstation furniture, especially since we show (further on) that perceived display and chair quality are important predictors of reported musculo-skeletal and eye strain respectively.

Assessment of working conditions and strains by the type of job tasks performed clearly indicate that with few exceptions the data entry workers have the worst of it. Again, these findings are consistent with prior observations (e.g. Cakir et al., 1978; Coe et al., 1980; Smith et al., 1981) suggesting that clerical and lower skilled VDT users are at greatest risk for job and health problems in VDT work. The indication is that abatement efforts should focus most intensively on these individuals. It is important to point out, however, that this recommendation is not only for the VDT users, since similar effects are observed among the non-users in the present study.

In explaining the very slight tendency toward increased eye and musculo-skeletal strain and the stronger indication of job disturbances among the VDT users, a possibility that cannot be completely dismissed is that perceived strains and adverse working conditions, or the propensity to report such effects, may be potentiated by beliefs or perceptions of health hazards incident to VDT use. This would also apply to all of the work to date indicating VDT users are at greater risk for job and health problems. None of the VDT stress research to date has incorporated designs or controls to adjust for such effects, and such controls might be difficult. This may be more of a problem today, as opposed to the time at which the present field work was conducted, considering the growing volatility of the VDT issue. We are not overly concerned about such an effect in the present work for several reasons. First, as mentioned in the methods section of this report, we took pains not to suggest potential health or job costs of VDT use in the conduct of the field work. Second, we have data indicating no trend toward the perception of VDTs as presenting job or health risks for the present population of VDT users, and VDT use was not a labor relations issue for the present population at the time of the field work.

The final question of the survey administered to the secondary sample asked the users whether or not they believed VDTs posed a hazard to their health. The distribution of responses for the 89 respondents is as follows: deninitely does - 10%; very likely - 17%; not sure - 37%; probably not - 19%; no - 17%.

Although the present sample was not biased toward the perception of risks incident to VDT use, we did find a connection between such perceptions and the reporting of strains and of working conditions as well. The implications of these connections, however, are not clear. When responses to the perceived health hazard question were examined in relation to reporting of specific health disturbances from the symptoms inventory, significant associations (rho, $p < .05$) were found with the following items: skin rash, back pain, arm pain, leg cramps, tearing eyes, blurred vision, dizziness, and digestive problems. In all cases the reported incidence rates increased as beliefs regarding potential hazards of VDT use became more positive. The effect was also observed in examining VDT hazard beliefs in relation to perceived changes in jobs and well-being incident to VDT use. Of the 27 conditions judged, nine were significantly associated (rho, $p < .05$) with hazard beliefs. As hazard perceptions became more certain, VDT users reported increases in problems with the chair, noise, and co-workers, increased eye, hand, back, and mental strain, and increased fatigue and digestive problems in their VDT jobs in comparison to their prior non-VDT jobs. The eye strain association was especially strong (rho = .50).

What do these associations signify? In conducting these analyses we had hoped such associations would not appear. This would essentially rule out the possibility that personal biases or perceptions regarding potential VDT hazards influenced the reporting of strains and working conditions. The fact that these associations occur, however, does not necessarily mean that the present observations are contaminated by the concerns or beliefs of VDT users. It is equally probable that the causal path is in the opposite direction. That is, VDT users perceive VDTs as being hazardous as a function of their experiencing adverse job and health effects in their VDT work.

THE RELATIONSHIPS OF WORKER CHARACTERISTICS WITH STRAINS

Aim and Rationale

By and large, prior research into the health implications of VDT work has not systematically examined or controlled for the possibility that strains may be influenced by individual characteristics of workers. The aim of the current analyses is to identify correlates of strain that tend to be fairly enduring characteristics of individuals. These factors can than be included as control variables in subsequent analyses investigating the effects of working conditions. This will not only help protect against the possibility of misplaced attribution of the causes of strain, but knowledge of the relative influence of the two types of potential strain determinants will address the question of the extent to which strain stems from person versus work sources and is subject to abatement through job redesign.

The present analyses first examine an array of general personal characteristics such as marital status, education etc., for their simple relationships with most of the health or well-being measures of the study. This is accomplished by a series of analysis of variance tests. Relationships with three strain indices, job dissatisfaction, mood disturbances, and illness symptoms, are of special interest because intensive efforts are also made to predict these particular strains on the basis of workplace conditions. For this reason, multiple regression techniques are utilized to sift and evaluate in a controlled fashion the predictive influence of the individual factors on each of these three strain measures. The significant individual predictors can then be considered in the analyses of workplace affects on the same strain measures for the control and comparative purposes indicated above.

Strain indices other than the dissatisfaction, mood, or illness measures are not systematically predicted from the worker characteristics examined here. The reason is that the remaining strain indices are fairly specific in terms of the types of health disturbances they denote (e.g. visuo-ocular or musculo-skeletal strain). In subsequent analyses to predict these more narrow strains from working conditions, we included as control variables alternate personal characteristics that would be highly likely to have a specific impact on these strains. An example would be the requirement for use of prescriptive eyewear in the prediction of visuo-ocular strain. This doesn't mean that the more general worker characteristics evaluated for their influence of mood disturbance, job dissatisfaction, or the illness symptoms measures are unimportant in the prediction of these more specific strains, but only that we did not give them priority in our analyses predicting the more specific strains. Some indication of their role can be obtained from the univariate analyses in which their simple relationships with the specific strain measures are evaluated.

Independent Variables (worker characteristics)

The potential individual sources of strain considered in these analyses are listed and described below. In selecting these factors for evaluation, we attempted to capture a broad range of individual attributes that are generally recognized as important determinants of health and well-being, and are frequently controlled or adjusted for in occupational and environmental health/stress research. Clearly some of these variables (e.g. tobacco or alcohol use) can also be regarded as manifestations of occupational stress. However, in the context of the present analyses they are treated as potential risk factors.

Family Situation: A dichotomous classification variable denoting whether or not an individual resides in a family-type living situation.

Breadwinner Status: A dichotomous classification variable denoting whether or not individuals regard themselves to have the primary fiscal responsibility for their family support.

Marital Status: A dichotomous classification variable denoting whether or not individuals are married at the time of the survey administration. While we appreciate the importance of alternate classification schemes regarding marital status (e.g. separated, divorced, never married) and these data were collected, low cell sizes prevented their meaningful evaluation in the framework of the current analyses.

Education: Participants were classified according to whether or not they received post-high school technical training or college education. Again, alternate schemes are possible and were evaluated. However, preliminary analyses showed the present separations have no less predictive power for strains than a more continuous treatment of this variable.

Alcohol Consumption: For the regression prediction of the dissatisfaction, mood and illness measures, study participants were classified simply as to whether or not they drink alcoholic beverages. Although continuous data denoting the weekly quantity (number of drinks) were obtained for those who consumed alcohol, these data were not used to predict strain in the regression analyses since we felt it was inappropriate to classify abstainers along a quantity continuum with those who consumed alcohol. For the individuals who consumed alcohol, the continuous data were associated with strain scores in bivariate correlations.

Tobacco Use: Participants were classified in the regression analyses also according to simply whether or not they smoked tobacco products. As with alcohol consumption, we felt that qualitative differences between smokers and nonsmokers precluded their representation together along a quantity of use continuum. Again, data were also collected on the quantity of use for the smokers in terms of number of cigarettes or pipefuls of tobacco per day, and the associations of this measure with strains were examined in bivariate correlations.

Number of People Supported: Ranks were assigned to study participants according to the number of people they financially supported, excluding themselves, either partially or fully.

Salary: This variable is the number of dollars earned in the previous year rounded to the nearest thousand. While salary is not extrinsic to the job, it tends to be a relatively stable and enduring characteristic, much like socio-economic status.

Some important demographic variables are conspicuous by their absence from this list. Among them are age, sex, and ethnic background. Sex and ethnic background were omitted from consideration due to lack of variation in the sample on these parameters. The primary sample included only 15 non-whites and 13 males. The relationship of age with strain was not ignored, it was simply bypassed in the present analyses. Preliminary analyses of the present data showed a consistent age-strain association. The importance of age as a predictor of physical health complaints has also been fairly strongly indicated in prior VDT research (most recently, Starr et al., 1983). We therefore reached the a priori conclusion that it would be mandatory to explain and control for the effects of age in further analyses investigating working conditions, whereas we were less certain with respect to the individual characteristics evaluated in the present analyses.

Dependent Variables (strain measures)

Associations of worker characteristics with indices of job dissatisfaction, affective disturbances, and physical health disturbances were examined. The specific strain measures are listed as follows:

1. Job dissatisfaction
2. Mood disturbance
3. Illness symptoms
4. Visuo-ocular strain
5. Musculo-skeletal manipulative strain
6. Musculo-skeletal postural strain
7. Behavioral-autonomic disturbance
8. Depression
9. Fatigue
10. Anger
11. Tension
12. Vigor
13. Confusion

Indices 1-7 are the derived scales described in the data collection section of this report. Indices 8-13 are subscales of the Profile of Mood States (POMS) instrument denoting specific types of transitory affective disturbances, whereas the mood disturbance index (no. 2) is a general overall measure of affective or mood impairment. Similarly, strain measures 4-7 represent specific types of somatic problems whereas the illness symptoms index (no. 3) provides a more global measure of health disturbance.

Analytical Techniques

First, the relationship of each of the worker variables with each of the strain variables was examined using two-way analysis of variance (ANOVA). In each analysis, a VDT use term (classification of participants according to whether or not they are VDT users) and a VDT use by worker characteristic interaction term were included to examine for differential effects of the worker variable between VDT users and non-users. ANOVA subgroups for the continuous variables (salary and number of people supported), were created by separation at the median. The possibility of VDT use dependent differential relationships of the salary and people supported variables with strain was double-checked through correlations of these variables with the strain measures in the user and non-user subgroups.

Finally, we examined the correlations of strain scores with quantity of tobacco use for smokers and with quantity of alcohol use for participants reporting they drink alcohol.

The sample for each ANOVA and correlation consisted of all study participants without missing data for each worker-strain variable pair. Since the derived (strain) scale scores were computed for 251 of the 333 participants, after accounting for missing data on some of the worker variables, analyses involving derived scale scores were based upon samples sizes ranging from approximately 225-251. Since the POMS subscale scores were calculated for all study participants without missing data for constituent items, after accounting for missing data on some of the worker variables, analyses involving POMS subscales were based upon sample sizes of approximately 300-325. All of these analyses were carried out using SPSS (Release 9).

Multiple regression was used to systematically evaluate the influence of the eight worker variables on the job dissatisfaction, mood disturbance, and illness symptoms strain scores. Because the number of regressors examined here is relatively small, an "all possible subsets" regression procedure was used to examine the combinations of predictors in developing a model for prediction of each of the three strain measures. The statistical package used for these analyses was BMDP (P9R, All Possible Subsets Regression).

The necessity for complete data for regressors and strain measures resulted in a regression sample of 160 (119 VDT users and 41 non-users). For all but one worker variable, family living situation, the regression sample breakdown for different levels of the predictor variables was adequate to ensure reliability. However, for the family living situation variable, only a few individuals were classified as not living in a family-type arrangement. Further, analyses indicated a fairly strong interdependence between the family living situation and marital status variables (phi = .48, $p < .01$), and that both variables tend to have an influence on strain, although the effect of the marital status variable was substantially stronger. For these reasons we are not confident that the regression analyses adequately depict the influence of the family living situation variable or its effects vis-a-vis the marital status variable. Further investigation will be needed to distinguish these effects.

Because the ANOVAs and correlations showed no tendency toward a differential relationship of worker variables with strain for VDT users and non-users, interaction terms of this type were not included in the regression models.

Results

The simple relationships between worker characteristics and the strain indices are summarized in Table 27. Tabled values show mean strain scale scores (VDT user and non-user groups combined) for categories of the worker variables. Values for the salary and number of people supported variables are correlation coefficients of their associations with strain scores for the VDT user and non-user groups combined. For the alcohol and tobacco use variables, the values shown in the rows labeled "quantity" are the correlations of the quantity consumed with strain scores, but only for the subgroup of participants that use these products.

As indicated above, interactions of worker variables with VDT use were almost completely absent, so the trends indicated in Table 27 are much the same for VDT users and non-users alike. In the combinations of eight worker variables with 13 strain measures, only three significant interactions occurred. None

Table 27. The relationship of individual characteristics with strain scores (tabled data are group means and correlations).

	Strain Measures				
	Mood Disturbance	Illness Symptoms	Job Dissatisfaction	Visuo-ocular Strain	Postural Strain
Family Living Situation					
Yes	9.83**	9.19	15.89**	-2.11	-1.99
No	12.36	9.89	16.92	-1.87	-1.90
Marital Status					
Married	9.47**	8.52**	15.52**	-2.36**	-2.32**
Single	11.62	10.33	16.80	-1.73	-1.58
Chief Breadwinner					
Yes	10.72	9.45	16.10	-2.14	-1.89
No	10.40	9.36	16.15	-2.01	-2.00
Education					
Secondary	10.16	9.32	15.61**	-2.14	-2.07
Post-secondary	10.81	9.46	16.60	-1.98	-1.87
Alcohol Use					
Yes	10.67	9.51	16.16	-2.00	-1.88
No	9.60	8.77	15.97	-2.36	-2.40
Quantity (rho)	-.02	.02	-.11	.02	-.00
Tobacco Use					
Yes	10.96	9.98	16.35	-2.09	-1.57
No	10.33	9.12	16.05	-2.00	-2.16
Quantity (r)	.13	.23*	.14	.16	.18*
Salary (r)	-.03	-.00	-.11	.02	-.08
People Supported (rho)	-.11	-.08	-.12*	-.07	-.03

Table 27 continued.

	Strain Measures				
	Manip-ulative Strain	Behavioral-autonomic Strain	POMS Depression	POMS Fatigue	POMS Anger
Family Living Situation					
Yes	-4.84	-5.13	7.00**	6.90**	6.61*
No	-4.59	-4.73	11.99	8.66	8.77
Marital Status					
Married	-5.17**	-5.40**	6.56**	6.65**	6.38*
Single	-4.33	-4.58	9.98	7.94	7.85
Chief Breadwinner					
Yes	-4.74	-4.92	8.29	7.66	7.60
No	-4.78	-5.05	8.19	7.06	6.82
Education					
Secondary	-4.80	-5.06	7.44	6.32**	7.07
Post-secondary	-4.74	-4.95	8.93	8.13	7.11
Alcohol Use					
Yes	-4.74	-4.94	8.50	7.29	7.42
No	-4.83	-5.36	6.54	7.13	5.21
Quantity (rho)	-.11	.07	-.04	-.07	-.06
Tobacco Use					
Yes	-4.59	-4.72	9.10	8.10	7.34
No	-4.85	-5.14	7.87	6.87	7.11
Quantity (r)	.20*	.15	.17*	.12	.10
Salary (r)	-.07	.06	-.06	.04	-.06
People Suported (rho)	-.04	-.07	.11	-.03	-.01

Table 27 continued.

	Strain Measures		
	POMS Tension	POMS Vigor	POMS Confusion
Family Living Situation			
Yes	8.14*	16.79	5.65**
No	10.53	16.59	7.52
Marital Status	7.71**	17.33	5.38**
Married	9.92	16.27	6.89
Chief Breadwinner			
Yes	9.04	15.86*	6.33
No	8.66	17.33	5.98
Education			
Secondary	8.68	17.17	6.13
Post-secondary	8.89	16.49	6.08
Alcohol Use			
Yes	8.92	17.11*	6.26
No	8.02	15.04	5.14
Quantity (rho)	-.05	.10*	-.02
Tobacco Use			
Yes	9.54	16.21	6.46
No	8.44	17.22	5.95
Quantity (r)	.09	-.01	.07
Salary (r)	-.05	.05	-.04
People Supported (rho)	-.04	-.03	-.01

* $p \leq .05$
** $p \leq .01$

involved the job dissatisfaction, mood disturbance, or illness symptoms variables.

Only one variable, marital status, is seen to have a consistent meaningful relationship with strain scores. For all indices, lower levels of strain are observed for married individuals. The differences are significant for all but the anger and vigor subscales of the POMS.

It is also evident that individuals reporting that they reside in a family living arrangement tend to experience less strain than those who do not, although the effect is not so pervasive as for marital status.

There exist few other important effects or trends in these data. Collectively, they suggest that other than marital status, worker characteristics are largely inconsequential in predicting job dissatisfaction or affective or somatic disturbances among VDT users and their office worker counterparts. Smoking and alcohol use, both conventionally regarded as important health risk factors, are indeed consistently associated with higher strain scores. However, the effect of alcohol use tends to be nonsignificant for both the dichotomous classification of this variable and for the quantity measures among the subgroup which uses alcohol. While the dichotomous classification of tobacco use is also not significantly related to strain, there is a significant tendency toward increasing physical health disturbances as quantity smoked increases. The association with depression is also positive and significant. Trends toward increasing strain with decreasing salary, fewer people to support, greater education, and greater financial responsibility (breadwinner status) are observed, but only rarely are the effects significant.

When these variables are cast into a multiple regression analyses for the prediction of the job dissatisfaction, mood disturbance and illness symptoms measures, the results were with one exception little different from prediction permitted on the basis of extrapolation from the univariate analyses. The best possible regressor subset for the prediction of the illness symptoms measure consisted of simply the marital status variable ($p < .05$), with classification as "married" associated with lower strain than the non-married classification (regression coefficient = -2.42, the non-married group was the reference group). None of the remaining variables were significant. Marital status accounted for approximately nine percent of the variance in the illness symptoms measure (adjusted $R^2 = .089$). In the prediction of the mood disturbance measure, the best possible subset ($p < .05$) consisted of the marital status and breadwinner status variables. Again, classification as married was associated with less strain (regression coefficient = -1.86) and greater financial responsibility predicted more strain (regression coefficient for the chief breadwinner indicator = 1.43) consistent with indications from the univariate analyses. However, of the variance explained by the these two variables (8.7%) the greatest contribution was again from the marital status variable (6.0%).

In the prediction of the job dissatisfaction index, the results were somewhat at variance with indications from the univariate analyses. Specifically, the univariate analyses indicate significant variation in the job dissatisfaction measure as a function of education, number of people supported, and family living arrangement, in addition to marital status. Yet, when the effects of these four variables were examined concurrently, or for any combination of the worker variables, significant effects ($p < .05$) were found for only the marital status variable (adjusted $R^2 = .054$, regression coefficient = -1.46).

Summary and Conclusions

The results and implications of these analyses are fairly clear-cut. Collectively, the personal attributes examined do not play a strong role in predicting strain in the current sample of office workers. However, there does seem to be something crucial about being married that mitigates or deters strain, and the effect is quite broad and no different for VDT users than non-users. As would be expected, in contrast to unmarried persons, individuals who are married also tend to reside in family living arrangements (phi = .48, $p < .01$) and tend to be financially responsible for the support of more individuals (eta = .45, $p < .01$). This would suggest that the marital status effect observed is in part due to a complex of conditions normally associated with family life. However, the fact that marital status consistently emerges as a significant predictor of increased well-being, and that the effects of neither the family living situation, nor people-to-support variables are not nearly so strong or pervasive in either the regression or univariate analyses, places greater emphasis on marital status per se. The association of the marital status variable with all other predictors of strain considered in these analyses is negligible and statistically nonsignificant. In subsequent analyses focussing on working conditions as predictors of strain, marital status is also shown to be significant after adjusting for age effects.

Due to the strong influence of the marital status variable in predicting job dissatisfaction, mood disturbances, and illness symptoms, it will therefore be useful to include this variable as a regressor in predicting these three types of strain from working conditions for control and comparative (person versus work effects) purposes.

GENERAL WORK ENVIRONMENT AND HEALTH ANALYSES

Aim of the Analyses

The objective of these analyses was to systematically examine the role of general job design factors and physical workplace conditions as risk factors in office and VDT work. Of major interest is whether the effects of the working conditions examined are any different for VDT users than for non-users, and whether there is some special attribute of VDT use per se (i.e. beyond the effects of the other working conditions considered) which seems to increase or reduce strains among office workers. Statistically, this amounts to: 1) determining whether VDT use (i.e. whether or not a participant is a VDT user) interacts with variables denoting working conditions to influence well-being, and 2) determining whether there exists a main effect of VDT use after adjusting for the effects of these variables.

Independent Variables-Regressors

As described in the research strategy section of this report, these analyses focus on a limited number of conditions which have been demonstrated or suggested in the occupational stress literature as potent job stress factors or moderators, and which appear to be of major concern and relevance in mechanized office work. The plan was to regress three measures of well-being (job dissatisfaction, mood disturbance, illness symptoms) upon these variables in order to clarify and prioritize their role in the stress process in office and VDT work.

The analyses were begun by examining the effects of the derived indices of job control/involvement, social environment/support, job/task performance demands, job/skill future certainty, and physical environmental problems. Age of participants was also included as a regressor at this stage. Because the extent of daily VDT use is widely considered to be a major determinant of health outcomes in VDT use (although empirical support is ambiguous), a continuous variable describing the hours of daily use of office machines (machine time) was also included. For the VDT users, this value was nearly equivalent to hours daily VDT use ($r = .93$ for the correlation of VDT hours/day with machine use hours/day). Finally, a variable corresponding to whether or not a participant was a VDT user was included as a main term and also interacted with all variables. As explained in the following description of the regression procedure, job classification variables and marital status (the only additional worker characteristic which proved to be of importance) were added in subsequent analyses.

Interaction Terms

Two types of interaction terms were formed and evaluated. The first is the more common type formed by products or ratios of two variables. Multiplication or division of the variables was chosen based upon the actual inspection of the response surface produced by pairs of variables for each of the well-being criterion measures. When strain was observed to result from increases in the level of both variables (e.g. higher strain with high job demands and high environmental problems, and lower strain with lower levels of these two variables), the values for the two variables were multiplied. If strain was observed to increase with increases in the level of one variable and decreases in the level of another (e.g. high strain with low social support and high environmental problems), the interaction term was formed by dividing one variable by the other (e.g. the environmental problems value divided by the social support value).

The method of formation of the interaction terms which were found to be of major relevance in the current regression analyses is indicated in the listing of these variables in Table 28 (division or multiplication is indicated in the interaction term labels).

The second type of interaction term formed approximates an effect somewhat similar to that occurring with moderator variables. Briefly, these terms consisted of an interaction between two variables (e.g. job control and job demands) that was allowed to vary or occur only at given levels of these variables (e.g high demands, low control). At all other levels of these variables (low demands-low control, high demands-high control, low demands-high control), the effect is nearly invariant. Karasek (1979) observed, for example, that for workers with varying degrees of job demands and job decision latitude (similar to the job control variable operationalized here) strain occurred mainly with low levels of decision latitude and high levels of demands exclusively.

This second type of interaction term was formed and evaluated for all pairs of the continuous predictor variables described above. The rationale for formulating and testing this type of interaction was not theoretical alone. The inspection of the response surfaces created by pairs of predictor variables for each of the outcome well-being measures indicated the need for these types of interaction terms.

Pictorial examples of such surfaces in the present data are provided in Figure 3. The x and y axes of these figures show quartiles for a pair of predictor variables, and the z axis shows the mean strain score for individuals within each x-y combination of quartiles. For plotting purposes, the strain score in the quartile combination with the lowest strain score was set to zero. Thus the proportions between strain scores in different quartiles combinations are not equivalent to the proportions created by the ratios of numeric values of strain shown at various x-y coordinates in the figure. In other words, the plots show the "peaks of mountains".

The lower plot in Figure 3 shows the magnitude profile of scores for one of the well-being outcome measures, illness symptoms, at various levels of the job demands and job control variables. Consistent with findings by Karasek (1979), it can be seen that strain (illness symptoms) is amplified at high levels of job demands and low levels of job control. At all other levels of these two variables (low control-low demands, high control-high demands, high control-low demands) strain does not vary in a consistent way. The same effect is observed in the upper plot in Figure 3 where reported strain (again illness symptoms) is comparatively pronounced only at extreme levels of job demands and low age. These types of effects cannot be accurately depicted by the simple multiplication or division of the predictor variables.

For the present analyses, two varieties of interaction terms were formulated to approximate the type of effects observed in Figures 3. The first variety was formed by allowing products or ratios of the values for pairs of variables to exist <u>above</u> the value formed by the product or ratio of the means for pairs of variables. At or below the product or ratio of the means, the interaction values were held constant at the product or ratio of the means. We refer to these as the "UP" interaction terms. The second variety of interaction term of this nature was formed by doing just the opposite. Here the product or ratio values for pairs of variables were allowed to exist <u>below</u> the value formed by the product or ratio of the means for pairs of variables. At or above the value formed by the product or ratio of the means, interaction values were held constant at the product or ratio of the means. We refer to these as the "DOWN" interaction terms. The formation of these two types of interaction terms is illustrated in Figure 4.

Before leaving the subject of interaction terms, it is worthwhile to digress briefly to a series of analyses carried out in which only the variables job demands, job control, and their interactions of the two major types defined above were used to predict the three general measures of well-being (illness symptoms, mood disturbance, and job dissatisfaction) that are the focus of the current analyses. The aim was to attempt to replicate Karasek's (1979) findings on the way in which job decision latitude conditions the stress

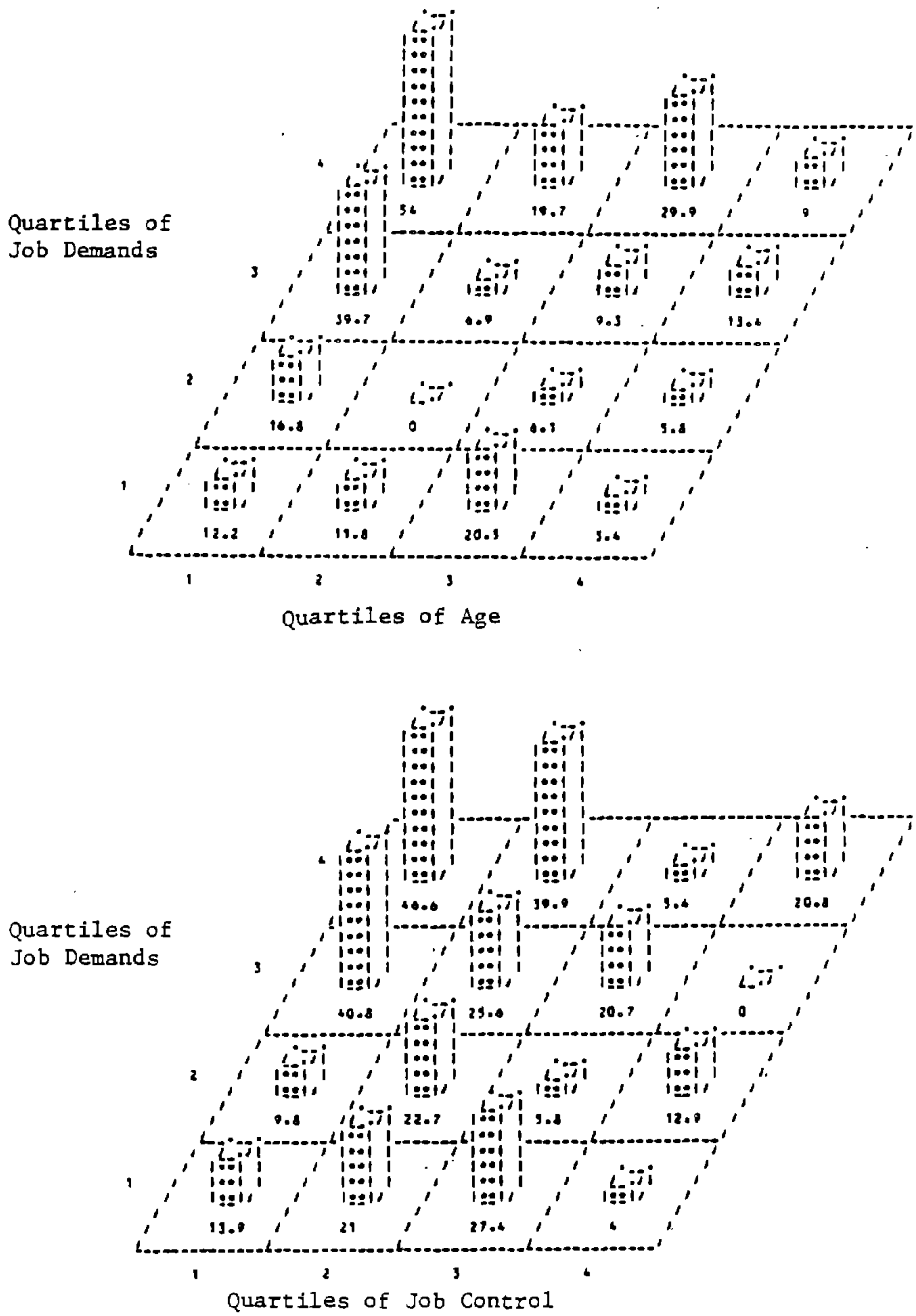
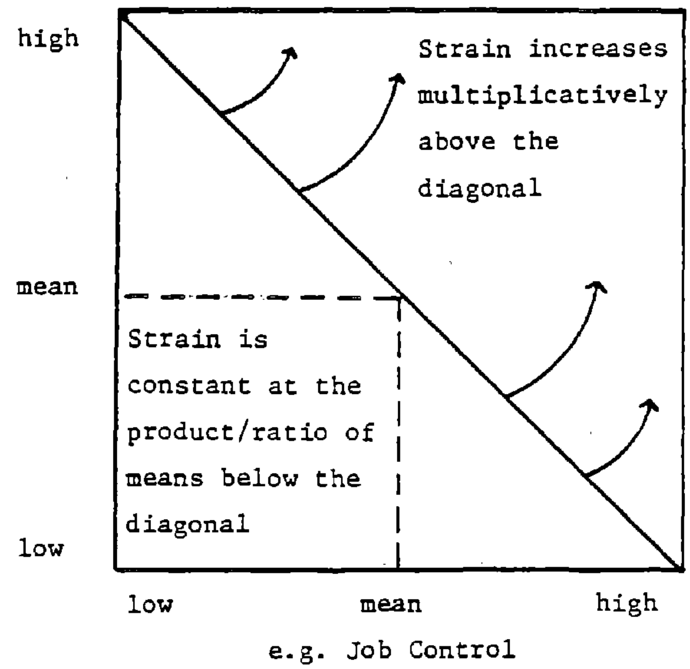


Figure 3. Examples of response surfaces approximated by the second type of interaction terms (z-axis represents scores for the Illness Symptoms index).

"Up" Type Interaction



"Down" Type Interaction

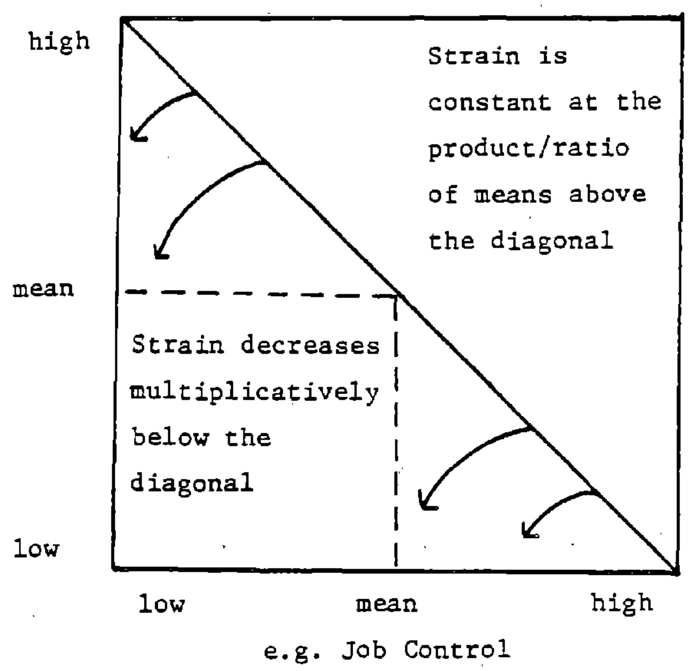


Figure 4. Formation of the two varieties of the second type of interaction term.

effects of job demands. Of interest is that when the job control-job demands interaction term of the second type was combined with the job control and job demands variables as regressors, the effect of the interaction term was significant in predicting both job dissatisfaction and illness symptoms. When the interaction of the first type (i.e. a simple ratio term) was combined with these two variables, the interaction effect was not significant in any case. These findings would seem to lend support to Karasek's (1979) findings and to the importance of forming these types of terms for the present analyses. However, despite the apparent importance of the second type of interaction term for interactions involving the job control variable, these interaction terms actually contributed little to the prediction of the well-being measures once the other major independent variables (and their interactions) were considered in the analyses.

The Dependent-Criterion Variables

As indicated, the well-being or outcome measures in the analyses at hand are the derived indices of job dissatisfaction, mood disturbance, and illness symptoms predicted previously from the individual worker variables.

The Regression Procedure

First, the three well-being measures were regressed in separate analyses on the independent variables described above (with the exception of job classification and marital status) and their interactions. Since this investigation is exploratory in nature, a stepwise technique (backward: $p >$ .05 out, $p \leq .05$ in) was chosen. As described further on, other regression procedures were utilized in checking the solutions we obtained with this procedure. The regression analyses were based upon the 186 VDT users and 65 non-users with complete data on all variables.

The main statistical package used was REGAN 3, a series of regression programs developed and used extensively over the years at the University of Wisconsin. The SAS (Statistical Analysis Systems, Raleigh, N.C.), Version 79.6 PROC REG routine and options available with REGAN were used for verification and diagnostic purposes on the final regression models.

In each of the three analyses (i.e. one for each outcome measure) we began by stepping on the interaction terms of the first type in the presence of the main effect terms which were locked in the model. Essentially the same procedure was then followed for the interactions of the second type. Interactions of both types which survived this preliminary stepping were combined along with all main effect terms, and the entire set of variables were then stepped in a subsequent analysis. Residual plots were examined for evidence of curvilinear effects of the main predictor variables indicating the need to form quadratic terms. As described further on in the results, this was warranted in only one instance.

In the description of the results of the prediction of the three well-being measures, tables are provided (Tables 30-32) showing the final models achieved. The interaction terms shown in these tables (either as remaining in or stepping out of the models) are the interaction terms which survived the preliminary stepping. Table 29 shows the simple correlation structure among the criterion measures and all the main independent variables in these analyses. All the interaction terms surviving the preliminary stepping are also included. Table 28 provides descriptive statistics for all of these variables.

Next, we took the three final models resulting from the regressions of each of the three well-being measures and then re-analyzed these models simultaneously allowing the outcome well-being measures from each of the three models to enter the other two models as regressors. In this fashion we were able to gain an understanding of the predictive relationships among the outcome well-being measures themselves, and their importance in relationship to the other "independent" predictor variables. The SAS SYSREG routine was used for this purpose. In these simultaneous analyses, variables were removed in a simple backward elimination process.

In deliberations over the results of these analyses with the NIOSH project officer, we became concerned that the analyses may be deficient in reflecting the influence that the type of office task or job may have on worker well-being. For example, Figure 2 shows variation in reported strain across the different job activity categories for the study participants, with an indication of a trend towards decreasing strain proceeding from the data entry category at the left toward programmers at the right. The question is whether there exists a job activity related variable which contributes to this variation beyond effects due to variables already considered in these analyses.

One option we considered was to include in the regression analyses classification variables denoting qualitatively different job activities performed. To this end, the sample was reclassified into the activity groups shown in Figure 2 (data entry, file maintenance, general clerical-secretarial, lead workers, and programmers). The three regression analyses described above were then repeated, but including variables corresponding to these classifications. The results were fruitless, adding no explanatory power to the analyses already conducted and for this reason are not reported further here.

It is also possible to roughly classify these different jobs along a more continuous dimension, and they are arranged in this fashion as they appear in Figure 2. Proceeding from data entry work to programming, the jobs tend to involve progressively greater quantities of the characteristics of professional jobs (greater knowledge, authority, responsibility, etc.), although perhaps with the exception of programmers, none of the jobs can be regarded as of a truly professional nature in an absolute sense. Based upon this somewhat rough continuum, dummy variables denoting professional status were created by classifying data entry and file maintenance workers as "lower professional" workers, and clerical secretarial workers and lead workers as "higher professional" workers. Programmers were included as a third classification. The three regression analyses described above were then again repeated with the inclusion of the higher professional and programmer classification variables (lower professionals served as the reference group) as regressors. The acronyms used for these two variables in the presentation of the data are PRF STAT (higher professional status indicator) and PROGR (programmers). The interaction of the professional status variable with all other independent variables was also included. The results of this second

Table 28. Descriptive statistics for all variables used in the general work environment analyses.

Variable	Mean	SD	Minimun	Maximum
JOB DIS	16.13	2.86	10.57	26.97
JOB CON	19.61	2.17	14.86	25.36
SOC SUP	22.20	2.50	15.66	27.59
JOB DEM	22.70	2.38	14.24	27.87
FUT CER	20.58	1.66	16.35	24.04
MD DIS	10.51	4.95	4.18	33.00
ILL SYM	9.39	3.76	3.34	24.37
ENV PROB	18.66	2.12	14.87	24.81
MTIME	6.10	2.45	0.00	10.00
AGE	32.61	10.35	18.00	62.00
VDT USE	0.74	0.44	0.00	1.00
PROGR	0.07	0.25	0.00	1.00
PRF STAT	0.22	0.41	0.00	1.00
MAR STAT	0.52	0.50	0.00	1.00
JOB DEM ÷ SOC SUP	1.04	0.16	0.70	1.64
ENV PROB ÷ SOC SUP	0.86	0.17	0.57	1.47
SOC SUP x FUT CER	457.98	70.70	276.01	637.90
VDT USE x JOB DEM	16.83	10.18	0.00	27.87
AGE ÷ ENV PROB	1.77	0.58	0.80	3.68
AGE x SOC SUP	722.84	237.98	313.08	1503.20
PRF STAT x JOB DEM	5.12	9.86	0.00	27.87
PRF STAT x FUT CER	4.50	8.63	0.00	23.61
PRF STAT x ENV PROB	3.97	7.66	0.00	22.85
PRF STAT x AGE	8.06	16.18	0.00	61.00
JOB CON "UP"	1.14	0.12	1.05	1.51

Table 29. Correlations (Pearson r) among the variables included in the <u>general</u> work environment analyses.

Variables	1. JOB DIS	2. MD DIS	3. ILL SYM	4. JOB CON	5. SOC SUP	6. JOB DEM
1. JOB DIS	1.000					
2. MD DIS	.549	1.000				
3. ILL SYM	.452	.553	1.000			
4. JOB CON	-.523	-.140	-.192	1.000		
5. SOC SUP	-.489	-.241	-.213	.414	1.000	
6. JOB DEM	-.036	-.072	.151	.115	.062	1.000
7. FUT CER	-.400	-.304	-.298	.430	.292	.241
8. ENV PROB	.415	.246	.373	-.287	-.384	.188
9. MTIME	-.030	-.023	.014	-.231	.075	-.113
10. AGE	-.163	-.220	-.094	-.047	-.033	.285
11. VDT USE	.082	-.071	-.012	-.217	-.085	.005
12. PROGR	-.057	-.071	-.044	.251	.000	.033
13. PRF STAT	-.025	.009	-.088	.262	-.043	.244
14. MAR STAT	-.223	-.217	-.242	.059	.113	.159
15. JOB DEM ÷ SOC SUP	.350	.146	.287	-.243	-.713	.641
16. ENV PROB ÷ SOC SUP	.545	.309	.377	-.424	-.824	.079
17. SOC SUP x FUT CER	-.556	-.334	-.307	-.518	.866	.167
18. AGE ÷ ENV PROB	-.288	-.282	-.200	.051	.103	.215
19. AGE x SOC SUP	-.313	-.299	-.162	.089	.311	.290
20. PRF STAT x JOB DEM	-.020	.007	-.083	.263	-.038	.289
21. PRF STAT x FUT CER	-.044	-.013	-.106	.277	-.025	.247
22. PRF STAT x ENV PROB	.005	.025	-.068	.244	-.070	.251
23. PRF STAT x AGE	-.062	.004	-.085	.235	-.050	.256
24. VDT USE x JOB DEM	.070	-.071	.019	-.192	-.072	.184
25. JOB CON "UP"	-.450	-.166	-.260	.685	.388	.008

Table 29 continued.

