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Visual Display Technology, Worker Disablement and Work Organization[1]

In Australia, as in other countries, new office technology has been adopted widely and rapidly in recent years. Associated with the introduction of visual display units (VDUs) there was, in the first half of the 1980s, a remarkable increase in disablement among employees who operated them. In the Australian Public Service between, 20 and 30 percent of keyboard and clerical employees were reported to be suffering from musculotendinous disorders known collectively as repetition strain injury (RSI). Disablement on a similar scale was being reported in the private sector, and there was also evidence of visual and neurophysiological damage. Unless prevented or apprehended in the early stages of development, many of these injuries can become crippling and persist for long periods of time, if not the duration of a person's life. The economic costs of lost production and workers' compensation payments reached serious proportions. There was a possibility that manufacturers and suppliers of visual display equipment might face legal liabilities. VDUs were discarded by some organizations. Late in 1984, the Australian government established a Task Force on Repetition Strain Injury in the Australian Public Service, and concern about RSI increased considerably in the private sector (*Business Review Weekly*, 1984). There was a strong perception of the sudden increase in injury

[1]A revised version of "Worker Disablement and Work Organisation," Human Relations, 38:1065-84, 1985.

as definitely related to the introduction of VDUs into the workplace, an issue which was not unique to Australia.

The evidence for a relationship between VDUs and worker disablement came largely from observed association. The human and economic costs of occupational injury made prevention and control an urgent priority. At the same time, the relationship between VDUs and RSI was not well understood. A technology had been introduced that was forcing human adaptation and giving rise to disorders in human functioning (Corlett and Richardson, 1981). There were considerable economic pressures to adopt new technology, but the introduction of VDUs may have pushed technological innovation to the limits of current knowledge about its effects on human beings.

Furthermore, there was a growing belief that injury was significantly affected by the design of work organization. Medical practitioners were advocating a search for solutions in work organization design on the grounds that substantial advances in medical knowledge and treatment would be too slow and that work redesign offered a means of prevention rather than cure (Ferguson, 1984). Ergonomists, who had made their own contribution through the design of workstations, were suggesting that further progress toward preventing injury depended on such factors as the volume, flow, speed and duration of keyboard work, which were determined by the organization of work. Moreover, developments in technology were allowing scope for choice in work organization design. Decisions about work organization were becoming less constrained by technological parameters than they had been by some of the energy-based technologies of industrial production (Buchanan and Boddy, 1982; Eason and Sell, 1981; Turner and Karasek, 1984).

This paper discusses current knowledge about the relationship between VDU's and worker disablement as a basis for examining the role of work organization in this relationship. It considers alternative basic work organization designs in relation to new technology and their likely consequences for occupational injury. The findings from a study of two Australian government departments with significantly different levels of reported occupational injury are examined and compared in terms of their work designs and VDU applications. The findings are consistent with the expectation that organizations which introduce new technology while retaining conventional bureaucratic work designs will experience greater occupational injury among workers than organizations in which work design provides employees with more variety and scope to control their own task performance.

Visual Display Technology and Worker Disablement

Most concern about worker disablement from VDUs in Australia has focused on RSI. This term refers to injuries

to the upper limbs, shoulder girdles and neck attributed to:

- static loading, or isometric contraction, of the neck, shoulder and upper arm muscles to support and fix the arm in a position of function;
- dynamic loading or repetitive movement of the forearms, hands and fingers (and sometimes upper arms) to execute a task;
- force used to execute a task (Browne et al., 1984).

The term RSI is applied to a large number of musculotendinous disorders. The same symptoms can arise synchronously from different causes: they can be associated with

recreational as well as work activities, and they can be related to personal stress and tension. The injuries can occur in some individuals engaged in a given activity but not in others. Hence, RSI is not precisely defined medically. It can have multiple causes, and its relationship to working with VDUs is not clearly or precisely understood (Browne et al., 1984; Ferguson, 1984). Nevertheless, RSI became extraordinarily prevalent among VDU operators, and outbreaks frequently followed the introduction of VDUs.

Several factors were considered to increase the risk of RSI and aggravate its symptoms. The main factors identified were

Biomechaical. Incorrect posture; the number, speed and frequency of repetitive movements; the amount of force used; extreme movements; faults in workstation equipment and task design; muscle tension associated with stress; operator adjustments to protect injured limbs; and individual susceptibility to strain injury.

