



System response time and method of pay: Stress effects in computer-based tasks

Lawrence M. Schleifer & Benjamin C. Amick III

To cite this article: Lawrence M. Schleifer & Benjamin C. Amick III (1989) System response time and method of pay: Stress effects in computer-based tasks, International Journal of Human-Computer Interaction, 1:1, 23-39, DOI: [10.1080/10447318909525955](https://doi.org/10.1080/10447318909525955)

To link to this article: <https://doi.org/10.1080/10447318909525955>



Published online: 23 Sep 2009.



Submit your article to this journal [↗](#)



Article views: 62



View related articles [↗](#)



Citing articles: 53 View citing articles [↗](#)

System Response Time and Method of Pay: Stress Effects in Computer-Based Tasks

Lawrence M. Schleifer, Benjamin C. Amick III*

Division of Biomedical and Behavioral Science
National Institute for Occupational Safety and Health
4676 Columbia Pkwy, C-24, Cincinnati, OH 45226

The effects of computer system response time (slow vs. rapid) and method of pay (incentive vs. nonincentive) on mood disturbances and somatic discomfort were evaluated in a computer-based data entry task among 45 professional typists. Self-ratings of mood disturbances and somatic discomfort were taken at regular intervals over four consecutive workdays. Regardless of method of pay, slow response time generated higher ratings of frustration and impatience than did rapid response time. In addition, ratings of rush and tension were higher with incentive pay than without incentive pay, regardless of system response time. Mood disturbances and somatic discomfort increased linearly with the amount of time spent performing the data entry task over the course of the workday. This effect was independent of system response time or method of pay. However, scheduled rest and lunch breaks moderated these cumulative increases in mood disturbances and somatic discomfort. The results indicate that computer systems which incorporate features such as rapid response times reduce work stress, while the motivational advantages of computer-based incentive pay programs must be balanced against the stress effects of this method of pay.

During the 1980s, the National Institute for Occupational Safety and Health established a program of research to investigate the stress/health effects of computer-mediated work (Sauter, Gottlieb, Jones, Dodson, & Rohrer, 1983; Smith, Cohen, Stammerjohn, & Happ, 1981). The data from this field survey work indicated the need for more focused and systematic studies of stress factors in the computerized office. The present laboratory study investigated the stress effects of computer system response time and method of pay. Previous reports indicate that these aspects of computer-mediated work may have implications for job demands and worker health (National Research Council [NRC], 1983; Office of Technology Assessment [OTA], 1985, 1987; Turner & Karasek, 1984).

Acknowledgments: The authors express their appreciation to R. McFarland for programming assistance in the work stress laboratory. The authors would like to acknowledge the helpful editorial comments of R. Biersner and S. Sauter. The following individuals also deserve recognition for their contribution to various aspects of this study: M. Cady, E. Fullman, R. Ley, M. Smith, and J. Stevens.

Disclaimer: Mention of any company name or products does not constitute endorsement by the National Institute for Occupational Safety and Health.

*Benjamin Amick III is now at the Department of Corrections, State of Connecticut, Hartford, CT.

SYSTEM RESPONSE TIME

In general, computer system response time is a function of a variety of factors including:

- (1) The actual processing time to handle the transaction;
- (2) the amount of computer power allocated to the on-line system;
- (3) the priority of the transactions being performed; and
- (4) the demands on the system at any given point in time (Nolan, Young, & DiSylvester, 1980).

Response time is an important factor in the productivity of human—computer interactions. Ericsson Information Systems (1984) found that an acceptable response time for users doing a simple query is 2 seconds. Thadhani (1981) measured the transaction rates of engineers and programmers and plotted these rates as a function of system response times. A strong correlation was found between system response time and the number of transactions processed. For example, at a 2.5-s response time, the transactions per user hour were 200. When response time dropped to 0.25 s, the transactions per user hour increased to 400 per hour. Similarly, Brady (1986) found that productivity doubled when response time was decreased from 2 s to a few tenths of a s.

Slow system response time is a problem endemic to human—computer interactions and a source of end-user dissatisfaction. In a survey of mainframe users, the Datapro Corporation (1983) found that only 56% of 1578 respondents were satisfied with response time. Barber and Lucas (1983) reported a drop in user satisfaction during work sessions in a large utility where response time was slow. Amick (1988) observed among insurance underwriters that poor system response time was a key factor in negative evaluations of the computer system. Johansson and Aronsson (1984) found that 63% of the VDT users at an insurance company would not tolerate delays of longer than 5 s.

Slow system response time is also a source of job stress. System delays can increase workload pressure resulting from lost production and from the need to meet inflexible deadlines. For example, Johansson and Aronsson (1984) reported that delayed response time and unscheduled downtime resulted in mood disturbances, elevated blood pressure, and increased catecholamine production. Komat-subhara, Yokomizo, Yamamoto, and Noro (1985) found that data entry operators using a system characterized by slow response time reported feelings of irritation and fatigue. Introduction of a new computer system reduced response time and decreased feelings of irritation and fatigue.

Kuhmann, Boucsein, Schaefer, and Alexander (1987) recently reported results that are inconsistent with those of other studies regarding the stress effects of response delays. These investigators found that systolic blood pressure, and reports of headache and eye pain, were higher under rapid than slow response times (i.e., 2 s vs. 8 s). Error rates were also higher. These unexpected findings may be explained by a confound between response time and workload factors. Subjects in the rapid response time condition were expected to perform 1248 detection tasks, while those

in the slow response time condition were expected to perform only 624 detection tasks.

In sum, current evidence suggests that rapid response times contribute to end-user satisfaction and reduced stress, and slow response times are associated with job stress, mental strain, and negative evaluations of the computer system.

System response delays belong to a class of stressors referred to as daily hassles (DeLongis, Coyne, Dakof, Folkman, & Lazarus, 1982; Kanner, Coyne, Schaefer, & Lazarus, 1981). Daily hassles are annoying, frustrating minor events of everyday life such as misplacing important papers, traffic jams, or repeated telephone interruptions. Lazarus and his co-workers have found that daily hassles are associated with adverse health status (DeLongis et al., 1982; Kanner et al., 1981).

Several features of slow system response time are characteristic of daily hassles. One feature is lack of predictability. It is difficult to predict when a response delay will occur. In addition, the length of the delay also can be highly variable, ranging from a few milliseconds to several minutes.

