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Correlates of Ocular and Somatic Symptoms among Video Display Terminal Users

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A cross-sectional survey was conducted among employees of a large newspaper company (1) to define the type of ocular and somatic complaints reported by video display terminal (VDT) users and to identify their relationship to VDT use, (2) to determine the association between symptoms and the participants' adequacy of correction of refractive errors for their jobs, and (3) to assess the prevalence of eye abnormalities, especially cataracts, and their relationship to VDT use. Poor visual clarity of the VDT screen explained the plurality of work-associated symptoms. These associations were independent of the effects of potential confounding variables. The relationships with headaches associated with work and changes in visual function were replicated in a small, independent sample. One qualitative and two quantitative VDT-use variables that suggested lesser skill or experience were associated with headaches. No meaningful relationship was found between adequacy of the participants' refractions, including the wearing of glasses with bi- or multifocal lenses, and the reporting of work-associated symptoms. No significant association was found between VDT use and the prevalence of eye abnormalities, including cataracts.

INTRODUCTION

There has been a growing apprehension over the proliferating use of video display terminals in the workplace. Three broad areas of concern appear to be dominant. First, there is the lingering fear that VDTs may be sources of radiation that may cause specific and/or unknown biological damage. However, it has repeatedly been demonstrated not only that X-ray, radiofrequency, ultrasound, visible, and infrared emissions are all within existing federal guidelines, but that such emissions are generally indistinguishable from background levels (Food and Drug Administration, 1981; Moss, Murray, Parr, Messite, and Karches, 1977; Petersen, Weiss, and Minneci, 1980; Terrana, Merluzzi, and Giudici, 1980; Weiss and Petersen, 1979; Wolbarsht, O'Fogludha, Sliney, Guy, Smith, and Johnson, 1980). Second, there is the recognition that a wide variety of somatic complaints are prevalent among VDT users. These include symptoms of visual discomfort and transient impairment of visual function, and musculoskeletal complaints. Third, there is the fear of office automation. Job insecurity and uncertainty about the future contribute to job dissatisfaction, alienation, and stress.

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This may be manifested as somatic symptoms or illness.

Much has been written about the nonradiation health problems associated with VDT use. Although the complaints expressed by operators may be no different from those of other office workers (Ward, 1980), the origin of the complaints is multifactorial, with many of the underlying factors interacting with each other. These factors include the postural relationship between the VDT and user (Hünting, Laübli, and Grandjean, 1980; Laville, 1980); characteristics of the VDT screen affecting clarity and readability of characters (Stammerjohn, Smith, and Cohen, 1981); workplace lighting (Laville, 1980; Ostberg, 1980); mode of VDT operation, for example, as a data entry terminal or as a conversational terminal (Grandjean, 1980); problems with the operators' visual function and accommodation (Krueger, 1980; Ostberg, 1980); and operators' fear of job regimentation and threats against job security (Grandjean, 1980; Krueger, 1980; Ostberg, 1980).

This study was undertaken at the request of an officer of the union representing a large number of employees of a newspaper company. Its purpose was to evaluate the effects of VDTs on the environment and health of employees who use them. A field survey was conducted to define the type of ocular and somatic complaints reported by VDT users and their relationship to VDT use; to determine the association, if any, between ocular and somatic complaints, and users' refractive abilities specific to their job tasks; and to assess the prevalence of lenticular opacities (cataracts) and retinal abnormalities among VDT users and non-users, and their relationship to VDT use. The survey instruments were designed so that multivariable causes could be considered in the analyses of symptom complaints.

METHODS

The union represented 588 of 1675 active newspaper employees. Because data were not available to identify VDT users and non-users, a short questionnaire was distributed to as many union members as could be contacted, to obtain demographic and VDT-use information. Participation in the survey was offered to all union members.