Work Organization. Excessive duration of work without rest; bonus and incentive schemes; inadequate training; work rate; work load; work flow; fragmentation and specialization of tasks; work monitoring; and work output norms.

Reporting and management. An unsympathetic climate in the workplace; anxiety about job security; failure of supervisors to recognize and act on signs of injury; lack of education about RSI and information concerning reporting procedures; lack of alternative work; language barriers; lack of management information and policy; inadequate availability of medical services; incorrect or delayed diagnosis; and inappropriate management of injury (Browne et al., 1984; Ferguson, 1984;

Stone, 1983).

In this prevalent view, RSI is primarily a physiological phenomenon. The symptoms of pain and weakness in muscles and tendons, and their presumed origins in biomechanical functioning and the demands of task performance suggest a basically physical interpretation of what is happening in the interaction between operators and VDUs. Similarly, apart from RSI, there is concern that working with VDUs can adversely affect visual functioning, but attention so far has been largely confined to the physical effects of "visual fatigue." This is generally regarded as muscle strain caused by prolonged convergence of the eyes at the point of attention and by alteration of the shape of the lens to focus on a near object (National Health and Medical Research Council, 1983). Physiologically oriented research and interventions have made important contributions to the understanding and prevention of injury associated with VDUs. It is not the intention here to devalue those contributions, but it is necessary to go further.

The physiological view of RSI points to demands of task performance as contributors to injury but not as characteristics of the technology. An obvious question is why RSI did not become widespread with the introduction of typewriters. It was a technological innovation that required considerable experimentation and learning and adaptation of postures, movement and techniques for efficient operation while avoiding discomfort and strain. These lessons may have been overlooked in the introduction of VDUs. Many operators may not have received adequate keyboard training, and there have been numerous cases where important ergonomic considerations were neglected. Also, keyboard work on VDUs is less varied and more repetitive with fewer opportunities for operators to move around in their work when

compared with typists. Rapid introduction of the technology and possibly inferior equipment would aggravate such difficulties. Nevertheless, these factors do not seem sufficient to explain the epidemic proportions that RSI reached. There appears to be some important qualitative difference between the technology involving even the advanced electromagnetic typewriter and the electronic VDU.

This possibility has been raised by Fred Emery (1984) in relation to tenosynovitis, potentially a very serious injury that is attributed to the drying up of synovial fluids in the tendon sheaths, caused by abrasion and inflammation. This may be explained physiologically by the fact that electronic keyboards, while reducing the force required to activate the keys, also make possible much faster keystroke rates than do conventional typewriters. A threshold may have been transgressed which previously was not known. However, it may be that the synovial fluids in the tendon sheath are not being replenished sufficiently because the touch pressure on the keys is too light to provide the feedback to the brain necessary for replenishment to occur. Alternatively, skin and bone joint stimulation may be projected directly into the human nervous system at a precortical level. If so, this would have emerged during human evolution under feedback conditions given the more familiar and much firmer uses of the hand such as grasping or prodding, rather than the feather stroking of an electronic keyboard. Either way, the feedback conditions of at least some electronic keyboards are outside the range in which the human perceptual system, in this case the haptic or touching subsystem, evolved. Emery notes that keyboard operation may constitute prolonged inactivity for the knuckles and wrist joints, which weakens the cartilage and makes it susceptible to damage from other activity. The symptoms of damage observed in cartilage research are very similar to those of tenosynovitis (F. Emery,

1984). Emery's line of inquiry does not preclude the effects of excessively fast keystroke rates but directs attention beyond physiological questions to the interaction between technology and human perceptual functioning.

As with RSI, the prevalent view concerning the effects of VDU operation on visual functioning concentrates on physical effects. Merrelyn Emery's research on television, which she has extended to VDUs, shows that more is involved. Many VDUs contain the same cathode ray tubes as television receivers. The main differences are that working with VDUs entails closer viewing distances and longer viewing periods. Hence, the effects found in television viewing are expected to be more pronounced in VDU operation (M. Emery, 1985; F. Emery, Vol. I).