Another stressful feature of system delays is lack of control. There is no instrumental response that the operator can make to avoid or terminate response delays. The operator can do little more than wait helplessly until the system responds. Slow response times transform a self-paced task (e.g., data entry) into a computer-paced task. Numerous studies of lack of control and unpredictability have demonstrated a range of stress/health effects including gastric ulcers and weight loss (Weiss, 1970), increased catecholamine production (Frankenhauser & Rissler, 1970), and elevated cardiovascular risk (Karasek, Baker, Marxer, Ahlbom, & Theorell, 1981). Glass and Singer (1972) have also observed performance decrements under such conditions.

METHOD OF PAY

The rapid growth of the information/service economy and the ability of computers to monitor productivity indicators (e.g., keystrokes) and to supervise work electronically has fostered the use of computer-based incentive pay programs for repetitive, short-cycle office tasks (Kopelman, 1986; OTA, 1987). Computer-based incentive pay programs are fairly common in data entry work (OTA, 1987), and represent an alternative method of pay to the hourly wage system.

Incentive pay programs reward employees for improving or maintaining high levels of performance. There are two basic types of incentive pay programs: piece wages and bonus pay (Levi, 1972). Under piece wages, payment is made at a rate per unit or piece of output. Under bonus pay, a large portion of the wages is paid on a flat or hourly basis, with additional pay awarded for each piece or unit of output.

Computer-based incentive pay programs are viewed as a boon to the productivity of office workers. However, there is concern that this method of pay results in work overload and encourages employees to suppress feelings of stress in an effort to earn higher pay.

Little is known about the stress and health implications of incentive pay programs, particularly computer-based incentive pay programs. Levi (1972) found that feelings

of rush and fatigue, and catecholamine production, were significantly higher for piece-wage than salaried conditions among a group of invoicing clerks. In a series of investigations, Cakir, Hart, and Stewart (1979) observed that VDT typists under piece-work conditions experienced more self-reported mood disturbances than VDT typists under nonpiece-work conditions. Alternatively, monetary incentives can have a favorable impact. Katzell, Yankelovich, Fein, Ornati, & Nash (1975) found monetary incentives increase employee satisfaction.

Computer-based incentives pay programs also have implications for physical comfort. Levi (1972) found that invoicing clerks reported more "physical discomfort" under piece-wage than under salaried conditions. The use of monetary incentives combined with repetitive keyboard tasks increases work rates and, as a result, may elevate the risk of repetitive arm/hand strain or injury.

SYSTEM RESPONSE DELAYS AND COMPUTER-BASED INCENTIVE PAY PROGRAMS

While slow response time and computer-based incentive pay are possible sources of stress, the combination of these factors in the same job situation may be particularly aversive. (For example, attempts to work rapidly and maximize incentive pay may be thwarted by response delays.) Current trends in office automation (NCR, 1983; OTA, 1985; 1987) suggest that this combination is fairly common in the electronic workplace. In addition to the lack of control that the worker experiences under these circumstances, there is also increased workload pressure associated with efforts to compensate for lost production time.

The present laboratory study evaluated the stress effects of computer system response time (slow vs. rapid) and method of pay (computer-based incentive pay vs. nonincentive pay). Professional typists performed a computer-based data entry task under highly realistic workplace conditions over a four-day period. Self-ratings of mood disturbances and somatic discomfort were taken at regular intervals.

The following hypotheses were tested:

- (1) Mood disturbances would be higher under slow computer response times than under rapid computer response times, regardless of method of pay.
- (2) Mood disturbances would be higher under slow computer response times with incentive pay than slow computer response times without incentive pay.
- (3) Arm/hand discomfort would be higher with incentive pay than without incentive pay, regardless of system response times.

Another objective of this study was to characterize the cumulative stress effects of performing a computer-based data entry task for extended periods of time, regardless of system response time or method of pay. While field studies have shown that data entry work results in symptoms of visual, musculoskeletal, and emotional strain (Sauter et al., 1983; Smith et al., 1981), little is known about the temporal pattern of these symptoms. Such information would be particularly useful for establishing optimal rest break schedules in computer-based tasks.

METHOD

Subjects

Forty-five female, professional typists (mean age = 28, range 19–41) with primarily a vocational or business school background were recruited from a clerical-secretarial agency. The subjects received a comprehensive medical exam and met the following selection criteria: (a) Good general health—no heart disease or hypertension; (b) corrected visual acuity of 20:20; (c) no current medication except aspirin; (d) not pregnant; and, (e) typing speed of at least 45 words per minute with no errors.

Data Entry Task

The subjects performed a data entry task developed by Dainoff, Fraser, and Taylor (1982), which consisted of entering records from paper copy into a computerized data base via a video display terminal. Each record contained 11 fields of alphanumeric information from a chemical stock inventory. Data entries were made in response to a series of prompts displayed on a video screen. A sample record is provided in Table 1.

Subjects commenced the task by entering the appropriate information next to the "Record Number" prompt and then pressing the return or "field termination" key. Data entries were made in a similar manner until the last field of information for a given record (i.e., "Location Code") was completed. This task cycle was then repeated for the next record.

Task Conditions

Subjects performed the data entry task under one of four conditions that were assigned on a random basis. All subjects received a base wage of \$5.30 per hour.

1. Rapid Response Time/Nonincentive Pay (RR/NI). A computer response delay of 350 milliseconds occurred each time a field of information was entered. During this delay interval, the computer would not accept any data inputs.

Table 1. A Sample Data Entry Record

Prompt	Sample Entry
Record Number	R100
Part Name	5-Sulfamyl
Stock Number	A320251XL3
Manufacturer	Akro-Mils, Inc.
Street Address	212 Railroad Drive
City, State	Atlanta, GA
Zip Code	50321
Phone	654-0871
Bin Number	2156
Price	\$532.20
Location Code	B3R25S227

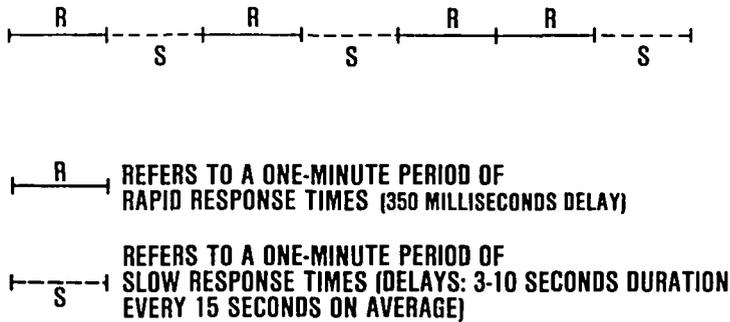


Figure 1. A sample schedule of response delays under the slow response time condition

2. *Slow Response Time/Nonincentive Pay (SR/NI)*. Response delays of longer duration than the RR condition were presented. A sample response time schedule designed to maximize uncertainty regarding the frequency and duration of response delays is shown in Figure 1. The "R" and "S" intervals shown in Figure 1 for this condition alternated on a random basis, but no more than three similar intervals were ever presented consecutively.