Ophthalmological examinations were performed on 10 Saturdays, from February to May, 1981. At the time of the examinations, participants answered a lengthier self-administered questionnaire, giving personal and job information, symptom complaints, and the participants' opinions on the pressure, pace, autonomy, security, and satisfaction associated with their jobs. Additional information was obtained on the use of eyeglasses, history of refraction, major illnesses, allergies, and medication use. The ophthalmological examination consisted of measurement of visual acuity, manifest and cycloplegic refractions, muscle balance, and intraocular pressure, as well as examinations of the anterior segment, lens, vitreous, and fundus of each eye.

The data were reduced to a computer file and were analyzed using standard, packaged statistical programs (SAS Institute, 1979). All tabulations and tests of statistical significance were performed using nonmissing responses to each question or examination item. The examiners were kept unaware of the participants' VDT use.

The questionnaire and examination forms are reproduced in a technical report (Smith, Tanaka, Halperin, and Richards, 1982). The questionnaire was designed so that participants' responses could be reduced by factor analysis. Questions that were factor analyzed were phrased so that the survey participants responded on an ordinal scale to indicate how

a statement applied to them during their usual job or during their VDT use. Factors were extracted by principal components analysis of the correlation matrix of a related set of questions, retention of components whose eigenvalues exceeded one, and varimax rotation of the retained components. The characters of the factors were inferred from the question/factor loadings (correlations). The derived factor scores had approximately a bell-shaped distribution with a mean of 0 and a standard deviation of 1. Reduction of a large number of questionnaire responses to a smaller number of latent factors distributed on a continuous scale ultimately allowed the data to be analyzed by multiple linear regression, taking into account potential confounding variables that might have influenced the questionnaire responses.

Since the statistical analyses were exploratory, few of the hypotheses tested were specified a priori. Because multiple comparisons were performed on the data, a nominal p level of 0.05 for statistical significance was presumed to be too high. It was estimated that between 5 and 30 comparisons were made for each symptom factor. This would suggest that a nominal p level between 0.01 and 0.001 would be appropriate. (Given n comparisons at the 0.05 level, the nominal p level, x, is $1 - 0.95^{1/n}$. If $n = 5$, then $x = 0.01021$. If $n = 30$, then $x = 0.00170$.) Because the analyses were exploratory, the less stringent nominal p level of 0.01 was chosen to suggest statistical significance. The true probability of finding at least one statistically significant comparison for each factor when a nominal p level of 0.01 has been chosen is likely to be greater than 5%. The choice of a more stringent p level would result in fewer of the associations being designated as statistically significant.

RESULTS

Data Reduction by Factor Analysis

The work/health questionnaire consisted of 213 questions, many of which clearly were not independent of each other. Factor analysis was used to identify underlying factors for five sections of the questionnaire as follows.

Four questions described the VDT user's typical pattern of VDT operation. Two factors were extracted, which jointly accounted for 74.3% of the total variance of the correlation matrix (Table 1). Factor 1 described a mode of VDT operation where the operator's eyes shift between the VDT screen and keyboard, and the source document (*eyes shifting*). Factor 2 described a mode of VDT operation where the operator's eyes are fixed on the VDT screen (*eyes fixed*).

Twelve questions asked "how bothersome" were various ergonomic aspects of the VDT as usually adjusted. Two factors were extracted, which jointly accounted for 60.3% of the total variance of the correlation matrix (Table 2). Factor 1 measured the physical relationship between the VDT and the user (the respondent); that is, "how bothersome" were the height, distance, and tilt of the screen and keyboard relative to the user. Factor 2 measured the user's perceptions of the readability of the VDT characters as a function of brightness, resolution, glare, and flicker.

Fifty-six questions were asked about headache symptoms. Four factors were extracted for 12 questions pertaining to the timing of the headaches, which jointly accounted for 61.6% of the total variance of the correlation matrix of these 12 questions (Table 3, Factors 1 to 4). Factor 1 described headaches occurring during periods of tension, worry, and/or stress. Factor 2 described headaches associated with work but did not differentiate be-

TABLE 1

"The following are some examples of how VDTs are operated . . ."