The cathode ray tube emits radiant light in contrast to the reflected light in which the human perceptual system evolved. The general effect is to induce high levels of attention (fixation) and recognition of symbols but reduction in cortical activity with resultant lower consciousness and alertness. In VDU operation this may raise two problems. First, the effect of viewing the screen is lower alertness and recall--but the task often requires alertness, recall and understanding. Second, a small percentage of the population is extremely sensitive to the radiant light of the cathode ray tube, "TV epilepsy." It is presumed that the rest of the population is normal--but there may be a spectrum of individual reactions to radiant light ranging from no or very little disturbance to neurophysiological functioning through mildly abnormal reactions to extreme reactions (Burch, 1984; M. Emery, 1985). If this is the case, a considerably larger number of individuals may experience more or less persistent mildly adverse effects from radiant light.

In several studies of VDU operators, a core of symptoms has been identified. Compared with individuals not working with VDUs, operators have been found to experience more difficulty in getting out of bed; eye strain; blurred vision; shoulder pain; neck pain; red eyes; irritability; frontal headaches; lower back pains; worsening of vision; and reduction of energy (M. Emery, 1985). These symptoms may arise, not only from the physical effects of VDU tasks, but from neurophysiological effects as well. The hypothesized relations between VDUs and miscarriages or birth defects do not have to rest on the considerable but controversial body of argument concerning radiation effects. The disturbances that radiant light may evoke in some individuals could be sufficient to induce biological malfunctioning (Burch, 1984).

The physiological perspective on VDUs directs attention to the repetitive nature of operators' tasks and to their constrained movements as principal sources of strain and injury. Tasks may involve data or text entry, data inquiry or dialogue between the operator and the system. These differences affect whether the operator is viewing hard copy or the screen or both and, in turn, the sources of musculoskeletal loading and potential strain. The effects of task demands can be aggravated or mitigated by the design of equipment and by the techniques that operators use. Individuals vary in their susceptibility to both musculotendinous and visual strain and, hence, the extent to which they are at risk when working with VDUs. Task analysis to determine the types of physical loading involved, ergonomic design, operator training and individual assessments are measures which can be taken to reduce the risk of injury among operators (Department of Employment and Industrial Relations, 1984; Joint Committee of Public Accounts, 1984). The studies by F. Emery and M. Emery suggest that VDUs represent a more fundamental technological discontinuity, particularly the introduction of the electronic keyboard

and the cathode ray tube, that creates perceptual and neurophysiological problems in the relationship between people and technology. Ultimately, the problems which they identify require change in the technology itself, more selective and appropriate application of technology and development of technology that is compatible with the evolution of the human species.

From both perspectives--human and technological--work organization may have important consequences. From the physiological perspective, the basic issue is the performance of repetitive tasks in constrained positions that gives rise to dynamic and static loading. The longer and faster the operators work, the greater is the risk of injury. Duration and speed of work can be varied, but in what ways and with what effects depends on how the work is organized. Time is also an important factor in the effects of VDUs on human perceptual and neurophysiological functioning. From this perspective, the issue is the duration of people's interaction with a technology that evokes maladaptive responses in them. Reducing and regulating the time that they spend in this interaction would not be a complete answer, but it is important. Moreover, although the immediate concern here is with occupational health and safety, the introduction of new technology raises wider issues in the future of work and its organization--whether the essential features of conventional industrial organization will be perpetuated and intensified or whether, with new technology, work will undergo basic socio-technical redesign.

VDU Technology and Work Organization Design

The role of work organization design in the interaction between VDU technology

and workers is brought into sharp focus by considering the two basic work design alternatives postulated by Emery (F. Emery, 1976; Emery and Emery, 1974; Emery and Thorsrud, 1977; Emery and Trist, 1972). One alternative, which Emery calls bureaucracy, is to subdivide work to a point where those performing the component tasks cannot control their own activities or coordinate with others performing related tasks. Control and coordination are imposed on task performance through hierarchical structures. The other alternative, participative democracy, is to integrate related tasks and create organizational units whose members are able to control their work, in cooperation with each other, to meet both the performance requirements of the organization and their own needs.