3. *Rapid Response Time/Incentive Pay (RR/I)*. Data entries were made under the RR condition. In addition to the base wage of \$5.30/hour, subjects were awarded 10 cents for each keystroke/minute above their prestudy baseline, but penalized 5 cents for each error/minute above baseline.

4. *Slow Response Time/Incentive Pay (SR/I)*. Data entries were made under the SR condition. In addition to the base wage of \$5.30/hour, subjects were awarded 10 cents for each keystroke/minute above their prestudy baseline and penalized 5 cents for each error/minute above their prestudy baseline.

Measures

Mood Disturbance. A review of the system response time and method of pay literature (Cakir, et al., 1979; Johansson & Aronsson, 1984; Komatsubhara et al., 1985; Levi, 1972; NRC, 1983; OTA, 1985, 1987) suggests that there are several dimensions of mood disturbance which are relevant to the present investigation.

The Frustration, Rush, Impatience, Irritation, and Tension scales shown in Table 2 were developed specifically for the purposes of this study. A modified version of the Fatigue scale derived from the Profile of Mood States (McNair, Lorr, & Droppelman, 1971) also was employed. Internal item consistency scores (Cronbach's Alpha coefficients) were above .90 for every scale except Impatience (.82).

The mood disturbance questionnaire was administered via a video display terminal. The questionnaire items were displayed on the VDT and responses were made using a numeric keypad. Subjects were instructed to rate on a continuum from 1 ("not at all") to 9 ("very much so") the extent to which the questionnaire items for each of the six scales reflected their mood state.

Somatic Discomfort. The scale items for somatic discomfort shown in Table 2 were developed by Dainoff et al. (1982). The response format for the three discomfort scales was the same as that used for the mood disturbance scales. Cronbach's Alpha coefficients were above .90 for every measure except Trunk/Legs Discomfort (.72).

Apparatus

The study was conducted in a simulated VDT workplace at the NIOSH Human Performance Laboratories. Three workstations were equipped with video display terminals (DEC VT 100), ergonomic tables and chairs (IBM Synergetix Furniture), wrist supports, micromesh contrast enhancement filters, and copyholders. Overhead fluorescent lighting fixtures were fitted with diffusing lenses. Ambient illumination levels were set at 50 foot-candles. All ergonomic adjustments were made on an individual basis to maximize physical comfort. A PDP 11/34 (DEC) computer system was used to simulate the task conditions, collect subject response data, and control the VDTs.

Design and Procedure

A mixed-factorial, repeated measures design was employed in which the between factors were Response Time (RR or SR) and Method of Pay (NI or I), and the within factors were Day (2, 3, or 4), Session (1 or 2), and Period (0, 1, 2, or 3). Following informed consent, subjects were assigned on a random basis to one of four task conditions: RR/NI ($n = 11$); SR/NI ($n = 12$); RR/I ($n = 10$); or SR/I ($n = 12$). The study was conducted over four consecutive days (Days 1, 2, 3, and 4), with each day consisting of a morning and afternoon session (Sessions 1 and 2). Each session was further divided into a baseline period (Period 0) and three, 50-minute work periods (Periods 1, 2, and 3). Self-ratings of mood disturbances and somatic discomfort were taken at the beginning of a session (Period 0) and again at the end of each work period (Periods 1, 2, 3). There was a 45-minute lunch break between the morning and afternoon sessions. A 10-minute rest also was taken after 75 minutes of work during the morning and afternoon sessions.

Table 2. Measures of Mood Disturbances and Somatic Discomfort

Frustration	= (interrupted + obstructed + impeded + blocked) / 4
Rush	= (pressed for time + rushed + hurried) / 3
Impatience	= (slowed down + impatience) / 2
Irritation	= (annoyance + aggravation + irritation) / 3
Tension	= (tension + on edge + keyed up) / 3
Fatigue	= (fatigue + tiredness + weariness + sluggishness + exhaustion) / 5

Somatic Discomfort

Visual Discomfort	= (focusing problems + eye irritation + eye fatigue) / 3
Arms/Hands Discomfort	= (arms + wrists, hands, or fingers) / 2
Trunk/Legs Discomfort	= (neck, shoulders or upper back + lower back + legs) / 3

The first day was devoted to familiarizing the subjects with the VDT workplace, making appropriate workstation adjustments, and practicing the data entry task. Baseline measures of mood disturbances and somatic discomfort were established on the second day, following which subjects performed the data entry task under the RR/NI condition. The subjects were instructed to perform the data entry task at their usual workplace and level of accuracy. At the end of the second day, subjects were informed of their assignment to task conditions. Data entries were made under the various response time and method of pay conditions on the third and fourth days of the study. Subjects assigned to the RR/I and SR/I conditions received feedback (displayed on the VDT) regarding amount of incentive pay earned at the end of each work period following completion of self-ratings of mood state and somatic discomfort.

Data Analyses

Multivariate analyses of variance on repeated measures were performed using General Linear Methods (SAS Institute, 1985) to determine whether there were any differences between the groups on self-ratings of mood disturbances and somatic discomfort. These analyses were performed primarily to determine whether there were Response Time \times Day or Method of Pay \times Day interactions, since this would demonstrate a differential change over time from baseline measures of mood disturbances and somatic discomfort.

Trend analyses (SAS Institute, 1985) were also performed on the within-Day Session and Period factors to characterize the manner in which the dependent measures changed as a function of time, irrespective of response time or method of pay effects.

There were missing mood and somatic discomfort measures at baseline for one of the subjects assigned to the SR/NI group on Day 2, Session 2, Period 3. The missing values were estimated by regression procedures using the mean scores for the 45 subjects on Day 2, Session 2, Periods 0-3. (See UCLA, BMDPAM, Estimate Missing Values, 1981.)