Variables	7. FUT CER	8. ENV PROB	9. MTIME	10. AGE	11. VDT USE	12. PROGR
7. FUT CER	1.000					
8. ENV PROB	-.202	1.000				
9. MTIME	-.062	.006	1.000			
10. AGE	-.022	.083	-.150	1.000		
11. VDT USE	-.096	.171	.136	.011	1.000	
12. PROGR	.109	.047	-.307	-.066	.159	1.000
13. PRF STAT	.103	-.053	-.466	.247	-.354	-.141
14. MAR STAT	.154	.038	.016	.284	.012	.038
15. JOB DEM ÷ SOC SUP	-.068	.434	-.126	.220	.064	.017
16. ENV PROB ÷ SOC SUP	-.305	.821	-.030	.072	.142	.012
17. SOC SUP x FUT CER	.727	-.378	.018	-.037	-.109	.098
18. AGE ÷ ENV PROB	.053	-.270	-.146	.931	-.058	-.081
19. AGE x SOC SUP	.077	-.060	-.106	.933	-.027	-.072
20. PRF STAT x JOB DEM	.107	-.045	-.460	.254	-.336	-.140
21. PRF STAT x FUT CER	.133	-.062	-.459	.239	-.361	-.141
22. PRF STAT x ENV PROB	.088	.004	-.474	.245	-.324	-.140
23. PRF STAT x AGE	.074	-.050	-.476	.377	-.314	-.135
24. VDT USE x JOB DEM	-.045	.199	.117	.063	.979	.163
25. JOB CON "UP"	.319	-.664	-.093	-.048	-.212	.088

Table 29 continued.

Variables	13. PRF STAT	14. MAR STAT	15. JOB DEM ÷ SOC SUP	16. ENV PROB ÷ SOC SUP	17. SOC SUP x FUT CER	18. AGE ÷ ENV PROB
13. PRF STAT	1.000					
14. MAR STAT	.059	1.000				
15. JOB DEM ÷ SOC SUP	.195	.015	1.000			
16. ENV PROB ÷ SOC SUP	-.002	-.052	.702	1.000		
17. SOC SUP x FUT CER	.026	.162	-.545	-.744	1.000	
18. AGE ÷ ENV PROB	.264	.266	.065	-.216	.099	1.000
19. AGE x SOC SUP	.220	.3090	-.040	-.219	.261	.922
20. PRF STAT x JOB DEM	.994	.069	.221	.000	.032	.269
21. PRF STAT x FUT CER	.997	.066	.183	-.019	.054	.260
22. PRF STAT x ENV PROB	.992	.052	.222	.047	-.001	.240
23. PRF STAT x AGE	.954	.083	.210	.007	.008	.391
24. VDT USE x JOB DEM	-.305	.040	.177	.152	-.074	-.016
25. JOB CON "UP"	.208	.002	-.282	-.593	.448	.189

Variables	19. AGE x SOC SUP	20. PRF STAT x JOB DEM	21. PRF STAT x FUT CER	22. PRF STAT x ENV PROB	23. PRF STAT x AGE	24. VDT USE x JOB DEM
19. AGE x SOC SUP	1.000					
20. PRF STAT x JOB DEM	.299	1.000				
21. PRF STAT x FUT CER	.220	.992	1.000			
22. PRF STAT x ENV PROB	.206	.989	.987	1.000		
23. PRF STAT x AGE	.339	.954	.947	.946	1.000	
24. VDT USE x JOB DEM	.026	-.283	-.312	-.275	-.263	1.000
25. JOB CON "UP"	.080	.206	.221	.157	.191	-.211

set of the three regressions were meaningful and are shown in Tables 30-32 along with the results from the first set.

Finally, the regression analyses undertaken to examine the influence of worker characteristics on well-being pointed to marital status as an important predictor of strain. For this reason, the marital status variable was added in a final regression prediction of each of the three well-being measures.

Diagnostics

In examining diagnostic statistics for the regression models in these analyses, particular attention was paid to four measures. The first was the "Studentized" residuals for the predictions (i.e. the standardized value of the difference between actual and predicted values for the criterion measure for each individual). Estimates which were greater than two and three standard deviations from the mean (outliers) were noted. The second was the "hat" value for each case. This is a measure of the "leverage" or influence of each observation (i.e. associated regressors for each case) on the predicted values produced by the model. In each model the critical value of this statistic which should not be exceeded for any case is equal to the quantity (3 x no. of regressors/sample size). The third statistic was the covariance ratio for each case which reflects the change in the precision of the estimated coefficients due to the values of the associated regressors for each case. Covariance ratios less than 0.9 were noted.

Results show that none of these three statistics indicate serious problems in any of the models. Only a small number of cases in all of the regression analyses reported in this study had values for these statistics outside the critical limits described here. The raw data for all of these cases were closely inspected for evidence suggesting the data to be unreliable (e.g. lack of variance in response to questionnaire items, large blocks of missing data, coding errors, etc.). For none of the cases tagged by the regression diagnostics was such evidence found, and therefore, none of the cases were deleted from the analyses.

Finally, the correlations among the values of the regressors themselves and among the regression coefficients for the different variables in the final models were examined. Regarding the former measure, although some of the correlations are in the neighborhood of 0.40, their frequency and magnitude do not suggest serious colinearity problems in these models. The majority of the correlations among the main regressor variables are much lower. Results show that only in a few instances do strong correlations exist between coefficients for the different regressors, usually between interaction terms and their component main effect terms.

Results of the Job Dissatisfaction Regressions

In predicting the three different well-being measures, the results for job dissatisfaction were the most acceptable. We describe first the results for the dissatisfaction regression in which the professional status and programmer variables were not included as predictors. The first section of Table 30 shows the final outcome of this regression. The top portion of the table shows the variables which remain in the final model; the bottom portion

Table 30. Results of the Job Dissatisfaction regressions.

Programmer and professional status indicators not included in the model:

Variables remaining in final model	Reg. coef.	Standardized reg. coef.	Partial correl. coef.	Sig level
Job Control	-.445	-.338	-.375	.000
Social Support	-.246	-.214	-.247	.000
Future Certainty	-.281	-.163	-.200	.002
Environmental Problems	.752	.557	.228	.000
Machine Time	-.160	-.137	-.178	.005
Age	-.317	-1.147	-.182	.004
Age ÷ Environmental Problems	4.735	.958	.147	.021
Variables stepping out of final model				
Job Demands	-	-	.088	.169
VDT Use	-	-	.049	.446

R = .702

R^2 (adjusted) = .478

Table 30 continued.

Programmer and professional status indicators included in the model:

Variables remaining in final model	Reg. coef.	Standardized reg. coef.	Partial correl. coef.	Sig. level
Job Control	-.469	-.075	-.376	.000
Social Support	-.240	-.061	-.246	.000
Future Certainty	-.272	-.088	-.195	.002
Environmental Problems	.776	.204	.239	.000
Machine Time	-.137	-.061	-.145	.024
Age	-.336	-.109	-.196	.002
Age ÷ Environmental Problems	5.231	2.032	.164	.011
Professional Status x Job Demands	.359	.116	.195	.002
Professional Status x Future Certainty	-.258	-.125	-.132	.040
Professional Status x Age	-.071	.031	-.148	.021
Variables stepping out of final model				
Job Demands	-	-	-.015	.816
Professional Status	-	-	.067	.303
Programmers	-	-	.022	.730
VDT Use	-	-	-.044	.494
Professional Status x Environmental Problems	-	-	.050	.441

$R = .722$
R^2 (adjusted) $= .501$

shows those stepped out. The second section of Table 30 is organized in the same way, except that the professional status classification and interactions with this variable, and the programmer classification are included among the regressors. Remember that the interaction terms shown in this table are those surviving the preliminary stepping on interaction terms alone.

The "fit" or adjusted R^2 of the model is 0.48. When age is omitted from either of these models to determine the explanatory power of factors that are predominantly job related, a slight decline of approximately three percentage points in the explained variance is seen.

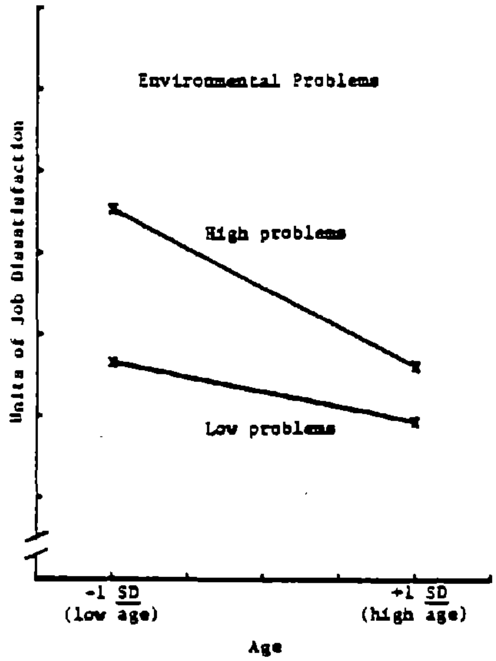
The job dissatisfaction model appears to be highly stable. Only 12 of the 251 predicted values were found to have Studentized residuals equal to or greater than 2.0, and only two exceeding 3.0. In examining the hat (leverage) values, only three observations were found to be in excess of the critical value of 0.084 indicating excessive influence. Just eight observations have covariance ratios of less than 0.9, and only 1 less than 0.8. The only indication of instability in this model is that the regression coefficients for the age, environmental problems, and age by environmental problems interaction terms are strongly intercorrelated.

Table 30 shows that most of the main effect terms considered in these analyses contributed significantly to the prediction of job dissatisfaction. This result stands in contrast to the final models for the regressions of the mood disturbance and illness symptoms measures in which, as shown further on, main effects are less prevalent.

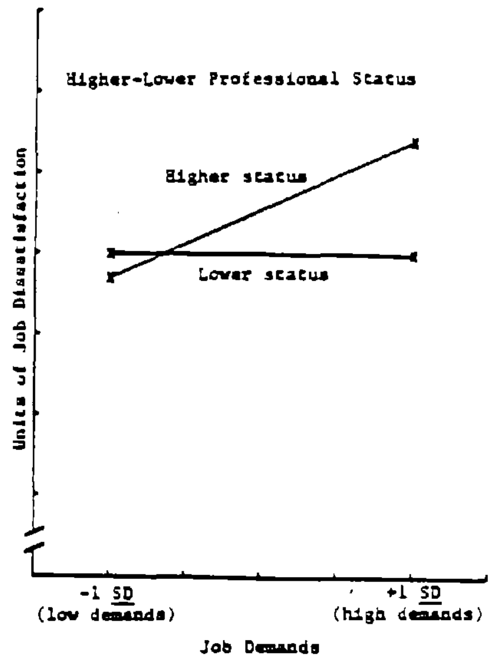
In the present regression only one interaction term (age by physical environmental problems) survived the preliminary stepping on interaction terms, and this term also contributes significantly to the prediction of job dissatisfaction in final models. The effect is shown pictorially in Figure 5 (Panel 1). Age seems to moderate the adverse effects of environmental problems. In other words, the effect of increased environmental problems is not nearly so great for older workers as it is for younger workers. This plot and all of the interaction plots presented here were created by calculating the predicted value for the dependent measure at values of plus and minus one standard deviation from the mean for the variables involved in each interaction, using the coefficients for these terms given in the regression model. Values for all terms not involved in the interaction were held constant at the mean. The ordinate in these plots is calibrated in units of the dependent measure (actual ranges given in Table 28). It will be seen that the age by environmental problems interaction effect is particularly strong throughout the analyses, also attaining significance in both the mood disturbance and illness symptoms models as well.

Table 30 shows that most of the main effects in the prediction of job dissatisfaction are in a direction which is compatible with expectations from the occupational stress literature. Decreases in job control, social support, future certainty, and increases in environmental problems all lead to increases in job dissatisfaction. Especially noteworthy here is the strong partial effect of job control.

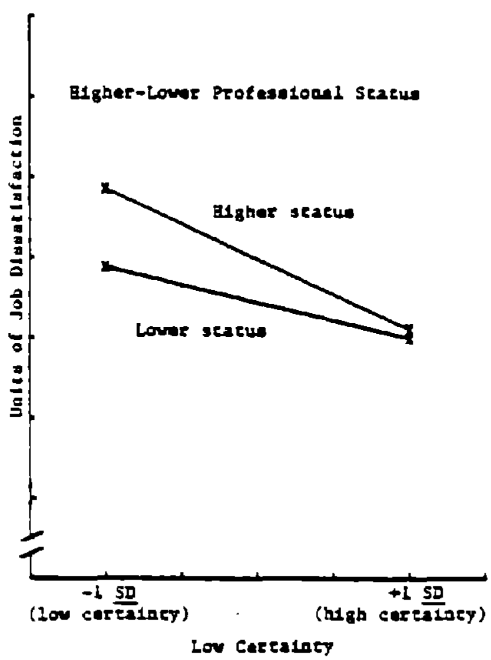
One of our concerns in interpreting the strong effect of job control on job dissatisfaction was that perhaps some of the items comprising the two scales



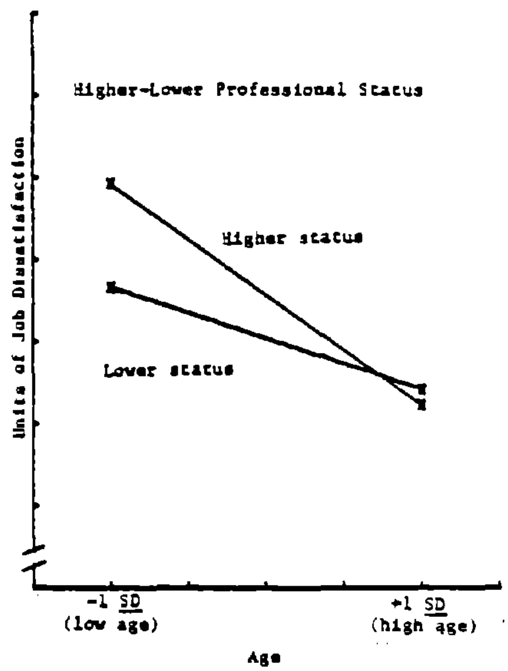
Panel 1. The interaction of environmental problems and age in predicting job dissatisfaction.



Panel 2. The interaction of higher-lower professional status and job demands in predicting job dissatisfaction.



Panel 3. The interaction of higher-lower professional status and future certainty in predicting job dissatisfaction.



Panel 4. The interaction of higher-lower professional status and age in predicting job dissatisfaction.

Figure 5. Plots of interactions in the prediction of Job Dissatisfaction.

are conceptually too similar, resulting in an artifactual relationship, although this is not readily suggested by inspection of the scale contents. Kasl (1978) described the seriousness of this type of problem in occupational stress research. To further explore this possibility we examined the relationship between the present job control scale and the job dissatisfaction scale of Caplan et al. (1975) which deals almost exclusively with the propensity to recommend or take again the present job. Interestingly, the correlation is about the same ($r = -.545$) as with the present job dissatisfaction measure ($r = -.53$). Similarly, the Caplan et al. (1975) participation scale which deals exclusively with decision latitude correlates at very nearly the same level with the present dissatisfaction scale ($r = -.33$) as with the Caplan et al. (1975) dissatisfaction scale ($r = -.32$). We therefore, dismissed the possibility of contamination of the job control effect.

In examining the univariate comparison of VDT users and non-users on the job stressor/moderator variables (Tables 19, 20, 22), it is notable that for the derived job control and environmental problems variables, as well as for related measures of these two types of conditions (management/supervisory control over workers and physical workplace comfort) the data indicate significantly less favorable circumstances for the VDT users. The same is true for staff-supervisory support. Similar findings were obtained by Smith et al. (1981). It may seem inconsistent that while the VDT users and non-users are differentiated on variables which play important roles in predicting job dissatisfaction, the univariate comparisons show no significant group differences in dissatisfaction, although dissatisfaction scores tend to be greater for the users . The explanation is probably that the group differences on these predictors are not large enough, particularly in light of other significant predictors for which no group differences appear, to cause significantly greater dissatisfaction among users. Remember also that the significant regressors explain just half of the variance in the job dissatisfaction measure.

The effect of the machine time variable shows that increased daily use of office machines is associated with decreased job dissatisfaction. The effect is the same for VDT users and non-users alike since the VDT use variable does not interact with the machine time variable. However, the effect does not appear to be particularly strong (this variable has the lowest standardized regression coefficient and second lowest partial correlation).

Prior data on the relationship between strain and the extent of daily VDT use is mixed. Some studies indicate a positive relationship between the length of VDT use and visuo-ocular strain (e.g. Gunnarsson and Soderberg, 1980; Haider et al., 1980). Dainoff et al. (1981) reported a correlation of 0.19 between percent time daily VDT use and an index of physical/mental stress. Smith et al. (1981) reported a correlation of similar magnitude between the extent of VDT use and health complaints. Cakir et al. (1978) found general central activation scores to be highest for users with 4-6 hours of VDT operation per day. On the other hand, Dainoff et al. (1981) reported a small negative correlation between percent time daily VDT use and fatigue, and Smith (1982) describes that no relationship was observed between the number of hours of daily VDT use or length of job tenure and vision defects in a recent NIOSH investigation. Ghiringhelli (1980) reports that job and stress complaints were actually most frequent among users who worked on VDTs for less than three hours per day.

Importantly, it appears that in some of this work the extent of VDT use variable may be confounded with other job factors such as nature of the task. There seems to be no prior data on the relationship of the extent of VDT or office machine use with job dissatisfaction per se.

One possible explanation for the effect of the machine time variable which deserves consideration is that it is attributable to factors converging to a degree with the machine time variable, but not considered in this particular model. In the regression including a classification variable denoting professional status, the jobs with the higher professional status are associated with increased mood disturbances, and the inspection of plots of the interaction of the professional status variable with other variables (Figure 5, Panels 2-4) also shows a tendency toward greater dissatisfaction in these jobs. These same jobs are shown to involve less intensive use of office machines than the less professional jobs (indicated in Table 29). In the regression of the dissatisfaction variable which includes the higher professional status indicator, the importance of the machine time variable is reduced (Table 30, second section). Still, the effect is significant and in the same direction. On the other hand, it might be simply that the result is linked to an appreciated task facilitative effect for individuals with greater access to office machines.

A question which might be raised at this point is whether use of the machine time variable distorts the relationship of extent of VDT use per se with dissatisfaction since number of hours machine time use and VDT use are not exactly equivalent for the VDT users. This is doubtful since the two measures are highly correlated ($r = 0.93$), and the simple correlations of VDT hours and machine time with job dissatisfaction are nearly identical for VDT users (r's = 0.029 and 0.030 respectively). The simple relationships of these two variables for the VDT users are also nearly the same for the other two well-being measures considered in these analyses (r's = -0.025 and -0.023 for the mood disturbance measure, and r's = -0.007 and 0.014 for the illness symptoms measure).

A second question relates to the appropriateness of this type of "exposure" index from the perspective of predicting strain. Hours of exposure daily was chosen mainly in the interest of comparability with prior work and because many of the adverse effects of VDT use reported thus far seem reversible with rest. The argument might be made, however, that for the types of outcome measures considered here, cumulative exposure could be a more appropriate or at least a viable alternative measure. In examining the relationship of numbers of months of VDT use with the three outcome measures in the present analyses, the correlations obtained were not much stronger and nonsignificant for the VDT users in all cases ($r = -0.127$ for the job dissatisfaction measure, -0.110 for the mood disturbances measure, and -0.078 for the illness symptoms measure). Further, no significant correlations were observed between VDT exposure measured in months and any of the more specific physical strain measures (visuo-ocular, musculo-skeletal strain) considered further on in the results, nor for any of the Profile of Mood States subscales indicating specific affective disturbances, nor for the derived scale denoting behavioral-autonomic manifestations of stress.

Like the machine time variable, age is negatively associated with job dissatisfaction. However, the influence indicated by the age regression coefficient is attenuated by the age by environmental problems interaction. As shown further on, the same effect occurs in the regression of the illness symptoms measure, and in general throughout all the analyses conducted in this study age is negatively associated with strain. There is little a priori rationale to suggest that age should either diminish or exacerbate dissatisfaction per se, although the same would not be true for health disturbances. One possibility we cannot examine is that older workers may have different (perhaps lower) expectations than younger workers. However, the fact that age is systematically associated with reduced strain suggests that some variation of the "healthy worker" effect may be operating such that dissatisfied workers or workers experiencing job and health problems self-select themselves out the types of office work examined. Alternately they may have never entered these jobs. It is of interest that this same type of age effect of was noted by Starr et al. (1983) for the reporting of physical symptoms. Ghiringhelli (1981) also noted a greater incidence job and health complaints among younger workers. No age-strain relationship was observed in the recent Canadian Labor Congress (1982) study. None of these investigators offer an explanation for the effect.

In examining scatterplots of the relationship between age and job dissatisfaction, it was observed that the effect approximates a curvilinear trend in which dissatisfaction drops rather precipitously until the mid-to-late 30's, but thereafter remains fairly stable. This effect is particularly apparent for the VDT users as shown in Figure 6 (top) where mean job dissatisfaction scores for the different age quartiles are plotted. Because this curvilinear trend was quite pronounced in a plot of the regression residuals for age, an age quadratic term was added to the job dissatisfaction regression model. However, no effect on the model was observed. The quadratic term stepped out and the linear term remained. The curvilinear effect was also pronounced in the regression of the illness symptoms measure where a significant main effect of age also occurred. The curvilinear effect for the VDT users was again stronger, and is also shown in Figure 6.

Relative to the issue of stress incident to VDT use, perhaps the most important observation in this first regression is that the VDT use term and all VDT use interaction terms step out of the model. This means that after adjusting for the effects of other variables in the model, knowing whether an individual is a VDT user or not is of no significance in predicting the level of job dissatisfaction experienced by that person. It also means that the way the significant variables contribute to dissatisfaction is no different for the VDT users than for their non-user counterparts. The former effect is seen even in the simple relationship of VDT use with job dissatisfaction. As described, VDT use is not associated with the job dissatisfaction measure ($eta = .082$, $p = .19$).

Finally, the model shows no significant influence of the job demands variable on dissatisfaction; neither is a meaningful simple relationship of these two variables observed (Table 29). Of interest, however, it will be shown further on that there may exist some influence of job demands on

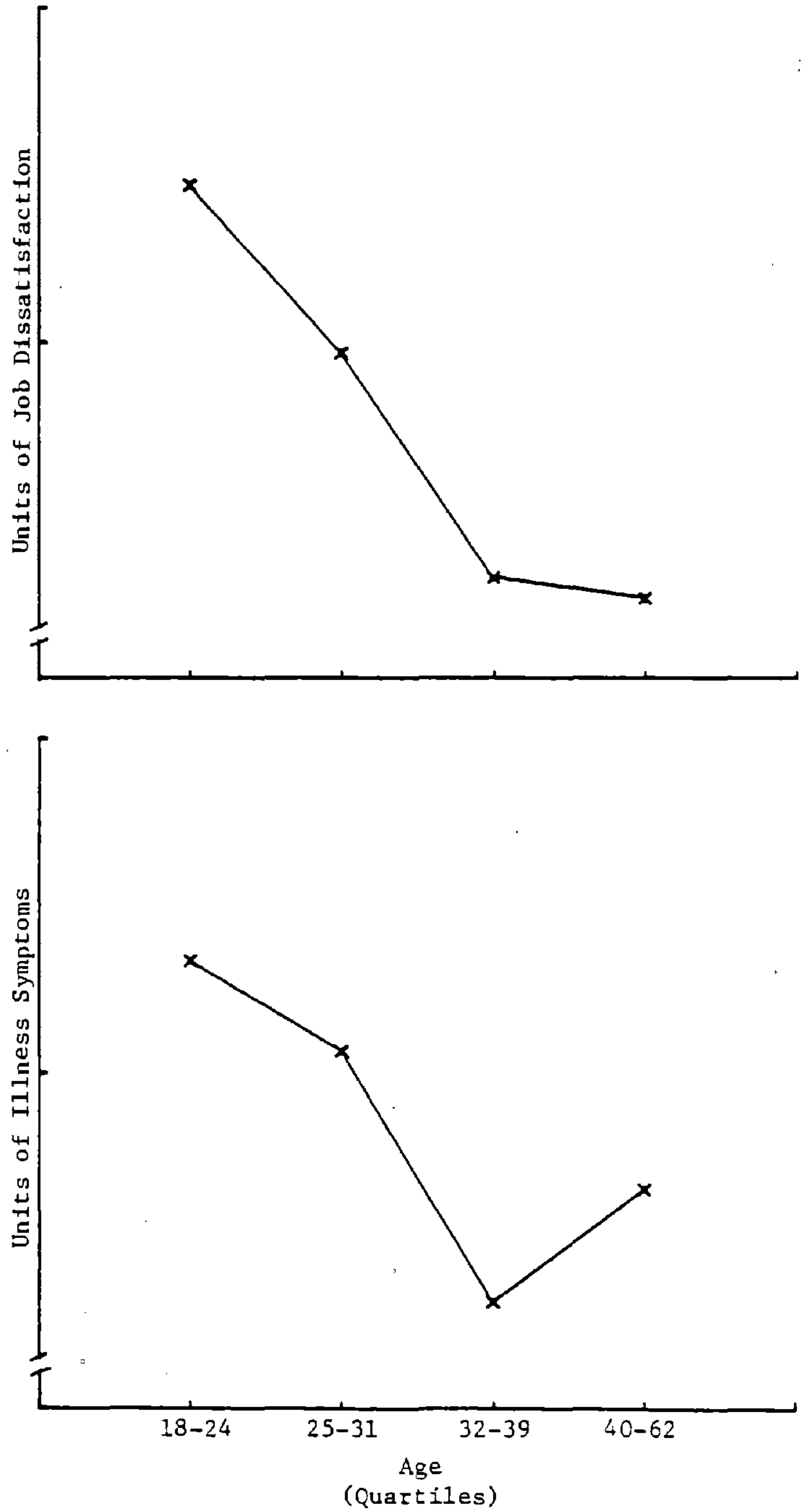


Figure 6. Job Dissatisfaction and Illness Symptoms scale scores in relation to Age for VDT users (n=186).

dissatisfaction since demands do contribute to illness symptoms which in turn affect dissatisfaction.

Effect of Including the Professional Status Variable—
In this analysis, classification variables denoting programmers and the workers with the higher professional status were included as regressors along with the variables and interaction terms considered in the prior analyses. The lower professional workers constituted the reference group. Interactions of the professional status indicator with all other variables were also examined. Because programmers were exclusively VDT users and the subgroup sample relatively small, interactions involving this term were not formed.

The second part of Table 30 shows the final model obtained in this analysis. Three observations are of interest. First the variables from the final model without the professional status variables retain their significance. Secondly, prediction with the model is improved somewhat (R^2=.501). Third, although there is no main effect of the programmer or professional status indicator, the latter variable is involved in significant interactions with the age, future certainty, and job demands variables. Note, then, that in contrast to the prior analyses, job demands is influential in predicting dissatisfaction when the professional status indicator is included as a regressor.

Plots of interactions involving the professional status indicator reveal effects that deviate from expectations. First, although there is no significant main effect of the professional status indicator, a tendency towards increased dissatisfaction is observed for the higher professional grouping of workers as shown Figure 5, (Panels 2-4). This relationship is also observed in the regression of the mood disturbance measure as reported further on, except there the main effect is in fact significant. In the regression of the illness symptoms measure, there is a significant main effect of the professional status indicator that is positive (implying greater strain for the more professional workers), but a strong interaction with the future certainty variable in that regression indicates that for the average person, the higher professional status classification is associated with reduced strain (illness symptoms). The second interesting feature of the professional status interaction plots shown in Figure 5 is that they suggest a greater influence of age, future certainty, and job demands for the higher professional group than for the lower professional group. This effect, too, is observed in the regressions of the mood disturbance measure as well as the illness symptoms measure where the interaction with the future certainty variable is also significant.

This pattern of results is puzzling in the sense that prior VDT research seems to fairly consistently point to greater resistance to stress and lower levels of strain (at least physical health problems) among more professional workers. With the exception of the illness symptoms measure, professional status in the present sample points, if anything, to increased strain. This inconsistency maybe due to the fact that in prior studies confounding of professional status with other influential variables may have occurred. In the current regression approach, the effect of certain important stress moderators such as job control are accounted for independently of the effect of the professional status indicator. Thus the effect of the higher professional status indicator we are observing here may be the residual negative influence of stressors associated with professional work after adjusting for the effect of buffers such as the job control or other variables (e.g. age or future certainty) which tend to counteract stress/strain and are somewhat increased in the more professional jobs (indicated in Table 29) in the present sample. What these adverse factors might be, however, is uncertain. Cakir et al. (1978) and Coe et al. (1980) both reported increased pressure at work by the more professional VDT users. One alternate explanation for the present findings is the possibly that the professional classification reflects less a distinction along a dimension of professional work than along some other dimension we haven't considered. As emphasized previously, the jobs included in the higher professional status classification are not generally considered professional in the conventional sense of the word.

Given the somewhat modest contribution and difficulty of interpreting regression effects relating to the professional status of workers, and considering that truly "professional" jobs are not well represented in the current sample, we are not inclined to attribute too much significance to these findings until further exploratory/confirmatory investigation of the effects can be undertaken.

Effects of Including the Marital Status Variable--
With the exception of age, marital status stands out among all other demographic variables as an important predictor of strain. When the regression sample is classified simply according to whether individuals are married or not, the associations with the three strain measures in the present analyses are significant (job dissatisfaction, eta = 0.22, $p<.01$; mood disturbance, eta = 0.22, $p<.01$; illness symptoms, eta = .24, $p<.01$) with decreased strain in all cases for the married individuals. Because the effects of influential individual factors in relation to working conditions are of interest, the marital status variable was locked into the job dissatisfaction, mood disturbance, and illness symptoms models, along with age, as a predictor variable. The influence of the marital status variable was significant in the prediction of both the job dissatisfaction and illness symptoms measures. The model for prediction of job dissatisfaction was unchanged (note terms eliminated), but prediction was improved (adjusted R^2=.513). However, as indicated by only a slight increment in explained variance, the actual effect of marital status is modest in comparison to cumulative effects of variables denoting working conditions. The standardized regression coefficient and partial correlation for marital status were -0.128 and -0.172 respectively ($p<.01$).

Summary and Conclusions--
The data show that both psychosocial/organizational and physical environmental attributes of the work environment are instrumental in predicting the job dissatisfaction of the present office workers, and the effects are generally consistent with expectations from the VDT and general occupational stress literature. Increases in personal job control, improvement in the social and physical environment, and increased future certainty all predict reductions in job dissatisfaction. Of interest, the influence of the job control variable is particularly strong, supporting the growing literature implicating this factor as an important mitigator of stress (e.g. Karasek, 1979).

Also of interest is the role of individual characteristics. Both age and marital status effects were significant, however it is important to note that they are the only two variables of a much larger set which were found to be influential. While the negative association of dissatisfaction with age is similar to the relationship between age and well-being observed in prior VDT stress research, and the "healthy worker" effect is not uncommon in the occupational health literature, the basis for decreased dissatisfaction per se with increasing age in office work requires further explanation. So too do the negative associations of dissatisfaction with machine time and the professional status effect which are more difficult to explain. Regarding the influence of the individual parameters vis-a-vis working conditions as predictors of dissatisfaction, it is important to note that neither contributed in a major way to the prediction of dissatisfaction. When the age and marital status variables were excluded from the model, a decline of less than 10 percent of the total explained variance is observed.

Perhaps most important is the implication that the mechanisms of job dissatisfaction are much the same for the VDT users and non-users alike. The results show that the influences of the dissatisfaction predictors identified are no different for the VDT users than for the non-users; they do not interact with the VDT use variable. In addition, after adjusting for these predictors, VDT use is of no consequence in predicting job dissatisfaction. This means that there is nothing else distinguishing VDT users from non-users which is of significance in predicting job dissatisfaction, although clearly there exist other factors which influence dissatisfaction for both groups since about 50% of the variance in the job dissatisfaction measure is unaccounted for with the present model. Still, the fact that half the variance is explained indicates that major determinants of dissatisfaction in VDT and office work are captured in the model.

The lack of a VDT use effect of any type in the present analyses does not mean that VDT work is not more or less dissatisfying than more conventional office work. Dissatisfaction among VDT users will vary with working conditions according to the prescriptions of the model, but the effect would be the same for non-users working under similar conditions. The concern raised by the present analyses is that certain conditions identified as important predictors in the model (job control and environmental problems) tend to be less favorable for the VDT users. So too do staff and supervisory support, elements of the social support measure. Exaggeration of these differences would lead to greater dissatisfaction among VDT users.

Results of the Mood Disturbance Regressions

The same regressors and regression procedures were used in these analyses as for the regression of the job dissatisfaction measure. As shown in Table 31, the fits of the final predictive models obtained are not as good as in the prediction of job dissatisfaction. That is, less than 30 percent of the variance in the mood disturbance measure is explained. The adjusted R^2 for the model without the programmer and professional status classifications is 0.262. With these classifications included, a slight increase to 0.273 is seen, but no change occurs with the addition of the marital status variable. Actually, we expected a poorer fit in the prediction of the mood disturbance measure (as well as in the prediction of the illness symptoms measure) than in the prediction of the job dissatisfaction measure because the regressors

Table 31. Results of the Mood Disturbance regressions.

Programmer and professional status indicators not included in the model:

Variables remaining in final model	Reg. coef.	Standardized reg. coef.	Partial correl. coef.	Sig. level
Social support	2.206	1.113	.255	.001
VDT Use	-18.914	-1.677	-.200	.002
Job Demands ÷ Social Support	-12.070	-.396	-.155	.016
Environmental Problems ÷ Social Support	30.046	1.039	.291	.000
Social Support x Future Certainty	-.037	-.533	-.288	.000
VDT Use x Job Demands	.769	1.582	.186	.004
Age ÷ Environmental Problems	10.573	1.236	.216	.001
Age x Social Support	-.032	-1.521	-.259	.000
Variables stepping out of the model				
Job Demands	-	-	.109	.089
Job Control	-	-	.048	.453
Future Certainty	-	-	.109	.090
Environmental Problems	-	-	-.034	.599
Machine Time	-	-	-.064	.317
Age	-	-	-.046	.479
Job Control ÷ Environmental Problems (relative excess UP interaction)	-	-	.024	.715

$R = .534$
R^2 (adjusted) $= .262$

Table 31 continued.

Programmer and professional status indicators included in the model:

Variables remaining in final model	Reg. coef.	Standardized reg. coef.	Partial correl. coef.	Sig. level
Social Support	1.953	.985	.225	.000
Professional Status	21.383	1.778	.143	.026
VDT Use	-16.566	-1.469	-.175	.0063
Job Demands ÷ Social Support	-11.030	-.362	-.141	.028
Environmental Problems ÷ Social Support	27.360	.946	.265	.000
Social Support x Future Certainty	-.031	-.443	-.229	.000
VDT use x Job Demands	.671	1.380	.162	.012
Age ÷ Environmental Problems	9.000	1.052	.183	.004
Age x Social Support	-.028	-1.353	-.230	.000
Professional Status x Future Certainty	-.991	-1.729	-.139	.031
Variables stepping out of final model				
Job Control	-	-	.032	.626
Job Demands	-	-	.102	.115
Future Certainty	-	-	.126	.050
Environmental Problems	-	-	.019	.766
Machine Time	-	-	-.032	.626
Age	-	-	-.076	.242
Programmers	-	-	-.035	.588

$R = .549$
R^2 (adjusted) = .273

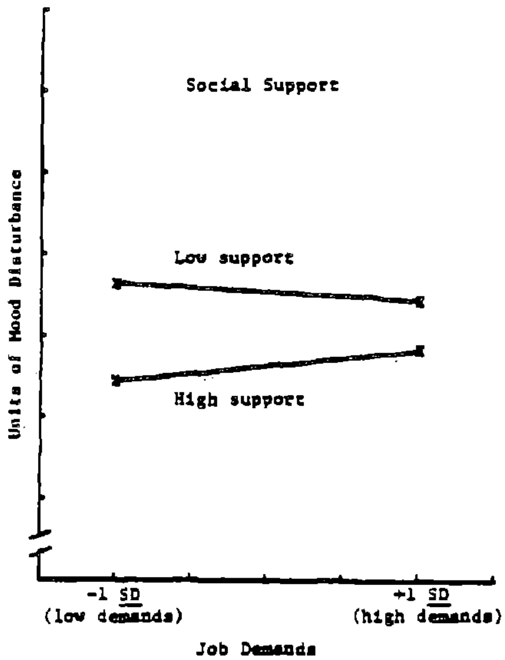
considered in the present set of analyses are predominantly job related, as is job dissatisfaction by definition job related, whereas disturbances of mood and physical health are intrinsically less so. In this regard, it is of interest that when age is removed from the mood disturbance model to examine the influence of variables intrinsic to the job, the explanatory power is rather severely affected. A drop in the explained variance to about 0.17 is seen.

Regression diagnostics show the model to be relatively stable. Studentized residuals for the predicted values exceeded 2.0 in nine cases, and 3.0 in four cases. Leverage or influence values beyond the criterion of 0.096 were found for nine observations. Ten cases have covariance ratios less than 0.9.

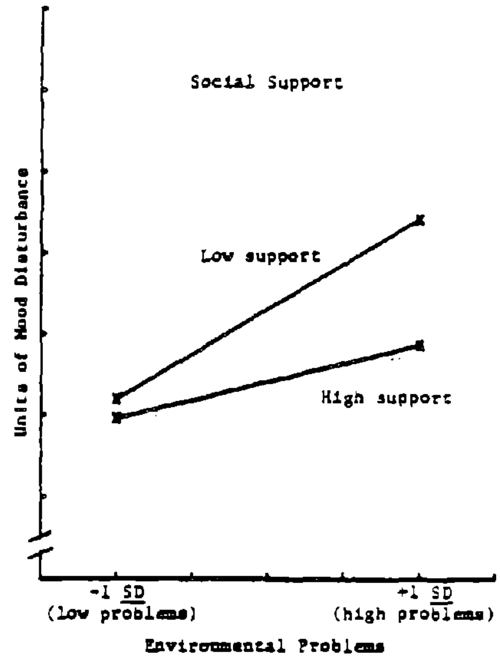
The model described in Table 30 shows that the prediction of mood disturbances is dominated by interaction effects. Perhaps the most important feature of this model is that VDT use is shown to be negatively related to the mood disturbance measure. This means that there is some aspect of VDT use or of VDT users beyond effects attributed to other causal variables considered here which is associated with improved affective states among VDT users. This finding runs contrary to the supposition that VDT use is a source of psychological strain considered in terms of affective impairment. This trend is reflected also in the univariate group comparisons for the present study. Table 21 indicates that the VDT users in comparison to non-users tended to report less overall mood disturbance and no greater disturbance on any of the six mood disturbance subscales of the POMS, although none of the group differences are statistically significant. Also, Table 23, showing group differences on behavioral-autonomic disturbance items, indicates significantly increased reporting of several symptoms of stress among non-users.

