

DEPARTMENT OF COMPUTER SCIENCE
UNIVERSITY OF TORONTO

CSC318S

**THE DESIGN OF
INTERACTIVE COMPUTATIONAL MEDIA**

Lecture 17 — 23 March 1998

ERGONOMICS AND THE PHYSICAL ENVIRONMENT

17.1 Health and safety hazards in the office	2
17.2 Prevalence, seriousness of problem.....	3
17.3 Ergonomic factors and productivity.....	10
17.4 Psychological stress.....	11
17.5 Musculoskeletal stress	11
17.6 Visual stress and eyestrain.....	13
17.7 Radiation	14

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17.1 Health and safety hazards in the office

Controlling health and safety hazards in the office (Fig. 21.1)
(Westin, Schweder, Baker, & Lehman, *The Changing Workplace: A Guide to Managing the People, Organizational, and Regulatory Aspects of Office Technology*, 1985, pp. 7-13)

Complaint or Problem => Possible Cause => Possible Solution

We will focus especially on:
Musculoskeletal stress
Visual stress
Psychological stress

Figure 17.1 Controlling health and safety hazards in the office (Westin, p. 7-13)

Figure 17.1 Controlling health and safety hazards in the office (Westin, p. 7-13)

Figure 7.5: Controlling Health and Safety Hazards in the Office

	Complaint or Problem*	Possible Cause	Possible Solution
Air quality	Irritation, discomfort, outbreaks of disease, sensitization	Formaldehyde, ozone, organics, allergens, micro-organisms	Ventilation, substitution enclosure, filtering
Temperature	Discomfort	Heat, cold, humidity, air circulation	Radiant control, air circulation, different location, individual control, humidity control
Musculoskeletal Stress	Neck, shoulders, back, arms: fatigue and chronic disorders	Workstation design, chair design, task repetitiveness, constrained posture	Furniture ergonomics, task redesign, job enlargement, rotation, rest breaks, exercise
Visual Stress	Eyestrain, burning or itching	Lighting, close work, quality of VDT and other viewed material, dry air, stress	Vision exams, illumination controls, equipment design, rest, exercise, work layout
Psychological Stress	Anxiety, tension, stress, boredom, headaches, job dissatisfaction, alienation, absenteeism, turnover, behavioral problems (smoking, drinking), ulcers, CHD, diabetes, other diseases	Repetitiveness, monotony, monitoring, lack of promotional opportunity, lack of job security, lack of control, pacing, piecework, work environment	Stress management, wellness, exercise, job redesign, worker control, job enlargement, job enrichment, rotation, environmental control
Noise	Irritation, interference, distraction	Conversations, equipment, ventilation systems	Barriers, equipment design enclosures, absorption
Accidents	Traumatic injuries	Work surfaces, furniture, equipment, lifting	Guarding, hazard removal, training
Radiation	None yet established	Low level radiation	Shielding, low voltage, alternative designs, work removal, time limits

17.2 Prevalence, seriousness of problem

Most white collar workers using PCs or workstations (Fig. 17.2)

Generally, people are positive, perceive benefits (Fig. 17.3, 17.4)

But VDT workers also report health complaints –

NIOSH, 1983, 248 State of Wisconsin workers (Fig. 17.5)

NIOSH, 1982, 300 U.S. Social Security Administration workers (Fig. 17.6)

Agreement in % of users reporting symptoms or discomfort:

	<i>Wisconsin</i>	<i>SSA</i>
Visual stress		
Burning eyes	75/71%	71%
Eye strain	75	69
Tearing, itching eyes	68	77
Musculoskeletal stress		
Back ache/pain	81/79	59
Neck/shoulder ache/pain	79/78	60
Psychological stress		
Depression	66	61
Easy irritability	66	71
High levels of tension	60	59
Difficulty sleeping	60	62

Not surprising, considering typical ergonomic conditions (83-84)

In 45 non-union settings of large VDT use, % of existing terminals in “minimum, ergonomically sound settings” defined as “adjustable chair, adjusted workstation, & proper environmental conditions (lighting, etc.)” reported to be:

0-5% in 42% of the cases

6-15% in 30% of the cases

16-75% in 16% of the cases

76-100% in 12% of the cases

Quotes from p. 9-3 of Westin et al. (1985):

“Only 5% of our terminals are in proper condition today. It’s painfully minimal. Terminals are sitting on standard height tables so that people are having to work with elbows up in the air. They’re glad to get the machines and so they cope – jack their chairs up. But it’s sad that no function here is looking at these ergonomic issues. I guess it’s just that ergonomics costs money.”