Since Day 1 was devoted to subject orientation and practice, the observations for this day were not included in the data analyses. An initial analysis of the data collected on Day 2 (baseline) indicated that the four groups were statistically equivalent on measures of mood disturbances and somatic discomfort. The four groups were also comparable with respect to age and educational background.

RESULTS

Response Time

Multivariate analyses of variance on repeated measures indicated significant Response Time \times Day interactions for Frustration, $F(2, 40) = 11.05, p < .001$, Impatience, $F(2, 40) = 19.73, p < .001$, and Irritation, $F(2, 40) = 8.33, p < .001$.

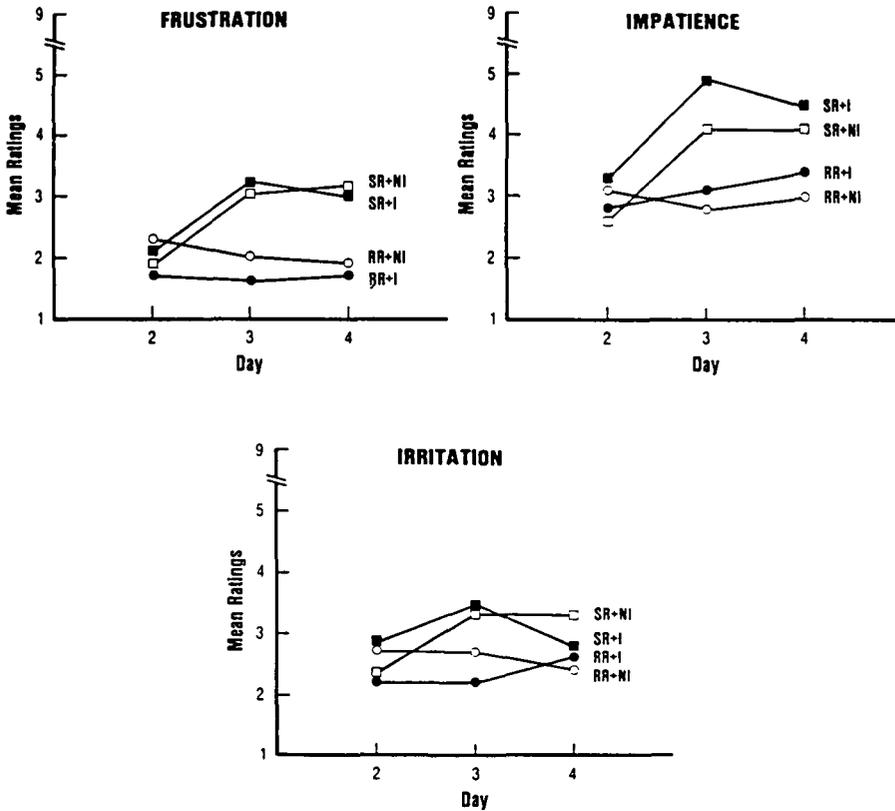


Figure 2. Mean ratings of mood disturbances as a function of Day and Group

This effect, which is shown in Figure 2, indicates that the increase in Frustration and Impatience across the workdays was greater for SR than for RR.

Further analyses were performed to explore the Response Time \times Day interactions. Pair-wise contrasts (one-tailed tests) indicated that, in comparison to Day 2, mood disturbances were higher for SR than RR on Day 3 for Frustration, $F(1, 41) = 20.17, p < .001$, Impatience, $F(1, 41) = 31.77, p < .001$, and Irritation, $F(1, 41) = 11.39, p < .001$, and on Day 4 for Frustration, $F(1, 41) = 10.62, p < .001$, and Impatience, $F(1, 41) = 8.91, p < .01$.

There was a significant Response Time \times Method of Pay \times Day interaction for Irritation, $F(1, 41) = 5.06, p < .05$, indicating that the increase in Irritation from Day 2 to Day 4 was greater for SR than RR only under NI conditions (Figure 2). While the increase in Irritation was greater for SR/I than RR/I from Day 2 to Day 3, this effect was not evident on Day 4.

There were no Response Time \times Day interactions for the other measures of mood and somatic discomfort.

Method of Pay

The mean ratings across the workdays for measures of Rush, Tension, and Fatigue are shown in Figure 3. The multivariate analyses of variance on repeated measures indicated that there was a significant Method of Pay × Day interaction for Rush, $F(2, 40) = 9.01, p < .001$, Tension, $F(2, 40) = 4.80, p < .05$, and Fatigue, $F(2, 40) = 3.74, p < .05$. Inspection of Figure 3 reveals that the increase across workdays for Rush and Tension was greater for I than for NI. The increase in Fatigue across workdays, however, was greater for NI than for I.

Pair-wise contrasts indicated that, in comparison to Day 2, mood disturbances were higher for I than for NI on Day 3 [Rush, $F(1, 41) = 17.60, p < .001$; Tension, $F(1, 41) = 8.59, p < .01$], and on Day 4 [Rush, $F(1, 41) = 10.65, p < .01$; Tension, $F(1, 41) = 8.55, p < .01$]. In comparison to Day 2, Fatigue was lower for I than for NI on Day 3 [$F(1, 41) = 7.38, p < .01$]. However, this Method of Pay effect on Fatigue did not carry over to Day 4.

There were no Method of Pay × Day effects for the other measures of mood and somatic discomfort.