	*Factor Loading**
Factor 1: *Eyes shifting*	
Your eyes shift between the VDT terminal and keyboard.	0.876
Your eyes shift among the source document, the VDT screen, and the keyboard.	0.786
Your eyes shift between the source document and the VDT screen for input and/or output.	0.610
Factor 2: *Eyes fixed*	
Your eyes are fixed on the VDT screen.	0.934

* Question/factor correlation
Questions whose factor loadings were less than 0.5 are omitted for clarity of presentation.

TABLE 2

"Considering the current set-up of your VDT as it is normally adjusted, how bothersome are the following . . ."

	*Factor Loading**
Factor 1: *Bothersome physical relationship between VDT and user*	
The height of the keyboard	0.853
The distance of the keyboard from you	0.808
The tilt of the VDT keyboard	0.799
Glare off the keyboard	0.724
The height of the screen	0.714
The distance of the screen from you	0.606
The tilt of the VDT screen toward you	0.571
Factor 2: *VDT readability*	
The brightness of the letters or numbers	0.854
The brightness of the screen	0.795
Glare off the VDT screen	0.777
The readability (size or sharpness)	0.718
Flicker of the screen display	0.596

* Question/factor correlation
Questions whose factor loadings were less than 0.5 are omitted for clarity of presentation.

tween headaches with onset during the first and last four hours of work. Factor 3 described headaches with miscellaneous temporal associations. Factor 4 described headaches occurring away from the job. Thirteen factors were extracted for 44 questions pertaining to symptoms accompanying, or descriptions of, the headaches. These 13 factors jointly accounted for 69.3% of the total variance of the correlation matrix of these 46 questions (Table 3, Factors 5 to 17). These included three factors suggestive of migraine headaches (Factors 5, 7, and 9), two factors suggestive of tension headaches (Factors 13 and 15), two factors describing different sets of visual symptoms in association with the headaches (Factors 8 and 14), and six factors describing different sets of miscellaneous associated symptoms or headache descriptions (Factors 6,10,11,12,16, and 17).

Twenty-three questions asked about symptoms that occurred during normal work activities. Four factors were extracted that jointly accounted for 60.6% of the total variance of the correlation matrix (Table 4). Factor 1 described uncomfortable visual symptoms, namely, burning, itching, aching, irritated eyes. Factor 2 described changed visual function: seeing colored fringes around objects, double or blurry vision, and difficulty focusing on characters. Factor 3 described pain and stiffness in the arms, hands, and legs (the appendicular musculature). Factor 4 described pain and stiffness in the neck, shoulders, and back (the axial musculature).

Twenty-three questions asked about attitudes and feelings toward the respondent's job. Seven factors were extracted that jointly accounted for 67.7% of the total variation of the correlation matrix (Table 5). These seven factors seemed, broadly, to describe the respondents' perceptions of job pressure, pace, and interest (Factors 1,2,4, and 5), predictability of job responsibilities (Factor 3), job security (Factor 6), and job autonomy (Factor 7).

TABLE 3

"Your headaches . . . :