Previous findings pertinent to psychological strain incident to VDTs are inconsistent. Some research shows favorable reactions to the implementation of VDTs in office workplaces. Johansson and Aronsson (1980) reported that none of the VDT users surveyed at Skandia Insurance preferred to revert to the more conventional mode of information management. The same was true for the information typists studied by von Schmude (Cakir et al., 1978). However, Johansson and Aronsson (1981) also reported that the users perceive greater "mental strain" subsequent to the transition to VDT jobs. Positive reactions in terms of job facilitation were noted by Gunnarsson and Ostberg (1977) in their investigation in the Scandinavian Airlines system. Even in the NIOSH (Smith et al., 1981) study which showed dramatic differences between VDT users and non-users in terms of health and job complaints (some of an affective/psychosomatic nature), a significant difference between users and non-users was found for only one dimension of affective disturbance (increased fatigue among users) using the same index (POMS) as used in the present investigation. The recent Canadian Labour Congress (1982) investigation provided evidence of increased affective and behavioral disturbances among VDT users.

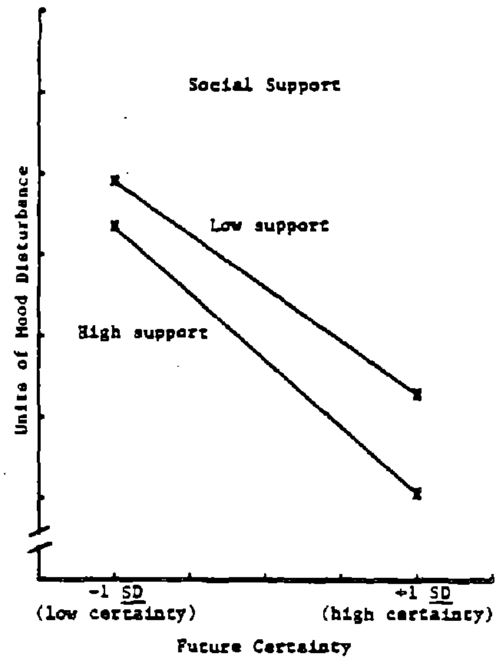
In considering the relationship between VDT use and mood status in the present study, however, attention must also be drawn to the fact that a fairly strong interaction exists between the VDT use and the job demands variables. This interaction (which is negative) tempers the positive effect of VDT use quite a bit (Figure 7, Panel 4). The effect is that increases in



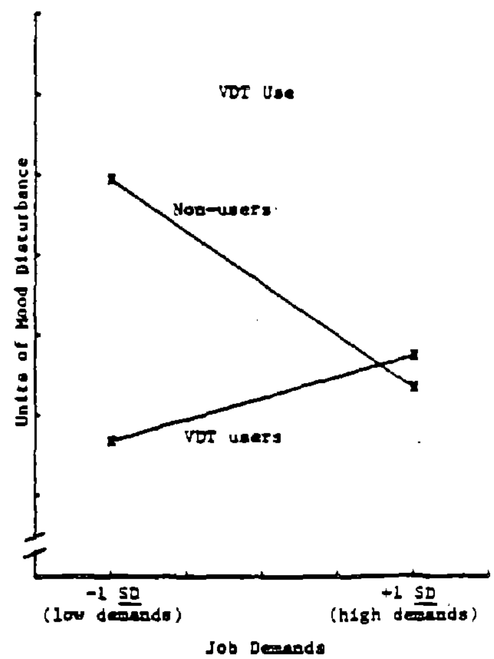
Panel 1. The interaction of social support and job demands in predicting mood disturbances.



Panel 2. The interaction of social support and environmental problems in predicting mood disturbance.

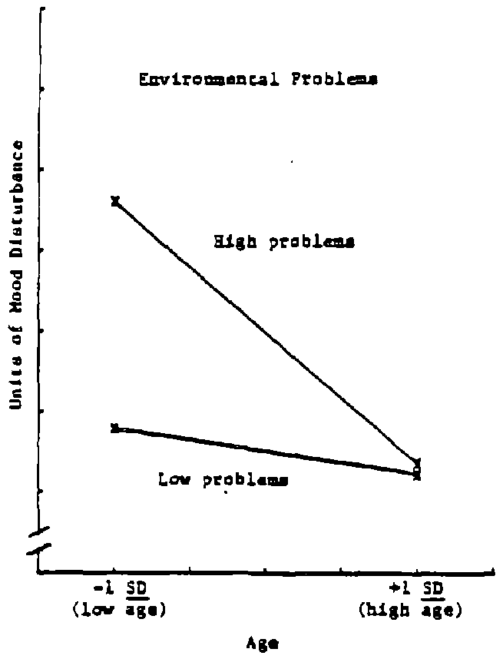


Panel 3. The interaction of social support and future certainty in predicting mood disturbances.

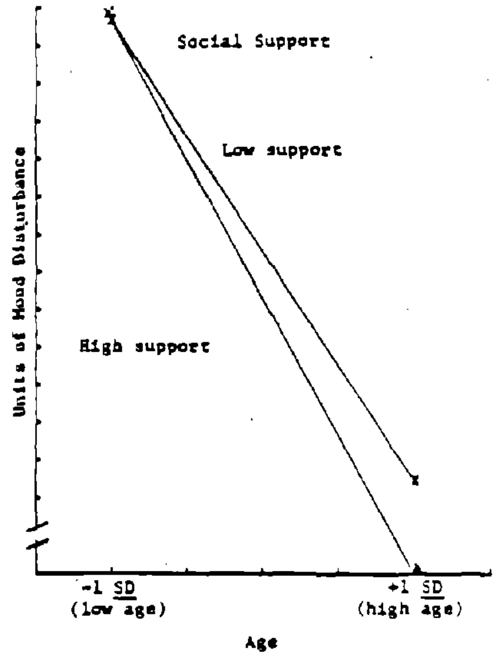


Panel 4. The interaction of VDT use and job demands in predicting mood disturbances

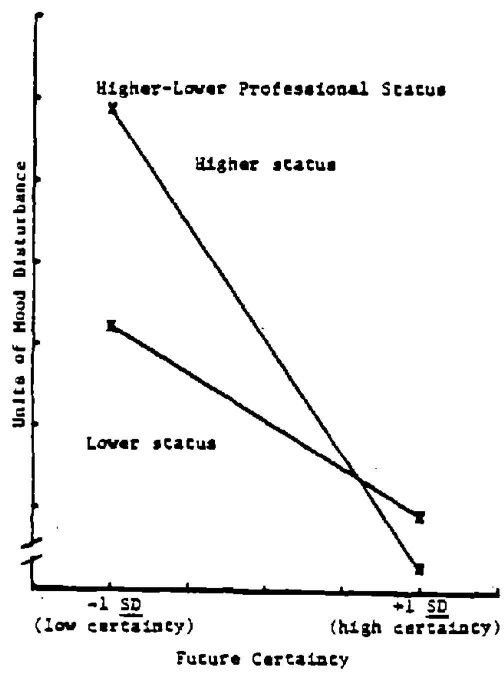
Figure 7. Plots of interactions in the prediction of Mood Disturbance (Panel 8 shows predicted effects of variation in Social Support).



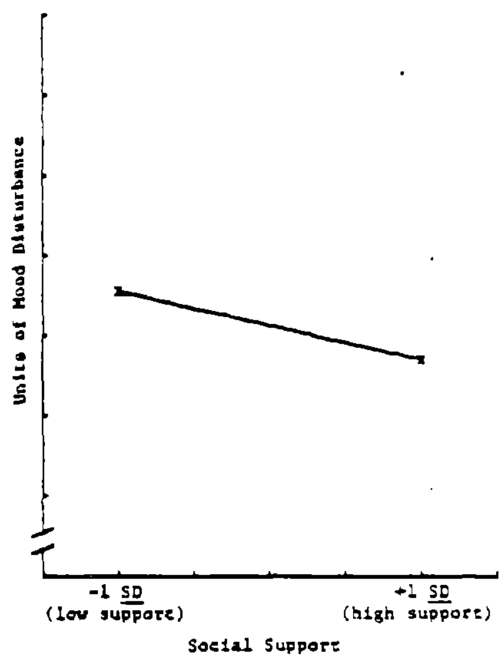
Panel 5. The interaction of environmental problems and age in predicting mood disturbances.



Panel 6. The interaction of social support and age in predicting mood disturbances.



Panel 7. The interactions of higher-lower professional status and future certainty in predicting mood disturbances.



Panel 8. The effect of increasing social support on mood disturbances.

Figure 7 continued.

job demands tend to predict increased mood disturbance in VDT users, but the opposite occurs for non-users. This is the only instance in this entire set of analyses where there exists a differential impact between VDT users and non-users of working conditions on strain.

The only other significant main effect in the prediction of mood disturbance in the present model is social support. At first glance the effect appears to be counter-intuitive and contrary to experience. That is, the relationship is positive suggesting that an improved social climate leads to heightened affective disturbances. This same type of relationship is observed further on in the prediction of illness symptoms. However, the effect of variation in social support cannot be ascertained without considering the interaction effects involving the social support variable. It is of interest that when values of social support are increased from -1 to +1 standard deviation from the mean holding values of all other variables constant at the mean (depicting the effect for the average person) the result is a sizeable net drop in mood disturbances (using the coefficients for social support and the social support interaction terms provided in the model in Table 31). This effect is shown in Figure 7, Panel 8. The same phenomenon occurs in the prediction of illness symptoms. The tendency towards improved moods with increases in social support can also be seen in Panels 1-3 of Figure 7 which shows plots of the social support interactions produced by varying social support as described above and varying its interacting variables in the same way (+1 and -1 standard deviation from the mean, again holding all other variables constant at the mean). Table 29 shows the simple relationship of social support with mood disturbances to be negative.

In further examining the interaction effects in the mood disturbance model, several observations are particularly notable. First is that so many of the interactions (4) involve the social support variable. Prior research (House and Wells, 1978; LaRocco et al., 1980) has strongly implicated social support as a moderator of stress-strain relationships via interactions with stressor variables. In the study by LaRocco et al. (1980), these effects were found to be more prevalent for strains characterized by affective disturbances (e.g. irritation, anxiety, boredom) than job dissatisfaction or somatic complaints, although House and Wells (1978) reported moderating effects for many physical disorders. Thus, the relatively large number of interactions involving the social support variable observed here in the prediction of mood disturbances is not unexpected and consistent to a degree with prior research. Note that no interactions of social support with other predictors occurred in the prediction of job dissatisfaction, and it will be shown that only one is of significance in the prediction of illness symptoms.

The moderating hypothesis for social support posits that the stress attenuating influence of social support will be most pronounced at high levels of the stressor it interacts with. That is, the beneficial effects of social support on well-being would be observed only under conditions where stress is likely. Inspection of the interaction plots involving the social support variable for the mood disturbance model seem to provide only limited evidence of such an effect. According to this prescription, social support clearly moderates only the effects of increasing environmental problems (Figure 7, Panel 2). That is, strain is attenuated more by social support at higher levels of environmental problems. In the age, job demands, and future certainty interactions, social support seems to be more important at levels of these variables which are least stressful (Figure 7, Panels 6, 1, and 3 respectively. However, when we re-analyzed the current data examining the interactions of social support with each of these variables (age, demands, and future certainty) singularly in different models along with the main effect terms for the interacting variables (consistent with prior methodologies for examining potential moderating effects of social support), plots showed that indeed social support moderates the effects of job demands as well. Thus, the ambiguity of the present model regarding moderating effects of social support may be in part a function of our analytical approach which adjusts concurrently for job dimensions not considered in prior research examining the moderating effects of social support.

A second observation of importance in the interaction plots is that the age, environmental problems, and future certainty variables are all seen to exert an influence similar to that seen for the prediction of job dissatisfaction, although none have a significant main (linear) effect. The trend for both the environmental problems and future certainty variables are consistent with expectations (i.e. increasing mood disturbance with increasing environmental problems and decreasing future certainty, [Figure 7, Panels 2 and 5, and 3 and 7 respectively]). The nature of the age by environmental problems interaction is also the same as in the prediction of job dissatisfaction (Figure 7, Panel 5), with age moderating strain associated with increasing environmental problems.

Finally, it is of some interest that one of the "second type" of interaction terms (job control by environmental problems UP) survived the preliminary stepping, but it was not strong enough to attain significance in the final model. In fact, this is the only instance in this entire set of analyses where an interaction formed in this fashion was strong enough to be considered in the final models. It is perhaps noteworthy that the effect involved the job control variable. The result was disappointing, however, considering that we felt there were fairly strong empirical and theoretical grounds for evaluating these types of interactions.

Despite the fact that the models predicting mood disturbance shown in Table 31 are readily interpretable and generally consistent with expectations, we were somewhat disconcerted with the complicated causal process suggested. Further, as would be expected, regression coefficients for some of the terms which share variables tend to be fairly strongly correlated. For these reasons, an extensive series of regression analyses were undertaken in an attempt to produce a more parsimonious model for the prediction of mood disturbances. One of the approaches taken was to lock into the model the main effect terms that were involved in interactions with which they were strongly correlated. Another was to include in the model only the main effect terms. Neither of these solutions nor any other attempt resulted in an improvement in the fit or interpretability of the model. In the "main effects only" model, the future certainty, environmental problems, and age variables did attain significance, and the influence was consistent with the trends exhibited in the interactions described above, but the overall fit of the model dropped by about one-third. Of interest relative to the previously discussed issue of the positive main effect of social support on mood disturbance, in the "main effects only" model the influence of social support was reversed (i.e. increasing social support predicted decreased mood disturbance).

Effect of Including the Professional Status Variable--
As in the prediction of job dissatisfaction, the addition of the programmer and professional status variables to the set of regressors for the prediction of mood disturbances resulted in a very modest increase in the fit of the model (R^2 = .301), with no substantive change in the influence of the variables in the original model (Table 31, second part). Also, the tendency toward increased strain among the more professional workers is again observed with a significant main effect of the higher professional status indicator. In addition, an interaction of the professional status variable with the future certainty variable similar to that seen in the prediction of job dissatisfaction is also observed (Figure 7 Panel 7).

Again, although a tenable interpretation of the professional status effect similar to that given in the discussion for the job dissatisfaction regression can be offered, we view these particular findings as requiring further investigation. Previous VDT research provides little evidence of increased psychological strain among professional users, although both Cakir et al. (1978) and Coe et al. (1980) reported findings suggesting elevated strain among editors.

Effects of including the marital status variable--
The previous evaluation of worker characteristics in relation to strains showed that marital status is significantly associated with the mood disturbance measure. Individuals who are unmarried appear to be at greater risk for mood disturbances. There is no indication of a differential effect between VDT users and non-users. However, unlike in the job dissatisfaction regression and in the illness symptoms regression reported further on, marital status failed to achieve significance when added as a regressor with the other predictors in the mood disturbances model (p = .07).

Summary and Conclusions--
The present analyses together with the univariate group comparisons indicate reduced mood impairment with VDT use. Since this effect is present after adjusting for influential individual variables and working conditions, the inference is that there is some aspect of VDT usage (or conditions associated with VDT usage or VDT users that we have not considered), that leads to improved affective states among users. Further investigation is needed to identify the source(s) of the effect. On the other hand, the data shows an adverse effect of VDT usage on moods related to an increase in strain with increasing job demands which occurs for VDT users only.

While job stress is sometimes cited as a risk of VDT use, particularly in the lay literature, there is no conclusive evidence that VDT use is associated with comparatively abnormal levels of psychological strain. This is nowhere more apparent than in the NIOSH (Smith et al., 1981) investigation, where clerical VDT users seemed under particular duress in their jobs, yet affective disturbances as measured by the Profile of Mood States instrument were greater for the clerical users on only the fatigue subscale. Several other studies have provided evidence of impaired affective states among VDT users, particularly in relation to the work period and the type of VDT work performed (Cakir et al., 1978; Dainoff et al., 1981; Elias et al., 1980;

Ghiringhelli, 1980; Haider et al., 1980), but comparisons with non-users were either not drawn or described in only a limited way.

The distinction must be made between psychological strain, and stress in terms of the perception of adverse working conditions. Stress in this sense would seem to be more prevalent among the present VDT users (i.e. they report less job control, staff-supervisory support, and greater environmental problems). Some of these conditions may lead to psychological strain (the present model provides a template), but as mentioned, evidence of comparatively abnormal levels of emotional debilities or affective disturbances among VDT users is scarce or ambiguous. The Canadian Labour Congress (1982) study reported a greater incidence of fatigue, irritability, headaches, sleeplessness, loss of appetitie, and dizziness (all labeled as "stress-related" problems) among VDT users than non-users. Smith et al (1981) also report a greater incidence of irritability, nervousness, and fatigue among users, but these findings stand in contrast to the general null effects on the Profile of Mood States instrument.

Despite the favorable predictive impact of VDT use on the affective status of users, the present findings raise some concern. This concern centers around the pervasive role that the social environment plays in the present model, coupled with limited evidence that computerization may potentially have a disruptive influence on the social environment in office workplaces. In the present study, univariate group comparisons suggest an adverse impact on staff and supervisory support (Tables 19, 22). Turner and Karásek (1983) describe how computerization may disrupt social structures in workplaces by creating new dependencies between operators, system support staff, and systems hardware and software. The implication of the current model is that these effects hold the potential for a negative impact on the psychological well-being of VDT users.

Results of the Illness Symptoms Regression

The same variables and regression techniques used in the prediction of job dissatisfaction and mood disturbance were used in the prediction of the illness symptoms measure. The results are shown in Table 32. The basic final model accounts for twenty-nine percent of the variance in the illness symptoms measure. When the age variable is removed from this model to identify the variance explained by primarily job related conditions, the R^2 drops by about six percentage points.

Regression diagnostics indicate a stable model. Of the 251 cases, eleven of the predicted values for illness symptoms are in excess of two standard deviations from actual values, and only one has a standardized residual greater than 3.0. Just six observations have leverage values in excess of the critical level (0.072) indicating excessive influence on the values predicted. Only one case had a covariance ratio of less than 0.9. However, as would be expected, correlations among the coefficients for the interactions and main effects of their component terms are quite strong.

Inspection of the basic model shown in Table 32 shows significant main effects of the social support, job demands, future certainty, and age variables. For the job demands variable, the effect is consistent with expectations. Increases in demands are associated with increased health

Table 32. Results of the Illness Symptoms regressions.

Programmer and professional status indicators not included in the model:

Variables remaining in final model	Reg. coef.	Standardized reg. coef.	Partial correl. coef.	Sig. level
Social support	.989	.657	.273	.000
Job Demands	.329	.208	.217	.001
Future Certainty	-.618	-.274	-.286	.000
Age	-.496	-1.366	-.244	.000
Environmental Problems ÷ Social Support	25.968	1.183	.328	.000
Age ÷ Environmental Problems	7.977	1.228	.214	.001
Variables stepping out of final model				
Job Control	-	-	.007	.911
Environmental Problems	-	-	.036	.575
Machine Time	-	-	-.022	.731
Treatment	-	-	-.080	.210

$R = .550$
R^2 (adjusted) $= .285$

Table 32 continued.

Programmer and professional status indicators included in the model:

Variables remaining in final model	Reg. coef.	Standardized reg. coef.	Partial correl. coef.	Sig. level
Social Support	1.007	.669	.281	.000
Job Demands	.349	.220	.229	.000
Future Certainty	-.490	-.217	-.219	.001
Age	-.551	-1.406	-.254	.000
Professional Status	15.680	1.717	.144	.024
Environmental Problems ÷ Social Support	26.166	1.192	.334	.000
Age ÷ Environmental Problems	8.282	1.275	.225	.000
Professional Status x Future Certainty	-.784	-1.800	-.151	.018
Variables stepping out of the final model				
Job Control	-	-	.032	.619
Environmental Problems	-	-	.044	.497
Machine Time	-	-	-.056	.385
Programmers	-	-	-.033	.614

$R = .568$
R^2 (adjusted) $= .301$

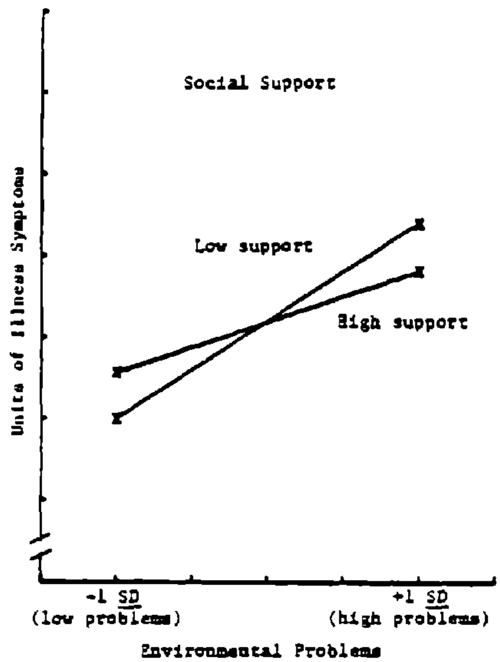
complaints. The same is true for the job/skill future certainty variable. In neither case is the effect significantly different for VDT users than non-users (i.e. VDT use interaction terms stepped out of the model). The effect of job demands seems especially predictable. Work tasks for many of the types of jobs studied, particularly in the lower professional groups (e.g. data entry and word processing), involve fairly stereotypic, repetitive, sensory-motor activity. Increases in job demands would serve as a direct source of physical stress to these systems.

As in the prediction of mood disturbances, the association of the social support variable with the illness symptoms measure is positive. However, the effect indicated is counteracted by the strong interaction between the social support and environmental problems variable. In fact, for individuals with average levels of environmental problems (i.e. holding the environmental problems variable constant at the mean), the effect of increasing social support from -1 to +1 standard deviation from the mean is a slight decline in strain using the coefficients given in the model (Figure 8, Panel 4). Note, too (Table 29), that the simple relationship between the social support and illness symptoms variables is negative. When the social support interaction term is removed from the model, the coefficient for the main effect is in fact negative, but not significant.

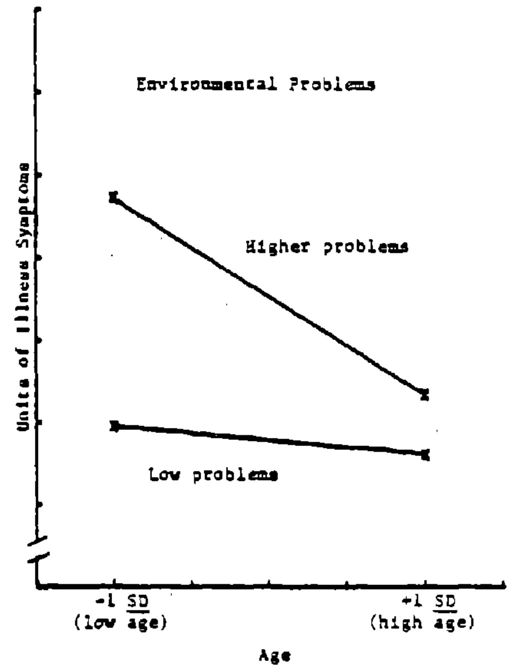
It may appear puzzling that the current model shows no significant main effect of environmental problems. Of the factors considered, this variable would seem to be one of the most likely to be a predictor of physical strain symptoms. In fact, a positive association with strain is indeed observed upon inspection of the plots of the interaction effects involving the environmental problems variables (Figure 8, panels 1 and 2). The effect just is not linear.

Again, a relationship of age with the reporting of symptoms of physical health impairment that is negative is observed as a significant main effect. Even after considering attenuation of this effect via the age by environmental problems interaction, there is still a fairly pronounced decline in the illness symptoms measure with increased age. As with the relationship between age and job dissatisfaction, a tendency toward a curvilinear effect was observed both in examination of a scatterplot of age by illness scores, and in the regression residual plots. Illness symptoms scores decline steadily until ages in the mid-to-late 30's, after which scores tend to stabilize. The effect is shown for VDT users in Figure 6. Still, the model was not improved with the addition or substitution of an age quadratic term.

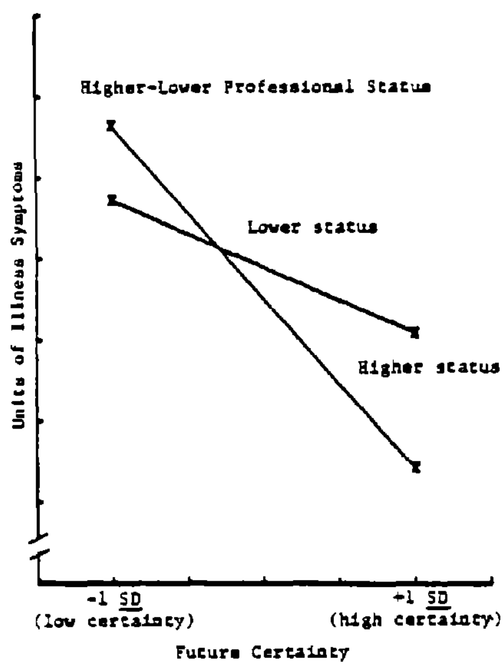
Despite the fact that the age strain relationship observed here is consistent with similar associations reported by Ghiringhelli (1980) and Starr et al. (1983), and that no connection was observed between age and health indicators in the recent Canadian Labor Congress (1982) study, we were still somewhat concerned over the trend observed in the present data. The implication is that older workers are less at risk for the physical strains of office work. While there may be little rationale for expecting any dramatic increases in physical disorders and complaints over the age range for workers in the current sample (the fourth quartile begins at only age 39), an opposite trend which is consistently appearing in VDT research seems unlikely considering the decline in physical resources and increase in chronic disorders often



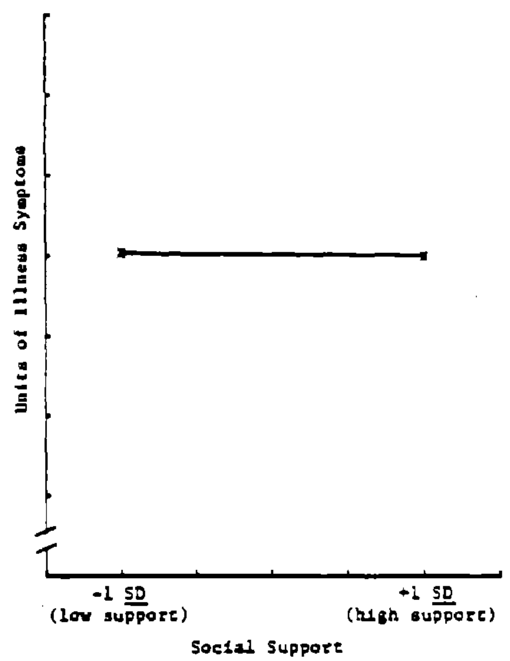
Panel 1. The interaction of social support and environmental problems in predicting illness symptoms.



Panel 2. The interaction of environmental problems and age in predicting illness symptoms.



Panel 3. The interaction of higher-lower professional status and future certainty in predicting illness symptoms.



Panel 4. The effect of increasing social support on illness symptoms.

Figure 5. Plots of interactions in the prediction of Illness Symptoms (Panel 4 shows predicted effects of variation in Social Support).

associated with increasing age. It is perhaps worthwhile to mention at this point, however, that in the Caplan et al. (1975) investigation of workers in 23 different occupations, age tended to be negatively correlated (but only slightly so) with certain physical strain indices (e.g. somatic complaints and dispensary visits). Again we feel the most likely explanation for this trend is a possible "healthy worker effect"; that is, selective attrition of workers from the current population based upon expected or perceived strains. Unfortunately, the cross-sectional nature of the current study allows little further resolution of this issue.

One alternate possibility explored was that perhaps the aggregate nature of the illness symptoms measure obscures strong relationships of specific physical strains with age. To investigate this possibility, the association between age and the reporting of each of the items comprising the illness symptoms measure was examined. Significant positive correlations (rho, $p < .05$) were observed for only a few items indicative of upper respiratory disorders and lower gastro-intestinal disorders (both of these trends were also observed by Caplan et al., 1975), and loss of physical strength. However, significant negative associations were far more prevalent and well distributed among all the major categories of strain represented in the illness symptoms measure. In fact, age is shown in regression analyses (reported further on) aimed at explaining specific physical strains to be a significant predictor of visuo-ocular impairment. Again the effect was negative.

While we tentatively posit a "healthy worker" explanation for these findings, clearly more investigation is necessary before conclusions regarding the health implications of age in office and VDT work can be drawn.

Perhaps as important or more so than the significant associations with the illness symptoms measure in the current model are the effects which failed to attain significance. In particular, the extent of daily use of office machines does not contribute significantly to the explanation of variance in the illness symptoms measure after adjusting for effects of other variables in the model. The effect is not even close to significant. Neither is there a meaningful simple relationship (Table 29). Further, this variable does not interact with VDT use; that is, there is no differential influence of the machine time variable for VDT users and non-users.

As with the age effect, we were also concerned that important effects related to increasing daily use of office machines or VDTs might be obscured by the aggregate nature of the strain index. To explore this possibility further, we first examined the associations between the number of hours spent daily operating a VDT and all of the 59 specific symptoms comprising the general illness symptoms inventory for the entire sample of VDT users. Significant positive correlations (rho, $p < .05$) were observed in only five cases, and three of these were so marginal that it is likely they would be rendered nonsignificant after adjusting for multiple comparisons. Pearson product moment correlations with visuo-ocular, behavioral autonomic, and the musculo-skeletal postural and manipulative strain scores were also small (the coefficients for the regression sample were .075, -.084, -.083, and .013 respectively). In addition, extent of daily VDT use did not correlate meaningfully with reports of disturbances by the physical configuration of the VDT workstation, display characteristics, or environmental lighting (i.e.

the workstation/VDT problems scale, the VDT display problems scale, and the environmental lighting problems scale).

The same types of relationships were than examined for the non-users (except the correlations were between the machine time variable and symptom frequencies and strain scale scores). Interestingly, significant associations were somewhat more prevalent. Of particular interest, significant correlations were found with reports of back pain (rho = .33, $p < .01$) and burning eyes (rho = .29, $p < .01$), and machine time was also significantly correlated with the manipulative strain index ($r = .27$, $p < .05$).

These findings may seem at variance with prior data on this subject. In fact, the existing data linking physical strains to the VDT work period are limited and ambiguous. Research by Dainoff (1981) showed a fairly dramatic increase in the number of individuals with vision related and musculo-skeletal complaints over the course of the workday, but only a modest correlation (rho = .19) of VDT time with a physical/mental stress scale. Smith et al. (1981) reported the same magnitude of association between the total number of health complaints and number of VDT hours per day. Laboratory studies by Holler et al. (1975) and Haider et al. (1980), and and field research by Gunnarsson and Soderberg (1979) have provided objective evidence of a positive association of visual strain/impairment with the VDT work period, but Smith (1982) reportd that in preliminary analyses of data collected in a recent NIOSH field investigation at a major U.S. newspaper, no relationship was observed between the prevalence of eye abnormalities and daily hours of VDT use. Dainoff et al. (1981) found no evidence of change in objective optometric measures for VDT users over the course of a workday. Gould et al. (1983) observed a slight but significant drop in far visual acuity, but no change in near visual acuity for VDT users over the course of a work day. The recent Canadian Labor Congress Study describes a very pronounced increase in reported physical strain with increasing daily VDT use, but Ghiringhelli (1980) reports just the opposite. However, in neither study were the effects isolated from potential effects of other possible stress factors. Cakir et al. (1978) described an increase in physical strains with increasing time spent at VDT tasks, but they were reluctant on the basis of their data to propose regulation of work time, opting instead for job re-organization to control these problems (page 200).

The implications of the present data are consistent with the perspective of Cakir et al. (1978). Physical and organizational characteristics of the workplace seem to be more important determinants of reported physical strain in office and VDT work than simply the number of hours spent working at office machines.

Of some concern was the fact that the job control variable failed to attain significance as a predictor of the illness symptoms measure. The simple correlation is significant ($r = -.192$, $p < .01$). Two recent studies (Karasek, 1979; Karasek et al., 1981) provide fairly strong evidence that work which allows high levels of individual decision latitude has a mitigating influence on the development of health disorders. Alternate regressions were conducted with the job control variable locked into the model. These analyses resulted in models which included a significant main effect of the job control variable, but not of the social support or future certainty variables (note that these two variables are fairly strongly correlated with the job control variable [Table 29]). However the effects of social support and future certainty were manifest in terms of additional interaction terms involving these variables which attained significance, and the main effect of job control was nearly negated by the interaction of the job control variable with other variables. Explanatory power did not change. In the interests of parsimony, we rejected these alternate models in favor of the present models shown in Table 32, and concluded that while job control seems to play a role in the prediction of illness symptoms, its influence seems to be of little consequence after adjusting for the effects of the other work related variables considered in the analyses.

Finally, it is again the case that knowing whether or not an individual is a VDT user is of no statistical significance in predicting reported illness symptoms.

Effects of Including the Professional Status Variable--
Re-analysis including programmers and the professional status indicator and its interactions with all other variables in the model resulted in significant effects of the professional status indicator and its interaction with the future certainty variable (Table 32, second part). The structure of the final model was otherwise unchanged from as described above. The variance explained is increased, but almost negligibly so (R^2 = 0.301). Again, an adverse effect related to more professional work was indicated, but when the effects of the interaction term are considered, the more professional workers are associated with lower predicted illness symptom scores at mean levels of the future certainty variable. Re-analysis locking the professional status indicator into the model and excluding the interaction term does, in fact, result in a negative coefficient for the professional status indicator (indicating less strain for the more professional workers), but the effect is nonsignificant. This tendency is consistent with a lower incidence of somatic complaints among the more professional VDT users studied by Smith et al. (1981), and Coe et al. (1980).

Effect of Including the Marital Status Variable--
Locking the marital status variable into the regression model along with the significant variables described above resulted in an improved model for predicting illness symptoms. The standardized regression coefficient and partial correlation were -0.205 and -0.233 respectively. The structure of the model is unchanged with no dramatic alterations in predictive power of other variables. Variance explained rises by over three percentage points to 33.6 percent. The negative coefficient indicates that classification as married is associated with lower scores on the illness symptoms measure.

Summary and Conclusions--
The data show that psychosocial and physical attributes of the job, workload demands, as well as individual worker characteristics are all important determinants of reported illness symptoms among the office workers studied.

Whether or not jobs involved the use of VDTs, however, appears to be of no consequence in predicting health outcomes. That is, working conditions and worker characteristics were associated with strain for the VDT users no differently than for the non-users. There was no predictive influence of VDT use on reported strain beyond effects related to factors that were examined.

Again, this does not guarantee that health disorders are not likely to develop among VDT users - only that the mechanisms appear much the same for VDT users and non-users alike. To the extent that the factors shown to be significant predictors of strain vary between users and non-users, differential levels of strain are likely to be experienced. In this regard, it should be emphasized that the current VDT user sample tended to report a more impoverished physical and social (supervisory-staff support only) work environment than did the non-users. According to the model, this would tend to promote strain among users. However no differences existed for other important predictors (job demands, job/skill future certainty, age).

One of the most important observations in the present analyses is that the machine time variable (hours daily VDT/office machine use) does not contribute to the explanation of reported illness symptoms. While it doesn't seem reasonable to conclude that the extent of daily use of VDTs and office machines is not at all instrumental in producing somatic strains, the present data suggest other job attributes are far more important among the present population. The implication of these data is that a narrow focus on this parameter alone as a strain control measure is unlikely to be effective.

Finally, the findings tend to suggest that although individual characteristics are potent indicators of strain expressions in office workers, their influence is superceded considerably by job conditions (age and marital status together account for less than 30 percent of the explained variance).

Results of the Simultaneous Analyses

Occupational strain manifest as job dissatisfaction or affective disturbances may progress to poor health and illness. In the automated officeplace, an interesting twist to this causal sequence is highlighted. Specifically, the experience or perception of potential health problems related to VDT use in turn seems to be shaping users' attitudes and behavioral and psychological reactions to their jobs. That is, a reciprocal effect occurs, with real or potential health outcomes causing stress and strain. In our laboratory for example, we receive several inquiries weekly from VDT users who are clearly distraught or agitated over either physical health disturbances they are experiencing and which they attribute to their work, or over fears that VDTs will result in some form of impairment to their health. Fear of health impairment is also listed as a source of stress among VDT operators investigated by Ghiringelli (1980). This situation suggested to us that in the course of examining how different individual and job characteristics predict strains among VDT users, the effects of the strains, themselves, upon one another should be explored. It seems plausible, for example, that both affective disturbances as caused by perhaps an adverse work climate, and an increased experience of somatic disturbances self-attributed to the job might heighten job dissatisfaction. Symptoms of ill health might promote anxiety and related affective disturbances as suggested above. Increased dissatisfaction and mood disorders may result in behavioral adjustments which are unhealthy, or may influence physical health through psychosomatic mechanisms. In fact, the three types of strains considered in these analyses are fairly strongly intercorrelated (Table 29).

To allow the job dissatisfaction, mood disturbance, and illness symptoms indices to come into play as predictors of one another, and to consider their influence relative to the other independent variables in the models for the prediction of each of these strains, we entered (as regressors) into each of the final models just described the strain measures from the other two models. That is, the job dissatisfaction and mood disturbance measures were entered as regressors into the illness symptoms model, illness symptoms and mood disturbance into the job dissatisfaction model, and dissatisfaction and illness symptoms into the mood disturbance model. The models into which they were entered were the final models not including the programmer/professional status or marital status variables. These three models were then re-analyzed simultaneously. That is, the outcome strain measure for each model was regressed upon all of its predictors, including the strain measures from the other two models, but the three regressions were carried out concurrently so that effects in one model would be reflected in terms of dynamic changes in the other two models. Essentially, this procedure explores the entire causal system postulated in Figure 1. Explained in more concrete terms, each of the independent variables shown to the right in Figure 1 may influence each of the "dependent" variables shown to the left, but at the same time the "dependent" variables may also influence one another. The current simultaneous regression allows us to model this entire causal system.

The statistical package used in these analyses was SAS PROC SYSREG. A simple backward elimination procedure was used (p .05, out). After the first simultaneous solution, all three resulting regression equations were examined and the nonsignificant regressor with the lowest significance level in any of the equations was removed...not from the entire system (all of the equations in which it was included as predictor), but only from the equation in which it reached this low level of significance. The three resulting models were then re-analyzed simultaneously minus this regressor in one of the models, and again the least significant predictor variable in the resulting models was omitted. This process continued until all predictors in the resulting equations were significant. In all, thirteen steps were required.