“Top management is not willing to buy ergonomic furniture, even though it doesn’t have to cost more than what they now buy on new procurement. It’s inexcusable!”

“Until a few months ago, VDTs in our order-entry department were on high desks. When we redesigned the office, we got excellent ergonomic stuff – the chairs, swivels for the VDTs, angled work surfaces, etc. Now we have to persuade management to do this for the other 80% of our terminals.”

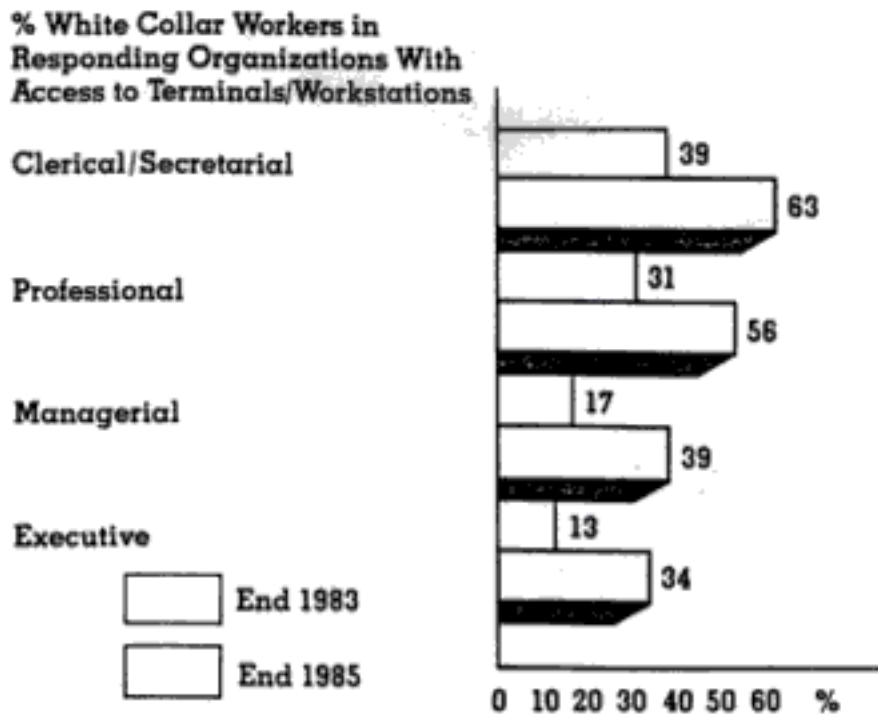
“Less than 1% of our terminal operators are using good ergonomic furniture. Our management would consider adding good equipment when we open new facilities, but they won’t change the old furniture.”

“We have adjusted the table height by cutting the legs down, so that the keyboard is at the right height, and we have open landscaping. We haven’t done anything else yet.”

“I’m ashamed to say we are still using old desks as VDT tables. We have atrocious lighting, and we haven’t paid enough attention to glare-free screens. But that’s changing now.”

One problem, as stated above, is that ergonomics costs money. The other problems are ignorance and apathy.

Figure 17.2 Usage of workstations
(Diebold Group, World Conference on Ergonomics, 1985, p. 15)



The Diebold Group, Inc.