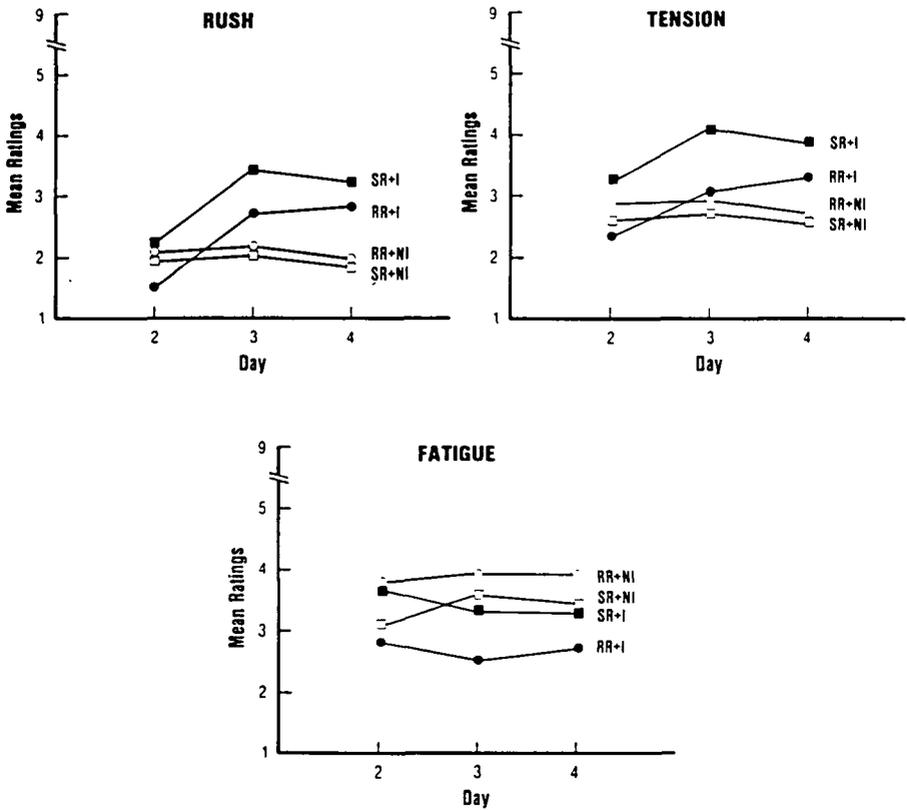


Figure 3. Mean ratings of mood disturbances as a function of Day and Group

Day. Trend analyses revealed a significant linear effect for Day on measures of Visual Discomfort, $F(1, 41) = 11.21, p < .01$, and Arms/Hands Discomfort, $F(1, 41) = 8.15, p < .01$, indicating an increase in somatic discomfort across the workdays. This linear effect was the same regardless of response time or method of pay.