Before discussing the results, we would like to mention that several alternate regression approaches were used to double-check the solution achieved via the simultaneous regression procedure. One involved the regression of each of the three strain measures simply upon the remaining two strain measures in separate analyses. In another, each strain measure was regressed in separate analyses upon a set of regressors which included the variables from its final predictive model plus the remaining two strain measures. The results failed to suggest any solution greatly at variance with the solution obtained with the simultaneous technique.

The final systems model obtained for predicting job dissatisfaction, mood disturbance, and illness symptoms is shown in Figure 9. Arrows pointing to each strain measure denote the variables from each of the final three equations which are significant predictors of these measures. Standardized regression coefficients and significance levels for each predictor are given in parentheses above each arrow. Variables and interaction terms without arrows are those which were significant in the preceding separate models predicting strain, but which were eliminated in the simultaneous regressions. The overall fit of the final systems model is adequate (adjusted $R^2 = .38$).

The systems model shows a few deviations from the singular solutions described previously in the prediction of strain. Of special interest is

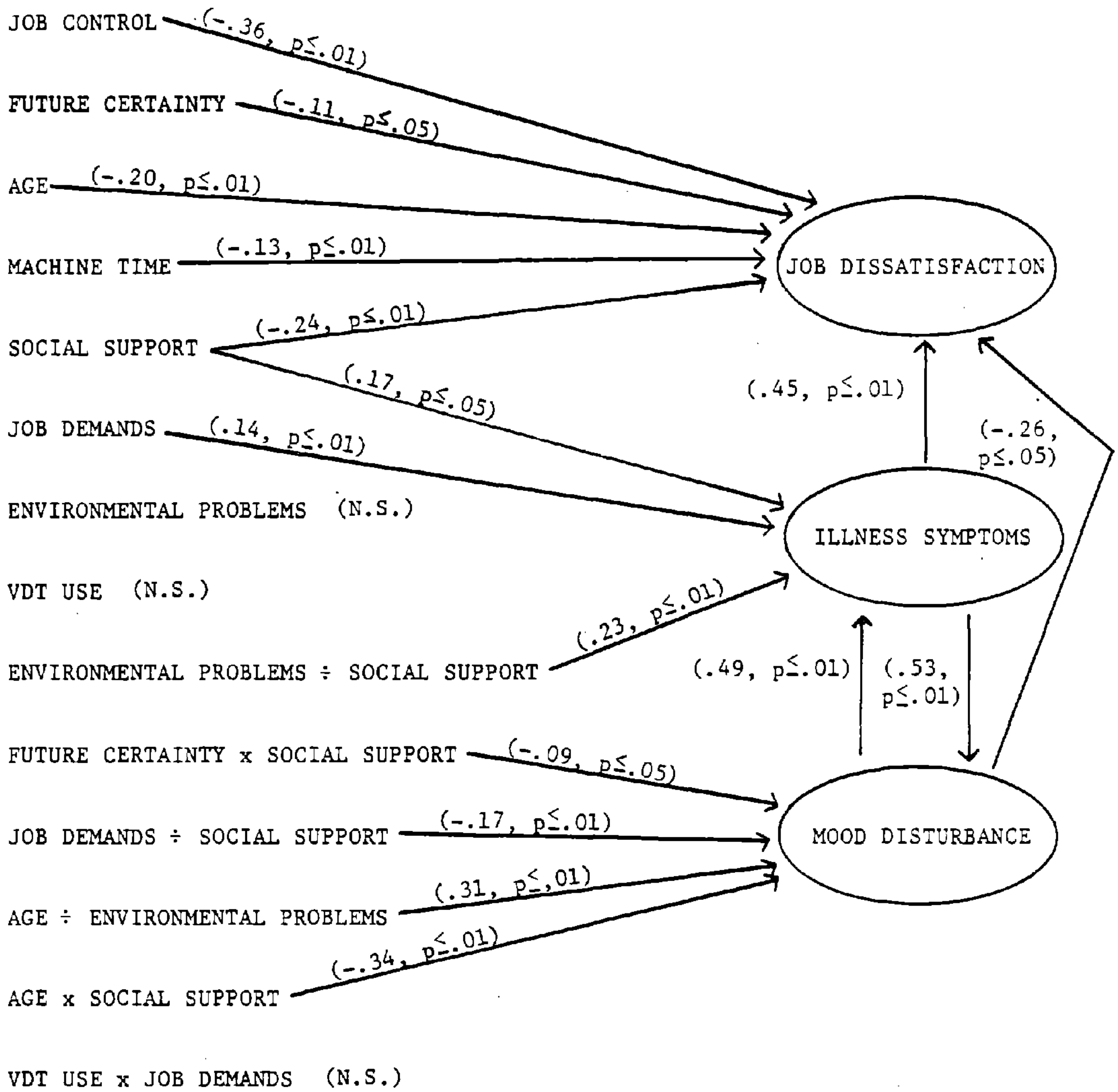


Figure 9. Results of the simultaneous (structural equation) analysis of the Mood Disturbance, Job Distress, and Illness Symptoms regression models.

that the VDT use variable and its interaction with job demands fail to attain significance in the system, tending to further depreciate the significance of VDT use per se as a predictor of strain.

The model may resolve a question arising from the singular strain models. Anecdotal data and some prior research suggest that increased workload demands incident to VDT use represent major job complaints of VDT users. In fact, work overload was listed as the number one cause of mental strain among the VDT users investigated by Johansson and Aronsson (1980). Smith et al. (1981) reported increased work pressure and quantitative workload (one of the two workload measures only) among clerical VDT users in comparison to clerical controls. Yet the present study shows a significant main effect of job demands on the illness symptoms measure only. Data from Caplan et al. (1975) also show a stronger relationship of workload demands with somatic complaints than with either job dissatisfaction or psychological strain indices. However, the current systems model shows that increases in illness symptom scores in turn predict increased job dissatisfaction as well as psychological strain. Intuitively, this would seem to be the primary mechanism by which job demands might result in job dissatisfaction or affective disturbances - that is, as a function of physical strain or functional impairment attributed to the demands.

However, the most important aspect of these analyses is the observation of predictive pathways among the strain measures themselves. As would be expected from the magnitudes of the simple correlations, the effects are quite substantial judging by the standardized regression coefficients. The reporting of illness symptoms is found to predict the reporting of both job dissatisfaction, and mood disturbances, and the mood disturbance measures is found to reciprocally predict the illness symptoms measure. However, job dissatisfaction predicts neither the reporting of mood disturbances nor illness symptoms. Some of these effects are consistent with speculation and limited prior data. The prediction of the illness symptoms measure by the mood disturbance measure supports the possibility raised by Dainoff et al. (1981) that the reporting of somatic complaints might be either exacerbated by, or in part a reflection of, psychological strain. The effect of the illness symptoms measure on both the mood disturbance and job dissatisfaction measure is consistent with Ghiringhelli's (1980) report and our suspicion that stress and strain in automated office work may be amplified by the experience or perception of potential physical health risks related to the job. Hunting et al. (1981) rule out job dissatisfaction as a cause of increased somatic strains among the VDT users they investigated (users and non-users were essentially equivalent in terms of satisfaction with various dimensions of the job), but they do not demonstrate that satisfaction is unrelated to the reporting of strains.

The negative association between the mood disturbance and job dissatisfaction measure is the one disconcerting result in this analysis, although the effect is the weakest of the associations among the strain measures. Without further probing of the data, compelling explanations for this unexpected effect are in short supply. Further investigation of the effect is needed.

Summary and Conclusions--

Taking the results of these analyses at face value, it might be inferred that certain strains experienced in VDT and office work mediate or compound the influence of job and worker attributes in the cause of other strains, and that the effects are quite strong. Specifically, job and worker characteristics are seen to be associated with the job dissatisfaction, mood disturbance, and illness symptoms measures, but the illness symptoms measure is also shown to predict the dissatisfaction and mood measure, and the mood measure to predict in turn the illness measure as well as the dissatisfaction measure. However, we urge caution in any inference of causation. The possibility exists that the predictive associations among strains may result less from true causal pathways then from a natural pattern of correlation among these variables related to their mutual causation by the types of independent variables examined in the present study, and/or lack of independence as a function of the way the strain variables are operationalized in the present study.

On the other hand, the predictive patterns produced by these analyses tend to be compatible with theory, and in the realm of VDT work, consistent with effects previously postulated (Dainoff et al., 1981) and documented to some degree (Ghiringhelli, 1980), and with our own anecdotal data. This tends to enhance the possibility of a causal mechanism. In addition, prior occupational stress research has also reported non-trivial relationships among these types of strain indices. For example, the correlations among somatic complaints, job dissatisfaction, and collectively, anxiety, irritation, and depression (psychological strains) in the Caplan et al. (1975) investigation range from about 0.2 to 0.5. The similarity with these data tends to discount the possibility that the predictive pathways observed are artifacts of the scale formation for the strain measures.

In light of prior data and theory, we feel the present results provide sufficient justification for a tentative conclusion that the interdependencies among strains in the present study reflect, in part, causal associations - particularly that psychological strains promote illness complaints, and that physical health strains are instrumental in promoting job dissatisfaction and psychological strain. However, further confirmatory investigation is warranted.

THE SPECIFIC WORK ENVIRONMENT AND HEALTH ANALYSES

Aim and Overview of the Analyses

Although the preceding analyses offer some insight into how general worker characteristics and workplace physical environmental and job design characteristics predict overall well-being in the current sample of VDT users and non-users, questions remain regarding the influence of specific aspects of VDT job and workplace design on specific somatic disturbances among VDT users. These questions are the focus of the current analyses. In these analyses, attention is turned to the relationships of eye and musculo-skeletal strains with operational aspects of VDT job tasks, and with specific ergonomic and physical design features and limitations of the VDT workstation and workplace environment. Specific worker characteristics such as corrective eyewear use, age, and working postures and anthropometric factors thought to be instrumental in evoking somatic disturbances are also investigated.

Causal relationships of many of these variables with eye and musculo-skeletal strain among VDT users have been indicated previously in numerous studies (Canadian Labor Congress, 1982; Cakir et al., 1978; Coe et al., 1980; Hunting et al., 1981; Laubli et al., 1981; Stammerjohn et al., 1981). In the present evaluations of these relationships, one goal was to improve upon the mainly piece-meal, bivariate analytical protocols of prior work which limit inferences regarding the attribution of strain. Our aim was to study concurrently select job operational and physical design features as well as VDT user characteristics for their prediction of reported somatic strains. In addition, we sought to explore relationships which have received insufficient attention or have not been unambiguously established at the time of inception of this study, but yet would have important implications (some already manifest in guidelines and recommendations) for job and workplace design to reduce strain in VDT work. Examples include the relationship of objectively quantified luminance and illumination levels and contrast ratios in the workplace with expressions of visual strain, the relationships of anthropometric angles and use of a detachable keyboard with musculo-skeletal strains, and the association of corrective eyewear use and eyewear type with eye discomfort as reported by Cakir et al. (1978). However, since our planning of these analyses, some further data on all of these issues have emerged (e.g. Laubli et al., 1981; Hunting et al., 1981).

Determinants of disturbances denoted by the behavioral-autonomic strain index (denoting adverse emotional reactions, sleep disorders, tremulousness, symptoms of extreme sympathetic arousal, etc.) were not investigated in the present analyses. However, this measure is included in the correlation matrix (of job, worker, and strain measures) shown in Table 33, enabling some evaluation of its relationship with certain of the independent variables included in the present analyses. Determinants of behavioral-autonomic disturbances among VDT users will be assessed more systematically in future research from the present data base.

We began the present analyses by examining the relationships of reports of eye and musculo-skeletal strain among VDT users with the types of conditions designated above as they were <u>subjectively</u> assessed by the users through the questionnaire survey. As in the preceding evaluation of more general worker and workplace characteristics, multivariable regression techniques were used to investigate and prioritize effects in a systematic and controlled fashion. In these analyses, not only did we assess the influence of an array of specific operational and physical design features of the job on somatic strains, but we also examined the relative importance of these specific factors in relation to select, broader job attributes investigated in the preceding analyses. Separate regressions are carried out for prediction of the visuo-ocular strain measure and for the two measures of musculo-skeletal strain.

Our next step was to evaluate the relationships of worker reports of eye and musculo-skeletal strain with characteristics of workers and of workstations/places that could be objectively assessed. Both multiple regression and bivariate analytical techniques were used to examine these relationships. However, a relatively low sample size and strong associations among some of the predictor variables prohibited meaningful multivariable analyses, so only the bivariate associations are reported.

Although the emphasis in the current analyses is on the specific determinants of strain for VDT users only, analyses are also carried out to determine whether certain variables examined in relation to strain in the VDT user sample have a similar influence on reported strains in the non-user sample. Since some of the attributes of VDT work investigated do not have qualitatively close analogs in more conventional office work (e.g. video display quality, computer response delays, etc.), a systematic appraisal of effects of these types of conditions for users and non-users as conducted in the preceding more general work environment analyses was not possible.

Somatic Strains and the Subjective Environment

Criterion Strain Measures--

Separate regression analyses were carried out for the prediction of the visuo-ocular and two musculo-skeletal strain scales derived through factor analysis from the survey symptom inventories. The musculo-skeletal strain indices denoting back/neck/shoulder disturbances (labeled as postural strain) and mainly arm/hand disturbances (labeled manipulative strain) parallel somewhat the neck-spinal and shoulder-arm classifications of musculo-skeletal disturbances by Cakir et al. (1978). Although prior investigators (Coe et al., 1980; Laubli et al., 1981) have also separated symptoms of visuo-ocular disturbance into categories denoting imperception and fatigue-irritation (asthenopia), factor analysis of these types of symptoms in the present study did not confirm such a separation. Rotation of a set of six items indicating both eye discomfort and visual imperception resulted in only one factor with an eigenvalue greater than 1.0, with all six items loading high (about 0.7 or greater) on that factor. For this reason, both types of eye related disturbance items were combined into a single index for the prediction of eye strain.

Predictor Variables--

Following below is a list of all of the regressors used in the prediction of the visuo-ocular and musculo-skeletal strain indices. Many of the variables are used in the prediction of both types of strain. A few are pertinent and hence used in the prediction of just one type of strain; for example, chair comfort in the prediction of musculo-skeletal strain. However, the same set of predictors used in the prediction of neck/back/shoulder strain was also used in the prediction of the musculo-skeletal strain measure denoting mainly arm/hand problems. The strains for which each variable was used as a predictor are indicated by the M-S (musculo-skeletal) or V-O (visuo-ocular) notation adjacent to each listed predictor variable. The job control and job demands variables are the same variables used as regressors in the preceding analyses for the prediction of the more general well-being indices. The "problems" and "adjustability" variables (no. 3-7) are the questionnaire-derived scales previously described in the data collection section of the report. Variables 8-16 are not scales, but rather specific questionnaire items chosen for inclusion as regressors in these analyses. The questionnaire location and description of each of these items is provided following the variable. Variables 17-20 are classification variables used to denote the job tasks of the VDT users. Not shown is a fifth classification (programmers). Programmers constituted the reference group for evaluating the effects of the different job classification variables. The parenthetical acronym following each variable is used to denote the variable in subsequent tabular presentations of data.

1. [M-S, V-O] Job control (JOB CON)
2. [M-S, V-O] Job demands (JOB DEM)
3. [M-S] Workstation/VDT physical configuration problems (VDT BOTH)
4. [V-O] VDT display problems (DISP BOTH)
5. [V-O] Ambient environmental lighting problems (ENV LUM BOTH)
6. [M-S] Workstation/VDT physical adjustability (PHYS ADJ)
7. [V-O] Workstation lighting adjustability (LUM ADJ)
8. [M-S] Chair Comfort (CHAIR CFT) - a five-point rating scale for chair comfort (questionnaire part 3, item 4)
9. [M-S] Number of hours spent in a seated position each day (TIM SIT) - questionnaire part 1, item 176
10. [M-S, V-O] Required to wait for computer response (WAIT) - a dichotomous classification variable denoting whether or not temporal delays were incurred while entering or retrieving data
11. [M-S, V-O] Discretionary breaks allowed (DISC BKS) - a five-point rating scale indicating the ability to take brief unscheduled rest breaks ad libitum (questionnaire part 1a, item 11)
12. [M-S, V-O] Proportion of time interactive with the VDT (INTER TIM) - denotes extent to which VDT tasks involve interactive (conversational) communication with the VDT/computer system versus simply data input or retrieval (questionnaire part 1a, item 12c)
13. [V-O] Extent of VDT display viewing (SCRN TIM) - a five-point rating scale denoting the amount of time spent viewing the VDT display as opposed to other visual sources such as the keyboard or source document, etc. (questionnaire part 1a, item 13a)
14. [M-S, V-O] Hours of VDT use per day (VDT HRS)
15. [M-S, V-O] Corrective eyewear use (EYE WR) - a dichotomous classification variable denoting whether or not VDT users wear prescription eyewear (questionnaire part 4, item 19c)
16. [M-S, V-O] Age (AGE)
17. [M-S, V-O] Data entry worker (DATA ENT) - a classification variable denoting data entry workers
18. [M-S, V-O] File maintenance worker (FILE MAIN) - a classification variable denoting file maintenance workers and word processors.
19. [M-S, V-O] Clerical-secretarial worker (CLER SEC) - a classification variable denoting general clerical-secretarial workers.
20. [M-S, V-O] Lead worker (LEAD WKR) - a classification variable denoting lead workers

In selecting this set of variables for evaluation, emphasis was placed on specific aspects of the task process and physical workplace/workstation that have either been identified in prior VDT research or would be implicated on the basis of the general ergonomic literature to impact eye and musculo-skeletal comfort of VDT users. Some high priority factors such as number of scheduled rest breaks or intensity of keyboard use may seem conspicuous by their absence. The number of scheduled rest breaks was omitted due to lack of variance in this measure. Scheduled rest breaks and their duration are regulated at constant values in State of Wisconsin service. We therefore substituted the discretionary work break variable. Intensity of keyboard use as measured by reports of proportion of time spent in simple information input is strongly associated with the interaction time measure ($r = -.50$, $p < .01$).

It may also be unclear as to why very specific factors such as keyboard height adjustability or improper keyboard adjustment were not included as predictors of strain. In fact, we attempted through factor analysis to obtain finer distinctions than exist in both the "adjustability" and "problems" scales, but the results did not permit further subdivision of items comprising these scales.

The issue of why the status or configuration of workplace conditions was assessed in terms of users' reactions (i.e. being "bothered") needs to be explained. The objective was to obtain data on variation in these conditions, and variation with respect to optimal conditions. Short of objective physical measurement by the investigators, this seemed to be the only way, although not necessarily the best way, to obtain these types of data. However, such measurement methods have important implications in the interpretation of results due to the potential conceptual or operational similarity of independent and dependent variables. Results show, in fact, that "problems" scales tend to be significantly associated with strain. One interpretation of these results might be simply that strain is associated with strain - that is, being "bothered" is equivalent to the perception of ailments or symptoms. These types of circularity problems are common in subjective studies of stress/strain, as in the relationship of role ambiguity or role conflict (independent variable) with role strain (dependent variable), or quantitative overload (independent variable) with workload dissatisfaction (dependent variable). The reader is referred to Kasl (1978) for a further discussion of this issue.

Despite the potential, our inclination is that this type of contamination is not a serious problem in the present analyses. The problem scale items do not directly connote somatic ailments, and these items and the symptom inventories are physically separated in the questionnaire. Further, objective measures of workstation lighting conditions (illumination at the keyboard and workplace source document site) correlate significantly with the visuo-ocular strain index ($r = .31$ and $.21$ respectively, $p < .05$) in the same way that the subjective environmental lighting "problems" scale is associated with the same strain scores in the current regression analyses. Similarly, objective measures of VDT screen illuminace and screen background luminance (both potentially contributing to display quality) are weakly associated with the visuo-ocular strain index ($r = .22$, $p = .07$; $r = .13$, $p = .15$ respectively), and the display lighting/quality problems scale is also associated (significantly) with the visuo-ocular strain index in the current regression analyses.

The rationale for inclusion of certain variables from the preceding analyses of more general workplace conditions in the present analyses of specific workplace attributes may also be unclear. The job demands variable was included as a measure of quantitative workload. It is reasonable to assume that workload demands would represent a direct source of biomechanical and eye/visual stress in VDT work.

Although the job control variable is qualitatively different from the remaining types of variables considered in these analyses in that it denotes a fairly broad job design attribute, it may be that in reality this parameter is considerably more important than specific task/environmental demands as a determinant of physical strains. Specifically, individuals with high levels of personal control and discretion in their job may be able to influence or avoid specific task or workplace challenges such as poor lighting or workstation design that may promote strain. The job control variable was added as a regressor to examine this possibility. However, some of the predictor variables examined such as the ability to adjust workplace lighting or the workstation physical configuration, or the opportunity to take discretionary work breaks, may actually represent variations of the job control construct. These capabilities should be more likely with increased personal freedom and discretion at work. In fact, the correlation of the job control variable with the workstation/VDT physical adjustability scale is strong ($r = .43$). In an effort to untangle the effects of the job control variable from effects of more specific variables potentially related to job control, separate analyses first excluding and then including the job control variable as a regressor were conducted as explained below.

As in the preceding analyses, the job classification variables were included in an effort to capture effects linked to qualitative aspects of general task activities not accounted for by other dimensions of VDT work examined here. As explained below, they were actually added subsequent to observations of only modest effects related to the other variables.

In the selection of user characteristics for examination in these analyses, we chose only those attributes which would seem to have clear and direct implications for the specific types of strain predicted. Thus, the marital status variable which was identified in the previous analyses as influential in the prediction of general well-being was not considered in the present analyses because a specific causal mechanism is not readily apparent.

One additional variable, VDT user stature (height), was originally considered for the prediction of musculo-skeletal strains. It might be expected that deviations from the norm would result in a poorer interface between personal and workstation physical dimensions, and hence promote strain. In fact, results show no relationship at all (neither linear nor curvilinear) of VDT user height with the musculo-skeletal postural or manipulative strain indices ($r = -.01$ and $.00$ respectively). We found, however, that height is significantly associated with the workstation/VDT physical configuration "problems" scale ($r = .18$, $p < .01$), and this scale tends to predict musculo-skeletal strains. Interestingly, a scatterplot indicates only a linear relationship between height and the physical configuration problems scores. Associations of height with specific scale items include keyboard tilt ($rho = .19$, $p < .01$), keyboard height ($rho = .15$, $p < .05$), screen distance ($rho = .15$, $p < .05$), and keyboard distance ($rho = .15$, $p < .05$).

Analytical Procedure--

In separate analyses, the visuo-ocular and two musculo-skeletal strain indices were regressed on the workplace and personal variables designated (in the margin to the left of the description of each variable) for the prediction of these different strains. Since only two variables denoting personal characteristics, age and corrective eyewear use are evaluated here, and since neither is highly correlated with the work related variables, effects of the individual and work related variables are examined concurrently in each regression analysis.

For exploratory purposes, different regression techniques were tried. We first examined models with the full set of designated regressors included, and then eliminated and added variables in a backward stepwise procedure ($p \leq .05$, in; $p > .05$ out) inspecting the model at every step. This was followed with a forward stepwise selection of variables (same criteria). The same statistical package (REGAN 3) used in the more general work environment analyses was used for the present analyses. The results of the two approaches were essentially equivalent. The results presented here represent the outcomes of the backward stepping process.

The regression sample for these analyses consisted of all VDT users with complete data on all of the predictor variables and the strain measures for each analysis. This is a subset of the VDT sample (n = 186) from the preceding general work environment analyses. Twenty-one of the VDT users from the prior sample had missing data on variables unique to the present analyses. Because the variables with missing data consisted of single questionnaire items, missing data for these variables could not be reliably estimated. Rank-normal transformation (Li, 1957) was applied to single item variables providing ordinal data. The simple correlation structure among the visuo-ocular and two musculo-skeletal strain indices and all predictor variables is given in Table 33. Table 34 provides descriptive statistics for all of these variables.

Diagnostic regressions using the SAS PROC REG routine were carried out on all final models. Correlations among estimates for significant predictors and the same diagnostic statistics (Studentized residuals, hat/leverage values, covariance ratios) examined in the preceding general work environment analyses were also examined here.

As indicated in the description of predictor variables, several models were examined in the prediction of each type of strain. Each strain measure was first regressed on all designated predictors with the exception of the job activity classification variables and the job control variable. The job control variable was then added in a secondary analyses in an effort to untangle its effects from more specific but potentially related variables (e.g. the workstation/VDT physical adjustability scale). These regression analyses were then repeated but with the job classification variables added. These classification variables were added in subsequent analyses for the same reason that they were added along with the professional status variables in the preceding general work environment analyses. As before, in examining the outcome of the first two regressions (with and without job control added as a regressor) we became concerned that there may exist potentially important effects related to differences in job tasks not accounted for with the original set of variables, particularly since the explanatory power of these first two models was quite limited in all cases.

In evaluating job activity variables, the reference group for each of the four classifications consisted of the group of programmers. Programmers were chosen as the reference group since they tended to have low strain scores in relation to the other job activity groups. For the VDT users, programmers'

Table 33. Correlations among all the variables included in the specific work environment analyses.

	Variables	1. VISOC STRN	2. POST STRN	3. MANIP STRN	4. BEH AUT	5. DATA ENT	6. FILE MAIN
1.	VISOC STRN	1.000					
2.	POST STRN	.521	1.000				
3.	MANIP STRN	.416	.555	1.000			
4.	BEH AUT	.459	.509	.424	1.000		
5.	DATA ENT	.066	.071	.193	-.039	1.000	
6.	FILE MAIN	.053	-.029	-.096	.067	-.656	1.000
7.	CLER SEC	-.110	-.011	-.085	.053	-.199	-.168
8.	LEAD WKR	-.056	.019	-.041	-.064	-.257	-.218
9.	JOB CON	-.236	-.231	-.178	-.182	-.503	.192
10.	JOB DEM	.134	.221	.062	.136	-.195	-.019
11.	ENV LUM BOTH	.132	-.089	-.008	.139	-.020	-.020
12.	DISP BOTH	.268	.268	.263	.177	-.066	.113
13.	VDT BOTH	.262	.211	.212	.280	.056	-.070
14.	LUM ADJ	.039	.130	.139	-.005	.144	-.134
15.	PHYS ADJ	-.143	-.141	-.141	-.007	-.391	.257
16.	CHAIR CFT	-.145	-.298	-.193	-.246	-.084	-.017
17.	TIME SIT	.006	-.109	.065	-.035	.088	.103
18.	WAIT	-.068	-.049	-.091	-.056	.202	-.173
19.	DISC BKS	-.089	-.118	-.154	-.122	-.207	.011
20.	INTER TIM	-.112	-.101	-.081	-.116	-.379	.102
21.	SCRN TIM	-.040	.036	.008	.128	-.354	.259
22.	AGE	-.100	.042	-.107	-.028	-.035	-.072
23.	EYE WR	.234	.260	.200	.188	-.077	.135
24.	VDT HRS	.075	-.083	.013	-.084	.403	.157

Table 33 continued.

	Variables	7. CLER SEC	8. LEAD WKR	9. JOB CON	10. JOB DEM	11. ENV LUM BOTH	12. DISP BOTH
7.	CLER SEC	1.000					
8.	LEAD WKR	-.066	1.000				
9.	JOB CON	.062	.227	1.000			
10.	JOB DEM	.140	.258	.118	1.000		
11.	ENV LUM BOTH	-.048	.183	-.073	.143	1.000	
12.	DISP BOTH	-.069	.009	.007	.040	-.043	1.000
13.	VDT BOTH	-.031	-.036	.007	.028	.008	.030
14.	LUM ADJ	-.040	.046	-.059	-.048	-.152	-.062
15.	PHYS ADJ	-.001	.019	.427	-.060	-.008	-.032
16.	CHAIR CFT	.008	.074	.241	-.022	-.195	-.043
17.	TIME SIT	-.060	-.358	-.163	-.088	.014	-.081
18.	WAIT	.052	.073	-.286	-.029	-.008	-.079
19.	DISC BKS	.082	.070	.267	-.104	-.143	-.188
20.	INTER TIM	-.048	.220	.377	.148	.051	.005
21.	SCRN TIM	.187	-.059	.137	.029	.066	.097
22.	AGE	.278	.101	-.111	.238	.105	-.058
23.	EYE WR	.136	-.027	-.037	.123	-.052	.002
24.	VDT HRS	-.299	-.389	-.397	-.198	.011	.005

	Variables	13. VDT BOTH	14. LUM ADJ	15. PHYS ADJ	16. CHAIR CFT	17. TIME SIT	18. WAIT
13.	VDT BOTH	1.000					
14.	LUM ADJ	-.017	1.000				
15.	PHYS ADJ	-.097	-.177	1.000			
16.	CHAIR CFT	-.032	.011	.045	1.000		
17.	TIME SIT	-.112	.035	.036	.057	1.000	
18.	WAIT	-.041	.134	-.180	.009	-.076	1.000
19.	DISC BKS	-.077	-.079	.177	-.003	-.046	.003
20.	INTER TIM	.014	-.020	.230	.102	-.127	-.250
21.	SCRN TIM	.054	-.148	.254	-.144	.001	-.243
22.	AGE	-.112	.040	-.026	.019	.087	.116
23.	EYE WR	.144	.097	-.012	-.175	.037	.062
24.	VDT HRS	-.118	-.067	-.153	-.088	.408	.075

Table 33 continued.

	Variables	19. DISC BK	20. INTER TIM	21. SCRN TIM	22. AGE	23. EYE WR	24. VDT HRS
19.	DISC BKS	1.000					
20.	INTER TIM	.032	1.000				
21.	SCRN TIM	.026	.144	1.000			
22.	AGE	-.049	-.058	.135	1.000		
23.	EYE WR	-.037	-.138	.010	.223	1.000	
24.	VDT HRS	-.176	-.316	-.124	-.074	.037	1.000

Table 34. Descriptive statistics for all of the variables included in the specific work environment analyses.

Variable	Mean	SD	Minimum	Maximum
JOB CON	19.33	2.18	14.86	25.36
JOB DEM	22.71	2.42	14.24	27.87
AGE	32.67	10.40	18.00	62.00
VDT BOTH	0.00	1.00	-1.38	3.68
DISP BOTH	0.00	1.00	-1.98	3.21
ENV LUM BOTH	0.00	1.00	-2.16	2.81
VISOC STRN	-1.99	1.84	-5.01	3.87
POST STRN	-1.91	2.09	-5.27	5.27
MANIP STRN	-4.71	1.66	-6.56	0.39
VDT HRS	5.82	2.69	0.20	9.80
CHAIR CFT	0.27	0.59	-1.16	1.16
TIM SIT	65.25	19.97	0.00	98.00
WAIT	0.25	0.44	0.00	1.00
DISC BKS	0.03	0.62	-1.16	1.16
INTER TIM	14.04	24.93	0.00	98.00
SCRN TIM	-.05	0.56	-1.16	0.50
EYE WR	0.74	0.44	0.00	1.00
PHYS ADJ	-1.19	1.52	-3.49	3.49
LUM ADJ	0.63	1.37	-2.96	3.53
DATA ENT	0.44	0.50	0.00	1.00
FILE MAIN	0.36	0.48	0.00	1.00
CLER SEC	0.05	0.22	0.00	1.00
LEAD WKR	0.08	0.27	0.00	1.00

scores were the lowest of all groups on the two musculo-skeletal strain indices, and were lower than scores for the data entry and file maintenance groups on the visuo-ocular strain index.

In all of these analyses only the main effects of the predictors were evaluated. However, residual plots for each variable were examined in order to detect the presence of curvilinear effects. In no case was this type of effect observed. Although it would have been desirable to evaluate interactions, the effort required for the correct formulation and systematic examination of interaction terms for the present set of predictors was beyond the scope and resources of the current project. This should not be a serious limitation, however, since interaction effects are often correlated with main effects for their constituent terms and would therefore likely be reflected as main effects in the present analyses.

Although the primary focus in the present analyses was on the determinants of strain among VDT users, limited efforts were also made to examine differences between VDT use and more conventional office work in terms of the influence of the types of variables evaluated here on eye and musculo-skeletal strain. However, a regression approach in which the interaction of VDT use/non-use with each variable is systematically evaluated (as in the preceding analyses) or a parallel regression of the three strain measures on the present predictors for non-users was impossible since some of the predictors are specific to VDT use only. Instead, each of the present set of variables common to VDT users and non-users was interacted with a VDT use/non-use classification variable. The interaction term, classification variable, and common variable were then evaluated for their influence on appropriate strain measures using two-way analysis of variance (ANOVA). One analysis of this type was carried out for each common variable. For some of the variables not shared by VDT users and non-users (e.g. the ambient lighting problems scale), certain questionnaire items comprising the variable were, in fact, responded to by both users and non-users (e.g. quantity of workplace lighting). Two way ANOVA was also carried out with shared scale items to approximate effects of the larger scale. The non-user sample for the ANOVA consisted of the 65 non-users from the preceding analyses.

Prediction of Visuo-ocular Strain--

Final regression models obtained for predicting the eye strain index are presented in Table 35. In this table and in subsequent tables describing the results of the regressions of the musculo-skeletal strain measures, the model without the job control or job classification variables added is presented first. Next the model with the job classification variables is presented, followed by a repeat of these two models in the same order but with the job control variable added.

Table 35 shows somewhat different models for the prediction of the visuo-ocular strain measure depending upon whether or not the job control variable is added as a regressor. However, there is no effect of adding the job classification variables in either case. The explained variance in the visuo-ocular strain index in the model excluding job control as a regressor is 16%, but rises to 21% in the model including the job control variable. Diagnostics show both models to be highly stable. Correlations among estimates for the significant predictors are weak in both models. The highest correlations were between the age and corrective eyewear estimates

Table 35. Results of the Visuo-ocular Strain regressions.

Job Control variable not included in model:

Variables remaining in final model	Reg. coef.	Standardized reg. coef.	Partial correl. coef.	Sig. level
Age	-.031	-.165	-.173	.027
Corrective Eyewear Use	1.170	.281	.287	.000
VDT Display Bother	.496	.265	.280	.000
Environmental Lighting Bother	.323	.175	.187	.017
Variables stepping out of the model				
Job Demands	-	-	.119	.133
Hours VDT Use/Day	-	-	.055	.492
Required to Wait for Computer Response	-	-	-.048	.544
Discretionary Breaks Allowed	-	-	-.013	.867
% Time Interactive with VDT	-	-	-.104	.188
Extent of VDT Display Viewing	-	-	-.064	.417
Adjustability of VDT/ Workstation Lighting	-	-	.070	.380

$R = .420$
R^2 (adjusted) $= .155$

Job-Task Activity variables included in the model: NO CHANGE.

Table 35 continued.

Job Control variable included in the model:

Variables remaining in final model	Reg. coef.	Standardized reg. coef.	Partial correl. coef.	Sig. level
Job Control	-.235	-.273	-.293	.000
Job Demands	.148	.177	.189	.016
Age	-.040	-.214	-.224	.004
Corrective Eyewear Use	.044	.249	.267	.001
VDT Display Bother	.467	.250	.274	.001
Variables stepping out of the model				
Environmental Lighting Bother	-	-	.155	.051
VDT Hours/Day	-	-	-.031	.696
Required to Wait for Computer Response	-	-	-.134	.092
Discretionary Breaks Allowed	-	-	.059	.460
% Time Interactive With VDT	-	-	-.018	.818
Extent of VDT Display Viewing	-	-	-.006	.938
Adjustability of VDT/ Workstation Lighting	-	-	.037	.646

R = .485
R^2 (adjusted) = .211

Job Control and Job Task Activity variables included in the model: NO CHANGE FROM MODEL WITH JOB CONTROL VARIABLE INCLUDED.

(about 0.2 in both models). For neither model did more than six of the predicted values have studentized residuals greater than 2.0, or more than two greater than 3.0. In neither model were hat/leverage values greater than critical levels in more than two cases. Only four observations had covariance ratios less than 0.9 in each model.

Inspection of the models predicting visuo-ocular strain shows effects consistent in many ways with prior suppositions and findings. Both the display problems and environmental lighting problems variables seem to be important determinants of reported eye strain symptoms. Since these two variables are uncorrelated, the effects suggest distinct contributions of each source to the reported eye strains. Although the environmental lighting problems effect is marginally nonsignificant in the model including the job control variable, it can hardly be ignored considering its influence in the model excluding the job control variable. Both the age and corrective eyewear variables are also significant in both models. The age effect, indicating greater strain for younger workers, is consistent with age effects observed in the preceding general work environment analyses.

Of special interest is the effect of the corrective eyewear variable. VDT users wearing glasses or contact lenses report greater eye strain than do those who do not. The eyewear and display problems variables each accounted for about six percent of the variance in the eye strain index, more than any other of the predictors.

Table 36 further illustrates the eyewear effect. To obtain the values shown in Table 36, we first calculated the proportions of VDT users reporting each of the six strain symptoms comprising the visuo-ocular strain index. The values shown are the means of the proportions reporting each symptom. The table shows that an additional 11 percent of the users wearing corrective eyewear report eye strain symptoms than do users without corrective eyewear, and an additional 6 percent report these symptoms on a frequent or constant basis.

In further probing of the eyewear effect, we found that it is mainly related to the use of monofocal glasses or contact lenses as opposed to bifocals or trifocals. This effect is illustrated in Table 37. Table 37 shows the proportion of VDT users with different types of eyewear reporting six symptoms of eye strain in relation to the proportion of individuals without corrective eyewear reporting these symptoms. Note that pronounced differences do not exist between the bifocal/trifocal and no eyewear groups in the reporting of symptoms for the VDT users. On the other hand, the proportions reporting symptoms for the monofocal and contact lens group are consistently much higher than for either the no eyewear or bifocal/trifocal groups.

These findings reinforce previous data (Cakir et al., 1978; Laubli et al., 1981) indicating increased eye strain incident to eyewear use among VDT users, and the Cakir et al. (1978) observation that the effect is linked mainly to the use of monofocal lenses. Cakir et al. (1978) tentatively attributed this effect to over-correction with conventional reading glasses considering the usual visual distances in VDT display viewing. Laubli et al. (1981) further reported that the eyewear use effect was actually amplified in conventional office workers. However, in further inspection of Table 37, it

Table 36. Incidence of eye and musculo-skeletal strain in VDT users wearing glasses or contact lenses (n=183) and users without corrective eyewear (n=65).*

	Symptoms experienced at least occasionally		Symptoms experienced frequently/constantly	
	Corrective eyewear	No corrective eyewear	Corrective eyewear	No corrective eyewear
Visuo-ocular Strain	66%	55%	19%	13%
Musculo-skeletal Postural Strain	70%	59%	25%	14%
Musculo-skeletal Manipulative Strain	37%	26%	7%	3%

*Each tabled value is the mean of the proportions of individuals reporting the different symptom items in the respective strain scale.