Figure 17.3 Impacts on clerical/secretarial workers
Diebold Group, World Conference on Ergonomics, 1985, p. 16)

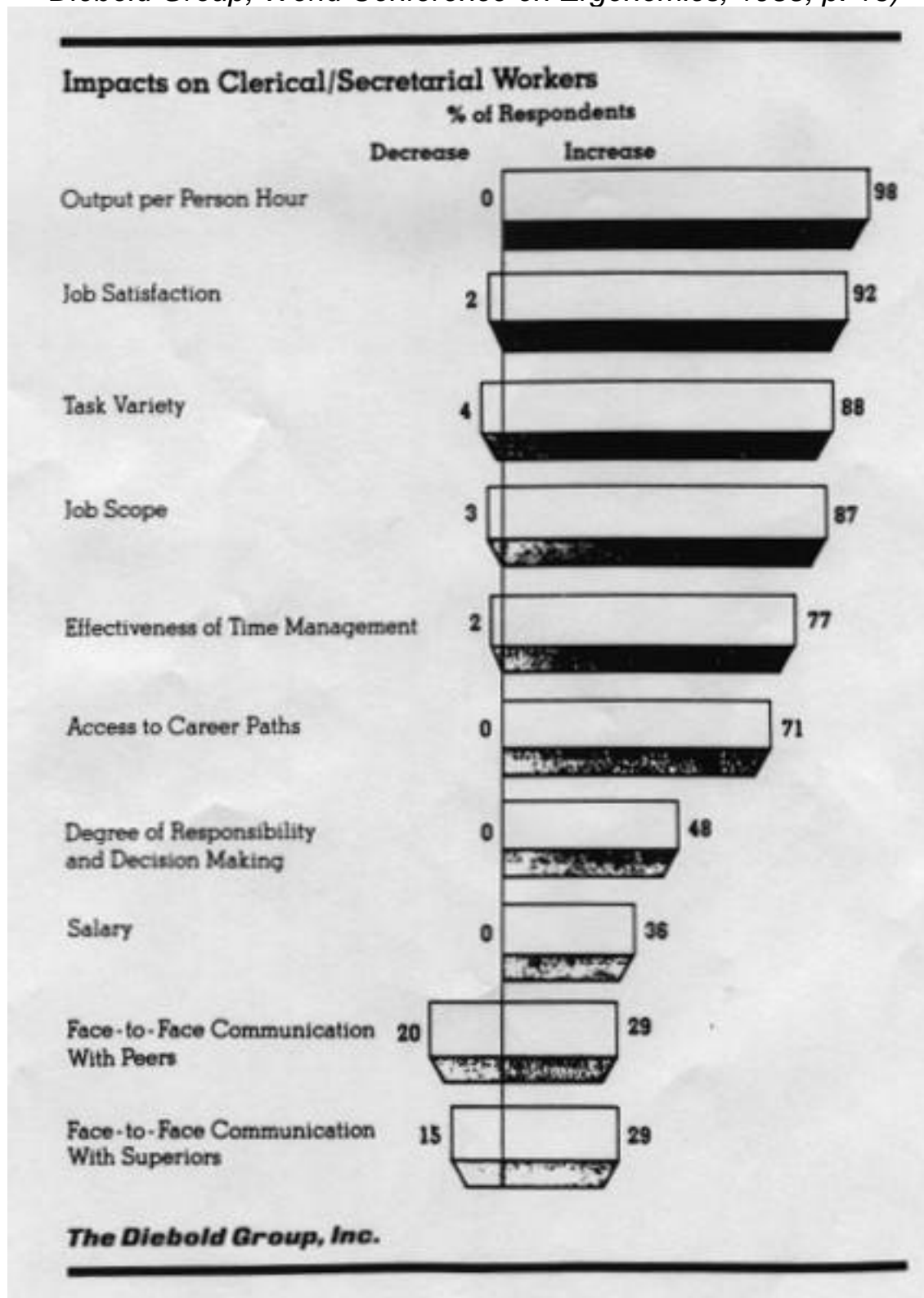
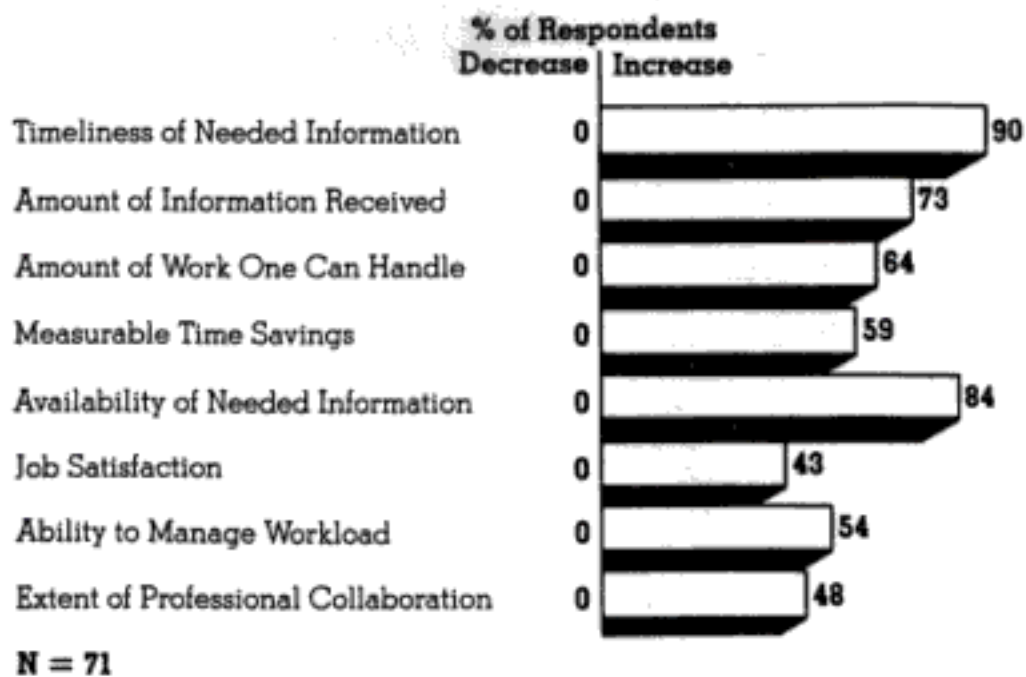