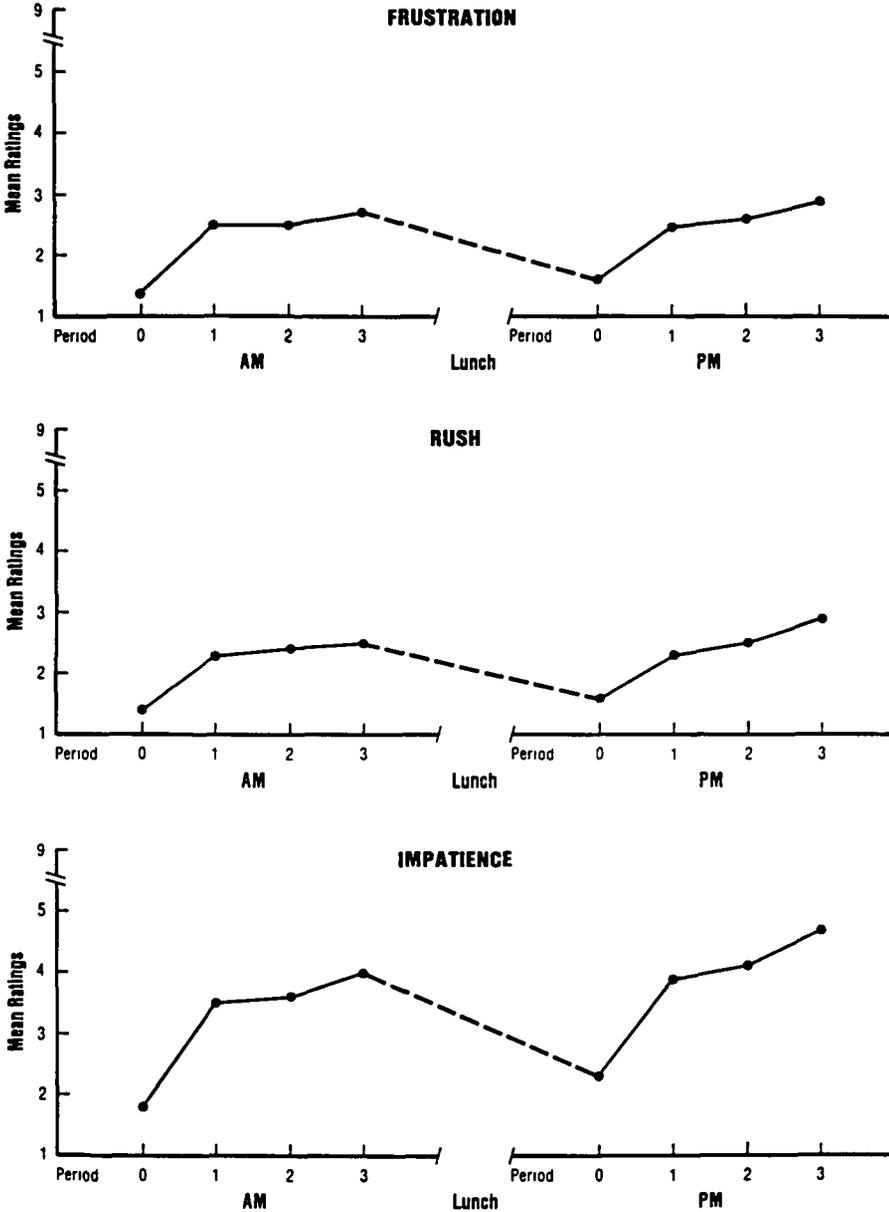


Figure 4. Mean ratings of mood disturbances as a function of Session and Period

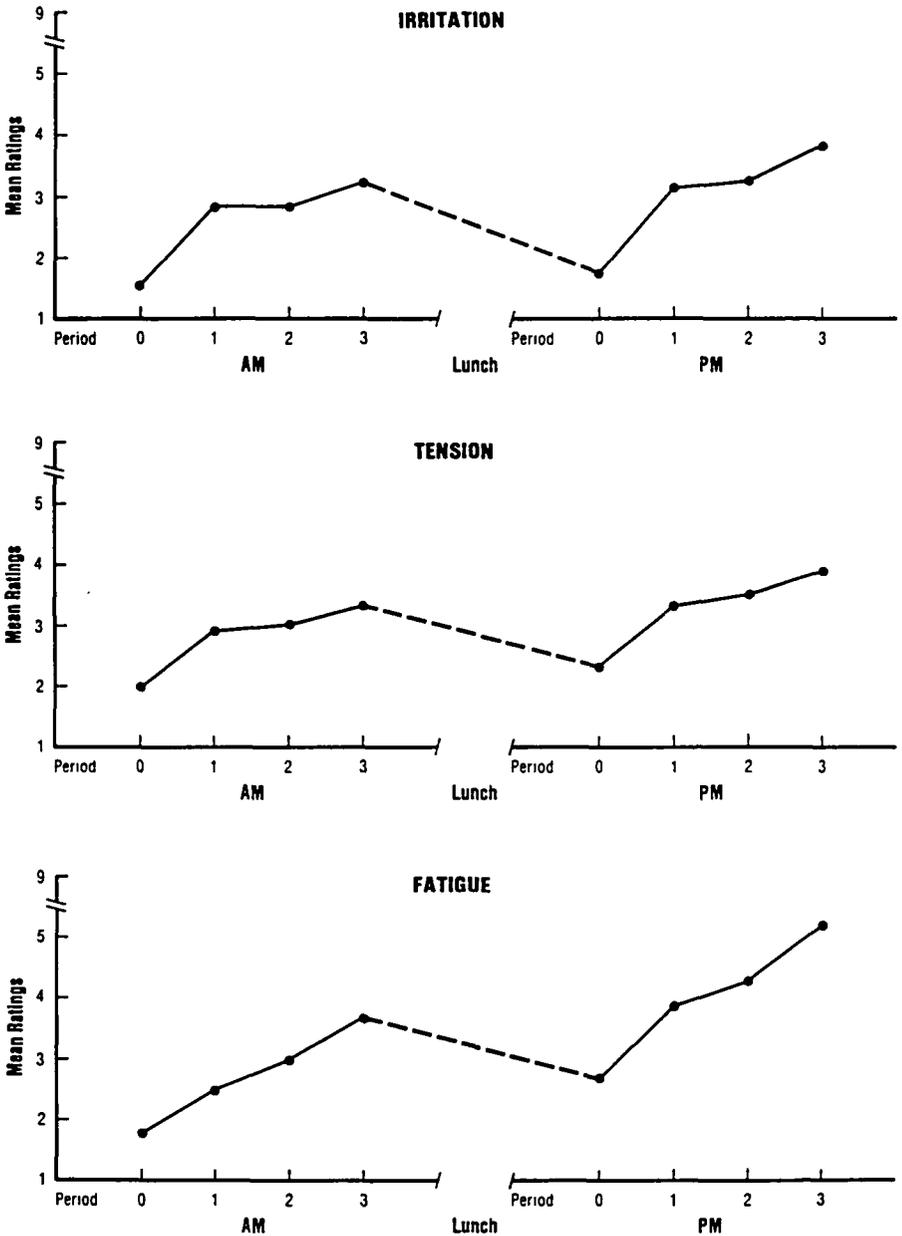


Figure 5. Mean ratings of mood disturbances as a function of Session and Period

There were no significant Day effects for the other measures of mood and somatic discomfort.

Session. Inspection of Figures 4–6 reveals that in all cases, except for Frustration, mood disturbances and somatic discomfort were higher in the afternoon than in the morning work sessions. The multivariate analyses of variance indicated

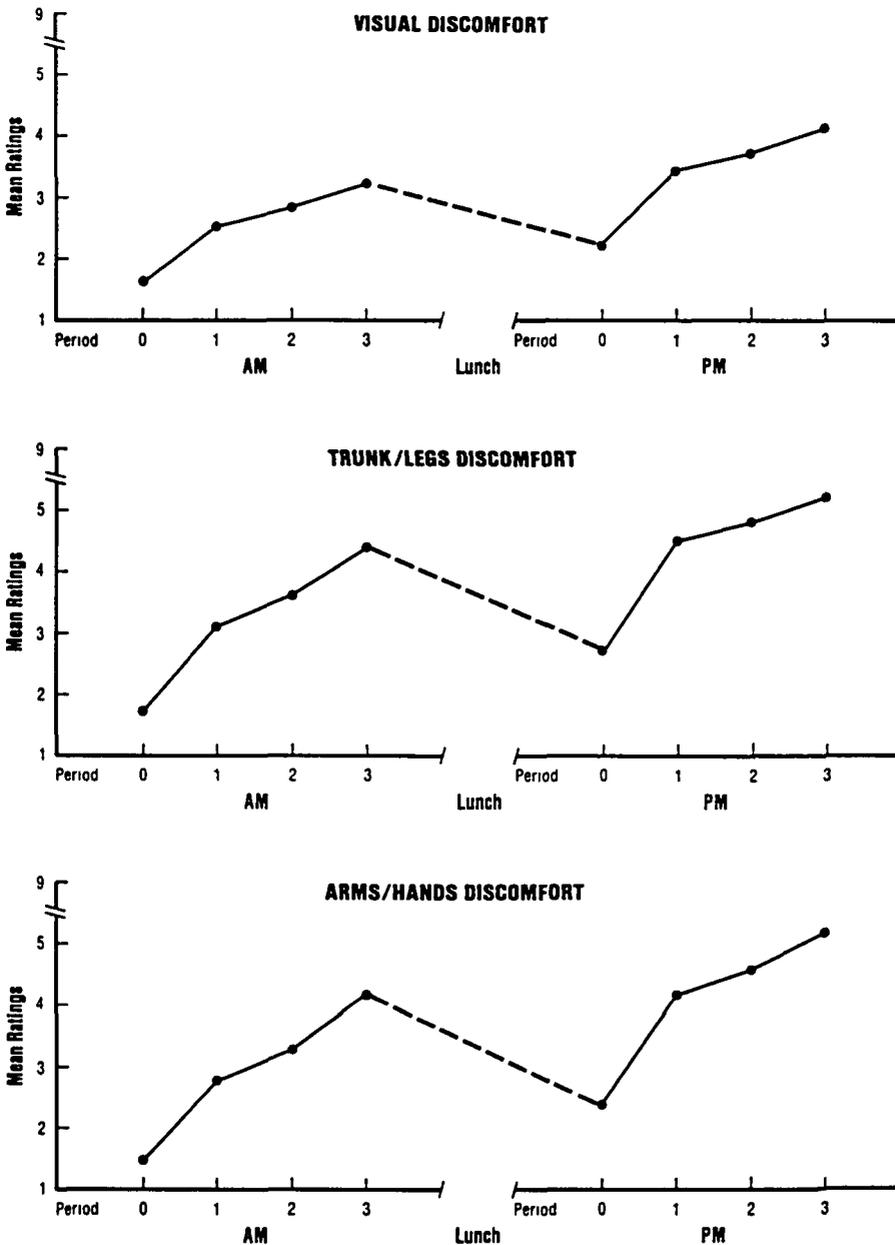


Figure 6. Mean ratings of somatic discomfort as a function of Session and Period

that there was a significant Session effect for Rush, $F(1, 41) = 12.48, p < .01$, Impatience, $F(1, 41) = 26.49, p < .01$, Irritation, $F(1, 41) = 15.61, p < .01$, Tension, $F(1, 41) = 22.57, p < .01$, Fatigue, $F(1, 41) = 109.44, p < .01$, Visual Discomfort, $F(1, 41) = 48.67, p < .01$, Arms/Hands Discomfort, $F(1, 41) = 98.72, p < .01$, and Trunk/Legs Discomfort, $F(1, 41) = 136.74, p < .01$. The increase in mood

disturbances and somatic discomfort from morning to afternoon was the same regardless of response time or method of pay.