Table 37. Incidence of visuo-ocular strain symptoms in relation to type of corrective eyewear in VDT users and non-users.*

Symptoms		Type of Corrective Eyewear: Monofocal glasses (n's= 124/42)	Bifocals/ trifocals (n's= 43/17)	Contact lenses (n's= 43/19)	No Corrective Eyewear (n's= 65/14)
Aching/burning eyes at work	VDT users	81%	67%	91%	66%
	Non-users	62%	62%	47%	71%
Focussing difficulty at work	VDT users	52%	51%	60%	45%
	Non-users	48%	38%	63%	43%
Tearing/ itching eyes	VDT users	76%	65%	86%	52%
	Non-users	55%	47%	79%	71%
Burning eyes	VDT users	78%	56%	91%	61%
	Non-users	57%	53%	74%	57%
Blurred vision	VDT users	41%	26%	46%	37%
	Non-users	43%	41%	42%	50%
Eye strain	VDT users	81%	63%	86%	68%
	Non-users	79%	65%	74%	79%
Mean	VDT users	68%	55%	77%	55%
	Non-users	57%	51%	63%	62%

*Tabled values show proportion of individuals reporting each symptom as occurring at least occasionally. The n's for types of corrective eyewear sum to greater than the n reporting eyewear use since some individuals reported the use of more than one type of corrective eyewear.

can be seen that the types of eyewear-eye strain associations appearing for VDT users are not evidenced for non-users in the present data. There is no tendency for non-users with corrective eyewear to report more eye strain than non-users without corrective eyewear, and only a modest trend for non-users with monofocal glasses or contact lenses to report eye strain more than non-users with bifocals/trifocals. In the two-way ANOVAs examining the influence of the present predictors in the VDT user and non-user samples, we found a significant interaction ($p < .05$) of VDT use/non-use with corrective eyewear use/non-use for visuo-ocular strain scores, indicating increased strain for VDT users with corrective eyewear but not for non-users with corrective eyewear.

In the model including the job control variable as a predictor of eye strain (Table 35, second part), decreases in job control and increases in job demands are shown to be associated with increased strain. Both effects are consistent with the effects of these variables in predicting the general illness symptoms index, although the influence of the job control variable is considerably stronger in the present analyses. An unequivocal explanation for the job control effect which is consistently significant throughout the present set of analyses is difficult. The most appealing hypothesis is that the effect stems from increased opportunities to take action to avoid or adjust troublesome or challenging job situations that would otherwise result in strain. The job control variable does have a non-trivial positive association with the discretionary breaks variable ($r = .27$) and the workstation/VDT physical adjustability scale ($r = .43$), but on the other hand is virtually unrelated in a simple way with the scale denoting adjustability of workstation lighting (Table 33). Alternately, the variable might represent more an indicator of a complex of positive, stress mitigating, psychosocial job attributes. In the previous (general work environment) analyses, job control is shown to be fairly strongly associated with both the social support and future certainty variables. The job control variable also tends to differentiate data entry jobs from other types of VDT work (indicated in Table 33). While we tend to favor the first interpretation, it is likely that the effect involves elements of both of these possibilities, and further work will be needed to more precisely pin-down the mechanism.

The fact that so many of the variables considered in these analyses failed to meaningfully contribute to the prediction of the eye strain index was surprising. Conventional wisdom would predict that most of these variables should play an important role in promoting or preventing eye strain. Yet these variables not only fail to predict reported strains after adjusting for the significant variables, they fail to show even a simple association with the visuo-ocular strain measure.

Tenable explanations can be offered for many of these null effects. The possibility of curvilinear relationships with the eye strain measure, however, is not viable since they were ruled out through inspection of regression residual plots and scatterplots for each predictor variable in relation to the eye strain index. The insignificant VDT hours use/day effect is not surprising considering the systematic failure of this variable to influence strain in a powerful way in analyses described thus far. The lack of an effect related to the lighting adjustability scale may be related to the relatively low reliability (KR-20 = .54) for this measure. Alternately, as suggested by Dainoff (1981) and as we have observed, VDT users may not be proficient in effectively adapting workplace lighting to minimize stress regardless of the potential. Note, however, that the degree of adjustability of workstation/VDT lighting conditions is negatively associated, although modestly so, with the scale denoting problems with environmental lighting ($r = -.15$, Table 33). Although neither the percent time VDT interactive or job classification variables (which differentiate users according to the extent to which tasks are display dependent) even approach significance in the prediction of the eye strain index, it is of some interest that a very modest positive linkage exists between the file maintenance job classification variable and the display problems variable (as indicated in Table 33). File maintenance VDT work tends to be more interactive, and hence display dependent, than data entry or clerical/secretarial work in the present sample (indicated in Table 33). Along this line, a stronger negative connection is seen between the discretionary work breaks variable and the display problems variable ($r = -.19$, Table 33). Perhaps most curious is that the variable denoting the extent of screen viewing has virtually no relationship with the eye strain index, although it has a very low positive correlation with the display problems variable ($r = .10$, Table 33).

Altogether, the present data almost seems to point to some type of ordered, or contingent causal pattern for eye strain in which: (1) greater screen exposure prompts somewhat greater viewing disturbances, but that physical strain hinges more directly on poor display quality or ambient lighting, or (2) lighting adjustability and screen exposure interact with the display or lighting problems scales. That is, lighting adjustability and screen exposure may be important only when display and ambient lighting characteristics are sub-optimal. Although these possibilities are highly speculative, and should be viewed with caution considering the low associations, they seem reasonable and worthy of further investigation based upon the data patterns described.

Although nonsignificant, the effect associated with computer response delays (required to wait variable) in the second model is worthy of comment. It also tends to approach significance in the musculo-skeletal postural strain regression where the job control variable is included as a regressor, and is in fact significant in predicting manipulative strain when the job control variable is included. While prior work (Johansson and Aronsson, 1980) has linked this condition to psychophysiological strain, the negative associations in the current regressions provide a limited indication that if anything, the effect may be to provide relief from stresses to the visual and musculo-skeletal systems.

Prediction of Neck/Back/Shoulder Musculo-skeletal Strain--
The outcomes of these regression analyses are shown in Table 38. As with the prediction of the visuo-ocular strain index, the job classification variables were of no significance in predicting back/neck/shoulder strain. However, again the addition of the job control variable resulted in changes in the model which increased the explained variance from about 18 percent to nearly 23 percent.

Regression diagnostics indicate that the models are stable. In the model excluding the job control variable, just six cases have Studentized residuals greater than 2.0, and only two greater than 3.0. Corresponding values for the model including the job control variable are 12 and zero. The model

Table 38. Results of the Musculo-skeletal Postural Strain regressions.

Job Control variable not included in the model:

Variables remaining in final model	Reg. coef.	Standardized reg. coef.	Partial correl. coef.	Sig. level
Job Demands	.179	.190	.206	.009
VDT/Workstation Physical Configuration Bother	.358	.173	.188	.017
Chair Comfort	-.942	-.259	-.274	.000
Corrective Eyewear Use	.797	.167	.177	.024

Variables stepping out of the model				
Age	-	-	-.018	.817
Time Sitting/Day	-	-	-.073	.359
Required to Wait for Computer Response	-	-	-.050	.532
Discretionary Breaks Allowed	-	-	-.090	.258
% Interactive Time With VDT	-	-	-.094	.236
Extent of VDT Display Viewing	-	-	-.020	.801
Adjustability of VDT/ Workstation Physical Characteristics	-	-	-.112	.158
Hours VDT Use/Day	-	-	-.062	.433

$R = .446$
R^2 (adjusted) = .179

Job-Task Activity variables included in the model: NO CHANGE.

Table 38 continued.

Job Control Variable included in the model:

Variables remaining in final model	Reg. coef.	Standardized reg. coef.	Partial correl. coef.	Sig. level
Job Control	-.251	-.259	-.258	.001
Job Demands	.180	.190	.209	.008
VDT/Workstation Physical Configuration Bother	.326	.157	.176	.026
Hours VDT Use/Day	-.128	-.154	-.158	.046
Chair Comfort	-.761	-.209	-.225	.004
Corrective Eyewear Use	.831	.174	.191	.016
Variables stepping out of the model				
Age	-	-	-.075	.344
% Time Sitting/Day	-	-	.062	.440
Required to Wait for Computer Response	-	-	-.132	.098
Discretionary Breaks Allowed	-	-	-.047	.553
% Time Interactive With VDT	-	-	-.048	.549
Extent of VDT Display Viewing	-	-	.008	.921
Adjustability of VDT/ Workstation Physical Configuration	-	-	-.021	.793

$R = .505$
R^2 (adjusted) = .227

Job Control and Job-Task Activity variables included in the model: NO CHANGE FROM THE MODEL WITH THE JOB CONTROL VARIABLE INCLUDED.

excluding job control has only seven observations with hat/leverage values in excess of the criterion, while the model including job control has none. No more than seven observations in either model have covariance estimates less than 0.9. Correlations among the estimates for the significant predictors did not exceed 0.16 in the model without job control, but in the model including the job control variable the estimates for the VDT hours/day variable were fairly strongly correlated with the job control estimates (r = .35). Other associations among estimates in this model were at about the same level as in the model excluding the job control variable.

Several interesting effects are common to both models shown in Table 38. Just as the ambient lighting and display problems scales were influential in predicting the eye strain index, the VDT/workstation physical configuration problems scale contributes significantly to the prediction of neck/back/shoulder strain. An increase in perceived problems with the distance, height, and tilt of the keyboard and screen is associated with increased reporting of strain. Stammerjohn et al. (1981) report very similar simple associations between ratings of the VDT physical configuration and musculo-skeletal complaints.

More negative ratings of the chair are also significantly associated with increased reporting of strain. As the regression statistics indicate, the chair comfort variable is the strongest determinant of postural strain scores, accounting for about eight percent of the variance in both models. This effect compliments findings in two recent large scale studies investigating the relationship between design aspects of office environments and worker comfort, performance, and satisfaction. In a cross-sectional survey of over 1000 office workers by the Harris organization (Steelcase, 1980), one of eight major findings highlighted was the importance of adequate chairs for the comfort of workers. In attributing the causes of back disorders experienced by 559 workers, an uncomfortable office chair was cited by nearly 30 percent of these individuals. Similarly, chair characteristics stood out among all office environment attributes as a correlate of worker satisfaction and productivity in yet a larger study by The Boston Organization for Office and Technological Innovation (Brill, 1982).

Table 39 shows how the chair comfort effect translates into the actual proportion of users reporting neck/back/shoulder strains in relation to chair ratings. The values shown in Table 39 are means of the proportions of VDT users reporting the seven different symptoms in the musculo-skeletal strain scale. Note that a substantially larger proportion of the users with lower chair comfort ratings than with higher comfort ratings report the experience of strain on a frequent or constant basis. As shown further on, the effect is much the same for the non-user sample (two-way ANOVA showed no interaction of VDT use/non-use with high/low chair comfort ratings in predicting the musculo-skeletal postural strain scores).

It is of interest that the univariate comparisons of VDT users with non-users showed that the VDT users rated their chairs significantly less comfortable than did the non-users. The fact that this difference does not result in a significant difference between users and non-users in terms of musculo-skeletal strain is probably due to the fact that although the chair comfort effect is highly significant, it alone accounts for a relatively

Table 39. Incidence of musculo-skeletal strains in VDT users reporting lower chair comfort (n=106) and users reporting higher chair comfort (n=142).*

	Symptoms experienced at least occasionally		Symptoms experienced frequently/constantly	
	Lower Comfort	Higher Comfort	Lower Comfort	Higher Comfort
Musculo-skeletal Postural Strain	70%	64%	29%	17%
Musculo-skeletal Manipulative Strain	37%	32%	8%	5%

*Each tabled value is the mean of the proportions of individuals reporting the different symptom items in the respective scale. Lower chair comfort = chair rated just adequate/somewhat uncomfortable/very uncomfortable. Higher chair comfort = chair rated somewhat comfortable/very comfortable.

small proportion of the variance in the measure denoting neck/back/shoulder strain.

As in the prediction of eye strain, the use of corrective eyewear is also seen to have a significant association with the reporting of neck/back/shoulder discomfort. The effect, illustrated in Table 36, is consistent with conventional wisdom. Table 36 shows that almost twice as many of the VDT users with corrective eyewear than without report these problems on a frequent or constant basis. There is a somewhat reduced tendency toward increased reporting of neck/back/shoulder strain with corrective eyewear use in the non-user control group. In a two-way ANOVA (VDT use/non-use by corrective eyewear use/non-use), there existed a trend toward an interaction, although the effect was not statistically significant ($p = .06$).

When the reporting of these musuclo-skeletal strains is examined relative to the type of eyewear used, the effects are contrary to expectations based upon casual observation of VDT users, but consistent with an earlier report by Cakir et al. (1978). Although bifocal users are frequently seen to adopt awkward postures in VDT viewing (e.g. head tilted back), the present data show that the proportions of individuals with monofocal or contact lenses reporting musculo-skeletal strain exceed the proportion of individuals with bifocal/trifocal lenses reporting these strains. However, the proportion of bifocal/trifocal wearers reporting strains is also in excess of the proportion of individuals without corrective eyewear reporting strains. This is illustrated in the data presented below which show proportions of VDT users and non-users reporting neck/back/shoulder strains in relation to type of corrective eyewear. Sample sizes are the same as given in Table 37 showing a similar breakdown, but for the reporting of eye strain.

	monofocal lenses	bifocals/ trifocals	contact lenses	no eye wear
VDT users	71%	65%	77%	59%
non-user	64%	62%	67%	60%

These data also illustrate the attenuation of the general eyewear effect as well as of the difference between monofocal/contact lens use and bifocal/trifocal use in the reporting of strain for the control group.

Both models indicate that increasing job demands are strongly associated with increasing neck/back/shoulder discomfort. The model including job control as a regressor also shows that the variable denoting extent of daily VDT use significantly predicts strain, but marginally so. Curiously, the relationship is negative. A literal interpretation of this effect may be inappropriate. Table 33 (showing the correlations among predictor variables) indicates a fairly strong connection between classification as a data entry user and the number of hours of VDT use per data. Both variables are in turn associated with the neck/back/shoulder strain index at about the same level. There is some likelihood, then, that the daily VDT use effect may be reflecting an effect related to data entry work. Supporting this possibility is the finding, presented further on, that the data entry classification is a significant predictor of the musculo-skeletal strain index denoting mainly arm/wrist/hand discomfort.

Again, both models show that several factors which are generally regarded as instrumental in either promoting or abating musculo-skeletal disorders in VDT use fail to achieve significance. Some of these null effects seem surprising and merit discussion. In particular, the VDT/workstation physical adjustability variable is seen to have a very modest simple association with musculo-skeletal strain ($r = -.14$, Table 33). Yet, after adjusting for effects of other variables in both models the influence is diminished. Note that the influence is almost nil in the model including job control as a regressor. This is most likely due to the relationship between the job control and adjustability variable ($r = .43$, Table 33). Factors contributing further to the modest effect of this variable might be its relatively low reliability (KR-20 = .66), or the possibility that adjustability is not effectively utilized. The variable denoting opportunities for discretionary breaks also has a low association (but in an expected direction) with musculo-skeletal strain that is further diminished in the presence of the job control variable. As in the association with eye strain, temporal delays in VDT system use seem to provide relief from musculo-skeletal strain, although again the effect is not statistically significant.

Thus, while the magnitude of effect for many of the variables which might be considered key determinants of musculo-skeletal strain are not meaningful in a statistical sense, they tend for the most part to behave in patterns which are consistent with general expectations. One main exception is the variable denoting the amount of time spent sitting. The expectation was that increases in this measure would connote increases in static loads and hence promote strain. Yet, in both models an increase in subjectively assessed sitting time is negatively associated with strain, although the effect does not approach significance. Sitting time also has the same type of relationship with the variable denoting problems with the VDT/workstation physical configuration (Table 33).

Prediction of Musculo-skeletal Strains Associated with Mainly the Arms/Wrists/Hands--

The outcomes of these regression analyses are shown in Table 40. Precisely the same set of regressors examined in the prediction of the neck/back/shoulder strain scale were evaluated in the prediction of this musculo-skeletal strain scale. Table 40 provides first a model without the job control or job classification variables. Next, a model including job classification variables but excluding the job control variable is shown. Finally, a model including the job control variable but excluding the job classification variables is presented.

There are two particularly notable features in the outcome of these analyses. The first is that unlike the models for prediction of eye or neck/back/shoulder strain, one of the job classification variables attains significance as a predictor of strain. The second notable feature is that the adequacy of all of the models in terms of explained variance is considerably

Table 40. Results of the Musculo-skeletal Manipulative Strain regressions.

Job Control variable not included in the model:

Variables remaining in final model	Reg. coef.	Standardized reg. coef.	Partial correl. coef.	Sig. level
VDT/Workstation Physical Configuration Bother	.336	.206	.210	.007
Chair Comfort	-.535	-.186	-.190	.015
Variables stepping out of the model				
Required to Wait for Computer Response	-	-	-.085	.283
Use of Corrective Eyewear	-	-	.147	.061
Job Demands	-	-	.055	.488
Age	-	-	-.085	.282
Hours VDT Use/Day	-	-	.022	.782
Time Sitting/Day	-	-	.103	.189
Discretionary Breaks Allowed	-	-	-.145	.064
% Time Interactive with VDT	-	-	-.068	.385
Extent of VDT Display Viewing	-	-	-.032	.688
Adjustability of VDT/ Workstation Physical Characteristics	-	-	.118	.134

$R = .282$
R^2 (adjusted) = .068

Table 40 continued.

Job-Task Activity variables included in the model:

Variables remaining in final model	Reg. coef.	Standardized reg. coef.	Partial correl. coef.	Sig. level
VDT/Workstation Physical Configuration Bother	.283	.170	.179	.022
Use of Corrective Eyewear	.717	.190	.195	.013
Data Entry Worker	.668	.195	.205	.009

Variables stepping out of the model	Reg. coef.	Standardized reg. coef.	Partial correl. coef.	Sig. level
Required to Wait for Computer Response	-	-	-.148	.056
Chair Comfort	-	-	-.149	.059
Job Demands	-	-	.079	.317
Age	-	-	-.136	.085
Hours VDT Use/Day	-	-	-.063	.423
% Time Sitting/Day	-	-	.064	.417
Discretionary Breaks Allowed	-	-	-.101	.200
% Time Interactive With VDT	-	-	.020	.796
Extent of VDT Display Viewing	-	-	.076	.335
Adjustability of VDT/ Workstation Physical Characteristics	-	-	-.051	.518
File Maintenance Worker	-	-	.030	.709
Clerical Secretarial Worker	-	-	-.073	.359
Lead Worker	-	-	.024	.760

$R = .336$
R^2 (adjusted) $= .097$

Table 40 continued.

Job Control Variable included in the model:

Variables remaining in final model	Reg. coef.	Standardized reg. coef.	Partial correl. coef.	Sig. level
Job Control	-.167	-.218	-.218	.005
VDT/Workstation Physical Configuration Bother	.297	.182	.189	.016
Required to Wait for Computer Response	-.588	-.157	-.158	.044
Use of Corrective Eyewear	.661	.175	.182	.020
Variables stepping out of the model				
Chair Comfort	-	-	-.115	.147
Job Demands	-	-	.062	.436
Age	-	-	-.148	.061
Hours VDT Use/Day	-	-	-.055	.486
% Time Sitting/Day	-	-	.034	.665
Discretionary Breaks Allowed	-	-	-.084	.289
% Time Interactive with VDT	-	-	-.020	.801
Extent of VDT Display Viewing	-	-	-.013	.867
Adjustability of VDT/ Workstation Physical Characteristics	-	-	-.067	.396

R = .356
R^2 (adjusted) = .105

Job Control and Job-Task Activity variables included in the model: NO CHANGE FROM THE MODEL WITH THE JOB CONTROL VARIABLE EXCLUDED, BUT WITH THE JOB-TASK ACTIVITY VARIABLES INCLUDED.

less than models for the prediction of eye or neck/back/shoulder strain. Table 40 shows that the fit (adjusted R^2) for these models ranges between only .07 and .11.

Regression diagnostics provide little evidence of instability in any of the three models presented in Table 40. Studentized residuals for predicted scale scores were in excess of two standard deviations in no more than seven cases for any model. No more than four observations had covariance ratios less than .90 in any model. The first model (job control and classification variables excluded) actually had 13 observations with hat/leverage values in excess of the criterion. However, because there were only two significant regressors in this model, the criterion was quite stringent (.032). The second model had only six observations in excess of the criterion (.048), and the third model just one (.065). In only one instance in all of the models did the correlations among estimates for significant predictors exceed .17, and in most cases they were much lower. The correlation between estimates for the job control variable and the variable denoting delays in VDT-computer system response was .28 in the third model (job control variable included, but job classification variables excluded).

In looking at all three models presented in Table 40 together, it can be observed that most of the variables that tended toward significance in the prediction of neck/back/shoulder strain also tend to be influential here. It is of interest, however, that the magnitudes of the effects are adjusted in a fashion that would be expected for the prediction of mainly arm/hand disturbances in contrast to the prediction of neck/back/shoulder strain. For example, chair comfort is significant only in the first model, and the effect is less pronounced than in the prediction of neck/back/shoulder strain. This seems consistent with the expectation that chair quality might have a greater impact on strains resulting from the posture of the back than from strains resulting from the postural and dynamic demands in the use of the arms and hands. Note, too, that temporal delays in VDT-computer system response significantly predict less strain in the third model, and the effect approaches significance in the second model. Again, it seems clear that such events could be associated with relief-providing periods of arm/hand inactivity, but a mechanism for providing relief from strains related to spinal support is less obvious. Even the eyewear variable fails to attain significance in the first model, although the effect is so strong it can hardly be ignored, and is in fact significant in the other two models. Again, a stronger linkage to problems associated with positioning of the neck and back would seem reasonable. Only the variable denoting problems with the physical configuration of the VDT and workstation is consistently associated with strain in all three models. The effect is about the same magnitude as in the prediction of neck/back/shoulder discomfort. This is to be expected since this variable is comprised of items suggesting interface problems that would affect both keyboarding and the overall posture of the VDT user at the workstation.

Perhaps most interesting in these analyses, however, is that the data entry job classification attains significance as a strong predictor of strain in both models which include job classification variables. This finding is consistent with expectations based upon the fact that the dynamic, keyboard intensive aspects of data entry work place greater demands on the neuro-motor systems of the arms and hands than would likely be encountered in the more conversational use of VDTs. Note that Table 33 indicates that the data entry job classification is fairly strongly associated in a negative way with the variable denoting the extent of interactive use of VDTs. The finding is also consistent with data presented by Hunting et al. (1981) showing increased hand discomfort among data entry VDT users in comparison to conversational users and conventional office workers and typists. Referring back to Figure 2, it can be seen that data entry workers (both VDT users and non-users) seem to have the worst of it not only in terms of arm/hand discomfort, but for neck/back/shoulder problems and eye strain as well. Yet it is only in the prediction of the arm/hand problems that this job classification is significant. Again, this finding is consistent with results reported by Hunting et al. (1981) showing increased "body" and "head" posture discomfort among data entry users in comparison to more conversational users, but the effect was less pronounced than for hand discomfort.

While it is reasonable to conclude, as we have done here, that the data entry job classification effect stems in large part from the fairly narrow and intensive demands of the task specific to data entry work, an expanded interpretation is also plausible. Recall that the current data entry workers also have a high incidence of eye strain relative to other workers (Figure 2). Laubli et al. (1981) showed little difference between data entry VDT users and conversational users in terms of the incidence of eye/vision complaints. But in terms of the persistence of eye-vision problems, the effect was actually significantly stronger for data entry VDT users than for conversational users or conventional office workers or typists. Yet, data entry work is usually less display intensive than other types of VDT work. Data presented in Table 33 indicates, for example, a strong tendency in the present sample toward diminished screen viewing among data entry VDT users in comparison to users in other job classifications. Looking back at Figure 2, it can also be seen that data entry workers in the present sample also tend to report less staff support, future certainty, and job control, and more boredom and environmental problems than workers in other job classifications (although only the boredom and job control effects are significant). Several of these factors have been shown in prior analyses to be important determinants of strain. These data might suggest that it is the overall quality of data entry work in addition to specific task demands which are responsible for complaints registered by data entry VDT users.

Again, several of the effects which fail to attain significance in these models merit discussion. It is notable that in contrast to the prediction of eye or neck/back/shoulder strain, the job control variable is eliminated from the model when the job classification variables are included. This is most likely due to the strong negative association between the data entry classification and the job control variable, and the fact that both are associated with the present strain index at about the same level, although the data entry association is somewhat stronger. As mentioned above, data entry VDT users report less job control than individuals in any other job classification (Figure 2).

Certain trends that were observed in the prediction of eye and neck/back/shoulder strain are also observed here. Both the opportunities for discretionary breaks and adjustability of the VDT/workstation physical configuration are associated with decreased strain, but only the discretionary breaks variable approaches significance in any of the models. The effect of age also approaches significance in the second and third models.

The most perplexing of all nonsignificant effects is the lack of influence of the job demands variable. Seemingly, increased job demands would represent a direct source of stress to the motor system. The models for prediction of neck/back/shoulder strain support this hypothesis. The job demands variable is also a significant determinant of eye strain. Yet Table 33 shows that the simple correlation of the job demands variable with the strain index denoting arm/wrist/hand discomfort is almost negligible, and there is no correlation between the job demands variable and any other predictor variable which is strong enough to suggest a colinearity problem in the present set of regressions. Although data entry workers tend to report fewer job demands than other VDT users, the significance of the job demands variable is actually greater in the model including the data entry job classification variable. Examination of residual plots and scatterplots also provide no indication of a curvilinear effect which would result in a low linear association. Since this null effect seems contrary to both conventional wisdom and results observed thus far, further investigation will be needed to clarify this result.

Examination for Differential Prediction of Musculo-skeletal and Eye Strain in VDT Users and Non-users--

Following are the results of efforts to investigate whether the effects witnessed in the prediction of eye and musculo-skeletal strains for VDT users are maintained in the non-user sample. To make this determination, a series of two-way ANOVA tests were conducted in which interactions of VDT use/non-use with select predictor variables from the preceding analyses were examined for their influence on the visuo-ocular and two musculo-skeletal strain indices. As mentioned, a more desirable and systematic analytical strategy would have been to either conduct a series of regression analyses for the non-user sample parallel to those conducted for the users, or to interact VDT use/non-use with each predictor variable in a multiple regression as in the preceding general work environment analyses. Both approaches were precluded, however, by the fact that several of the variables used to predict eye and musculo-skeletal strain for the users were specific to VDT use (e.g extent of VDT display viewing, temporal delays in VDT-computer system response, etc.) and hence these variables or close analogs pertinent to conventional office work could not be formulated for the non-user control group.

Table 41 summarizes the results of 10 separate sets of ANOVAs examining the effects of specific worker and job attributes for VDT users relative to non-users. The VDT user group for these analyses consisted of the same sample from the prior regression analyses without missing data on the independent variables. The non-user sample consisted of the 65 control subjects from the preceding general work environment analyses.

Each row in Table 41 shows significance levels for the main effects of VDT use/non-use, the main effect of the predictor variable identified in that row, and the interaction effect of the two terms in the prediction of the visuo-ocular or two musculo-skeletal strain indices. The variables labeled job demands, job control, age, corrective eyewear, chair comfort and proportion of time sitting per day are the same variables examined in the preceding regressions for prediction of eye and musculo-skeletal strains in VDT users only. The machine time variable represents the number of hours of

Table 41. Results summary of 2-way ANOVAs for effects of select variables examined in the specific work environment analyses (Tabled values show significance levels).

ANOVA model	Visuo-ocular Strain	Musculo-skeletal Strain Postural	Musculo-skeletal Strain Manipulative
Job Control*	p=.04	p=.00	p=.07
VDT use	p=.59	p=.92	p=.59
Interaction	p=.73	p=.51	p=.23
Job Demands*	p=.18	p=.00	p=.27
VDT use	p=.31	p=.41	p=.34
Interaction	p=.32	p=.90	p=.96
Age*	p=.18	p=.70	p=.41
VDT use	p=.27	p=.44	p=.32
Interaction	p=.56	p=.78	p=.69
Corrective eyewear use	p=.04	p=.00	p=.03
VDT use	p=.24	p=.32	p=.26
Interaction	p=.03	p=.06	p=.09
Hours daily machine use*	p=.37	p=.95	p=.29
VDT use	p=.41	p=.47	p=.45
Interaction	p=.29	p=.23	p=.04
Chair comfort	-	p=.00	p=.07
VDT use	-	p=.78	p=.78
Interaction	-	p=.43	p=.60
Lighting quality (WES 20)	p=.02	-	-
VDT use	p=.63	-	-
Interaction	p=.29	-	-

Table 41 continued.

ANOVA model	Visuo-ocular Strain	Musculo-skeletal Strain Posutral	Musculo-skeletal Strain Manipulative
Lighting quantity (part 3, item 2b)§	p=.07	-	-
VDT use	p=.41	-	-
Interaction	p=.23	-	-
Lighting comfort (part 3, item 3d)	p=.00	-	-
VDT use	p=.46	-	-
Interaction	p=.13	-	-
Proportion of time sitting*	-	p=.92	p=.20
VDT use	-	p=.46	p=.47
Interaction	-	p=.11	p=.33

(-) indicates variable not used as a predictor in the regression analyses

* ANOVA subgroups were formed by categorizing individuals above and below the median score for continuous variables.

§ Lighting level was reclassified correct, somewhat high/low, much too high/low.

office machine use per day for VDT users (essentially equivalent to number of hours of daily VDT operation) and non-users. This is the same variable used in the prediction of moods, illness symptoms, and dissatisfaction in the preceding general work environment analyses. The three "lighting" variables represent specific questionnaire items (questionnaire source identified in parentheses following each term) comprising the environmental lighting problems scale on which data were obtained for both VDT users and non-users. The results of analyses involving these terms can therefore provide a limited projection as to how ambient lighting problems affect strain in non-users vis-a-vis VDT users. For none of the remaining variables from the preceding regression prediction of eye and musculo-skeletal strain in VDT users were analogous variables formulated for the non-user sample. Neither do any of the remaining variables contain questionnaire items which were also pertinent and hence administered to non-users. Thus the specific working conditions denoted by those variables could not be included in the present analyses. For each predictor variable, an ANOVA is conducted for only the strain measure(s) the term was used to predict in the preceding regression analyses.

There are three notable features in the results of these analyses. First, inspection of Table 41 shows a uniform absence of main effects of VDT use/non-use in the prediction of eye and musculo-skeletal strain. This result is consistent with the univariate comparison of VDT users and non-users for these types of strain which show no significant group differences (Table 20), although the incidence is greater in the VDT group. The results are also consistent with the outcomes of the general work environment analyses indicating no meaningful impact of classification as a VDT user or non-user in the prediction of illness symptoms.

Table 41 also shows the pattern of main effects demonstrated in the previous regression analyses for VDT users only. The job control, job demands, corrective eye wear, chair comfort, and ambient lighting variables all tend to be significant predictors of strain.

The main focus of the present analyses, however, is on the effects of interaction terms. Table 41 shows that with only one exception (corrective eyewear use), the variables examined fail to interact with VDT use/non-use in a meaningful way in the prediction of eye or musculo-skeletal strain. It is of particular interest that the effects of the chair and ambient lighting ratings are not statistically different for VDT users than non-users. In the present sample, VDT users spend more time sitting than do non-users, and the effect approaches statistical significance ($F = 3.18$, $p = .08$). It might be speculated that by the nature of VDT work, this would be a common distinction between VDT users and non-users that may potentiate strain associated with poor chair design. Yet the effect of perceived chair comfort is much the same for VDT users and non-users. Although not unambiguously demonstrated in terms of visuo-ocular manifestations or by any other measure, it also does not seem unreasonable to postulate that VDT use may be more visually demanding than more conventional office work considering the nature of tasks, dynamic displays, and opportunities for glare provided by the display. Under these circumstances, one might suspect that VDT users may be more sensitive to perturbations in ambient lighting than non-users, but this postulate is not sustained by the present analyses. Associations of ratings of ambient lighting and reported eye strain are much the same for VDT users and non-users alike. For two of the ambient lighting items (lighting quality and lighting quantity) strain scores did in fact increase at a higher rate for the VDT users as ratings became more negative. However, the differential effect is not significant, and for the third lighting item, the trend was reversed. Strain scores increased faster for the non-users as lighting ratings became more negative.

These results do not necessarily mean that equivalent lighting and chair design would result in no more or less strain for VDT users than non-users. The possibility exists that similar subjective appraisals of chair and ambient lighting by VDT users and non-users do not reflect equivalent objective conditions. Arndt (1982) found the same chairs were rated as less comfortable by VDT users. In the present study, chair comfort was also rated lower for the VDT users, although we could not ascertain whether in fact the chairs were objectively of lower quality (there is no reason to suspect so). If improved chair design and lighting in VDT use is required for the same degree of comfort perceived with lesser quality chairs and lighting in non-VDT work, strain would be increased for the VDT users with chair and lighting quality that is objectively similar to the quality for non-users since the predictive effects of perceived quality is the same for both users and non-users.

Although there is no clear indication of an interaction of VDT use/non-use with perceived chair or lighting quality, Table 41 shows that VDT use/non-use does interact with the use of corrective eyewear in the prediction of the eye strain index. The effect also approaches significance in the prediction of the two musculo-skeletal strain indices. The bottom of Table 37 shows that in the entire study sample, the proportion of VDT users reporting eye strain symptoms is considerably higher for the subgroup of users with corrective eyewear. Proportions of non-users reporting eye strain is about the same in the subgroups with and without corrective eyewear. In the present ANOVA sample, the same pattern is observed in scores on the visuo-ocular strain index. For the VDT users only, visuo-ocular strain scores are worse (lower) in the subgroup with corrective eyewear. Similarly, corrective eyewear use is associated with an increase in neck/back/shoulder strain scores and an increase in arm/hand strain scores for the VDT users. But, musculo-skeletal strain scores are about the same for the subgroups of non-users with and without corrective eyewear. The differential effect (between users and non-users) approaches significance.

The general eyewear effects evidenced in VDT users, the multifocal-monofocal eyewear effects evidenced most strongly in VDT users, and the differential VDT user/non-user general eyewear effect described here all require further investigation to establish a rationale for their basis. Before too much is made of the differential (user/non-user) effect, it should be pointed out that the non-user subgroup without corrective eyewear is quite small (Table 37), possibly compromising the ability to draw reliable inferences. This effect, manifest in the interaction described here, requires replication. Data presented by Laubli et al. (1981) do not correspond to the present findings. They reported (but do not present the data), that the general eyewear effect described here is less apparent in VDT users than in non-users. The general eyewear effect and the multifocal-monofocal eyewear effect witnessed in the VDT group, however, is unlikely to be influenced by a sample size problem.

At minimum, future methodologies for explicating these effects should involve optometric measures of visual status and visual correction, and measures of visual distances and working postures in VDT operation as independent variables. The monofocal eyewear effect could be due to over-correction of lenses for normal VDT viewing distances if reading glasses were abundant in this group.

One possible explanation for the monofocal-multifocal effect witnessed here and by Cakir et al. (1978) is that it may be contaminated somewhat by age. Remember, from Table 37, that the eyewear effect is most strong for individuals with monofocal lenses. It is likely that individuals who wear monofocal lenses are younger than those who wear multifocal lenses. The data also show that younger workers report more strain. There is some possibility, then, that the monofocal-multifocal difference in reported strain is due in part to age differences separating individuals with monofocal lenses and those with multifocal lenses. On the other hand, it would seem reasonable to conjecture that individuals with multifocal lenses may also be older than individuals without corrective eyewear since accommodative function is progressively impaired with age. Yet there is no differential in strain between individuals with multifocal lenses and without corrective eyewear.

Finally an interaction between the VDT use/non-use and hours of daily machine use variables in the prediction of arm/wrist/hand strain is observed in Table 41. The effect is toward increased strain with increasing machine use among non-users, with only a negligible change for the VDT users. We cannot confidently offer an explanation for this effect. One speculation is that work activities such as keyboarding provide less chronic stress to arm-hand neuro-motor systems in VDT work than incurred in the operation of more traditional office machines. However, a literal interpretation of this interaction effect may be inappropriate in the absence of analyses which control for other potential causal variables.

Summary and Conclusions--

The types of operational and physical workplace/workstation aspects of VDT jobs investigated in these analyses span a range from the fairly narrow or specific (e.g. temporal delays in computer response) to the fairly broad (e.g. job control). A surprising and somewhat disappointing aspect of these results was that many of the more narrow job or workplace attributes which would be expected on the basis of prior VDT stress research or general ergonomic principles to influence eye and musculo-skeletal strains failed to achieve significance as predictors of these strains. This would include factors such as the amount of time spent in VDT operation, extent of display viewing, extent of information input (reflecting keyboard intensive work) versus conversational use of VDTs, opportunities for discretionary breaks, adjustability of lighting and workstation configuration, etc. In most cases these factors leveled an influence in an expected direction and sometimes approached significance, but in few cases could their effects be considered meaningful. Along the same line, although all regression models were statistically significant, it was discouraging to find that even the best-fit models accounted for only a small proportion of the variance in the visuo-ocular and musculo-skeletal strain indices. We are quite certain that aside from the potential existence of interaction effects, the modest fit of these models is not a product of the analytical procedure. The different regression approaches identified yielded about the same results and extensive evaluation of scatterplots and residuals plots indicated simply a poor association between many predictors and the strain measures.

There exist several likely explanations for these weak associations. One is that the conditions assessed simply do not have the degree of influence that might be expected. The VDT stress research has yet to demonstrate dramatic effects of many of the conditions investigated. For the factors that did tend to rise to prominence in these analyses (e.g. chair quality, eyewear use), their importance has been fairly well substantiated in prior research. Another basis for the weak associations might be that reliable assessment of certain of the conditions investigated may be difficult with subjective survey methodologies. A third is that VDT users may not utilize, or effectively utilize available resources denoted by some of the variables examined (e.g. discretionary rest breaks, equipment and lighting adjustability) that would impact the stress process. It is also possible that in reality it is the broader work system, including psychosocial aspects, which is more important in defining the potential for the strains of VDT operators than specific task characteristics. The present analyses show, for example, that classification as a data entry user is a far better predictor of arm/hand musculo-skeletal strain than is knowledge of keyboarding demands. Likewise, the job control variable levels a strong influence throughout most of these analyses. Finally, it is possible the present analyses may have neglected important stressors in VDT work such a specific physical attributes of workstation/workplace design that are difficult to assess using survey methods.

On the other hand, the present analyses do strongly suggest that display and ambient lighting perturbations, and a poor physical interface with the chair and workstation, as well as production demands constitute sources of strain for VDT users. These findings are consistent with prior VDT research and conventional wisdom in ergonomics (Cakir et al., 1980; Grandjean, 1981; Stammerjohn et al., 1981), although in absolute terms the effects cannot be regarded as dramatic.

Three other findings in these analyses are worthy of special emphasis. One is, again, that the number of hours of VDT use per day by itself is a poor, almost meaningless, predictor of eye or musculo-skeletal strain. If this effect is generalizable beyond the current sample, it would seem to have important implications in terms of current efforts in many quarters toward effective control measures for stress and strain in VDT work. Secondly, the data reinforce prior indications (Cakir et al., 1981; Laubli et al., 1981) that the use of eyewear seems to be an important stress factor in VDT use. Importantly, the magnitude of the effect is on par with or exceeds the influence of many job-task and physical workplace attributes in the prediction of eye strain. More work is needed to define the basis and control measures for the general eyewear and monofocal-multifocal effects for the VDT users. More work is also needed to determine the reliability and basis of the differential eyewear effect which suggests that VDT users with corrective eye wear are at greater risk for somatic strains than non-users with corrective eye wear.