Figure 17.4 Impacts on professional and managers
Diebold Group, World Conference on Ergonomics, 1985, p. 17)

Impacts on Professionals and Managers

B. Managers/Executives



The Diebold Group, Inc.

Figure 17.5 NIOSH State of Wisconsin study results
(Westin et al., 1985, p. 7-4)

Figure 7.3: NIOSH State of Wisconsin Study

In this 1983 NIOSH-sponsored study at the University of Wisconsin, Sauter surveyed health complaints for 248 VDT users and 85 non-users all of whom were office workers employed by the State of Wisconsin. Users reported the following complaints:

	% Reporting Symptom	% Reporting Frequently or Constantly
Eyes ache/burn at work	75	27
Eye strain at work	75	24
Burning eyes	71	20
Tearing, itching eyes	68	19
Problems focusing vision	50	12
Blurred vision	39	5
Backache at work	81	35
Neck/shoulder ache at work	79	34
Back pain	79	27
Neck or shoulder pain	78	24
Shoulder soreness	59	12
Pressure in neck	52	15
Periods of depression	66	14
Easy irritability	66	10
Severe fatigue/exhaustion	62	13
High levels of tension	60	14
Difficulty sleeping	60	14

*Figure 17.6 NIOSH Social Security Administration study results
(Westin et al, 1985, p. 7-4)*

Figure 7.4: NIOSH Social Security Administration Study

In this 1982 study of 300 VDT users at the Social Security Administration in Washington, those users reporting discomfort had the following complaints:

Discomfort	% of VDT Users Reporting Discomfort
Burning eyes	71
Tearing or itching eyes	77
Eye strain or sore eyes	69
Headaches	81
Back pain	59
Pain or stiffness in neck/shoulders	60
Pain or stiffness in arms/legs	48
Swollen or painful muscles or joints	44
Occasions of easy irritability	71
Difficulty sleeping	62
Periods of depression	61
High levels of tension	59
Nervous or shaking inside	38
Periods of extreme anxiety	43

17.3 Ergonomic factors and productivity

Can ergonomics be cost justified?

One study, by Dainoff et al. (Human Factors Society, 26th Annual Meeting, 1982) done at NIOSH:

“An experimental simulation of a VDT data entry task was conducted during which subjects alternated between good and poor ergonomic conditions involving postural adjustment, lighting, and glare. Performance measures were taken during the session and a battery of psychophysical/physiological measures and subjective complaints were taken before and after the work session. Preliminary results indicated a 24.5% improvement in performance as well as a decrease in musculoskeletal complaints attributed to good ergonomic design characteristics.”