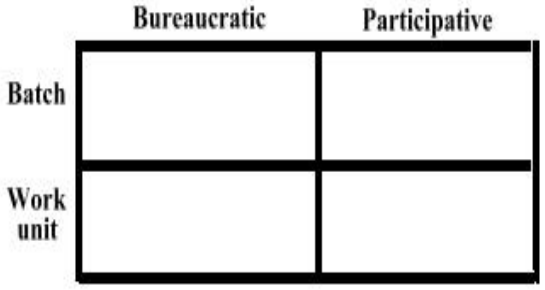
This choice applies not only to work organization but to the design and application of technology. With computer technology, application systems can take the form of batch processing or work unit processing. In batch processing, all processing of a particular type is completed before the next processing stage commences. Processing cycles tend to be short and repetitive, and the system encourages subdivision of tasks. There is little requirement to provide operators with a coherent model of the system's operation, because operators at each stage are concerned with only one or a very few steps in the process. In work unit processing, all processing of a particular item or transaction is completed before the next one is handled. Work is carried out in modules that lend themselves to decentralized processing structures in which operators can have a high degree of interaction with the system, tend to be involved in complete operations and have scope for intervention in, and control over, the process (Turner and Karasek, 1984).

Consideration of the basic work designs and computer application designs gives

the array of socio-technical alternatives shown in Figure 1.

Figure 1

Socio-technical Alternatives



The work organization and computer application dimensions represent the same socio-technical choice from two perspectives. Thus, Turner and Karasek (1984, pp. 665, 671) note, "when a new system is implemented, intentionally or not, labor is reallocated between man and machine ... Task allocation decisions on the part of a system designer are tantamount to defining the human's job." However, maintaining a distinction between the work organization and system design dimensions serves to emphasize that there are two related but distinct choices about technology and work organization, and that a choice on either dimension could take precedence over the other. The choices can be, and often are, made separately or at different stages in the process of introducing new technology. The technical system may be defined first with little or no attention to the effects on work organization and on employees in their jobs. This approach assumes that human and organizational adjustments to accommodate the new technology will follow from the way in which the technical system is designed. The alternative

is to integrate technical and human requirements from the start in the design not just of a new technology but of a new socio-technical system (F. Emery, 1980; Herbst, 1974; Williams, 1983, 1988).

The choices of social and technical design in the introduction of visual display technology have a direct bearing on the extent to which work is repetitive and on control over the volume, flow, speed and duration of keyboard work. In the bureaucratic/batch system, the tendency toward maximum subdivision of work increases the repetitiveness of tasks, and employees have little control over their work. Also, much faster keystroke rates compared with typing tend to be reflected in output norms not only of managers and supervisors but also of the operators. Management's expectations of higher productivity are usually the main reason for introducing VDUs, and the technology makes it possible to monitor precisely the volume and accuracy of each employee's output. Moreover, when operators are engaged in a small number of repetitive tasks, their keystroke rates tend to increase progressively, and this can be encouraged by incentive schemes. Hence, the bureaucratic/batch system enables higher productivity to be pursued through highly subdivided tasks and monitoring and control of individual performance. It entails no fundamental change from conventional work organization, and batch processing is easier to program than the alternative of work-unit processing (Turner and Karasek, 1984).

Most Australian organizations introduced visual display technology while retaining conventional bureaucratic work designs. In response to the growing incidence of worker disablement associated with VDUs, a variety of measures have been adopted. These include ergonomic analysis and design; upper limb and visual acuity assessment to identify individual susceptibility; and improved operator training. There is a trend toward discontinuing

output incentives and machine monitoring. Rest breaks and exercise programs have been introduced. It is becoming accepted that employees should not work full time on VDUs and that their jobs should include nonkeyboard tasks. These are measures to reduce the disabling effects of VDUs without changing the basic work organization or the technical processing system.

However, problems have been encountered with these measures. Ergonomic analysis and design have been accepted by managements and unions as important but limited in their capacity to prevent injury. Assessments of individual susceptibility are recognized as in the interest of employees but are rejected by unions as a basis for excluding people from employment involving VDUs. The importance of operator training is acknowledged, but there is growing concern that operators generally have so little knowledge and understanding of the systems they are working in that their work is meaningless.