Third, the present data suggest that eye and musculo-skeletal effects of variation in certain specific attributes of the VDT workplace (e.g. ambient lighting and chair quality), as well as more general features of the job design may be much the same for VDT users and non-users alike. However, the present analyses are based upon the perceived environment. There is some indication that for the chair in particular, similar perceptions of adequacy by VDT users and non-users may require objectively improved conditions for the VDT users. The result would be increased strain for VDT users under conditions objectively similar to those for non-users.

Somatic Strains and the Objective Environment

Aim of the Analyses--.

These analyses focus on the relationships of objectively assessed VDT user and VDT workplace characteristics with reported eye and musculo-skeletal strains. The primary purpose was to extend the previous regression analyses by investigating the association of somatic strains with specific characteristics of VDT users and their workplaces that are not amenable to subjective assessment. A lesser purpose was to address the reliability of associations established in prior analyses on the basis of subjective evaluations of workplaces. As indicated, these analyses examine correlates of strain for VDT users only. While a comparable analysis of these relationships among non-users would also be of interest, such an effort was beyond the scope of the current project.

While the main thrust of these analyses was to investigate the relationships of worker and workplace attributes with strain, we were also interested in examining associations among VDT user/workplace conditions which might reflect potentially important causal connections (e.g. VDT user posture and workstation configuration).

The strain measures in these analyses are the visuo-ocular, manipulative (mainly arm/hand discomfort) and postural (back/neck/shoulder discomfort) strain indices predicted in the preceding regression analyses.

Worker and Workplace Measures--

The factors evaluated for their relationships with eye and musculo-skeletal strains are listed below along with the acronym used to denote the variables in tabled results. A more detailed description of these variables and their method of measurement is provided in the data collection section of the report.

<u>Factors examined in relation to musculo-skeletal strain</u>
Quality of the frontal plane of the trunk (BACK PLANE)
Quality of the frontal plane of the neck (NECK PLANE)
Use of the back support of the chair (BACK SPPT)
Use of an adjusted keyboard (KYBD ADJ)
Eye-to-screen angle (GAZE ANGLE)
Forearm angle (FOREARM ANG)

<u>Factors examined in relation to eye strain</u>
Screen background luminance (SCRN LUM)
Screen standard luminance (SCRN STD)
Keyboard luminance (KYBD LUM)
Keyboard standard luminance (KYBD STD)
Background luminance left, right, center (BKGD LUM <u>L</u>, <u>R</u>, <u>C</u>)
Average background luminance (ABKGD LUM)
Screen illuminance (SCRN ILL)
Work surface illuminance (WRK SURF ILL)
Keyboard illuminance (KYBD ILL)
Screen to background luminance ratio (SB LUMR)

Screen reflectance (SCRN REF)
Number of screen quadrants with glare (GLA QUAD)

Many of the VDT user and workplace factors targeted for investigation here have been touted as significant for the visual comfort of VDT users (Cakir et al., 1980). While several prior studies investigating eye strain among VDT users have objectively assessed many of the specified ambient and task lighting conditions (e.g. Cakir et al., 1978; Hultgren and Knave, 1973; Laubli et al., 1981; Mourant et al., 1981; Seppala, 1974; Stammerjohn et al., 1981), it is surprising that only a few appear to have systematically evaluated their relationships with measures of eye discomfort as did Laubli et al. 1981.

Similarly, objective measures of workstation configuration and worker posture at the VDT/workstation have not been systematically evaluated in relation to reports or signs of musculo-skeletal strains in much of the prior research. Recent work by Dainoff, Fraser, and Taylor (1982) Grandjean, Hunting, and Nishiyama (1982), and Hunting et al. (1981) have made important advances in this direction.

While the ambient and task lighting factors investigated are quite comprehensive, the conditions examined in relation to musculo-skeletal discomfort center mainly on user posture. Clearly additional measures of anthropometric and workstation distances and angles would be of interest in terms of their association with musculo-skeletal discomfort. However, the effort required for a more comprehensive assessment of worker and workstation physical parameters was beyond the scope of the resources of the current project. The postural and detachable keyboard data were obtained from photographic records. This not only improved economy in measurement by minimizing on-site activities, but unobtrusively taken photographs also interfere only minimally with the process or variable measured, thereby reducing the potential for reactive effects of measurement.

A critical issue related to the present methodology is the representativeness of these simple time-slice and static photographic measures of worker and workplace conditions. On the one hand, this may present an important limitation in the present work, possibly accounting for some of the relatively low associations reported below. On the other hand, Arndt (1982) and Grandjean et al. (1982) report data on VDT user posture and VDT/workstation configuration in which multiple samples within and across days suggest remarkable stability of these parameters. In addition, many of the relationships described here are in fact quite strong considering the relatively low sample size. This would be unlikely with excessive instability in the parameters assessed.

Descriptive statistics for all of the specified worker and workplace conditions are present in Table 42.

Sample--
The sample for these analyses consisted of all 62 VDT users/workstations from which objective data were obtained in this investigation. A primary limiting factor for objective measurement of each user/workstation was the ability to obtain the necessary photographs of the workstation. For the VDT users/workstations not included in these analyses, photographs were prohibited due to either failure of the user to provide informed consent to be

Table 42. Descriptive statistics for all variables used in the objective ergonomic analyses.

	Mean	SD	Minimum	Maximum
SCRN LUM	3.02	3.39	0.38	26.00
SCRN STD	29.99	15.59	7.40	81.70
KYBD LUM	15.09	10.17	1.90	47.70
KYBD STD	48.64	23.78	4.80	115.10
BKGD LUML	14.75	11.82	0.74	55.60
BKGD LUMC	17.64	16.79	1.33	99.80
BKGD LUMR	14.78	15.72	1.00	89.20
SCRN ILL	30.53	15.87	9.90	93.60
KYBD ILL	57.38	23.49	16.00	134.00
WRK SURF ILL	55.98	26.06	11.40	171.30
SB LUMR	0.30	0.30	0.03	1.53
SCRN REF	0.10	0.06	0.02	0.36
GLA QUAD	1.42	1.05	0.00	4.00
BACK PLANE	0.78	0.42	0.00	1.00
NECK PLANE	0.73	0.45	0.00	1.00
BACK SPPT	0.76	0.43	0.00	1.00
KYBD ADJ	0.48	0.50	0.00	1.00
GAZE ANG	27.19	9.87	5.00	51.00
FOREARM ANG	79.41	9.05	60.00	105.00
VISOC STRN	-1.86	1.89	-5.01	3.72
MANIP STRN	-4.68	1.49	-6.56	-1.09
POST STRN	-2.14	1.96	-5.27	3.16

photographed, or to a workstation configuration which prevented an adequate photograph (e.g. a side-angle photograph prevented by the alignment of VDTs in rows on tables). As described in the methods section of this report, the objective data were obtained at the time of survey administration. Nearly every worksite surveyed is represented in the present sample. Thirty-eight of the 62 users/workstations from which objective data were obtained are among the VDT users from the preceding regression sample. Twelve are among the users who were excluded from those regressions for lack of complete data on the regressors. An additional 12 are from the VDT users in the secondary sample.

For a few of these 62 VDT users/workstations, data were missing on some of the objective variables. This was due mainly to the inability to make reliable measures from the slide photographs when they were evaluated subsequent to worksite assessment. For 12 worksites, data on screen and and keyboard illuminance were not obtained due to an oversight. However, because the present analyses are univariate in nature as explained below, cases with missing data are not omitted. Rather tests of associations are simply based upon the number of cases with complete data for the variables in consideration.

Analytical Procedure--

Our original intention was to systematically assess the associations of the specified worker and workplace variables with the eye and musculo-skeletal strain indices using multiple regression techniques. This approach, however, proved unsatisfactory due to a combination of reasons involving mainly a relatively low sample size and strong correlations among certain of the predictor variables. For these reasons, the present analyses are limited to the evaluation of simple relationships only.

Analysis of variance, focussing on eta coefficients, was used to evaluate the association of categorical variables with strain measures. Associations between continuous worker/workplace variables and strain indices were examined through the inspection of bivariate scatterplots and Pearson product moment correlations.

In the results presented below, we describe first the associations of the postural and keyboard adjustability variables with the musculo-skeletal strain indices. Next the associations of task and ambient lighting variables with the visuo-ocular strain index are described. In presenting these results, we provide not only the associations between VDT user/workplace and strain variables, but associations among the user/workplace variables themselves. Inspection of these associations enables some inferences regarding potential causal linkages among VDT user and workplace environmental correlates of strain (e.g. user posture in relation to use of a detachable keyboard; VDT screen glare in relation to ambient lighting). Associations among user/workplace variables that are categorical in nature are evaluated through inspection of contingency tables and reference to phi coefficients. Associations between categorical and continuous user/workplace variables are evaluated through analysis of variance and attention to eta coefficients. Associations among continuous user/workplace variables are evaluated via Pearson product moment correlations.

Correlates of Musculo-skeletal Strain--
Table 43 summarizes associations among VDT user postural measures and the detachable keyboard variable, and associations of these variables with the musculo-skeletal strain index denoting neck/back/shoulder discomfort (postural strain: POST STRN) and the index denoting predominantly arm/hand discomfort (manipulative strain: MANIP STRN).

At first glance, Table 43 seems to suggest little association of the VDT user postural indices with musculo-skeletal strain. Relationships of ratings of back and neck posture, and of use of the back support of the chair with both strain measures do not even approach significance. Similarly, the forearm angle is not significantly associated with either strain measure. These findings are contrary to expectations based upon widely cited ergonomic prescriptions for VDT work (e.g. Cakir et al., 1980).

On the other hand, the gaze angle and detachable keyboard measures are in fact significantly associated with the strain measure denoting mainly arm/hand discomfort. The gaze angle relationship which is quite strong indicates greater strain with increased depression of the line of sight below the horizon. A similar trend is seen with the neck/back/shoulder strain index, with increased strain at greater gaze angles, although the effect is not significant. For the keyboard measure, arm/hand strain scores of individuals who used keyboards in a detachable mode were significantly lower than the scores of those who did not use separated keyboards. Remember that the keyboard measure indicated not simply whether the keyboard could be separated from the VDT main chassis, but rather, whether in fact it was adjusted in relation to the main chassis in a way which would be impossible with a keyboard affixed to the chassis.

Looking more closely at the associations summarized in this table, it can be seen that the keyboard measure is also significantly associated in a very strong manner ($r = .72$) with the gaze angle measure. In this case, the use of a keyboard in a detached mode is related to a <u>reduced</u> depression of line of sight. For the individuals using a detached keyboard ($n = 28$), the mean gaze angle was 20 degrees. The gaze angle for individuals with keyboards which were not used in a detached mode ($n = 31$) was 34 degrees.

The table also shows a modest but nonsignificant association ($eta = .20$) between the forearm angle and the keyboard measure. Here, the forearm angle is greater (i.e. hands lower in relation to the elbow) with a keyboard used in a detached mode. The mean forearm angle for individuals using the keyboard in this fashion was 81 degrees, and 78 degrees for keyboards which were not used in a detached fashion (angles measured from the vertical axis extending upward at the elbow).

The table also shows a strong significant association of the neck posture with the back posture ($phi = .50$), and a near significant association of neck posture with use of a chair back support. The actual data indicate that when neck/cervical postures are poor (inclined or thrust forward), back postures are likewise poor (excessive forward inclination of the back of hunching of the shoulders), and the back tends not to be contiguous with the chair back support.

Table 43. Relationships among anthropometric measures and musculo-skeletal strain indices.

	BACK PLANE	NECK PLANE	BACK SPPT	KYBD ADJ	GAZE ANG	FORE-ARM ANG	POST STRN
	-Phi values-						
NECK PLANE	.50 (59) p=.00						
BACK SPPT	.18 (59) p=.30	.29 (59) p=.06					
KYBD ADJ	.18 (59) p = .29	.20 (59) p = .22	.05 (59) p = .93				
	-Eta values-						
GAZE ANG	.10 (59) p=.45	.11 (59) p=.14	.22 (59) p=.10	.72 (59) p=.00			
						-Pearson r-	
FORE ARM ANG	.00 (59) p=.98	.21 (59) p=.11	.05 (59) p=.71	.20 (59) p=.14	.04 (59) p=.38		
POST STRN	.06 (59) p=.64	.09 (59) p=.49	.05 (59) p=.73	.11 (59) p=.39	.14 (59) p=.15	.01 (59) p=.48	
MANIP STRN	.16 (58) p=.24	.12 (58) p=.39	.07 (58) p=.63	.28 (58) p=.03	.39 (58) p=.00	.15 (58) p=.13	.50 (61) p=.00

Modest but statistically nonsignificant associations are also seen between the gaze angle and back support and neck posture measures. The data indicate a trend toward poor neck posture and lack of back support with increased gaze angle.

Although it is somewhat hazardous to infer patterns of causation from the matrix of simple associations shown in Table 43, collectively they would seem to suggest that keyboard adjustment or configuration vis-a-vis the display may be an important determinant of musculo-skeletal strain in VDT use which is likely mediated by postural adaptations stimulated by the keyboard position. With a separable keyboard, the display and keyboard can be adjusted independently of one another to optimize angles in display viewing and keyboard operation. Table 43 shows significant variation in gaze angle and a slight trend toward variation in forearm angle with a separated keyboard which are consistent with ergonomic prescriptions for minimizing stress in VDT viewing and keyboarding. That is, the gaze angle is reduced and the forearm angle increased (hands lowered). With reduced gaze angle, neck posture tends to improve and strain is significantly reduced in the arm/hands, and tends toward a reduction in the neck/back/shoulders.

It is of interest that the forearm angle is not significantly associated with either strain index. With a detachable keyboard, forearm angle tends to be somewhat greater (i.e. hands lowered), but the greater angle also tends to be associated with somewhat greater arm/hand strain, although neither trend is statistically significant. The latter effect is contrary to conventional wisdom in VDT ergonomics, but not to data presented by Hunting et al. (1981) showing reduced strain with more elevated keyboards, and recent data by Grandjean et al. (1982) indicating user preference for a forearm position with the hands elevated relative to the elbow, although the mean elbow interior angle exceeded 90 degrees. Similar preference data have been reported by Arndt (1982). Thus, the present data suggest that the primary benefit to be obtained from a separable keyboard may be increased opportunity for improved neck/back/head posture in VDT viewing brought about by a reduced viewing angle. Arm angle effects associated with a detached keyboard seem counterproductive in light of the relationships with strain seen here and witnessed in the studies cited. It would seem that similar positive effects toward strain reduction might be obtained by elevating worksurfaces for VDTs with affixed keyboards so long as precautions are taken to avoid excessive arm-hand angles or static loading of the arms. This is somewhat consistent with the conclusion of Hunting et al. (1981) that the reduced musculo-skeletal strain they observed among VDT users with more elevated keyboards may be the result of improved posture in document viewing brought about by the raised work surface. It is unclear, however, why the present effects related to the adjusted keyboard and gaze angle are stronger for the index denoting mainly arm/hand strain than for the neck/back/shoulder strain index, although the two indices are strongly correlated ($r = .50$), and similar trends are noted in each. It would be of interest to know the effects of increased elevation of the hands in terms of arm/hand strain for the VDT users investigated by Hunting et al. (1981). Only neck/back/shoulder strains were reported in that study.

Despite the fact that the keyboard and gaze angle effects observed here are quite strong, a precautionary note is in order. The analyses described in this section of the report are limited in that they do not preclude the possibility of confounding effects. We feel further investigation and substantiation of the present findings and conclusions, as well as effects observed by Hunting et al. (1981) is warranted. This work should be carried out under more controlled circumstances with additional anthropometric and workstation measures. Grandjean et al. (1982) have made an important advance in this regard.

Finally, we must mention that when we went back and looked at musculo-skeletal strain scores in relation to survey self-reports of whether VDTs used were equipped with detachable keyboards, the effects were not as strong. Arm/hand strain was greater for users reporting non-detachable keyboards, but not significantly so. A likely explanation for this discrepancy may be the way keyboard detachment was assessed in the present objective analyses. Keyboards which were detachable but not used in this mode (i.e. contiguous with the VDT main chassis so that for all practical purposes detachability was meaningless) were not regarded as detached in the assessment process. Under these circumstances they would offer no advantage over VDTs with keyboards affixed.

Correlates of Visuo-ocular Strain--
Table 44 summarizes associations among workplace/workstation/VDT display lighting measures and the visuo-ocular strain index (VISOC). Perhaps the most important observation in this matrix is the association of visuo-ocular strain scores with illumination measures at VDT work surfaces/visual targets. Strain is significantly correlated with illumination at the keyboard ($r = .31$), at the workplace location with where the source document is normally positioned ($r = .21$), and the association with illumination at the screen approaches significance ($p = .07$).

Although the background luminance measures are not significantly associated with the eye strain measure in a direct way, the measures tend to be strongly correlated with work surface luminance and illumination measures which are in turn significantly correlated with the eye strain measure. Average background luminance measures are significantly correlated with luminance of the screen standard ($r = .46$) and of the keyboard standard ($r = .53$), and with illuminance at the screen ($r = .44$), at the keyboard ($r = .46$), and at the workplace document site ($r = .42$).

Thus, these data are highly consistent with general ergonomic principles of lighting for VDT work which stipulate that increases in illumination are liable to lead to increases in visual/eye discomfort, although clear empirical demonstrations of a linkage between VDT workplace lighting characteristics and eye related strain are almost non-existent in the literature. The present data are quite strong in suggesting that increases in workplace ambient lighting (as indicated roughly by the background luminance measures) are linked to increased workstation and task lighting (illuminance), which is in turn associated with an increased incidence of eye strain. These findings are also consistent with, and therefore reinforce, the results of the previous regression predictions of eye discomfort in which the environmental lighting problems index to be a significant determinant of visuo-ocular strain scores.

Of interest is that certain of the lighting related parameters reflecting conditions generally thought to represent stress factors fail to achieve significant correlations with the eye strain index. No meaningful trends were observed between visuo-ocular strain scores and the screen to background

Table 44. Relationships among lighting-related parameters and the Visuo-ocular Strain index.

- - - - - - P E A R S O N   C O R R E L A T I O N   C O E F F I C I E N T S - - - - -

	VISOC	SCRNLUM	SCRNSTD	KYBDLUM	KYBDSTD	BKGDLUML	BKGDLUMC	BKGDLUMR
VISOC	1.0000	.1312	.2388	.0638	.2804	.1575	-.0056	.0279
	(0)	(62)	(62)	(62)	(62)	(62)	(62)	(62)
	P= *****	P= .155	P= .031	P= .311	P= .014	P= .111	P= .483	P= .415
SCRNLUM	.1312	1.0000	.4963	-.0610	.1795	-.0889	.0336	-.1089
	(62)	(0)	(62)	(62)	(62)	(62)	(62)	(62)
	P= .155	P= *****	P= .000	P= .319	P= .086	P= .246	P= .398	P= .200
SCRNSTD	.2388	.4963	1.0000	.0978	.6910	.1869	.3509	.4965
	(62)	(62)	(0)	(62)	(62)	(62)	(62)	(62)
	P= .031	P= .000	P= *****	P= .225	P= .000	P= .073	P= .003	P= .000
KYBDLUM	.0638	-.0610	.0978	1.0000	.0529	-.1027	.2250	.0334
	(62)	(62)	(62)	(0)	(62)	(62)	(62)	(62)
	P= .311	P= .319	P= .225	P= *****	P= .341	P= .213	P= .039	P= .398
KYBDSTD	.2804	.1795	.6910	.0529	1.0000	.4186	.3558	.4662
	(62)	(62)	(62)	(62)	(0)	(62)	(62)	(62)
	P= .014	P= .086	P= .000	P= .341	P= *****	P= .000	P= .002	P= .000
BKGDLUML	.1575	-.0889	.1869	-.1027	.4186	1.0000	.2178	.3853
	(62)	(62)	(62)	(62)	(62)	(0)	(62)	(62)
	P= .111	P= .246	P= .073	P= .213	P= .000	P= *****	P= .045	P= .001
BKGDLUMC	-.0056	.0336	.3509	.2250	.3558	.2178	1.0000	.5167
	(62)	(62)	(62)	(62)	(62)	(62)	(0)	(62)
	P= .483	P= .398	P= .003	P= .039	P= .002	P= .045	P= *****	P= .000
BKGDLUMR	.0279	-.1089	.4965	.0334	.4662	.3853	.5167	1.0000
	(62)	(62)	(62)	(62)	(62)	(62)	(62)	(0)
	P= .415	P= .200	P= .000	P= .398	P= .000	P= .001	P= .000	P= *****
SCRNILL	.2157	.2162	.9203	.0843	.6888	.1356	.2821	.5584
	(50)	(50)	(50)	(50)	(50)	(50)	(50)	(50)
	P= .066	P= .066	P= .000	P= .280	P= .000	P= .174	P= .024	P= .000
KYBDILL	.3139	.0692	.8451	.2196	.8519	.2504	.2635	.5412
	(50)	(50)	(50)	(50)	(50)	(50)	(50)	(50)
	P= .013	P= .316	P= .000	P= .063	P= .000	P= .040	P= .032	P= .000
WRKILL	.2135	.5212	.8076	.1518	.7622	.1571	.3602	.4019
	(62)	(62)	(62)	(62)	(62)	(62)	(62)	(62)
	P= .048	P= .000	P= .000	P= .120	P= .000	P= .111	P= .002	P= .001
SBLUMR	-.0126	.7129	.2440	-.2230	-.0022	-.3977	-.2858	-.3651
	(62)	(62)	(62)	(62)	(62)	(62)	(62)	(62)
	P= .461	P= .000	P= .028	P= .041	P= .493	P= .001	P= .012	P= .002
SCRNREF	.0423	.6681	-.0880	-.1431	-.2267	-.1232	-.2144	-.3566
	(62)	(62)	(62)	(62)	(62)	(62)	(62)	(62)
	P= .372	P= .000	P= .248	P= .134	P= .038	P= .170	P= .047	P= .002
GLAQUAD	-.0230	.3078	-.0913	-.1180	-.1750	-.3213	-.4336	-.3529
	(60)	(60)	(60)	(60)	(60)	(60)	(60)	(60)
	P= .431	P= .008	P= .244	P= .185	P= .091	P= .006	P= .000	P= .003
ABKGDLUM	.0645	-.0642	.4648	.0902	.5333	.6293	.8032	.8460
	(62)	(62)	(62)	(62)	(62)	(62)	(62)	(62)
	P= .309	P= .310	P= .000	P= .243	P= .000	P= .000	P= .000	P= .000

Table 44 continued.

	SCRNILL	KYBDILL	WRKILL	SBLUMR	SCRNREF	GLAQUAD	ABKGDLUM
VISOC	.2157 (50) P= .066	.3139 (50) P= .013	.2135 (62) P= .048	-.0126 (62) P= .461	.0423 (62) P= .372	-.0230 (60) P= .431	.0645 (62) P= .309
SCRNLUM	.2162 (50) P= .066	.0692 (50) P= .316	.5212 (62) P= .000	.7129 (62) P= .000	.6681 (62) P= .000	.3078 (60) P= .008	-.0642 (62) P= .310
SCRNSTD	.9203 (50) P= .000	.8451 (50) P= .000	.8076 (62) P= .000	.2440 (62) P= .028	-.0880 (62) P= .248	-.0913 (60) P= .244	.4648 (62) P= .000
KYBDLUM	.0843 (50) P= .280	.2196 (50) P= .063	.1518 (62) P= .120	-.2230 (62) P= .041	-.1431 (62) P= .134	-.1180 (60) P= .185	.0902 (62) P= .243
KYBDSTD	.6888 (50) P= .000	.8519 (50) P= .000	.7622 (62) P= .000	-.0022 (62) P= .493	-.2267 (62) P= .038	-.1750 (60) P= .091	.5333 (62) P= .000
BKGDLUML	.1356 (50) P= .174	.2504 (50) P= .040	.1571 (62) P= .111	-.3977 (62) P= .001	-.1232 (62) P= .170	-.3213 (60) P= .006	.6293 (62) P= .000
BKGDLUMC	.2821 (50) P= .024	.2635 (50) P= .032	.3602 (62) P= .002	-.2858 (62) P= .012	-.2144 (62) P= .047	-.4336 (60) P= .000	.8032 (62) P= .000
BKGDLUMR	.5584 (50) P= .000	.5412 (50) P= .000	.4019 (62) P= .001	-.3651 (62) P= .002	-.3566 (62) P= .002	-.3529 (60) P= .003	.8460 (62) P= .000
SCRNILL	1.0000 (0) P=******	.8220 (50) P= .000	.7328 (50) P= .000	.0479 (50) P= .371	-.3101 (50) P= .014	-.0844 (48) P= .284	.4386 (50) P= .001
KYBDILL	.8220 (50) P= .000	1.0000 (0) P=******	.8721 (50) P= .000	-.0109 (50) P= .470	-.3881 (50) P= .003	-.1671 (48) P= .128	.4606 (50) P= .000
WRKILL	.7328 (50) P= .000	.8721 (50) P= .000	1.0000 (0) P=******	.2113 (62) P= .050	-.0741 (62) P= .284	-.0624 (60) P= .318	.4156 (62) P= .000
SBLUMR	.0479 (50) P= .371	-.0109 (50) P= .470	.2113 (62) P= .050	1.0000 (0) P=******	.5762 (62) P= .000	.5082 (60) P= .000	-.4453 (62) P= .000
SCRNREF	-.3101 (50) P= .014	-.3881 (50) P= .003	-.0741 (62) P= .284	.5762 (62) P= .000	1.0000 (0) P=******	.3965 (60) P= .001	-.3116 (62) P= .007
GLAQUAD	-.0844 (48) P= .284	-.1671 (48) P= .128	-.0624 (60) P= .318	.5082 (60) P= .000	.3965 (60) P= .001	1.0000 (0) P=******	-.4847 (60) P= .000
ABKGDLUM	.4386 (50) P= .001	.4606 (50) P= .000	.4156 (62) P= .000	-.4453 (62) P= .000	-.3116 (62) P= .007	-.4847 (60) P= .000	1.0000 (0) P=******

luminance ratio, the screen reflectance measure (this is actually a ratio of screen background luminance to screen standard luminance), or the screen glare measure. However, these measures do vary significantly with task/ambient lighting. Screen reflectance varies with illumination at the screen ($r = -.31$), glare varies with background illumination ($r = -.48$), and the screen to background luminance ratio varies with background luminance ($r = -.45$) and with workstation illumination ($r = .21$ with illumination at the work surface).

A particularly curious finding was that the screen glare measure (indicating number of screen quadrants in which reflected glare of any type could be detected) is associated with the background luminance levels in a manner which might seem counter-intuitive. While it might be predicted that decreases in ambient lighting would reduce the potential for glare, the relationship shown in Table 44 is actually negative. Reduced background luminance is strongly associated with increased presence of glare ($r = -.48$ for the association with average background luminance). This seemingly anomalous finding might be explained by the fact that simply reducing the illumination of the workplace does not necessarily remove luminaires or other point sources of light as sources of glare. In such environments, the contrast between these sources and the background may increase and improve chances for their detection on the display. This effect is sometimes witnessed in VDT installations where simple solutions to reducing ambient illumination by removing alternate luminaires have been attempted, or with other techniques resulting in non-uniform background lighting.

In terms of associating glare with eye discomfort, an alternate and possibly more appropriate measure might be the brightness of reflections. Laubli et al. (1981) reported a correlation of glare luminance with VDT user annoyance, but not with eye strain. Along this line, the present data show a low positive ($r = .13$) but nonsignificant correlation between visuo-ocular strain scores and screen background luminance, which is in turn significantly associated with the glare measure ($r = .31$). Further investigation relating glare with eye discomfort is needed, but it is not immediately obvious what the critical parameter would be considering the complexities of reflections/glare possible from video displays and the many potential impacts on display quality.

Laubli et al. (1981) also concluded that excessive contrasts in the visual field may promote eye strain, and this is consistent with conventional beliefs in VDT ergonomics. The present data, however, show no meaningful association of the ratio of screen background luminance to visual field background luminance (the average background luminance ratio is designed to approximate an integrated measure of background luminance) with the visuo-ocular strain index. Since many of the VDT operators in the present sample utilized a variety of source documents, we were unable to obtain a reliable measure of source document luminance and hence compute a contrast ratio involving this measure. However, to the extent that white paper was utilized for source documents, the screen reflectance measure (ratio of screen background luminance to screen standard luminance) might tend to approximate the screen to document luminance ratio. Still, the screen reflectance measure is not correlated with the eye strain index ($r = .04$). However, the data do show that with increased illumination of the work surfaces the reflectance ratio decreases (increased contrast between screen background and screen standard), and work surface illumination is in fact associated with increased eye strain.

Thus, while the present data are fairly compelling in suggesting that there is something about increased lighting at VDT workplaces which promotes eye strain among users, they do not allow direct and simple attribution of the effect to conditions such as glare, screen reflectance, or contrast ratios which vary with workplace lighting. The present data point to the need for further work to determine and prioritize the specific mechanisms of lighting related eye strain in VDT use.

Summary and Conclusions--

These data clearly show that expressions of strain in VDT users can be linked to objective attributes of VDT workplaces. Most distinctively, use of a keyboard separated from the terminal display and the associated reduction in gaze angle are related to a lower incidence of musculo-skeletal discomfort, and reduced workstation illumination to a lower incidence of eye complaints. While these findings may come as no great surprise considering existing ergonomic prescriptions for hygienic use of VDTs, such relationships have not been amply or unambiguously demonstrated in prior empirical research.

Aspects of the present data also add to growing uncertainties regarding some of the conventional wisdom in VDT ergonomics (e.g. Grandjean et al., 1982). For example, hand elevation in keyboard operation was not significantly associated with reported strain. If anything, consistent with results by Hunting et al. (1981), a trend toward reduced musculo-skeletal strain with increased hand elevation was observed.

While the present data link objective aspects of VDT workplaces to somatic strains, further research is needed to tease out and prioritize causal pathways or mechanisms in a more precise and controlled fashion than could be accomplished in the present study or has been possible in much of the work to date. The present methods and data do not enable a complete or conclusive explanation of the mechanisms linking keyboard adjustment with reduced musculo-skeletal strain, nor the process by which decreased illumination is associated with reduced eye strain.

Uncertainties in the present work and questions regarding the importance of many of the conventional beliefs in VDT ergonomics are likely to be resolved only through systematic research in which conditions thought to be important determinants of strain are manipulated and effects assessed in a controlled fashion. The breadth and stringency of ergonomic guidelines is somewhat surprising considering the limitations of the existing data base and the dearth of research of this type.

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Appendix A. Agency/department solicitation.

UNIVERSITY OF WISCONSIN

CENTER FOR HEALTH SCIENCES

•DEPARTMENT OF PREVENTIVE MEDICINE

John Rankin, M.D., Chairman

Occupational-Environmental Medicine and Toxicology Section

Vernon N. Dodson, M.D., Director
504 Walnut St.
Madison, WI 53706
(608) 263-1905

Dear ______________,

We intend to respond to an RFP from the National Institute of Occupational Safety and Health related to stress in video display (computer) terminal (VDT) operators. The RFP requires that a self-administered questionnaire be completed voluntarily by 150 VDT operators and 150 non-terminal user clerical office staff. We hope to use State Employees as subjects. We are therefore seeking your support for this study. The questionnaire will take 60-75 minutes. Unfortunately we will not be able to reimburse your agency for this time. We have written to all the major state agencies that use VDT's and would therefore not expect that more than 50-70 employees from any single agency would be involved.

If you are willing to participate with us in this effort we would appreciate receiving from you by March 5th a letter indicating that we will have access to your employees and the names(s) of the individual(s) whom we could contact for information about your agency's terminal usage. I apologize for the urgency of this request. Unfortunately we are facing a March 12 deadline for the submission of the proposal. If you have any questions regarding this request please call Dr. Steve Sauter, the principal investigator, at 263-6706. Also for further information see attachment.

It is conceivable that the information generated by our research may be of ultimate benefit to your employees.

Sincerely,

John Rankin, M.D.
Chairman, Preventive Medicine

JR/dd

Attachment

Appendix B. Suggested memo for agency/department administrators to inform employees of the study.

This is to inform you that the <u>(Department or Agency)</u> has agreed to allow researchers from the University of Wisconsin-Department of Preventive Medicine to approach employees of <u>(Department or Agency)</u> in order to request your voluntary participation in a study of job demands and office work. I would like to stress that the choice as to whether you participate in this study is entirely your decision. The <u>(Department or Agency)</u> will permit you to participate in this study during working hours should you choose to volunteer to participate.

In the near future you may be contacted by the University researchers who will explain the study to you and request your voluntary participation. I understand that participation in this study would involve your completion of a questionnaire which the University has designed. The <u>(Department or Agency)</u> has been told by the researchers that <u>no</u> individual information from these questionnaires will be provided, and that only summarized data will be made available in order to protect the anonymity of those who participate.

Again I should stress that your participation is totally voluntary, and that if you choose to participate, you will be able to withdraw from participation in the study at any time, should you so desire, without incurring any penalty.

Appendix C. Consent form.

UNIVERSITY OF WISCONSIN

CENTER FOR HEALTH SCIENCES

DEPARTMENT OF PREVENTIVE MEDICINE

John Rankin, M.D., Chairman

Occupational-Environmental Medicine and Toxicology Section

Vernon N. Dodson, M.D., Director
504 Walnut St.
Madison, WI 53706
(608) 263-1905

As you may be aware, having received a recent memo from your employer, you are being asked to volunteer to participate in a study of the demands or stresses of office work and their impacts. This study will involve your completion of a questionnaire which your employer has agreed to allow you to fill out on-the-job. Your participation is completely voluntary, and should you choose not to participate, you will suffer no penalty.

Please read over the attached Consent Form which describes the study. Sign it and return it to us in the envelope provided whether or not you choose to participate in the study. We would appreciate it if you could mail* us your Consent Form immediately. Please feel free to contact us if you have any questions (608)263-6706.

Your help in this project will be greatly appreciated. Thank you for your consideration in this matter.

Sincerely,

Steven L. Sauter, Ph.D.
Co-Principal Investigator

Mark S. Gottlieb
Project Coordinator

MG:lv

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* Forms were actually retrieved on site for most participants.

CONSENT FORM

I have been asked to participate in a study to evaluate the demands of office work as it may relate to various aspects of health and well-being. I am being asked to participate in this study because of the type of office work I do. This study will be conducted by the University of Wisconsin Department of Preventive Medicine and will be supported by the National Institute for Occupational Safety and Health. I understand that my participation in this study is completely voluntary, and that if I refuse to take part in the study or withdraw from the study at any time, this will not be held against me in any way.

I understand that the purpose of this study is to evaluate the nature of the job demands or job stresses which I and other office workers experience, and to determine whether any pattern or relationship exists between these aspects of my job and other elements of my life such as my health, health-related habits, my social life, my family life, etc. It has been explained to me that this evaluation will be accomplished by a questionnaire which I will complete on my own while at work. I further understand that although the items on the questionnaire are not considered to be highly sensitive, I may refuse to answer any questions I feel are too sensitive, without having my refusal to answer held against me in any way. I understand that my employer has agreed to allow me time on my job to complete the questionnaire. In addition to completing the evaluation questionnaire, which is expected to take 60 to 90 minutes, I understand that certain participants in this study will have still photographs taken of their work stations as part of the data for this study. I further understand that one of these photographs will require that a profile of the participant appear in the picture. I understand that I may refuse to participate in this part of the study and still participate in the remainder of this study. My refusal to be photographed will not be held against me in any way. If I agree to be photographed, I understand that no public use of any photograph which can identify me can be used without my permission.

It has been made clear to me that although the data and information collected in this study may be made public in the form of reports, my name will not be used in reporting group responses or my individual response. All materials containing my responses and other data in this study will be identified by a code known only to myself and to the researchers. Therefore, only the study researchers will be able to determine how I as an individual performed in this study, and this information cannot be released to anyone else without my written permission. I understand that it is the opinion of the researchers that these procedures should avoid any individual identification, which is the only known risk to me in this study.

I have read the following statement which I understand is a necessary part of all consent forms used by researchers at the University of Wisconsin Center for Health Sciences.

The United States Government Department of Health, Education, and Welfare requires us to state that in the event physical injury occurs as the result of this study, which we believe is unlikely, The University does not automatically provide reimbursement for medical care or other compensation. If physical injury is suffered in the course of this research, or for more information, please notify the investigator in charge.

I realize that my participation in this study is not likely to provide me with any direct personal benefit. However, the results of this study may be used to improve certain aspects of the type of office work I do.

I have a good understanding of the goals and procedures of this study. I understand that before signing this form, I am free to ask questions I may have about the study either by talking to the researchers in person or by contacting: Steven L. Sauter, Co-Principal Investigator, or Mark Gottlieb, Project Coordinator, at (608) 263-6706.

- -

(If you agree to participate, complete the following)

I, ____, have read the above and decide to participate in the research study described above. My signature also indicates that I have received a copy of this consent form.

________________________________ ________________
(your signature) (date)

________________________________ ________________
(signature of Principal Investigator or person obtaining consent) (telephone)

- -

(If you do not wish to participate, complete the following)

I, ____, have read the above and decide that I do not wish to participate in the research study described above.

________________________________ ________________
(your signature) (date)

Appendix D. Survey instruments.

PART 1

O.M.B. Clearance #68-R1648
Expiration Date 12-05-80

JOB DEMANDS AND OFFICE WORK QUESTIONNAIRE

Code # ____ Employer ____________________ Agency, Division ____________

I. JOB DESCRIPTION

The following questions are designed to provide us with a picture of what your job and work tasks involve.

1. What is your present job title and/or classification? ______________

____

2. Briefly list your main work tasks and the approximate percentage of your work time you spend on each task (e.g. xeroxing forms - 20%, typing - 35%, entering data - 20%, writing reports - 10%). The percentage of time you work on all job tasks shouldn't add up to more than 100%.

	Work Task	% Time
a.	____________________	________
b.	____________________	________
c.	____________________	________
d.	____________________	________

3. Are you: (circle the most appropriate number)

   a. A full-time permanent employee 1

   b. A part-time permanent employee 2

   c. A full-time non-permanent employee 3

   d. A part-time non-permanent employee 4

4. (Answer the following question(s) by giving the appropriate number of years and months, e.g., 4 years 2 months; or 0 years, 8 months.)

   a. How long have you worked for your present employer? ____yrs. ____mos.

   b. How long have you worked in your current job (position)? ____yrs. ____mos.

5. In your job, do you work with any of the following machinery (circle 1 for yes, or 2 for no)?

If you circled yes, estimate how many hours a day (average) you work with this type of machine. Also, estimate how much experience you have had working with this type of machine (in your total work experience). (Total hours shouldn't exceed the number of hours you work in one day!)

	YES	NO	HRs./DAY	YEARS	MONTHS
a. VDT's (computer T-V display terminal)	1	2	____	____	____
b. Memory type Typewriter	1	2	____	____	____
c. Standard Typewriter	1	2	____	____	____
d. Microfilm Reader (Microfiche)	1	2	____	____	____
e. Key Punch Machine	1	2	____	____	____
f. Telephone	1	2	____	____	____
g. Calculator	1	2	____	____	____
h. Other(s) . (Please specify)					
____________________	1	2	____	____	____
____________________	1	2	____	____	____

6. Not including your current job (position), have you ever regularly worked with a VDT device at previous jobs. (one hour a day or more)?