Study measured the effect of good & poor ergonomic conditions on clerical worker productivity

Ergonomically “poor” room	Ergonomically “good” room
Nonadjustable chairs	Adjustable chairs
Limited lumbar support	Lumbar support
Maladjusted workstations	Adjusted workstations
Glare conditions	Glare controlled w. diffuser
No copy holder	Copy holder
No wrist rests	Wrist rests

Result: In “good” room, higher productivity by 25% (measured by keystroke and error rates), also fewer musculoskeletal complaints

17.4 Psychological stress

Complaints or problems

Dissatisfaction, anxiety, boredom

Anxiety, tension, stress

Headaches, ulcers, other “physical symptoms”

Behavioural problems: fighting, drinking, smoking

Absenteeism

Causes, stresses	Possible solutions
Repetitiveness, monotony	Job rotation
Lack of participation, piecework	Job enlargement, enrichment
Lack of control, monitoring	Worker control
Role ambiguity	Clarification of role
Complexity	Job redesign, simplification
Responsibility	Job redesign, training
Pacing, work overload, deadlines	Job redesign, employee involvement in setting goals
Lack of promotional opportunity	Negotiation with management
Lack of job security, threat of unemployment	Negotiation with management

17.5 Musculoskeletal stress

Basic causes

Stationary nature of VDT work causes circulation through muscles to be impaired, waste products (lactic acid) to build up, muscle fatigue and pain

Damage to bones, muscles, tendons through biomechanical forces from awkward positions and repetitive motion — Repetitive Strain Injury (RSI), Carpal Tunnel Syndrome

Back strain

Chair must have:

- Full backrest with low protusion for lumbar support
- Solid seat (large enough) that tilts back only slightly
- Chair controls: seat height, back height, seat angle
- 5-legged base
- (Optional) armrests

Worktable:

- Adjustable surface height
- Adjustable display height (could be done with display)

Work materials:

- Alignment of materials according to frequency of use
- Reach distance
 - Keyboard: 7-10" maximum
 - Other materials: 14-18" maximum
- Viewing distance: typically 20" maximum
- Lighting control
 - Minimize glare
 - Minimize contrast between screen and paper

Neck and shoulder strain

Causes

- Extreme twists or tilts of neck and head
- Fixed posture
- Lack of support of arms and wrists

Solutions

- Proper alignment of display and document
- Distance to display and document
- Gaze angle: 10-20 degrees from horizontal comfortable
- Arm rests, elbow rests, wrist rests (somewhat tricky)

Repetitive strain injury

Causes

- Tendons share narrow passageway ("carpal tunnel") through wrist with a major nerve

Repetitive motion can cause tendon or nerve irritation or damage

Solutions

Proper keyboard alignment

Proper keyboard height and angle

Wristrests so wrist need not bend backward

Support for arms and elbows

17.6 Visual stress and eyestrain

Basic cause: physical adjustment of eyes

Papillary adjustment because of high contrast

Less curvature, effort to maintain close focus,
refocusing between near and distant objects

Rotation of eyeballs in text scanning – Interruption of
normal movements

Prevention of eye strain

Display quality

Character and background brightness (and contrast)

Colour

Character sharpness

Character design

Spacing

Steadiness

Lighting

Eliminating bright lights, glare, reflection

Eliminating high contrasts between display,
materials, and surroundings

Ensuring that there is adequate light on materials
and desk for non-VDT tasks

Interaction between visual and musculoskeletal stress

17.7 Radiation

Lots of “anecdotal” evidence about problems, cataracts, miscarriages, other serious problems

Difficulties with epidemiological studies

Often problems, unaccounted factors, confounds
in many studies

Controlled studies have not found effects

Radiation (Ionizing, x-rays; non-ionizing: RF, microwave, infrared, visible, ultra-violet)

Less than other sources (e.g., TV, x-rays, sun, etc.)
by several orders of magnitude

Less than “standards” for safety
by several orders of magnitude

But still no absolute guarantees

Recently, concerns over very low frequency radiation due
to reported problems with embryo development

Legitimate concern over VDT use during pregnancy