	*Factor Loading**
Factor 1:	
. . . occur during periods of worry.	0.898
. . . occur during periods of emotional stress.	0.890
. . . occur during periods of tension.	0.886
Factor 2:	
. . . are associated with your usual job at work.	0.826
. . . first occur within the second four hours of work.	0.739
. . . first occur within the first four hours of work.	0.717
Factor 3:	
. . . occur with changes in the weather.	0.724
. . . are due to an allergy.	0.717
. . . awaken you from sleep.	0.540
. . . occur upon awakening, but do not actually awaken you from sleep.	0.529
Factor 4:	
. . . occur hours after work.	0.785
. . . occur off the job.	0.704
. . . occur soon after work.	0.616
Factor 5:	
. . . are preceded by flashing bright lights in your field of vision.	0.826
. . . are preceded by spots in your field of vision.	0.824
. . . are accompanied by flashing bright lights in your field of vision.	0.820
. . . are accompanied by spots in your field of vision	0.784
Factor 6:	
. . . are made worse by bright light	0.774
. . . are made worse by use of your eyes to do close work	0.758
. . . are made worse by noise.	0.701
. . . are made worse by poor light.	0.553
Factor 7:	
. . . are preceded by vomiting.	0.828
. . . are accompanied by nausea.	0.804
. . . are accompanied by vomiting.	0.790
. . . are preceded by nausea.	0.751
. . . are accompanied by loss of appetite.	0.501
Factor 8:	
. . . are accompanied by itching eyes.	0.791
. . . are accompanied by burning eyes.	0.754
. . . are accompanied by watery eyes.	0.753
Factor 9:	
. . . are accompanied by weakness of one or both arms.	0.812
. . . are accompanied by weakness of one or both legs.	0.775
. . . are accompanied by disturbances of sensation in your arms or legs.	0.766
Factor 10:	
. . . are generally on one side of your head.	0.713
. . . are located around your eyes.	0.524
. . . are located around your lower face.	0.517
Factor 11:	
. . . are made worse by coughing.	0.846
. . . are made worse by sneezing.	0.837

TABLE 3—*continued*

"Your headaches . . . :

Factor 12:	*Factor Loading**
. . . are located superficially.	0.688
. . . generally begin on one side of your head, but progress to involve both sides.	0.547
Factor 13:	
. . . radiate into your shoulders.	0.814
. . . are accompanied by muscle tenseness.	0.747
Factor 14:	
. . . are accompanied by double vision.	0.630
. . . are preceded by double vision.	0.575
Factor 15:	
. . . feel like a tight band.	0.799
. . . feel like a constriction.	0.759
Factor 16:	
. . . are located around the top of your head.	0.704
. . . are located around your temples.	0.564
Factor 17:	
. . . are accompanied by sweating.	0.672
. . . are accompanied by flushing of your skin.	0.553

* Question/variable correlation
Questions whose factor loadings were less than 0.5 are omitted for clarity of presentation.

Target Population

The target population consisted of 588 active union members. The short demographic and VDT-use questionnaire was completed by 456 (77.6%) members, whereas 283 (48.1%) completed both the long questionnaire and underwent the eye examination. One hundred other newspaper employees participated in the survey as well. Except where noted below, the data analyses that follow were limited to the 283 union members.

Participants Compared with Nonparticipants

Union participants in the examinations were compared with union nonparticipants who answered the demographic and VDT-use questionnaire but declined completion of the symptom questionnaire and participation in the eye examinations (Table 6). Although participants did not differ in mean age or length of employment at the newspaper, they did differ on VDT use characteristics. Thus, a greater proportion of participants than nonparticipants currently used a VDT in their work. Among VDT users, participants reported a greater mean number of hour per week of VDT operation and years of VDT operating experience than did nonparticipants. As a group, participants reported having a greater number of years of education than did nonparticipants.

Exploratory Data Analyses

Among participants in the examinations, there were no significant differences between current VDT users and non-users in occurrence, frequency, duration, or severity of headaches. The only significant association between VDT use and symptom factors (Tables 3 and 4) was in relation to pain and stiffness in the axial musculature, with VDT users reporting a greater amount of such discom-

TABLE 4

"During your usual work activities . . ."