YES . . . . 1 (If yes, please answer a and b below and continue.)

NO . . . . 2 (If no, please continue with question number 7)

a. How many years experience did you have working with VDT's? ___yrs. ___mos.

b. How long ago did this past job end? (working with VDT) ___yrs. ___mos.

7. The following questions deal with your work schedule:

a. My work schedule is determined by : (circle one)

mainly myself 1

mainly myself with some input from my supervisor(s) 2

myself and my supervisor(s) equally 3

mainly my supervisor(s) with some input from me 4

mainly my supervisor(s) 5

others (please specify ________________________ . . 6

b. Do you work a fixed work schedule or does your work schedule change?

fixed schedule . . . . . 1 (If 1, go on to c and continue)

schedule changes . . . . 2 (If 2, answer (1) below and then go on to c)

(1) If your work schedule changes, please explain briefly how it changes regarding the following:

i. How often your work schedule changes ____________________

____

ii. The hours of the day you work ____________________

____

iii. The days off you have each week ____________________

____

c. Are you required to start your job at the same time at the beginning of each scheduled work shift or does the time you start work vary?

same time 1

time varies 2

d. Do you finish work at the end of a scheduled work shift at the same time or does the time you finish work vary?

same time 1

time varies 2

e. What time(s) approximately, do you start work? (If your work schedule changes, give the three most common times you start work; if your schedule is fixed, give the most common time).

____A.M. ____P.M.

____A.M. ____P.M.

____A.M. ____P.M.

f. What time(s) approximately, do you finish work? (for changing schedules, give the three most common times, for a fixed schedule, give the most common time)

____A.M. ____P.M.

____A.M. ____P.M.

____A.M. ____P.M.

8. How many hours do you normally work per week (not counting overtime)?

_____ hours

9. How many hours of overtime do you work in an average week? _____ hours

10. How often do you work on the following days?

	NEVER	INFREQUENTLY (RARELY)	SOME-TIMES	FAIRLY OFTEN	VERY OFTEN
a. Saturdays	1	2	3	4	5
b. Sundays	1	2	3	4	5
c. Holidays	1	2	3	4	5

11. In a normal work shift, how many breaks (not including your meal break) do you normally get? (circle the right number)

before meal break . . . . 0 1 2 3 4 5 more than 5

after meal break . . . . 0 1 2 3 4 5 more than 5

a. How long are your breaks? (average)

meal (lunch) break _______ minutes

before meal breaks _______ minutes each

after meal breaks _______ minutes each

12. During an average work day, for how many hours do you: (a + b hours should equal a full work day)

a. work alone . . . . _____ hours

b. work together with others . . . . _____ hours

(1) for how much of the time that you work with others can you talk with them . . . . _________ hours/day

13. The following questions deal with the pace or rate at which you normally work.

a. Are you expected to work at a specific work pace or "make" a certain rate (e.g. type a certain number of words per minute, process a certain number of forms per hour, key a certain number of characters per minute, etc.) Circle 1 for yes or 2 for no.

Yes 1

No 2

b. How much influence do you feel each of the following persons or conditions have on setting the rate or pace you work at: (circle one number for each)

	A LOT OF INFLUENCE	SOME INFLUENCE	LITTLE OR NO INFLUENCE
(1) your (yourself)	1	2	3
(2) your co-workers	1	2	3
(3) your supervisor(s)	1	2	3
(4) the equipment you work with . .	1	2	3
(5) other factors (explain)	1	2	3

c. Briefly describe the pace or rate at which you work the best you can.

14. Are there other persons working around you who do the same types of job tasks as you do?

Yes 1

No 2

15. During an average work day do you perform the same type of job task, or do you change or rotate among a number of tasks? (circle number 1 or 2 below)

Same task . . . . . . 1 (If 1, continue with question number 16.)

Change tasks . . . . 2 (If 2, answer a through f below and continue.)

a. How many different tasks do you perform each day? _____ tasks

b. Approximately how many time do you change tasks each day? _____ times

	YES	NO
c. Does the work station you work at change when you change job tasks	1	2
d. Does the equipment (machines) you work with change when you change job tasks	1	2

D3

e. Can you choose the times during the work day that you can change job tasks?

most of the time 1

sometimes 2

rarely or never 3

16. How much specific job training has your employer given you for your job tasks? (Circle the number most appropriate.)

A great deal of training 5
A lot of training 4
Some training 3
A little training 2
No training 1

17. During the average workday, approximately how many hours do you work?

a. Standing in one place _____hours

b. Sitting _____hours

c. Moving around _____hours

(Total number of hours should add up to the number of hours you work during an average workday.)

II. PERCEIVED JOB CHARACTERISTICS

The following questions are designed to measure your attitudes toward various aspects of your job, or how you would prefer your job to be designed.

We would like you to think about the type of work you do in your job. Circle One Number Per Item.

1. Knowing what you know now, if you had to decide all over again whether to take the type of job you now have, what would you decide?

I WOULD.....

1	2	3
Decide Without Hesitation Take the Same Job	Have Some Second Thoughts	Decide Definitely Not to Take This Type of Job

2. If you were free right now to go into any type of job you wanted, what would your choice be?

I WOULD.....

1	2	3
Take the Same Type of Job As Now Have	Take A Different Type of Job	Not Want to Work

3. If a friend of yours told you he or she was interesting in working in a job like yours, what would you tell him? (Circle one Number)

I WOULD.....

1	2	3
Strongly Recommend It	Have Doubts About Recommending It	Advise Him Against It

4. All in all, how satisfied would you say you are with your job? (Circle One Number)

I AM.....

1	2	3	4
Very Satisfied	Somewhat Satisfied	Not Too Satisfied	Not At All Satisfied

5. How often do you feel the following things about your job? (Circle One Number Per Item.)

	Very Often	Fairly Often	Sometimes	Occasionally	Rarely, Never
a. My work is interesting to do..........................	5	4	3	2	1
b. I dislike the amount of work I'm expected to do....	5	4	3	2	1
c. I feel bored with the work I have to do..............	5	4	3	2	1
d. I am dissatisfied with the pace of my work............	5	4	3	2	1
e. The work on my job feels dull........................	5	4	3	2	1
f. I am unhappy about my current work load.............	5	4	3	2	1

6. In the last six months have you tried to find a different job from the one you now have (a new position)?

YES 1
NO 2

7. These questions deal with different aspects of work. Please indicate how often these aspects appear in your job. Circle One Number Per Item.

	Very Often	Fairly Often	Some-times	Occa-sionally	Rarely Never
a. How often are you clear on what your job responsibilities are?	5	4	3	2	1
b. How often can you predict what others will expect of you on the job?	5	4	3	2	1
c. How much of the time are your work objectives well defined?	5	4	3	2	1
d. How often are you clear about what others expect of you on the job?	5	4	3	2	1
e. How often does your job require you to work very fast?	5	4	3	2	1
f. How often does your job require you to work very hard?	5	4	3	2	1
g. How often does your job leave you with little time to get things done?	5	4	3	2	1
h. How often is there a great deal to be done?	5	4	3	2	1
i. How often can you set the rate (pace) at which you work?	5	4	3	2	1
j. How often do you have more than 1 week's work piled up for you to do?	5	4	3	2	1
K. How often can you choose the kind of work you do?	5	4	3	2	1
L. How often does your job require your full attention?	5	4	3	2	1
M. How often are you concerned or bothered about losing your job or being laid off?	5	4	3	2	1

8. The next set of items deals with the use of your skills and abilities. Indicate how often you use each type. Circle One Number Per Item.

	Very Often	Fairly Often	Some-times	Occa-sionally	Rarely Never
a. How often does your job let you use your skills and knowledge you learned in school?	5	4	3	2	1
b. How often are you given a chance to do the things you do best?.	5	4	3	2	1
c. How often can you use skills from your previous experience and training?	5	4	3	2	1
d. Compared to others in your organization, do you get your fair share of chances to use your skills, knowledge, abilities, and your own ideas?	5	4	3	2	1

9. Again, concerning your job:

	A Great Deal	A Lot	Some	A Little	Hardly Any
a. How much slowdown in the work load do you experience? . . .	5	4	3	2	1
b. How much time do you have to think and contemplate?. . . .	5	4	3	2	1
c. How much work load do you have?	5	4	3	2	1
d. What quantity of work do others expect you to do?	5	4	3	2	1
e. How much time do you have to do all your work?.	5	4	3	2	1
f. How many projects, assignments, or tasks do you have?	5	4	3	2	1
g. How many lulls between heavy work load periods do you have?	5	4	3	2	1
h. How much do you "day dream" on the job?.	5	4	3	2	1
i. How much do you worry about being reprimanded by your supervisor?	5	4	3	2	1

10. The following items deal with different aspects of work. Indicate to what extent each applies to your job. Circle One Number Per Item.

	A Great Deal	A Lot	Some	A Little	Hardly Any
a. How much do you take part with others in making decisions that affect you?	5	4	3	2	1
b. How much do you participate with others in helping set the way things are done on your job?	5	4	3	2	1
c. How much do you decide with others what part of a task you will do?	5	4	3	2	1

11. The following questions deal with how you perceive yourself in regards to how you do your job in relation to yourself or to others. (Circle the appropriate number)

a. Compared to other people in your work group, do you work:

Much faster 5
Somewhat faster 4
About the same 3
Somewhat slower 2
Much slower 1
Don't know 0

	Very Often	Fairly Often	Sometimes	Occasionally	Rarely Never
b. How often do you have to push yourself to get work accomplished?	5	4	3	2	1
c. How often do you make mistakes?	5	4	3	2	1
d. When you make mistakes, do you have to correct them yourself?	5	4	3	2	1

e. Compared to other people in your work group, do you make: (Circle appropriate number)

Many more mistakes 5
Somewhat more mistakes 4
About the same number of mistakes . . . 3
Somewhat fewer mistakes 2
Many fewer mistakes 1
Don't know 0

The next three questions (#12, 13, and 14) ask about your health and your moods or feelings as you feel they are affected by your job. Questions similar to these will be asked later about your overall health and feelings.

12. Have you experienced any of the following during the PAST MONTH on the job? (Circle one number per item)

	Never	Occasionally	Frequently	Constantly
a. Your hands trembled enough to bother you	1	2	3	4
b. You were bothered by shortness of breath when you were not working hard or exercising	1	2	3	4
c. Your neck or shoulders ached	1	2	3	4
d. You were bothered by your heart beating hard	1	2	3	4
e. Your hands sweated so that you felt damp and clammy	1	2	3	4
f. Your back ached	1	2	3	4
g. You had spells of dizziness	1	2	3	4
h. You were bothered by having an upset stomach or stomach ache	1	2	3	4
i. Your eyes burned or ached noticeably.	1	2	3	4
j. You were bothered by your heart beating faster than usual	1	2	3	4
k. You were in ill health which affected your work	1	2	3	4
l. You had problems focusing your vision.	1	2	3	4
m. You experienced a loss of appetite	1	2	3	4
n. Other (specify) ____________	1	2	3	4

13. Below are some phrases which indicate how you might see yourself in your work. For example, if you think that you are very "successful" in your work, put a circle around the number nearest the word "successful." If you think that you are not at all successful in your work, circle the number nearest the words "not successful." If you think you are somewhere in between, circle the appropriate number.

a. Successful	1	2	3	4	5	6	7	Not successful
b. Sad at work	1	2	3	4	5	6	7	Happy at work
c. Not important at work	1	2	3	4	5	6	7	Important at work
d. Doing my best	1	2	3	4	5	6	7	Not doing my best

14. Based on the way you <u>generally feel at work</u>, where would you rate yourself concerning the following feelings (circle the appropriate number for each pair).

a. Nervous	1	2	3	4	5	6	7	Relaxed
b. Full of pep	1	2	3	4	5	6	7	Listless
c. Confused	1	2	3	4	5	6	7	Certain
d. Comfortable	1	2	3	4	5	6	7	Uneasy
e. Discouraged	1	2	3	4	5	6	7	Encouraged
f. Good-natured	1	2	3	4	5	6	7	Grouchy
g. Sympathetic	1	2	3	4	5	6	7	Unconcerned
h. Happy	1	2	3	4	5	6	7	Miserable
i. Spiteful	1	2	3	4	5	6	7	Even-handed
j. Energetic	1	2	3	4	5	6	7	Sluggish
k. Belligerent	1	2	3	4	5	6	7	Friendly

15. Conflicts can occur in any job. For example, someone may ask you to do your work in a way which is different from what you think is best or you may find that it is difficult to satisfy everyone. <u>How often</u> do you face problems in <u>your work</u> like the ones listed below? <u>Circle One Number Per Item</u>.

	Rarely or Never	Occa-sionally	Some-times	Fairly Often	Very Often
a. Persons equal in rank and authority over you ask you to do things which conflict	1	2	3	4	5
b. People in a good position to see if you do what they ask give you things to do which conflict with one another	1	2	3	4	5
c. People whose requests should be met give you things which conflict with other work you have to do	1	2	3	4	5

16. How indicate how often you experience each of the following changes on your job. <u>Circle one number per item</u>.

	Rarely or Never	Occa-sionally	Some-times	Fairly Often	Very Often
a. A marked increase in the work load	1	2	3	4	5
b. A marked increase in the amount of concentration required on your job	1	2	3	4	5
c. A marked increase in how fast you have to think	1	2	3	4	5

17. Rank the importance of the following factors in your taking your job with your current employer.

	Not at all Important	Very Little Importance	Of Some Import-ance	Fairly Import-ant	Very Import-ant
a. Location of job	1	2	3	4	5
b. Pay on job	1	2	3	4	5
c. Job security	1	2	3	4	5
d. Chance to use skills or education	1	2	3	4	5
e. Job is interesting	1	2	3	4	5
f. Importance of job	1	2	3	4	5
g. The people you work with .	1	2	3	4	5

18. Considering your current skills and experience:

	Very Difficult	Somewhat Difficult	Somewhat Easy	Very Easy	Don't Know
a. How easy would it be for you to find another job <u>like the one you have now</u> which pays as well or better than your current job	1	2	3	4	0
b. How easy would it be for you to find another job <u>different</u> than the kind you now have which pays as well or better than your current job . . .	1	2	3	4	0

The next four questions (#19-22) in this section are designed to give a picture of what you would like your job to be like if you could design your job.

19. How many hours of overtime would you like to work each week? _______hours.

20. How often would you like to work on the following days? (Circle one number per item)

	Never	Occa-sionally	Some-times	Fairly Often	Very Often
a. Saturdays	1	2	3	4	5
b. Sundays	1	2	3	4	5
c. Holidays	1	2	3	4	5

21. Again, if you were designing a job for yourself, how much of each of the following would you like to have in such a job? Circle One Number Per Item.

	Very Little	A Little	Some	A Lot	A Great Deal
a. How much work load would you like to have?	1	2	3	4	5
b. How much time would you like to have to do all your work?	1	2	3	4	5
c. How much slowdown in the work load would you prefer?	1	2	3	4	5
d. How much time to think and contemplate would you like?	1	2	3	4	5
e. What quantity of work would you prefer others to expect of you?	1	2	3	4	5
f. How much of a variety of job tasks would you like to have?	1	2	3	4	5

	Hardly Any	A Few	Some	A lot	A Great Deal
g. How many projects, assignments, or tasks would you like to have?	1	2	3	4	5
h. How many lulls between heavy work load periods would you like to have?	1	2	3	4	5

22. Here are some items which describe different aspects of jobs. If you could have your own way about designing a job for yourself, how would you like each of the following to be? Circle One Number Per Item.

	Rarely	Occasionally	Sometimes	Fairly Often	Very Often
a. How much of the time would you like your work objectives to be well defined?	1	2	3	4	5
b. How often would you like to be clear on what others expect of you?	1	2	3	4	5
c. How often would you like to be able to predict what others will expect of you on the job?	1	2	3	4	5
d. How often would you like to be clear on what your job responsibilities are?	1	2	3	4	5

23. In the future some jobs will be changing while others will be staying the same. Here are some questions which deal with this topic. (Circle One Number Per Item.)

	Uncertain	A Little Uncertain	Somewhat Certain	Fairly Certain	Certain
a. How certain are you about what your future career picture looks like?	1	2	3	4	5
b. How certain are you of the opportunities for promotion and advancement which will exist in the next few years?	1	2	3	4	5
c. How certain are you about whether your job skills will be of use and value five years from now?	1	2	3	4	5
d. How certain are you about what your responsibilities will be six months from now?	1	2	3	4	5

24. How likely is it that in the next few years your job will be replaced by computers or other machines or that it may be eliminated or given to someone else? (Circle One Number.)

Not At All Likely	A Little Likely	Very Likely	Will Definitely Occur
1	2	3	4

25. What level of formal education do you feel is needed by a person in a job such as yours? Circle One Number.

1. None
2. Grades 1-4
3. Grades 5-6
4. Grades 7-8
5. Grades 9-11
6. Grade 12 (completed high school)
7. Completed high school plus other non-college training (technical or trade school).
8. Some college
9. Completed college with bachelor's degree
10. Completed college with advanced or professional degree (M.A., M.S., Ph.D., M.D., D.V.M., etc.)

YOUR WORKPLACE

INSTRUCTIONS: Here are 40 statements about the place in which you work. The statements are intended to apply to all work environments, though some words may not be suitable for your work environment. For example, the term supervisor is meant to refer to the boss, manager, department head, or the person to whom an employee reports.

You are to decide which statements are true or which are false concerning your environment.

Please be sure to answer every statement.

(Circle one)

T F 1. The work is really challenging.

T F 2. People go out of their way to help a new employee feel comfortable.

T F 3. Supervisors tend to talk down to employees.

T F 4. Few employees have any important responsibilities.

T F 5. People pay a lot of attention to getting work done.

T F 6. There is constant pressure to keep working.

T F 7. Things are sometimes pretty disorganized.

T F 8. There is a strict emphasis on following policies and regulations.

T F 9. Doing things in a different way is valued.

T F 10. It sometimes gets too hot.

T F 11. There is not much group spirit.

T F 12. The atmosphere is somewhat impersonal.

T F 13. Supervisors usually compliment an employee who does something well.

T F 14. Employees have a great deal of freedom to do as they like.

T F 15. There is a lot of time wasted because of inefficiencies.

T F 16. There always seems to be an urgency about everything.

T F 17. Activities are well-planned.

T F 18. People can wear wild looking clothing while on the job if they want.

T F 19. New and different ideas are always being tried out.

T F 20. The lighting is extremely good.

T F 21. A lot of people seem to be just putting in time.

T F 22. People take a personal interest in each other.

T F 23. Supervisors tend to discourage criticisms from employees.

T F 24. Employees are encouraged to make their own decisions.

T F 25. Things rarely get "put off till tomorrow."

T F 26. People cannot afford to relax.

T F 27. Rules and regulations are somewhat vague and ambiguous.

T F 28. People are expected to follow set rules in doing their work.

T F 29. This place would be one of the first to try out a new idea.

T F 30. Work space is awfully crowded.

T F 31. People seem to take pride in the organization.

T F 32. Employees rarely do things together after work.

T F 33. Supervisors usually give full credit to ideas contributed by employees.

T F 34. People can use their own initiative to do things.

T F 35. This is a highly efficient, work-oriented place.

T F 36. Nobody works too hard.

T F 37. The responsibilities of supervisors are clearly defined.

T F 38. Supervisors keep a rather close watch on employees.

T F 39. Variety and change are not particularly important.

T F 40. This place has a stylish and modern appearance.

III. WORKPLACE ENVIRONMENT

These questions are intended to evaluate your opinions of the physical environment in which you work.

1. In general would you say that as a workplace environment your office is: (circle the most appropriate number)

   Very pleasant 5
   Somewhat pleasant 4
   Just adequate 3
   Somewhat unpleasant 2
   Very unpleasant 1

2. In regards to the following elements of your workplace environment, how do you feel about:

	Much Too High	Somewhat High	Correct	Somewhat Low	Much Too Low
a. The noise level in your office	5	4	3	2	1
b. The level of lighting in your office	5	4	3	2	1
c. During the summer is the temperature of your office	5	4	3	2	1
d. During the winter is the temperature of your office	5	4	3	2	1
e. The overall level of distractions in your office	5	4	3	2	1

3. The following questions relate to the lighting at your principal work station:

   a. Which of the following sources does the main lighting at your work area come from: (circle as many numbers as appropriate)

      Natural light (windows) 1
      Flourescent light 2
      Incandescent light (light bulbs) 3

	YES	NO
b. Do you have any supplemental lighting (other than normal light) at your work area?	1	2
c. Can you adjust the lighting at your work area?	1	2
d. Is the lighting of the background areas around your work station at all bothersome?	1	2

4. Is the chair you sit in: (Circle the most appropriate number.)

   Very comfortable 5
   Somewhat comfortable 4
   Just adequate 3
   Somewhat uncomfortable 2
   Very uncomfortable 1

5. Is the chair you sit in:	YES	NO
a. the correct height	1	2
b. are you able to adjust your chair to the height you prefer	1	2

6. Are you bothered in your work by any of the following:

	Rarely Never	Occasionally	Sometimes	Fairly Often	Very Often
a. Odors, fumes, or smells . .	1	2	3	4	5
b. Dust	1	2	3	4	5
c. Cigarette or other tobacco smoke	1	2	3	4	5
d. Feeling crowded	1	2	3	4	5
e. Noise from office machines.	1	2	3	4	5

7. Can you change the location of the furniture and machinery at your work station so you can work comfortably? (Circle one number below)

   As much as is necessary 5
   To a great degree 4
   Somewhat 3
   Very little 2
   Not at all 1

NOTE: This section is only for those who work with VDTs.

JOB DEMANDS AND OFFICE WORK QUESTIONNAIRE PART Ia

VDT OPERATOR SPECIFICS SECTION

These questions are designed to be answered by those who work at VDT devices. VDT's (video display terminals) are combination television screens and typewriter keyboards. These devices are often called "Tubes", "CRT's" (cathode ray tubes), and "VDU's" (video display units). Base your answers on the VDT unit you use most frequently (if you regularly use more than one VDT).

1. In your job working with VDT's, what is (are) your principal work task(s)? (circle the numbers corresponding to <u>any of the following</u> which apply to your job).

   Enter and verify information from forms or records into data storage through VDT's 1

   Retrieve information through VDT from data storage for report or inquiry request 2

   Update or correct information on data file through VDT 3

   Enter, correct, or adjust, and retrieve (output) information through VDT (typing, proofing own input) 4

   Other job task with VDT (explain) ________________

   ________________ 5

2. On an average, how many hours per day do you spend working with VDT's

   ______hours per day

3. If you know it, please give the manufacturer's name and model (name or number) of your VDT.

   ____________________Manufacturer

   ____________________Model

4. What is the color of:

   a. The <u>letters and numbers</u> on the screen? ____________________

   b. The background (or blank screen)? ____________________

5. Is the keyboard of your VDT fixed (rigidly attached) to, or separable (flexible) from, the display screen? (Circle one number)

   fixed 1

   separable (flexible). 2

6. On your VDT can <u>you</u> adjust: (Circle one number each)

	Yes	No	Don't Know
a. The color of the VDT screen	1	2	3
b. The color of the letters or numbers . . .	1	2	3
c. The brightness of the screen	1	2	3
d. The brightness of the letters or numbers .	1	2	3
e. The sharpness or focus of the letters or numbers	1	2	3
f. The size of the letters	1	2	3
g. The tilt (angle) of the VDT screen toward you	1	2	3
h. The tilt (angle) of the VDT keyboard . . .	1	2	3
i. The height of the VDT screen	1	2	3
j. The height of the VDT keyboard	1	2	3
k. The distance from you of the screen . . .	1	2	3
l. The distance from you of the keyboard . .	1	2	3
m. The amount of noise coming from your VDT .	1	2	3
n. The amount of flicker of the screen display	1	2	3
o. The brightness of the light around the VDT station	1	2	3
p. The angle of the lighting around the VDT	1	2	3

7. Is your VDT located on: (Circle one number)

   a special stand 1

   a regular desk 2

   a regular table 3

   Other (specify) ________________ 4

   ____

8. Considering the current set-up of your VDT, as it is normally adjusted, how bothersome are each of the following:

	No Bother or Problem	Occasionally Bothersome	Often Bothersome	Very Often Bothersome	Constantly Bothersome
a. The brightness of the screen	5	4	3	2	1
b. The brightness of the letters or numbers . . .	5	4	3	2	1
c. The readability (size or sharpness)	5	4	3	2	1
d. The tilt (angle) of the VDT screen	5	4	3	2	1
e. The tilt (angle) of the VDT keyboard	5	4	3	2	1
f. The height of the screen	5	4	3	2	1
g. The height of the keyboard	5	4	3	2	1
h. The distance of the screen from you	5	4	3	2	1
i. The distance of the keyboard from you	5	4	3	2	1
j. Glare from the VDT screen	5	4	3	2	1
k. Glare from the keyboard .	5	4	3	2	1
l. Noise from the VDT . . .	5	4	3	2	1
m. Flicker of the screen display	5	4	3	2	1

9. In your job tasks with the VDT do you:

	YES	NO
a. Key (enter) information from paper records	1	2
b. Key information from tape recorder, or dictaphone, etc. . .	1	2
c. Key information from some other display . . . . If yes, what kind of display? ______________________	1	2
d. Key information directly from conversations with people (directly or by phone)	1	2

e. Other (specify) ______________________

10. Does your VDT task require you to wait for a response from the VDT or computer while entering or retrieving information? (Circle one number below.)

Yes . . . . 1 (If yes, answer a-e below and continue)

No . . . . 2 (If no, go on to question 11)

a. Is the amount you have to wait for the machine (VDT or computer) constant or variable? (Circle 1 or 2 below)

Constant 1

If constant, how long (approximately) do you have to wait for the machine?

_____seconds

or _____minutes

Variable 2

If variable, what is the (approximately) longest period of time you have to wait . . .

_____seconds, or _____minutes

What is the shortest period of time you have to wait. . .

_____seconds, or _____minutes

Does the length of time you have to wait change? (Circle one number)

Very often 5

Fairly often 4

Sometimes 3

Rarely/Infrequently . . 2

	Not at All	Very Little	Somewhat	A Lot	A Great Deal
b. Does waiting for the VDT (computer) to respond to your input bother you.	1	2	3	4	5
c. Does waiting for the VDT to respond to your input disrupt your work pace	1	2	3	4	5
d. Does waiting for the VDT to respond to your input disrupt your work rhythm	1	2	3	4	5
e. Does waiting for the VDT to respond to your input provide you with a chance to relax .	1	2	3	4	5

11. Are you able to take brief, unscheduled, rest breaks from VDT work when you feel you need them?

Never 1
Rarely/Infrequently 2
Sometimes 3
Fairly often 4
Very often 5

12. Approximately, what proportion (percentage) of your VDT task involves: (the percentage values for a, b, and c should add to 100%)

a. Just inputting information . . . . ______%
b. Just retrieving information . . . . ______%
c. Interactive communication with the VDT (computer) system (input and output) . . . . ______%

13. While you are working at your VDT, about how often are you looking at the following?

	Never	Rarely, Infrequently	Sometimes	Fairly Often	Very Often
a. The display screen . . .	1	2	3	4	5
b. The keyboard	1	2	3	4	5
c. The material being keyed in/out	1	2	3	4	5
d. The windows of the room	1	2	3	4	5
e. The room lights	1	2	3	4	5
f. Other places in the room (like other people, the clock, the wall, etc.).	1	2	3	4	5

14. Do you feel you have been adequately trained to do your job task on the VDT?

Yes 1
No 2

15. How easy or difficult is it to handle (process, enter, retrieve) the information you have to process with the VDT system you use? (Including the data formats, the entry formats, the overall organization of the VDT system.)

Very easy 1
Somewhat easy 2
Just about average 3
Somewhat difficult 4
Very difficult 5

16. What changes or modifications of the VDT system (physical set-up, staffing, entry/retrieval design, etc.) have you made to make your work at the VDT more efficient, comfortable, or convenient? ______________________

____

____

____

17. What changes would you like to see made to make work with the VDT's more efficient, comfortable or convenient; if any changes are necessary?

____

____

____

____

IV. HEALTH INFORMATION

This section of the questionnaire is designed to assess your state of health generally and specifically with regards to certain health problems of interest to this study. Also asked are a group of questions regarding your health habits. Some of these questions are of a personal nature, but we would not be asking them if they weren't very necessary to this study. Remember that all information will be kept confidential.

1. In general, how would you describe your health? (Circle one number.)

   Excellent 1
   Good 2
   Fair 3
   Poor 4

2. During the past year have you been hospitalized for any reason? ___Yes, ___No

   a. IF YES: How many times? _____ times
      IF YES: For how many days total? _____days
      IF YES: Why were you hospitalized? ______________________

      ____

3. During the past month, about how many days of sick leave did you take? ____days
   (Please write "0" if none.)

4. Please indicate about how often you used each of the following medications during the past month:

	Not at all	Less than once a week	1-2 times a week	3-4 times a week	Every day
a. Aspirin	1	2	3	4	5
b. Aids for stomach or digestion problems.	1	2	3	4	5
c. Laxatives	1	2	3	4	5
d. Cough, cold or sinus medicine . .	1	2	3	4	5
e. Medication to pep you up.	1	2	3	4	5
f. Medication to calm you down . . .	1	2	3	4	5
g. Headache medicine	1	2	3	4	5
h. Prescription medicines: (Please specify)					
1) ________________		2	3	4	5
2) ________________		2	3	4	5
3) ________________		2	3	4	5

5. The following questions concern your body and the way you and it function. Please try to answer each question by circling a number to indicate how often you have experienced each of the following items within the past year in general.

	Never	Occasionally	Frequently	Constantly
a. Shortness of breath or trouble breathing..........................	1	2	3	4
b. Frequent colds or sore throats.....	1	2	3	4
c. Persistent cough and spitting up sputum..........................	1	2	3	4
d. Coughing up blood.................	1	2	3	4
e. Fever, chills, and aching all over.	1	2	3	4
f. Hay fever or sinus trouble.........	1	2	3	4
g. Wheezing in your chest.............	1	2	3	4
h. Respiratory infections..............	1	2	3	4
i. Jaundice, yellow eyes or skin......	1	2	3	4
j. Skin rash, itching skin, allergic skin reactions.....................	1	2	3	4
k. Swollen or painful muscles and joints..........................	1	2	3	4
l. Back pain..........................	1	2	3	4
m. Pain or stiffness in your arms or legs...........................	1	2	3	4
n. Pain or stiffness in your neck or shoulders........................	1	2	3	4
o. Changes in your ability to see colors	1	2	3	4
p. Tearing or itching of eyes.........	1	2	3	4
q. Persistent numbness or tingling in any part of your body.............	1	2	3	4
r. Burning eyes......................	1	2	3	4
s. Occasions of easy irritability.....	1	2	3	4
t. Difficulty sleeping................	1	2	3	4
u. Periods of depression..............	1	2	3	4
v. Ringing or buzzing in ears.........	1	2	3	4
w. Headaches..........................	1	2	3	4
x. Fainting spells or dizziness.......	1	2	3	4
y. Nervous or shaking inside..........	1	2	3	4
z. Times when you feel sweaty or trembly	1	2	3	4
aa. Increased urination................	1	2	3	4
bb. Painful urination..................	1	2	3	4
cc. Bloody urine......................	1	2	3	4
dd. Alarming pain or pressure in your chest............................	1	2	3	4
ee. Pain down your arms................	1	2	3	4
ff. "Racing" or pounding heart.........	1	2	3	4
gg. Leg cramps.........................	1	2	3	4
hh. Times of severe fatigue or exhaustion..........................	1	2	3	4
ii. Acid indigestion, heartburn, or acid stomach.......................	1	2	3	4
jj. Diarrhea for more than a few days..	1	2	3	4

No. 5 (Continued)

		Never	Occa-sionally	Fre-quently	Con-stantly
kk.	Gas or gas pains	1	2	3	4
ll.	Nausea or vomiting	1	2	3	4
mm.	Blood in your bowel movement	1	2	3	4
nn.	Constipation	1	2	3	4
oo.	Tight feeling in stomach	1	2	3	4
pp.	Bloated or full feeling	1	2	3	4
qq.	Feeling of pressure in the neck	1	2	3	4
rr.	Hemorrhoids or piles	1	2	3	4
ss.	Periods of extreme anxiety	1	2	3	4
tt.	Trouble digesting food	1	2	3	4
uu.	Blurred vision	1	2	3	4
vv.	Dryness in the mouth	1	2	3	4
ww.	Stomach pains	1	2	3	4
xx.	Belching	1	2	3	4
yy.	High levels of tension	1	2	3	4
zz.	Difficulty with feet and legs when standing for long periods	1	2	3	4
aaa.	Shoulder soreness	1	2	3	4
bbb.	Loss of feeling in the fingers or wrists	1	2	3	4
ccc.	Neck pain that radiates into shoulder, arm or hand	1	2	3	4
ddd.	Cramps in hands and fingers relieved only when not working	1	2	3	4
eee.	Loss of strength in arms or hands	1	2	3	4
fff.	Eye strain or sore eyes	1	2	3	4
ggg.	Stiff or sore wrists	1	2	3	4

6. Have you gained or lost weight since you started your present job?

Yes, I've gained.... 1 (If YES, answer a and b
Yes, I've lost...... 2 below and continue--
No.................. 3 If NO, go on to Question 7).

a) How many pounds? ______
b) Was this change in weight deliberate?

Yes.................. 1
No................... 2

7. Within the past five years has a doctor ever told you that you have, or has he treated you for, any of the following conditions (please circle the appropriate number).

		Yes	No	Don't Know
a.	Diabetes	1	2	3
b.	Cancer	1	2	3
c.	Hernia or rupture	1	2	3
d.	Tuberculosis	1	2	3
e.	Asthma	1	2	3
f.	"High" blood pressure	1	2	3
g.	Heart disease	1	2	3
h.	Arthritis or rheumatism	1	2	3
i.	Epilepsy (Convulsions or fits)	1	2	3

7. Continued

		Yes	No	Don't Know
j.	Glaucoma of the eyes	1	2	3
k.	Paralysis, tremor, or shaking	1	2	3
l.	Kidney or bladder trouble	1	2	3
m.	Lung or breathing problems	1	2	3
n.	Stroke	1	2	3
o.	Anemia	1	2	3
p.	Gall bladder, liver problems	1	2	3
q.	Thyroid trouble or goiter	1	2	3
r.	Insomnia	1	2	3
s.	Gastritis (nervous stomach)	1	2	3
t.	Colitis (inflamed color)	1	2	3
u.	Stomach ulcer	1	2	3
v.	Cataracts	1	2	3
w.	Mental or psychological problems	1	2	3

8. Has a member of your immediate family (mother, father, brothers, sisters, children) ever: (Circle one number for each)

		Yes	No	Don't Know
a.	Had high blood pressure	1	2	3
b.	Had a heart attack?	1	2	3
c.	Had diabetes.	1	2	3
d.	Suffered a "nervous breakdown"?	1	2	3
e.	Committed suicide?	1	2	3

9. The following questions deal with your sleep patterns:

a. How much sleep would you like to get every 24 hours? ____(hours)
b. About how much sleep do you actually get during every 24 hours? ____(hours)
c. How long does it usually take you to get to sleep. ____(minutes)
d. How often do you usually wake up tired or sleepy?

Not at all 1
Occasionally . . . 2
Frequently 3
Always 4

e. About how often do you feel tired or sleepy at work?

Never 1
Less than once a month . 2
Once or twice a month . . 3
Once a week 4
2 or 3 times a week . . . 5
About every day 6

f. About how often do you feel tired or sleepy after completing your work?

Never 1
Less than once a month . 2
Once or twice a month . . 3
Once a week 4
2 or 3 times a week . . . 5
About every day 6

10. During the past 6 months, have you had any <u>on-the-job</u> accidents which caused you to miss work?

Yes...............1 (If YES, answer a and b and continue)
No...............2 (If NO, go to question 11)

a. How many accidents have you had? _____(accidents)
b. How much <u>total</u> time were you off work due to these accidents? _____(days)

11. During the past 6 months, have you had any <u>off-the-job</u> accidents which caused you to miss work?

Yes...............1 (If YES, answer a and b and continue)
No...............2 (If NO, go to question 12)

a. <u>IF "YES"</u>: How many? ________(accidents)
b. How much <u>total</u> time were you off work due to these accidents? _____(days)

This next set of questions (12 through 18) deal with your habits regarding drinking alcohol, coffee, and soft drinks and smoking tobacco products.

12. Do you ever drink alcoholic beverages? (Circle one number below).

Yes . . . . . 1 (IF YES, answer the rest of the alcohol questions, a-c and questions 13-15 and continue.)
No . . . . . 2 (IF NO, go on to question 17)

a. During a typical week, on approximately how many days do you drink alcoholic beverages? _____ (days)

b. <u>If you drink</u>, do you ever drink on those days when you work?

Yes . . . . . . 1 (IF YES, answer c and continue)
No . . . . . . 2 (IF NO, go on to question 14)

c. Do you normally drink... (Circle all that apply)

Before going to work 1
After finishing work 2
During lunch breaks 3
During rest breaks when at work 4

13. On those days when you do drink, about how many <u>of each</u> of the following do you usually drink: (Mark 0 for those beverages you don't drink)

a. Bottles of beer _____ (Bottles)
b. Glasses of wine _____ (Glasses)
c. Shots of liquor (shot = 1 1/2 oz.) _____ (shots)

14. Would you say that the amount of alcohol you have been drinking lately has ...

Increased 1
Decreased 2
Remained about the same . . . 3

15. Would you say that you use alcohol to help you get to sleep?

Frequently 1
Occasionally . . . 2
Seldom 3
Never 4

16. Do you currently smoke any tobacco products (cigarettes, cigars, pipes)

Yes . . . 1 (If YES, answer a and b and continue)
No . . . 2 (If NO, go on to question 17)

a. On an <u>average</u> day, how many of each of the following do you smoke? (Give the number in the blanks below)

cigarettes ____(cigarettes)

cigars ____(cigars)

pipefuls of tobacco ____(pipefuls)

b. How many years have you been smoking tobacco? ____(years)

c. How likely are you to smoke during the following parts of your day?

	Almost Always	Fairly Likely	Some what Likely	Fairly Unlikely	Never or Very Unlikely
Before going to work	1	2	3	4	5
Early in your work shift . . .	1	2	3	4	5
During the rest of your work shift (day)	1	2	3	4	5
During your work meal (lunch)	1	2	3	4	5
Right at the end or just after work	1	2	3	4	5
Later in the day (after work)	1	2	3	4	5
Just before bed	1	2	3	4	5

d. Are you allowed to smoke at your work station?

Yes 1
No 2

e. If no, can you take regular breaks to smoke elsewhere?

Yes 1
No 2

17. Do you drink coffee or tea beverages more than <u>one a week</u>?

Yes . . . . . 1 (If yes, answer a and be below, then continue)

No . . . . . 2 (If no, go on to question 18)

a. If yes, how many cups of tea or coffee do you drink per day (average)? (circle the most appropriate number)

less than 1 cup per day 1
1 to 4 cups per day 2
5 to 9 cups per day 3
10 to 19 cups per dya 4
20 or more cups per day 5

b. How likely are you to drink tea or coffee drinks during the following parts of the day.