Period. Inspection of Figures 4–6 indicates that, in every case, mood disturbances and somatic discomfort increased as a function of time spent performing the data entry task. Trend analyses revealed a linear effect for Period on measures of Frustration, $F(1, 41) = 37.30, p < .01$, Rush, $F(1, 41) = 42.54, p < .01$, Impatience, $F(1, 41) = 115.10, p < .01$, Irritation, $F(1, 41) = 73.50, p < .01$, Tension, $F(1, 41) = 68.54, p < .01$, Fatigue, $F(1, 41) = 119.23, p < .01$, Visual Discomfort, $F(1, 41) = 88.35, p < .01$, Trunk/Legs Discomfort, $F(1, 41) = 145.20, p < .01$, Arms/Hands Discomfort, $F(1, 41) = 116.64, p < .01$. There were also significant quadratic ($p < .01$) and cubic ($p < .01$) trends for Period on every measure except Fatigue. The most pronounced trend, however, was linear. The trend in mood disturbances and somatic discomfort across work periods was the same regardless of response time or method of pay.

Inspection of Figures 4–6 indicates that the quadratic and cubic trends reflect, respectively, the leveling-off effect during Period 2, where a 10-minute rest break occurred, and a reaccelerating effect during Period 3. Further inspection of Figures 4–6 also shows that there was a significant reduction ($p < .001$, two-tailed, correlated t -test) in mood disturbances and somatic discomfort following the 45-minute lunch break. In every case, however, mood disturbances and somatic discomfort were higher at the end than at the beginning of a work session (i.e., Period 3 vs. Period 0).

DISCUSSION

Consistent with the response time hypothesis, slow response time generated higher ratings of Frustration and Impatience than did rapid response time, regardless of the method of pay. Slow response time also evoked higher ratings of Irritation than did rapid response time, but this effect was sustained across workdays only under nonincentive pay conditions. Thus, the findings of this study indicate that computer response delays are a technological hassle that can generate acute stress effects.

Consistent with the method of pay hypothesis, incentive pay generated higher ratings of Rush and Tension than nonincentive pay. The effects of this method of pay were evident under both rapid and slow response time conditions, suggesting that computer-based monetary incentives have a psychological effect which is independent of system response time. While incentive pay generated lower ratings of fatigue than nonincentive pay, this effect was not sustained across the workdays and thus its reliability may be in question. Overall, these findings are consistent with those of Levi (1972), and suggest that computer-based monetary incentives can evoke mood disturbances.

Contrary to the study hypothesis, computer-based monetary incentives did not generate higher ratings of arm/hand discomfort than nonincentive pay. Similarly, there were no method of pay effects for the other indicators of somatic discomfort. One explanation for these findings is that the physical demands of the task (i.e.,

constrained postures and repetitive keying) exerted a greater influence on somatic discomfort than did method of pay.

The differential mood effects of response time and method of pay suggest the influence of separate psychological processes. Specifically, increases in Frustration and Impatience associated with slow response time are consistent with a lack of control/unpredictability, whereas the Rush and Tension generated by incentive pay corresponds with work overload. Other investigators have found that psychological reactions can vary as a function of different sources of stress. For example, Broadbent (1985) has shown that anxiety and depression are associated with different workplace conditions.

Another objective of this study was to characterize the cumulative stress effects of data entry work, regardless of system response time or method of pay. The results indicate that mood disturbances and somatic discomfort increased as a function of the amount of time performing the data entry task. This time-dependent effect was evident despite concerted efforts to maximize physical comfort, and it is consistent with the premise that even under ideal physical ergonomic conditions, VDT users will experience discomfort due to task characteristics or deficiencies in job design (Scuter, Chapman, & Knutson, 1986; Smith, 1984).

One approach to alleviating cumulative psychological and physical strain associated with computer-based tasks is to schedule regular rest breaks. In the present study, the reduction in mood disturbances and somatic discomfort following the 45-minute lunch breaks, and the leveling off in these effects following a 10-minute rest break, have favorable implications for scheduled breaks in work activity. The benefits of regular rest breaks observed in this study are comparable to those found in other investigations (Dainoff, 1985; Zwahlen, Hartmann, & Kothari, 1986).

Although the conventional rest-break schedule in the present study provided temporary relief, it did not prevent the cumulative stress effects of the data entry task. Mood disturbances and somatic discomfort were consistently higher at the end of a work session than at the beginning despite regular rest breaks. These results suggest the need for developing alternative rest-break regimens that are effective in reducing the cumulative stress effects of repetitive computer-based tasks.

The results of this study suggest that computer systems which are designed for rapid response times will reduce affective strain in data entry work. This salutary effect suggests that the rationale for rapid system response time extends beyond the economic considerations of more efficient human-computer interactions. In sum, computer systems that contain ergonomic features such as rapid response times have favorable implications for both system productivity and worker health.

With respect to method of pay, the results of this study indicate that the productivity advantages of computer-based incentive pay regimens may not be realized without some psychological costs to the worker. In this regard, it should be noted that certain types of computer-based incentive pay regimens may be more stressful than others; for example, workload demands may be higher under a piece wage system than under a bonus pay system. Additional stress factors in computer-based incentive pay regimens include electronic performance monitoring/feedback and the use of performance standards (Amick & Smith, 1988). Further investigation of

these factors is needed to establish a balanced computer-based pay system that enhances productivity without excessive stress effects.