Factor 1: *Uncomfortable visual symptoms*	*Factor Loading**
Your eyes feel irritated.	0.833
Your eyes burn.	0.801
Your eyes feel uncomfortable.	0.794
Your eyes feel hot.	0.732
Your eyes feel tired.	0.729
Your eyes ache.	0.712
You have eyestrain.	0.704
Your eyes feel dry.	0.657
Your eyes feel itchy.	0.629
Factor 2: *Changes in visual function*	
You see colored fringes around objects.	0.694
You have difficulty reading.	0.633
You have blurry vision.	0.629
Your ability to see colors changes.	0.594
You have difficulty focusing on characters.	0.588
You have double vision.	0.564
You have difficulty maintaining your attention.	0.504
Factor 3: *Pain or stiffness in the appendicular musculature*	
You have pain or stiffness in your legs.	0.787
You have pain or stiffness in your hands.	0.778
You have pain or stiffness in your arms.	0.776
Factor 4: *Pain or stiffness in the axial musculature*	
You have pain or stiffness in your neck.	0.867
You have pain or stiffness in your shoulders.	0.855
You have pain or stiffness in your back.	0.697

* Question/variable correlation
Questions whose factor loadings were less than 0.5 are omitted for clarity of presentation.

fort than non-users. Such an analysis gives an oversimplified impression of VDT-use/symptom associations because it classifies VDT users regardless of duration, amount, or mode of use. The objective of the survey was to examine the relationship between symptom factors as outcomes and VDT-use variables as predictors, in the presence of other potentially confounding variables. Therefore, the 17 headache factors (Table 3) and the 4 somatic symptom factors (Table 4) were defined as outcomes. The following VDT-use variables were defined as predictors: hours per week of VDT operation, total years of VDT operating experience, typical mode of VDT operation (Table 1), and the degree to which participants judged as bothersome various aspects of their VDT as usually adjusted (Table 2). The following were defined as potential or actual confounders: age, sex, education level, workplace lighting characteristics, use of glasses with bi- or multifocal lenses, and the 7 job attitude factor scores (Table 5). All bivariate relationships were examined between symptoms, predictors, and potential confounders (Smith et al., 1982). For those symptom/VDT-variable associations that were confounded by additional predictors the relationships were recomputed, controlling for the confounders. The relationships for which significant symptom/VDT variable associations were found were further examined by multiple linear regressions with backward stepwise

TABLE 5

Job Attitudes

	Factor Loading*
Factor 1: *Job pace*	
Your job requires you to work very hard.	0.848
Your job requires you to work very fast.	0.819
There is a great deal to be done.	0.739
Your job leaves you with little time to get things done.	0.546
Factor 2: *Job boredom*	
The work on your job is dull.	0.872
You feel bored with the work you have to do.	0.838
You are unhappy about your current workload.	0.649
You are dissatisfied with the pace of your work.	0.644
Your work is interesting to do.	−0.721
Factor 3: *Clarity of expectations*	
You are clear about what your job responsibilities are.	0.813
You can predict what others will expect of you on the job.	0.801
Your work objectives are well defined.	0.749
Factor 4: *Workload and pressure*	
You have more than one week's work piled up to do.	0.758
You have time to do all your work.	−0.801
Factor 5: *Intermittency of workload*	
You daydream on the job.	0.767
There are lulls between heavy workload periods.	0.655
Factor 6: *Fear of reprimand or job loss*	
You are concerned about losing your job or being laid off.	0.797
You worry about being reprimanded by your supervisor.	0.730
Factor 7: *Job autonomy*	
You can set the pace at which you work.	0.740
You can choose the kind of work you do.	0.650

* Question/variable correlation
Questions whose factor loadings were less than 0.5 are omitted for clarity of presentation.

elimination, retaining those predictors or confounders whose F statistics were significant at the 0.01 level. Thus, the following factor scores were so modeled:

Headache Factor 1: Headaches occurring during periods of stress, tension, and worry
Headache Factor 2: Headaches associated with work
Headache Factor 8: Headaches with itching, burning, watery eyes
Headache Factor 12: Headaches located superficially that generally begin unilaterally but spread bilaterally
Headache Factor 14: Headaches preceded and accompanied by double vision
Symptom Factor 3: Changes in visual function
Symptom Factor 4: Pain and stiffness in the axial musculature

Those somatic symptom factors not described in Table 7 were not significantly associated with any VDT-use variable, in the presence of additional potential confounders.