	Almost Always	Fairly Likely	Some-what Likely	Fairly Unlikely	Never or Very Unlikely
Before going to work	1	2	3	4	5
Early in your work shift . . .	1	2	3	4	5
During the rest of your work shift (day).	1	2	3	4	5
During your work meal (lunch) .	1	2	3	4	5
Right at the end or just after work	1	2	3	4	5
Later in the day (after work)	1	2	3	4	5
Just before bed					

18. Do you drink soft drinks (soda) more than <u>once a week</u>?

Yes . . . . . 1 (If yes, answer a-c below, then continue)

No . . . . . 2 (If no, go on to question 19)

a. If yes, how many <u>diet</u> soft drinks do you drink each day (average)? (Circle the most appropriate number)

less than one drink per day 1
1 to 3 drinks per day 2
4 to 8 drinks per day 3
9 to 12 drinks per day 4
more than 12 drinks per day 5

b. How many <u>non-diet (regular)</u> soft drinks do you drink each day (average)?

less than one drink per day 1
1 to 3 drinks per day 2
4 to 8 drinks per day 3
9 to 12 drinks per day 4
More than 12 drinks per day 5

c. How likely are you to drink soft drinks during the following parts of the day?

	Almost Always	Fairly Likely	Some what Likely	Fairly Unlikely	Never or Very Unlikely
Before going to work	1	2	3	4	5
Early in your work shift . . .	1	2	3	4	5
During the rest of your work shift (day)	1	2	3	4	5
During your work meal (i.e. lunch)	1	2	3	4	5
Right at the end or just after work	1	2	3	4	5
Later in the day (after work).	1	2	3	4	5
Just before bed	1	2	3	4	5

19. The following questions relate to your vision:

a. During the past year has your vision gotten

better 1
worse 2
no change 3

b. Since you started your present job has your vision gotten

better 1
worse 2
no change 3

c. Do you wear <u>corrective</u> eye wear (glasses or contacts)

Yes . . . . . 1 (If yes, answer (1) below and continue)
No . . . . . 2 (If no, go on to question 20)

(1) Do you wear:	Yes	No
Glasses (not bifocals)	1	2
Bifocals or trifocals	1	2
Contacts	1	2

(2) For how long have you worn corrective eye wear?

__________ years.

(3) Can you read without corrective eye wear

Yes 1
No 2

(4) Do you have trouble seeing things (without corrective eye wear) (circle all that apply)

close-up 1
far away 2
in dim light 3
other __________ 4

20. [a]Exercise activities.

21. Do you feel that you get enough exercise? Yes 1
No 2

22. When you exercise, how often do you exercise for the following reasons

	Very Often	Fairly Often	Some-Times	Occa-sionally	Rarely Never
a. for my health	5	4	3	2	1
b. for personal appearance	5	4	3	2	1
c. for relaxation	5	4	3	2	1
d. for social reasons	5	4	3	2	1
e. for other reasons (specify) . . .	5	4	3	2	1
______________	5	4	3	2	1
______________	5	4	3	2	1

These next three questions relate to how you perceive and deal with stresses, tensions and personal problems.

23. Do you feel you have personal problems, stresses, and/or tensions which you have a difficult time handling by yourself? (Circle one number below.)

Never 1
Rarely, Infrequently . 2
Sometimes 3
Fairly often 4
Very often 5

24. When you have stresses, tensions, or personal problems, which areas of your life do they come from: (Please circle one number for each)

	Very Often	Fairly Often	Some-Times	Rarely, Infrequently	Never
a. Your job	5	4	3	2	1
b. Your career	5	4	3	2	1
c. Financial or money concerns .	5	4	3	2	1
d. Relationships with other people	5	4	3	2	1
e. Concerns for your health . .	5	4	3	2	1
f. Too little time to do too much	5	4	3	2	1
g. Source of stress uncertain or don't know	5	4	3	2	1

25. [a]Coping methods.

[a] Attempts were made using factor analysis to characterize personal exercise habits and coping styles from items within questions 20 and 25 respectively. Since these efforts were not fruitful, these questions were excluded from consideration in further analyses. They are omitted here for the sake of brevity.

MOOD SCALE

THIS IS DESIGNED TO HELP DETERMINE YOUR MOODS SINCE THE WAY YOU FEEL IS A PART OF YOUR HEALTH. THE LIST OF WORDS BELOW DESCRIBES FEELINGS PEOPLE HAVE. PLEASE READ EACH ITEM AND CIRCLE ONE NUMBER FOR EACH WORD WHICH DESCRIBES HOW YOU HAVE BEEN FEELING DURING THE PAST WEEK, INCLUDING TODAY

	Not at all	A little	Moderately	Quite a bit	Extremely
Friendly	0	1	2	3	4
Tense	0	1	2	3	4
Angry	0	1	2	3	4
Worn out	0	1	2	3	4
Unhappy	0	1	2	3	4
Clear-headed	0	1	2	3	4
Lively	0	1	2	3	4
Confused	0	1	2	3	4
Sorry for things done	0	1	2	3	4
Shaky	0	1	2	3	4
Listless	0	1	2	3	4
Peeved	0	1	2	3	4
Considerate	0	1	2	3	4
Sad	0	1	2	3	4
Active	0	1	2	3	4
On edge	0	1	2	3	4
Grouchy	0	1	2	3	4
Blue	0	1	2	3	4
Energetic	0	1	2	3	4
Panicky	0	1	2	3	4
Hopeless	0	1	2	3	4
Relaxed	0	1	2	3	4
Unworthy	0	1	2	3	4
Spiteful	0	1	2	3	4
Sympathetic	0	1	2	3	4
Uneasy	0	1	2	3	4
Restless	0	1	2	3	4
Unable to concentrate	0	1	2	3	4
Fatigued	0	1	2	3	4
Helpful	0	1	2	3	4
Annoyed	0	1	2	3	4
Discouraged	0	1	2	3	4
Resentful	0	1	2	3	4
Nervous	0	1	2	3	4

	Not at all	A little	Moderately	Quite a bit	Extremely
Lonely	0	1	2	3	4
Miserable	0	1	2	3	4
Muddled	0	1	2	3	4
Cheerful	0	1	2	3	4
Bitter	0	1	2	3	4
Exhausted	0	1	2	3	4
Anxious	0	1	2	3	4
Ready to fight	0	1	2	3	4
Good-natured	0	1	2	3	4
Gloomy	0	1	2	3	4
Desperate	0	1	2	3	4
Sluggish	0	1	2	3	4
Rebellious	0	1	2	3	4
Helpless	0	1	2	3	4
Weary	0	1	2	3	4
Bewildered	0	1	2	3	4
Alert	0	1	2	3	4
Deceived	0	1	2	3	4
Furious	0	1	2	3	4
Efficient	0	1	2	3	4
Trusting	0	1	2	3	4
Full of pep	0	1	2	3	4
Bad-tempered	0	1	2	3	4
Worthless	0	1	2	3	4
Forgetful	0	1	2	3	4
Carefree	0	1	2	3	4
Terrified	0	1	2	3	4
Guilty	0	1	2	3	4
Vigorous	0	1	2	3	4
Uncertain about things	0	1	2	3	4
Bushed	0	1	2	3	4

MAKE SURE YOU HAVE ANSWERED EVERY ITEM

V. PEOPLE AROUND YOU

These next few questions are intended to evaluate how you relate to specific groups of people around you, especially in terms of the kind of support you feel you get from these people. Circle one number per item.

1. How much does each of these people go out of their way to do things to make your life at work easier for you?

	Very Much	Some-what	A Little	Not At All	Don't Have Any Such Person
a. Your immediate supervisor (boss)	5	4	3	2	1
b. Other people at work	5	4	3	2	1
c. Your wife and/or family	5	4	3	2	1
d. Your friends	5	4	3	2	1

2. How easy is it to talk with each of the following people?

	Very Much	Some-what	A Little	Not At All	Don't Have Any Such Person
a. Your immediate supervisor	5	4	3	2	1
b. Other people at work	5	4	3	2	1
c. Your wife and/or family	5	4	3	2	1
d. Your friends	5	4	3	2	1

3. How much can each of these people be relied upon when things get tough at work?

	Very Much	Some-what	A Little	Not At All	Don't Have Any Such Person
a. Your immediate supervisor	5	4	3	2	1
b. Other people at work	5	4	3	2	1
c. Your wife and/or family	5	4	3	2	1
d. Your friends	5	4	3	2	1

4. How much is each of the following people willing to listen to your personal problems?

	Very Much	Some-what	A Little	Not At All	Don't Have Any Such Person
a. Your immediate supervisor	5	4	3	2	1
b. Other people at work	5	4	3	2	1
c. Your wife and/or family	5	4	3	2	1
d. Your friends	5	4	3	2	1

5. When on lunch or a rest break, how much time do you spend talking about work or things that happen at work?

All of the time 5
Most of the time 4
Some of the time 3
Rarely 2
None of the time 1

6. In general, how well do the people in your work group get along with one another?

Extremely well 5
Somewhat well 4
All right 3
Somewhat badly 2
Very badly 1

7. In general, how do you feel about the people in your work group?

Dislike them very much 1
Dislike them somewhat 2
Indifferent towards them 3
Like them somewhat 4
Like them very much 5

8. How often do you get together with the persons you know from work outside of the workplace?

Very often 5
Fairly often 4
Sometimes 3
Rarely, infrequently 2
Never 1

VI. TIME AVAILABILITY

These questions are intended to give us a picture of how much time you feel your job allows you for other aspects of your life.

1. How satisfied are you with the amount of time your work schedule allows you to spend:

	Very Satisfied	Moderately Satisfied	Slightly Dissatisfied	Moderately Dissatisfied	Very Dissatisfied	Not Applicable
a. With your friends at work.....	5	4	3	2	1	0
b. With your friends off work....	5	4	3	2	1	0
c. Dealing with your own needs and desires.................	5	4	3	2	1	0

2. If you are married or cohabiting (if not, go on to Question #3), how satisfied are you with the amount of time your work schedule allows you to spend with your husband or wife:

	Very Satisfied	Moderately Satisfied	Slightly Dissatisfied	Moderately Dissatisfied	Very Dissatisfied	Not Applicable
a. Discussing family and personal problems..........	5	4	3	2	1	0
b. Working and helping around the house..................	5	4	3	2	1	0
c. Entertaining relatives and friends................	5	4	3	2	1	0
d. Shopping and relaxing together...................	5	4	3	2	1	0
e. Going out together to movies, for dinner, etc....	5	4	3	2	1	0

3. If you have children (if not, go on to Section VII.), how satisfied are you with the amount of time your work schedule allows you to spend with them:

	Very Satisfied	Moderately Satisfied	Slightly Dissatisfied	Moderately Dissatisfied	Very Dissatisfied	Not Applicable
a. Discussing their problems or talking about things that interest them.........	5	4	3	2	1	0
b. Relaxing together by watching T.V. or working on a project.......................	5	4	3	2	1	0
c. Attending P.T.A meetings, Boy Scout Groups, ball games, school plays, etc..........	5	4	3	2	1	0
d. Attending church or other family social activities...	5	4	3	2	1	0

VII. RECENT LIFE EVENTS

INSTRUCTIONS

Listed below are 43 statements which describe life events. Please read each item carefully and then circle the appropriate answer depending upon whether this event occurred within the past year. For example, on the first item "1. Marriage," if you got married within the past year circle 1 Yes; if you did not get married during the past year, circle 2 No.

Please be sure to respond to each item.

Event	Response Yes	No
1. Marriage	1	2
2. Troubles with the boss	1	2
3. Detention in jail or other institution	1	2
4. Death of spouse	1	2
5. Major change in sleeping habits (a lot more or a lot less sleep, or change in part of day when asleep)	1	2
6. Death of a close family member	1	2
7. Major change in eating habits (a lot more or a lot less food intake, or very different meal hours or surroundings)	1	2
8. Foreclosure on a mortgage or loan	1	2
9. Revision of personal habits (dress, manners, associations, etc.)	1	2
10. Death of a close friend	1	2
11. Minor violations of the law (e.g., traffic tickets, jay-walking, disturbing the peace, etc.)	1	2
12. Outstanding personal achievement	1	2
13. Pregnancy	1	2
14. Major change in the health or behavior of a family member	1	2
15. Sexual difficulties	1	2
16. In-law troubles	1	2
17. Major change in number of family get-togethers (e.g., a lot more or a lot less than usual)	1	2
18. Major change in financial state (e.g., a lot worse off or a lot better off than usual)	1	2
19. Gaining a new family member (e.g., through birth, adoption, oldster moving in, etc.)	1	2
20. Change in residence	1	2
21. Son or daughter leaving home (e.g., marriage, attending college, etc.)	1	2
22. Marital separation from mate	1	2
23. Major change in church activities (e.g., a lot more or a lot less than usual)	1	2
24. Marital reconciliation with mate	1	2
25. Being fired from work	1	2
26. Divorce	1	2
27. Changing to a different line of work	1	2

Event	Yes	No
28. Major change in the number of arguments with spouse (e.g., either a lot more or a lot less than usual regarding child-rearing, personal habits, etc.)	1	2
29. Major change in responsibilities at work (e.g., promotion, demotion, lateral transfer)	1	2
30. Wife beginning or ceasing work outside the home	1	2
31. Major change in working hours or conditions	1	2
32. Major change in usual type and/or amount of recreation	1	2
33. Taking on a mortgage greater than $10,000 (e.g., purchasing a home, business, etc.)	1	2
34. Taking on a mortgage or loan less than $10,000 (e.g., purchasing a car, TV, freezer, etc.)	1	2
35. Major personal injury or illness	1	2
36. Major business readjustment (e.g., merger, reorganization, bankruptcy, etc.)	1	2
37. Major change in social activities (e.g., clubs, dancing, movies, visiting, etc.)	1	2
38. Major change in living conditions (e.g., building a new home, remodeling, deterioration of home or neighborhood)	1	2
39. Retirement from work	1	2
40. Vacation	1	2
41. Christmas/Hanukah	1	2
42. Changing to a new school	1	2
43. Beginning or ceasing formal schooling	1	2

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VIII. DEMOGRAPHIC DATA

These questions are intended to provide us with certain factual information about yourself. Your answers to these questions will allow us to determine what, if any, effect factors such as sex, age, income, personal responsibilities, etc. have (if any) on the issues we are studying.

1. Which sex are you?

   Female....................1
   Male......................2

2. What is your ethnic background?

   American Indian or Alaskan Native...........1
   Asian or Pacific Islander...................2
   Black not of Hispanic origin................3
   Hispanic....................................4
   White, not of Hispanic origin...............5

3. How much schooling have you had? Circle One.

   1. None
   2. Grades 1-4
   3. Grades 5-6
   4. Grades 7-8
   5. Grades 9-11
   6. Grade 12 (completed high school)
   7. Completed high school plus other non-college training (technical or trade school)
   8. Some college
   9. Completed college with bachelor's degree
   10. Completed college with advanced or professional degree (M.A., M.S., Ph.D., M.D., D.V.M., etc.)

4. How old are you ______years

5. How tall are you? ______feet, and ______inches

6. How much do you usually weigh? ______pounds

7. What is your marital status?

   Married...................1
   Single....................2
   Separated.................3
   Divorced..................4
   Widowed...................5

8. Not counting yourself, how many persons do you have to support either partially or completely with your earnings? Include spouse, children, parents, grandparents, brothers, sisters, etc.?

   ______Persons (enter number)

9. Do you have any children?

   Yes . . . . 1 (If YES, answer a through d, and continue)
   No . . . . 2 (If NO, go to question 10)

   a. If yes, how many children are now living at home? _____ children.

   b. If you have children living at home, how many are in each of the following age groups? (Fill in number)

      Under 4 years . . . . ______children
      4 through 12 years . . . . ______children
      13 through 18 years . . . . ______children
      19 and over . . . . ______children

   c. Who has the major responsibility for disciplining your children, checking on their schoolwork, handling their personal problems, etc.

      My spouse has all the responsibility 1
      My spouse has most of the responsibility 2
      We share the responsibility about equally 3
      I have most of the responsibility 4
      I have all of the responsibility. 5

   d. How satisfied are you with this arrangement?

      Very satisfied 1
      Moderately satisfied 2
      Slightly satisfied 3
      Slightly dissatisfied 4
      Moderately dissatisfied 5
      Very dissatisfied 0

10. How many people are living with you at your home? (Do not include yourself) _____Persons

    How many of these people are presently employed? (Do not include yourself) _____Persons

11. Do you live in what you consider to be a family type situation?

    Yes . . . . 1 (If yes, answer question 12 and continue)

    No . . . . 2 (If no, go on to question 13)

12. Who is the chief breadwinner in your family (circle one)

Yourself	1
Your mate	2
Self and mate equally	3
Father	4
Mother	5
Other (please specify ________)	6

Is this person's job: (circle one)

Steady	1
Seasonal	2
Part-time	3

13. How much did you earn on this job in 1979 before any taxes or other deductions? (round to the nearest thousand)

____________ in 1979
(fill in amount)

14. Considering your education, knowledge, ability, experience, your overtime work, and how hard you work, how much do you think you should have been paid in 1978? (round to nearest thousand)

____________ in 1979
(fill in amount)

END of QUESTIONNAIRE . . . THANK YOU

Items omitted from the questionnaire for the secondary sample:

Part 1: P1Q5H, P1Q6, P1Q6A, P1Q6B, P1Q7A (Others), P1Q7B-P1Q7F, P1Q10A-P1Q10C, P1Q11, P1Q11A, P1Q12A, P1Q12B, P1Q13B (Others), P1Q13C, P1Q14, P1Q15A-P1Q15E.

Part 2: P1Q17A-P2Q17G, P2Q19, P2Q20A-P2Q20C, P2Q21A-P2Q21H, P2Q22A-P2Q22D, P2Q25.

Part 4: P4Q4A-P4Q4H, P4Q6A, P4Q6B, P4Q7A-P4Q7W, P4Q8A-P4Q8E, P4Q10, P4Q10A, P4Q10B, P4Q11A, P4Q11B, P4Q12, P4Q12B, P4Q12C, P4Q15, P4Q16, P4Q16A (Cigars, Pipefuls of tobacco), P4Q16C, P4Q16D, P4Q16E, P4Q17B, P4Q18C, P4Q19C1-P4Q19C4, P4Q20, P4Q22E, P4Q25A-P4Q25V.

Part 6: P6Q2A-P6Q2E, P6Q3A-P6Q3D, P4Q20A-P4Q20W.

Part 7: P7Q9C, P7Q9D.

Part 1A: P1AQ1H (Other job task), P1AQ7 (Other), P1AQ9A-P1AQ9E, P1AQ10 ("If" statements omitted), P1AQ13A-P1AQ13F, P1AQ16.

Items added to the questionnaire for the secondary sample:

Part 2: P2Q12H - headaches

P2Q16, P2Q17, P2Q18 - Would you say the amount of tobacco / coffee/tea / soft drinks you consume has in the last six months

Increased	1
Decreased	2
Remained same	3
I don't consume ______	0

Part 1A: P1AQ8H - Heat from the VDT

P1AQ18 - In what ways has VDT made your job

Better: ____________________

Worse: ____________________

Part 6: The following questions:

1. If you previously worked at a job-task similar to the one you now perform with a VDT, please indicate whether the following aspects of your job or your health have changed since you began working with VDTs. (If you did not do a similar job task before you started to work with VDTs, skip this question).

		decreased a lot	decreased somewhat	stayed the same	increased somewhat	increased a lot
a.	your personal freedom in doing your work	1	2	3	4	5
b.	your responsibilities in performing your work or job..	1	2	3	4	5
c.	the demand for your attention or concentration in the work you do	1	2	3	4	5
d.	the amount of work you have to do ..	1	2	3	4	5
e.	the difficulty of your work	1	2	3	4	5
f.	the variety of tasks you have to do in your work	1	2	3	4	5
g.	any problems you may have with your supervisor(s) ...	1	2	3	4	5
h.	any problems you may have with your co-workers	1	2	3	4	5
i.	your ability to do your job well ...	1	2	3	4	5
j.	your ability to do your job quickly .	1	2	3	4	5
k.	any problems with the lighting at your work station.	1	2	3	4	5
l.	any problems with your chair or desk adjustment ..	1	2	3	4	5
m.	any problems with noise at your work station	1	2	3	4	5

		decreased a lot	decreased somewhat	stayed the same	increased somewhat	increased a lot
n.	any problems with the temperature at your work station.	1	2	3	4	5
o.	any problems with your vision or eyes	1	2	3	4	5
p.	any problems with your neck or arms	1	2	3	4	5
q.	any problems with your fingers or wrists	1	2	3	4	5
r.	any problems with your back or legs	1	2	3	4	5
s.	any problems with headaches	1	2	3	4	5
t.	any problems with your stomach or with digestion ..	1	2	3	4	5
u.	other health problems specify: _______	1	2	3	4	5
	_______________	1	2	3	4	5
	_______________	1	2	3	4	5
v.	the extent to which you feel tired when you get home from work	1	2	3	4	5
w.	your freedom to move around in your work place	1	2	3	4	5
x.	your efficiency in performing your job	1	2	3	4	5
y.	the extent to which you feel rushed in performing your job	1	2	3	4	5

	decreased a lot	decreased somewhat	stayed the same	increased somewhat	increased a lot
z. any problems with feeling mental strain at work	1	2	3	4	5
aa. overall satisfaction you feel with your job	1	2	3	4	5
bb. the number of routine tasks you have to do	1	2	3	4	5

2. a. Do you believe that video display terminals pose a direct hazard to your health?

   Definitely does 1

   Very likely 2

   Not sure 3

   Probably not 4

   No 5

   b. If you do believe they pose a hazard, explain the hazard:

   ____

   ____

   ____

   ____

Appendix E. Data form for on-site lighting measurements.

Code no.__________

Date__________

Location: ____

Comments: ____

____

____

Luminance: @________FL(Screen) ________FL(Screen Std)

________FL(Keyboard) ________FL(Keyboard Std)

________FL	________FL	________FL
left	center (Background)	right

Illumination: @________FC(Screen) ________FC (Work surface - 1)

________FC(Keyboard) ________FC (Work surface - 2)

	f-stop	shutter speed	
Photo Date:	________	________	#1 (profile)
	________	________	#2 (screen)
	________	________	#3 (work station)

VDT Type: ________ (mfg.) ________ (model no.)

Appendix F. Content and computation of questionnaire scales (P = questionnaire part, Q = question number in each part).

Caplan et al. (1975)

Role ambiguity: -P2Q7A - P2Q7B - P2Q7C - P2Q7D + 24

Quantitative workload: P2Q7E + P2Q7F + P2Q7G + P2Q7H - P2Q9A - P2Q9B + P2Q9C + P2Q9D - P2Q9E + P2Q9F - P2Q9G + 24

Role conflict: P2Q15A + P2Q15B + P2Q15C

Workload variance: P2Q16A + P2Q16B + P2Q16C

Job future ambiguity: -P2Q23A - P2Q23B - P2Q23C - P2Q23D + 24

Underutilization of abilities: -P2Q8A - P2Q8B - P2Q8C + 18

Participation: P2Q10A + P2Q10B + P2Q10C

Social support from supervisors: P5Q1A + P5Q2A + P5Q3A + P5Q4A - 4

Social support from others at work: P5Q1B + P5Q2B + P5Q3B + P5Q4B - 4

Social support from spouse/family: P5Q1C + P5Q2C + P5Q3C + P5Q4C - 4

Social support from friends: P5Q1D + P5Q2D + P5Q3D + P5Q4D

Job dissatisfaction: $[(P2Q1 - 1.4894^{*})/.5947^{\dagger} + (P2Q2 - 1.6869^{*})/.6504^{\dagger} + (P2Q3 - 1.5366^{*})/.5945^{\dagger} + (P2Q4 - 1.8610^{*})/.7699^{\dagger}]/4$

Workload dissatisfaction: P2Q5B + P2Q5D + P2Q5F

---

* Mean score for each question.

† Standard deviation each question.

Boredom: P2Q5A + P2Q5C + P2Q5E + 6

Work Environment Scale

Job involvement: -WES1 + WES11 + WES21 - WES31 + 2

Peer cohesion: -WES2 + WES12 - WES22 + WES32 + 2

Staff support: WES3 - WES13 + WES23 - WES33 + 2

Job autonomy: WES4 - WES14 - WES24 - WES34 + 5

Task orientation: -WES5 + WES15 - WES25 - WES35 + 5

Work pressure: -WES6 - WES16 - WES26 + WES36 + 5

Clarity of expectations: WES7 - WES17 + WES27 - WES37 + 2

Control: -WES8 + WES18 - WES28 - WES38 + 5

Innovation: WES9 - WES19 - WES29 + WES39 + 5

Physical comfort: WES10 - WES20 + WES30 - WES40 + 2

Profile of Mood States

Tension-anxiety: POMS2 + POMS10 + POMS16 + POMS20 - POMS22 + POMS26 + POMS27 + POMS34 + POMS41 + 4

Depression: POMS5 + POMS9 + POMS14 + POMS18 + POMS21 + POMS23 + POMS32 + POMS35 + POMS36 + POMS44 + POMS45 + POMS48 + POMS58 + POMS61 + POMS62

Mood disturbance: (.2534)POMS2 + (.2676)POMS3 + (.1947)POMS4 + (.2664)POMS5 + (.1806)POMS7 + (.2353)POMS8 + (.1999)POMS9 + (.3099)POMS10 + (.2477)POMS11 + (.2230)POMS12 + (.2704)POMS14 + (.1162)POMS15 + (.2867)POMS16 + (.3004)POMS17 + (.2701)POMS18 + (.1523)POMS19 + (.3041)POMS20 + (.3133)POMS21 + (.2035)POMS22 + (.2562)POMS23 + (.3045)POMS24 + (.2828)POMS26 + (.2176)POMS27 + (.2293)POMS28 + (.2060)POMS29 + (.2858)POMS31 + (.2540)POMS32 + (.2615)POMS33 + (.2492)POMS34 + (.1885)POMS35 + (.3177)POMS36 + (.3348)POMS37 + (.2060)POMS38 + (.3188)POMS39 + (.2095)POMS40 + (.1900)POMS41 + (.2560)POMS42 + (.3207)POMS44 + (.3417)POMS45 + (.2741)POMS46 + (.2504)POMS47 + (.3364)POMS48 + (.2544)POMS49 + (.3304)POMS50 + (.1731)POMS51 + (.2865)POMS52 + (.2583)POMS53 + (.0691)POMS54 + (.1442)POMS56 + (.2844)POMS57 + (.2883)POMS58 + (.1857)POMS59 + (.0631)POMS60 + (.3422)POMS61 + (.2660)POMS62 + (.0621)POMS63 + (.2126)POMS64 + (.2210)POMS65 + 20

Illness symptoms: (.4202)P2Q12A + (.3554)P2Q12B + (.2913)P2Q12C + (.4933)P2Q12D + (.2847)P2Q12F + (.3462)P2Q12G + (.3266)P2Q12H + (.2930)P2Q12I + (.4942)P2Q12J + (.2596)P2Q12L + (.3342)P2Q12M + (.2938)P4Q5A + (.2191)P4Q5C + (.2180)P4Q5J + (.2431)P4Q5K + (.3054)P4Q5L + (.3340)P4Q5M + (.3238)P4Q5N + (.2797)P4Q5P + (.2770)P4Q5Q + (.2875)P4Q5R + (.3090)P4Q5S + (.2534)P4Q5T + (.3130)P4Q5U + (.3081)P4Q5W + (.4167)P4Q5X + (.3230)P4Q5Y + (.3213)P4Q5Z + (.3134)P4Q5EE + (.4198)P4Q5FF + (.2959)P4Q5GG + (.3283)P4Q5HH + (.2941)P4Q5II + (.3555)P4Q5JJ + (.2925)P4Q5KK + (.3761)P4Q5LL + (.2259)P4Q5NN + (.3073)P4Q5QQ + (.2954)P4Q5SS + (.3979)P4Q5TT + (.2997)P4Q5UU + (.3937)P4Q5WW + (.3421)P4Q5YY + (.1873)P4Q5ZZ + (.3189)P4Q5AAA + (.2654)P4Q5BBB + (.3242)P4Q5CCC + (.3297)P4Q5DDD + (.4397)P4Q5EEE + (.3084)P4Q5FFF + (.3246)P4Q5GGG + 20

Behavioral-autonomic strain: (.5121)P2Q12H + (.5241)P4Q5S + (.4761)P4Q5T + (.5579)P4Q5U + (.5708)P4Q5Y + (.7533)P4Q5FF + (.5594)P4Q5HH + (.4728)P4Q5II + (.6485)P4Q5LL + (.3968)P4Q5NN + (.6272)P4Q5SS + (.6771)P4Q5TT + (.6467)P4Q5WW + (.6423)P4Q5YY

Anger: POMS3 + POMS12 + POMS17 + POMS24 + POMS31 + POMS33 + POMS39 + POMS42 + POMS47 + POMS52 + POMS53 + POMS57

Vigor: POMS7 + POMS15 + POMS19 + POMS38 + POMS51 + POMS56 + POMS60 + POMS63

Fatigue: POMS4 + POMS11 + POMS29 + POMS40 + POMS46 + POMS49 + POMS65

Confusion: POMS8 + POMS28 + POMS37 + POMS50 - POMS54 + POMS59 + POMS64 + 4

Total Mood Disturbance: TENSION + ANGER + DEPRESSION + FATIGUE + CONFUSION - VIGOR

Derived Scales*

Job control: (.3972)P1Q13A + (.1659)P2Q7I + (.3360)P2Q7K + (.3385)P2Q8A + (.4589)P2Q8B + (.3004)P2Q8C + (.4314)P2Q10A + (.4728)P2Q10B + (.5008)P2Q10C + (.3560)P2Q13C + (.4449)WES4 + (.2020)WES8 + (.4588)WES14 + (.4457)WES24 + (.3737)WES28 + (.3594)WES38 + 20

Future certainty: (.5112)P2Q7M + (.6528)P2Q23A + (.5336)P2Q23B + (.6562)P2Q23C + (.6551)P2Q23D + (.5368)P2Q24 + 20

Social support: (.3453)WES2 + (.3877)WES3 + (.3795)WES11 + (.3514)WES12 + (.3831)WES13 + (.3297)WES22 + (.2749)WES23 + (.4157)P5Q1A$^{\alpha}$ + (.4402)P5Q1B$^{\alpha}$ + (.3771)P5Q2A$^{\alpha}$ + (.4841)P5Q2B$^{\alpha}$ + (.4084)P5Q3A$^{\alpha}$ + (.4838)P5Q3B$^{\alpha}$ + (.3656)P5Q4A$^{\alpha}$ + (.4201)P5Q4B$^{\alpha}$ + (.4618)P5Q6 + (.5201)P5Q7 + (.1200)P5Q1C$^{\beta}$ + (.2009)P5Q1D$^{\beta}$ + (.1511)P5Q2C$^{\beta}$ + (.2871)P5Q2D$^{\beta}$ + (.1484)P5Q3C$^{\beta}$ + (.2104)P5Q3D$^{\beta}$ + (.1606)P5Q4C$^{\beta}$ + (.2561)P5Q4D$^{\beta}$ + 20

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* Where appropriate, items were reverse scored so that increasing magnitude was consistent with increases in the construct denoted by the scale label. Weights were based upon normal score transformations of item values (Li, 1957).

α Coding note: Parts a and b of question P5Q1 - Q4 recoded such that if a and b equal 1 then a and b equal 2; if a=1 then a=b; if b=1 then b=a.

β Coding note: 1's recoded as missing data.

Job demands: (.4642)P2Q7E + (.4834)P2Q7F + (.4028)P2Q7G + (.5711)P2Q7H + (.4573)P2Q7L + (.2544)P2Q9B + (.6652)P2Q9C + (.6763)P2Q9D + (.4129)P2Q9F + (.3222)P2Q9G + (.3205)P2Q9H + (.1749)P2Q11B + (3575)P2Q16A + (.3876)P2Q16B + (.3694)P2Q16C + (.2309)WES1 + (.3152)WES6 + (.3625)WES16 + (.3494)WES26 + (.3934)WES36 + 20

Environmental problems: (.3196)WES10 + (.4043)WES20 + (.5540)WES30 + (.5176)WES40 + (.5576)P3Q1 + (.4506)P3Q2A* + (.4575)P3Q2B* + (.3884)P3Q2E* + (.4587)P3Q3D + (.2289)P3Q4 + (.4192)P3Q6A + (.4423)P3Q6B + (.2712)P3Q6C + (.4328)P3Q6D + (.3176)P3Q6E + 20

Job distress/dissatisfaction: (.4153)P2Q1 + (.4265)P2Q3 + (.4332)P2Q4 + (.3113)P2Q5A + (.1836)P2Q5C + (.2406)P2Q5D + (.2969)P2Q5E + (.2382)P2Q5F + (.3292)P2Q9I + (.3653)P2Q13A + (.4066)P2Q13B + (.3143)P2Q14A + (.3822)P2Q14B + (.3608)P2Q14C + (.3438)P2Q14D + (.3704)P2Q14E + (.4439)P2Q14F + (.2459)P2Q14G + (.4797)P2Q14H + (.2908)P2Q14I + (.3959)P2Q14J + (.3722)P2Q14K + (.2758)P4Q24A + 20

Visuo-ocular strain: (.7857)P2Q12I + (.7653)P2Q12L + (.7982)P4Q5P + (.8372)P4Q5R + (.8563)P4Q5UU + (.8244)P4Q5FFF

Musculo-skeletal postural strain: (.7424)P2Q12C + (.6798)P2Q12F + (.7053)P4Q5L + (.7952)P4Q5N + (.6848)P4Q5QQ + (.7612)P4Q5AAA + (.7509)P4Q5CCC

Musculo-skeletal manipulative strain: (.6900)P4Q5K + (.9195)P4Q5M + (.8325)P4Q5Q + (.9026)P4Q5GG + (1.0077)P4Q5BBB + (.9879)P4Q5DDD + (1.0285)P4Q5GGG

VDT/workstation physical adjustability: (.6889)P1AQ5 + (.8309)P1AQ6G† + (.9066)P1AQ6H† + (1.2622)P1AQ6I† + (1.1733)P1AQ6J† + (.6218)P1AQ6K† + (.7503)P1AQ6L†

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* Coding note: 4's recoded to 2's and 5's recoded to 1's.
† Coding note: 3's have been recoded as missing data.

VDT/workstation lighting adjustability: (1.0695)P1AQ6A* + (1.2402)P1AQ6B* + (.5057)P1AQ6C* + (.6344)P1AQ6D* + (.8472)P1AQ6E* + (-.9468)P1AQ6O* + (-1.0612)P1AQ6P*

VDT display luminance bother: (.796)P1AQ8A + (.840)P1AQ8B + (.717)P1AQ8C + (.346)P1AQ8D + (.388)P1AQ8E + (.160)P1AQ8F + (.260)P1AQ8G + (.124)P1AQ8H + (.037)P1AQ8I + (.432)P1AQ8J + (.248)P1AQ8K + (-.029)P1AQ8L + (.327)P1AQ8M + (-.013)WES10 + (.095)WES20 + (.152)WES30 + (-.005)WES40 + (.053)P3Q1 + (.049)P3Q2A† + (.097)P3Q2B† + (-.136)P3Q2E† + (.222)P3Q3D + (.043)P3Q4 + (.083)P3Q6A + (.199)P3Q6B + (-.078)P3Q6C + (.157)P3Q6D + (.101)P3Q6E

Environmental lighting bother: (.839)WES20 + (.231)P3Q1 + (.853)P3Q2B† + (.567)P3Q3D + (.157)WES10 + (.143)WES30 + (.084)WES40 + (.013)P3Q2A† + (.058)P3Q2E† + (.187)P3Q4 + (.049)P3Q6A + (.078)P3Q6B + (.080)P3Q6C + (.132)P3Q6D + (-.002)P3Q6E + (.203)P1AQ8E + (.075)P1AQ8F + (-.028)P1AQ8G + (.092)P1AQ8H + (.187)P1AQ8I + (.246)P1AQ8J + (-.028)P1AQ8K + (.132)P1AQ8L + (.224)P1AQ8M

VDT physical configuration bother: (.724)P1AQ8D + (.546)P1AQ8E + (.812)P1AQ8F + (.552)P1AQ8G + (.833)P1AQ8H + (.779)P1AQ8I + (.360)P1AQ8J + (.133)P1AQ8K + (.274)P1AQ8L + (.241)P1AQ8M + (.101)WES10 + (.081)WES20 + (.150)WES30 + (.199)WES40 + (.090)P3Q1 + (-.099)P3Q2A† + (.061)P3Q2B† + (.061)P3Q2E† + (.260)P3Q3D + (.035)P3Q4 + (-.062)P3Q6A + (.082)P3Q6B + (.025)P3Q6C + (.231)P3Q6D + (-.016)P3Q6E + (.183)P1AQ8A + (.177)P1AQ8B + (.225)P1AQ8C

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* Coding note: 3's have been recoded as missing data.

† Coding note: 4's recoded to 2's and 5's recoded to 1's.

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REPORT DOCUMENTATION PAGE	1. REPORT NO.	2.	3. PB84-240449

4. Title and Subtitle The Well-Being of Video Display Terminal Users: An Exploratory Study

5. Report Date 83/02/00

6.

7. Author(s) Sauter, S. L., M. S. Gottlieb, K. M. Rohrer, and V. N. Dodson

8. Performing Organization Rept. No.

9. Performing Organization Name and Address

Division of Biomedical and Behavioral Science, NIOSH, U.S. Department of Health and Human Services, Cincinnati, Ohio,

10. Project/Task/Work Unit No.

11. Contract(C) or Grant(G) No. (C) 210-79-0034 (G)

12. Sponsoring Organization Name and Address

Same as box 9

13. Type of Report & Period Covered

14.

15. Supplementary Notes

16. Abstract (Limit: 200 words)

Assessments of job disturbances, health disturbances, and potential causes of strain among 248 video display terminal (VDT) users were made. A questionnaire on working conditions, job characteristics, biodemographic characteristics, and health and well being was administered to VDT users and 85 comparisons. Multidimensional indices of well being and job attributes were derived from the questionnaires. Scores for users and comparisons were correlated. Objective measures of workplace lighting, screen glare, and measures related to worker anthropometry and the use of keyboards were surveyed. No significant differences were found between users and comparisons on scales of job dissatisfaction or affective or somatic disturbances. The correlation of measures of work station illumination with reported eye strain was positive and significant. VDT users had a greater incidence of burning eyes than comparisons. Eye and musculoskeletal strain are more frequently reported by VDT users. Use of a detached keyboard and decreased gaze angle were associated with less musculoskeletal strain. Extent of daily VDT use or cumulative exposure in months was not an important correlate of strain. The authors conclude that there is little evidence that VDT users suffer greater somatic disturbance than nonusers.

17. Document Analysis a. Descriptors

b. Identifiers/Open-Ended Terms

NIOSH-Publication, NIOSH-Contract, Physiological-response, Exposure-levels, Clinical-symptoms, Occupational-exposure, Workplace-studies, Clinical-diagnosis, Occupational-hazards, Contract-210-79-0034

c. COSATI Field/Group

18. Availability Statement:	19. Security Class (This Report)	21. No. of Pages 245
	20. Security Class (This Page)	22. Price