REFERENCES

- Amick III, B. C. (1988). *A case study of an expert system application in an insurance company*. Working paper.
- Amick III, B. C., & Smith, M. J. (1988). *The job stress and health implications of computer-based work monitoring and measurement systems* (Contract No. 88-789885). Cincinnati: National Institute for Occupational Safety and Health.
- Barber, R. E., & Lucas, H. C. (1983). *System response time, operator productivity, and job satisfaction* (CRIS # 31, GBA # 82-11). New York University, New York: Center for Research on Information Systems.
- Brady, J. T. (1986). A theory of productivity in the creative process. In *Proceedings of the IEEE Computer Graphics Conference*. Washington, DC: IEEE Institute.
- Broadbent, D. (1985). Clinical impact of job design. *British Journal of Clinical Psychology*, 24, 33–44.
- Kakir, A., Hart, D. J., & Stewart, T. F. M. (1979). *The VDT manual*. Darmstadt, West Germany: Incar Fieg Research Association.
- Dainoff, M. J. (1985). *Ergonomic comparison of video display terminal workstation-III: Effects of work-rest breaks*. Cincinnati: National Institute for Occupational Safety and Health.
- Dainoff, M. J., Fraser, L., & Taylor, B. J. (1982). Visual, musculoskeletal and performance differences between good and poor VDT workstations: Preliminary findings. In *Proceedings of the Human Factors Society 26th Annual Meeting*. Seattle: Human Factors Society.
- Datapro Corporation (1983). *User ratings of computer systems*. Delran, NJ: Author.
- Delongis, A., Coyne, J. C., Dakof, G., Folkman, S., & Lazarus, R. S. (1982). Relationship of daily hassles, uplifts and major life events to health status. *Health Psychology*, 1, 119–136.
- Ericsson Information Systems. (1984, September). *Proceedings of the World Conference on Ergonomics in Computer Systems* Garden Grove, CA: Ericsson Communications.
- Frankenhaeuser, M., & Rissler, A. (1970). Effects of punishment on catecholamine release and the efficiency of performance. *Psychopharmacologia*, 17, 378–390.
- Glass, D. C., & Singer, J. E. (1972). *Urban stress: Experiments on noise and social stressors*. New York: Academic.
- Johansson, G., & Aronsson, G. (1984). Stress reactions in computerized administrative work. *Journal of Occupational Behavior*, 5, 159–181.
- Kanner, A. D., Coyne, J. C., Schaefer, C., & Lazarus, R. S. (1981). Comparison of two models of stress measurement. *Journal of Behavioral Medicine*, 4, 1–39.
- Karasek, R., Baker, D., Marxer, F., Ahlbom, A., & Theorell, T. (1981). Job decision latitude, job demands, and cardiovascular disease: A prospective study of Swedish men. *American Journal of Public Health*, 71, 694–705.
- Katzell, R. A., Yankelovich, D., Fein, M., Ornati, & A. Nash (1975). *Work, productivity, and job satisfaction*. New York: The Psychological Corporation.
- Komatsubhara, A., Yokomizo, Y., Yamamoto, S., & Noro, K. (1985). Mental strain in a VDT task imposed by computer system response time. In *Proceedings of the 9th International Ergonomics Association Meeting* (pp. 316–318). Bournemouth, England: International Ergonomics Association.
- Kopelman, R. E. (1986). *Managing productivity in organizations: A practical people-oriented perspective*. New York: McGraw-Hill.
- Kuhmann, W., Boucsein, W., Schaefer, F., & Alexander, J. (1987). Experimental investigation of psychophysiological stress-reactions induced by different system response times in human-computer interactions. *Ergonomics*, 30, 933–943.
- Levi, L. (1972). Conditions of work and sympathoadrenomedullary activity: Experimental

- manipulations in a real life setting. In L. Levi (Ed.), *Stress and distress in response to psychosocial stimuli Acta Medica Scandinavica*, 191 (supplement 528), 106–118.
- McNair, D. M., Lorr, M., & Droppleman, L. F. (1971). *The Profile of Mood States*. San Diego, CA: Educational and Industrial Testing Service.
- National Research Council. (1983). *Video displays, work, and vision*. Washington, DC: National Academy Press.
- Nolan, R. E., Young, R. T., & DiSylvester, B. C. (1980). *Improving productivity through advanced office controls*. New York: AMACON.
- Office of Technology Assessment, Congress of the United States. (1985). *Automation of America's offices (OTA-CIT-287)*. Washington, DC: U. S. Government Printing Office.
- Office of Technology Assessment, Congress of the United States. (1987). *The electronic supervisor: New technology, new tensions (OTA-CIT-333)*. Washington, DC: U. S. Government Printing Office.
- Sauter, S. L., Chapman, L. J., & Knutson (1986) *Improving VDT work*. (University of Wisconsin Board of Regents) Lawrence, KS: Report Store.
- Sauter, S. L., Gottlieb, M. S., Jones, K. C., Dodson, V. N., & Rohrer, K. M. (1983). Job and health implications of VDT use: Initial results of the Wisconsin-NIOSH study. *Communications of the Association for Computing Machinery*, 26, 284–289.
- SAS Institute. (1985). *SAS User's Guide: Statistics*, Version 5. Cary, NC: SAS Institute.
- Smith, M. J. (1984). Ergonomic aspects of health problems in VDT operators. In B. G. F. Cohen (Ed.) *Human aspects in office automation* (pp. 97–114). Amsterdam, The Netherlands: Elsevier.
- Smith, M. J., Cohen, B. G. F., Stammerjohn, L. W., & Happ, A. (1981). An Investigation of health complaints and job stress in video display operations. *Human Factors*, 23, 387–400.
- Thadhani, A. J. (1981). Interactive user productivity. *IBM Systems Journal*, 20, 407–423.
- Turner, J., & Karasek, R. (1984). Software ergonomics: Effects of computer application design parameters on operator task performance and health. *Ergonomics*, 27, (6), 663–690.
- UCLA, Department of Biomathematics. (1981). *BMDP statistical software, Estimate Missing Values*. Los Angeles: UCLA.
- Weiss, J. M. (1970). Somatic effects of predictable and unpredictable shock. *Psychosomatic Medicine*, 32, 397–408.
- Zwahlen, H., Hartmann, A., & Kothari, N. (1986). How much do rest breaks help to alleviate VDT operator subjective ocular and musculoskeletal discomfort? In *Proceedings of the International Scientific Conference: Work With Display Units* (pp. 503–506) Stockholm, Sweden, May 12–15, 1986.