The plurality of symptoms explained by some aspect of VDT use was associated with Factor 2 of Table 2 (e.g., bothersome visual aspects of the VDT as usually adjusted). These symptoms included headaches associated with work (Table 3, Factor 2); headaches accompanied by itching, burning, watery eyes (Table 3, Factor 8); changes in visual

TABLE 6

Comparison of Study Participants and Nonparticipants

	Participants	*Nonparticipants*
Mean (S.D.) age (years)	38.1 (11.1)	37.4 (12.4)
Mean (S.D.) length of employment (years)	9.7 (8.8)	9.8 (9.6)
Use VDT in current job (proportion answering yes)	0.714	0.537
Mean (S.D.) hours per week of VDT use among VDT users	21.7 (12.0)	19.6 (12.2)
Mean (S.D.) total years of VDT use among VDT users	3.37 (1.96)	2.92 (1.78)
Use of home computer (proportion answering yes)	0.007	0.033
Education:		
Proportion <12 years	0.392	0.522
Proportion ≥12 years and <16 years	0.421	0.382
Proportion ≥16 years	0.186	0.095

function (Table 4, Factor 2); and pain and stiffness in the axial musculature (Table 4, Factor 4). Hours per week of VDT operation were negatively associated with headaches preceded and accompanied by double vision (Table 3, Factor 14). Years of VDT operating experience were negatively associated with headaches that occur during periods of stress, tension, and worry (Table 3, Factor 1). The "eyes-shifting" mode of VDT operation was positively associated with superficially located headaches (Table 3, Factor 12).

Having identified the statistically significant relationships between VDT use and symptom variables, the remaining data from the 100 other newspaper employee participants were examined to determine if the relationships identified through the exploratory analyses on the union participants could be extrapolated beyond that group. A nominal p level of 0.05 was reasonable for statistical significance, since the hypotheses were specified a priori.

Among the additional survey participants, only bothersome visual aspects of the VDT as usually adjusted were significantly correlated with headaches associated with work ($r = 0.3809$, $p = 0.0016$) and changes in visual function ($r = 0.2702$, $p = 0.0208$). These were two of the major complaints that provided the motivating force for this survey; namely, headaches associated with work and changes in visual function. None of the other hypothesized associations were found at a p level of 0.05.

Association between Somatic Symptoms and Adequacy of Refraction, Stereopsis, Muscle Balance, and Ocular Accommodation

It was assumed that symptoms, if related to inadequate refraction, might occur among persons who, with their usual corrective lenses (which might be no corrective lenses) were relatively hyperopic. Among these persons, the visual image would come to a focus behind the retina, and the lens of the eye would have to increase accommodation to bring the image into focus on the retina (Krueger, 1980). The association was examined between somatic symptoms and relative

TABLE 7

Symptom Factors Modeled as Linear Functions of VDT-Use Variables and Potential Confounders

Predictor	*Direction of Association*	*p-value*	*Coefficient of Determination*
Table 3, Factor 1: *Headaches that occur during periods of worry, stress, or tension:*			
Years of VDT operating experience	Negative	0.0037	0.0487
Table 3, Factor 2: *Headaches associated with work:*			
VDT readability (Table 2, Factor 2)	Positive	0.0003	0.1879
Sex	Positive	0.0097	
Job pace (Table 5, Factor 1)	Positive	0.0094	
Fear of reprimand or job loss (Table 5, Factor 6)	Positive	0.0045	
Table 3, Factor 8: *Headaches accompanied by itching, burning, watery eyes*			
VDT readability (Table 2, Factor 2)	Positive	0.0017	0.0566
Table 3, Factor 12: *Headaches located superficially, that begin on one side of the head, but spread bilaterally*			
"Eyes shifting" (Table 1, Factor 1)	Positive	0.0012	0.0602
Table 3, Factor 14: *Headaches preceded and accompanied by double vision*			
Hours per week of VDT operation	Negative	0.0010	0.0626
Table 4, Factor 3: *Changes in visual function*			
VDT readability (Table 2, Factor 2)	Positive	0.0059	0.0933
Job boredom (Table 5, Factor 2)	Positive	0.0035	
Table 4, Factor 4: *Pain or stiffness in the axial musculature*			
Years of employment	Negative	0.0002	0.2007
Workstation lighting	Positive	0.0001	
VDT readability (Table 2, Factor 2)	Positive	0.0090	

hyperopia (defined as a difference between cycloplegic refraction and manifest refraction greater than zero) and adequacy of refraction with full reading correction (which might be no correction), taking into account age in the analysis. None of the somatic symptom factors (Tables 3 and 4) were significantly associated with either relative hyperopia or adequacy of refraction. It was further hypothesized that symptoms might be related to abnormalities of binocular vision, muscle balance, or accommodation. Again, none of the somatic symptoms were significantly associated with any of these traits.

Association of VDT Use and Ophthalmologic Examinations

The relationship was examined between VDT use and abnormalities of the anterior segment of the eye, the lens, and the retina. None of the ophthalmologic examination findings were significantly associated with current VDT use at a nominal p level of 0.05, let alone 0.01. For the ophthalmologic examination findings for which there were greater than five abnormalities among VDT users, the associations with hours per week and total years of VDT operating experience

were examined. No associations were noted with either variable at a nominal p level of 0.05. These analyses are discussed at great length in Smith et al., 1982.

DISCUSSION

Participation in this survey was offered to as many union members "as would participate"; that is, the study population was composed of volunteers. It was demonstrated that active union employees who participated differed from nonparticipants in terms of VDT use in their current job (Table 6). Therefore, caution should be exercised in extrapolating the survey beyond the group actually studied. The data were first analyzed for union participants alone. Two of the relationships observed among union participants were identified among the additional participants. It is arguable whether the relationships found among both groups of participants, analyzed separately, ought reasonably to be extrapolated beyond those two groups. Certainly the results of this survey may be compared with other VDT research performed on groups of participants that similarly have unknown participant biases, and areas of agreement and disagreement may be noted.

A number of observational studies have documented the presence of symptoms of visual discomfort, musculoskeletal complaints, and psychological dysfunction among VDT users. In general, the studies suffer from the problems intrinsic to observational research. For instance, the relationships between exposure (VDT use) and outcome (somatic symptoms, psychological dysfunction) are generally confounded by important covariates, such as age. As well, it frequently is not altogether clear whether the exposure (VDT use) is even relevant because it may merely be a correlate of some underlying factor, such as workplace lighting characteristics, constrained postures, paced work, or alienation from work. Other problems that characterize the literature include inadequate definition of the target populations of the surveys and lack of attention to participant bias.

The studies without comparison groups (Greico, Molteni, Picolli, and Perris, 1980; Gunnarsson and Soderberg, 1979, 1980; Hollar, Kundi, Schmid, Thaler, and Winter, 1975) are useful in identifying problem areas to be considered in regard to assessing work with VDTs. VDT users have been miscellaneously reported to complain of visual discomfort (e.g., burning eyes and lachrymation, frontal and occipital headaches, difficulty in fixation, blurred vision, and changes in color perception). Discomfort glare and reflections on the screen seemed to be the source of complaints at one site (Hultgren and Knave, 1974).

The studies with comparison groups typically provide little or no information on response rates and participant biases. In general, confounding is ignored and multivariable causes are disregarded.

Johannson and Aronsson (1980) found autonomy, threats to job security, and machine pacing to be stressors in some VDT jobs. Complaints of stress were primarily among individuals who did monotonous coding work. Individuals with varied tasks tended to regard the VDT as a useful technical aid. Elias, Cail, Tisserand, and Christmann (1980) found that female VDT operators with fragmented job tasks expressed greater job dissatisfaction and more complaints about vision-related symptoms. Rey and Meyer (1980) found symptom complaints to be functions of age, task (VDT versus non-VDT use), and duration of work, and they concluded that the increase in symptom complaints among VDT operators was not due to excess eye defects. Binaschi, Albonico, Gelli, and Morelli di Popolo (1980) found sociopsychological factors due to work organization to be more important in assessing self-reported fatigue than

was VDT use. Ghiringelli (1980) reported eye discomfort, headache, back and neck aches, and psychological troubles as being "significant factor(s)" among VDT operators, and concluded that "VDUs seem to add their own troubles and emphasize the usual problems of employees, and we suggest that they could become a symbolic focus of discomfort" (p. 231). Laübli, Hünting, and Grandjean (1980) noted a correlation between measured intensities of light reflections and annoyance, but no relation between measured luminance of reflections and visual impairment. Dainoff (1980, 1981) found a relatively high prevalence of symptoms suggestive of eye fatigue, as well as complaints regarding glare and lighting, which appeared to be independent of job pressure and hostility toward office computerization. Smith, Stammerjohn, and Cohen (1980) and Smith, Cohen, and Stammerjohn (1981) concluded that although there may be a relationship between job activities and VDT use that brings about job stress and health complaints, the problems do not lie solely with VDT use. Stammerjohn, Smith, and Cohen, (1981) studied the ergonomics of the Smith et al. (1980, 1981) study sites. VDT users reported more difficulties with their background lighting (glare, shadows) than did non-users. A significant correlation was noted between visual function complaints and employee rating of glare, screen angle, VDT noise, and screen flicker. Among professional employees, musculoskeletal complaints correlated with screen angle, height, glare, and flicker.

In this survey, symptom complaints were not associated with merely using a VDT. Particular aspects of VDT usage were associated with headache and somatic symptoms. Workplace lighting and bothersome visual aspects of the VDT screen as they impacted on clarity and readability were the factors that singly or jointly explained the plurality of symptoms. These associations were independent of the effects of actual or potentially confounding variables. The fact that the association between bothersome visual aspects of the VDT and both headaches associated with work and changes in visual function were replicated in a smaller, independent sample of workers suggests that these specific findings may be generalizable beyond the study population.

Statistically significant relationships were found between three other VDT-use variables and specific types of headaches. Two of the variables are quantitative, namely, hours per week of VDT operation and years of VDT operating experience; the third is qualitative, namely, the "eyes-shifting" mode of VDT operation, and suggests inexperience with VDT use. Taken as a whole, the relationships suggest that problems arise among inexperienced operators, and they contradict the otherwise simple hypothesis that VDT use automatically causes problems, with greater usage resulting in more problems.

Important negative findings include the absence of any significant relationships between symptoms and the adequacy of the users' ocular refractions or between symptoms and the wearing of glasses with bi- or multifocal lenses. The absence of any relationship between VDT use and ophthalmological examination abnormalities, however, is of lesser significance. The average number of years of VDT operating experience was 3.4, with a maximum of 9.2 years. If a minimum duration of VDT usage is postulated to be required prior to eye abnormalities being detectable, then the group of participants in this survey may well be judged to have had an insufficient amount of VDT usage for such associations to be identified. Therefore, this survey may well have been inadequate, in terms of amount of VDT use, to resolve such issues as the putative association of ophthalmological abnormalities (e.g., cataracts) and VDT usage.

These results suggest that future emphasis should be placed on characteristics of workplace lighting and VDT visual characteristics. The problems appear to require adjustment in workplace and terminal design, with the purpose of altering those aspects of the VDT viewing environment (including the VDT itself) that adversely affect the viewing process. These problems are best addressed experimentally. Epidemiological studies suggest from what area the problems arise. However, the solutions are technological and are not capable of resolution through observational research.

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