The other measures appear to be more promising. It is within management's prerogative to restrict or eliminate work incentives, overtime and machine monitoring of performance. In practice, pressures for production undermine these policies. Also, the electronic keyboards are designed for fast keying, and keystroke rates tend to increase despite limits imposed by management or established by agreement with unions, and attempts to enforce the limits may be resented by the operators. Similar problems are encountered with rest breaks and exercise programs. In many organizations rest periods have been introduced to be taken by operators at regular prescribed intervals. Again, this may conflict with production pressures. Operators, who are located throughout the organization in sections where other staff do not operate VDUs, may suffer ridicule and embarrassment if they take the rest breaks. Operators can become frustrated at having to take breaks at exact times when this interrupts the rhythm or

completion of their work. When rest breaks and exercise programs are established by management, although they are intended for the good of the operators, they may be perceived by the latter as further regimentation of their working lives.

One further recourse is to give nonkeyboard as well as keyboard tasks to employees. However, in bureaucratically designed work organization, the scope for combining keyboard and nonkeyboard tasks to create meaningful jobs for individuals is limited due to the highly fragmented nature of most tasks and the inability of employees to control their work and to coordinate with others (Australian Public Service Board, 1984).

Not only is worker disablement from VDUs more likely in bureaucratic/batch systems, but the organizational characteristics of these systems make it difficult to adopt effective measures to prevent disablement. The workers are performing repetitive tasks and lack control over the factors affecting their work. Therefore, hierarchical controls offer the only means of regulating the effects of VDUs on the people operating them, but the work organization design itself constrains or defeats these measures.

The alternative is to develop participative democratic work organization designs in conjunction with introducing new technical systems based on batch or work-unit processing. Although RSI became a generally serious problem for the Australian public service, the prevalence of reported RSI varied between departments from zero to 38 percent.

From the above analysis, it would be expected that departments that differ significantly in their levels of reported RSI would display different characteristics of system and work organization design. They may, of course, differ in other respects, but the purpose of the study reported below is to establish whether departments with relatively high and low levels of

reported RSI had adopted different approaches to systems applications and work design. The central hypothesis is that departments with relatively high reported RSI will have introduced batch processing systems while retaining traditional bureaucratic work organization. Departments with relatively low RSI are expected to have developed work designs and systems applications with participative work-unit attributes (although the combination of participative work design with batch processing should also be reflected in lower prevalence of injury). In contrast to bureaucratic/batch systems, participative work design should provide operators with greater control over their work and the RSI risk factors; more varied work; more opportunities for learning; more scope to help and support each other; and more involvement in the production of meaningful outcomes.

RSI, New Technology and Work Design: A Comparative Study

The prevalence of RSI among Australian government employees in December 1986 was estimated by dividing total reported RSI by total staff numbers in each department, location and employment designation group. (Data were taken, respectively, from *Census on Repetition Strain Injury in the Australian Public Service*, quarterly December 1984 to June 1987; and Public Service Board's *Statistical Bulletin*, 1985-86.)

The incidence of RSI was evenly distributed between clerical and keyboard designation groups, with 48 percent occurring among clerical employees and 52 percent among keyboard workers. But there were over seven times more clerical than keyboard staff employed in the Australian public service. RSI was, therefore, largely a keyboard problem in the public service.

The differences between departments that are of greatest interest concern the prevalence of reported RSI in keyboard designations. Departments with comparatively high and comparatively low keyboard RSI were selected to study their systems applications and work organization designs to establish whether and in what ways the departments were different in these respects. Two departments have been studied sufficiently for the findings to be reported.

The difference in RSI prevalence between these two departments (14.6 percent for Department A and 8 percent for Department B) is statistically significant at the one percent level (Table 1: $chi^2 = 18.14$; $p = .01$ for one degree of freedom). The expected RSI frequencies

Table 1

Departmental Differences in RSI Incidence*

	o	e	o − e	(o − e)2	(o − e)2/e
Department A					
Non-RSI	1221	1251	30	900	0.72
RSI	209	179	30	900	5.03
Department B					
Non-RSI	610	580	30	900	1.55
RSI	53	83	30	900	10.84
				x^2 = 18.14; p = .01	

*RS1 frequencies: o = observed, e = expected

are those that should have occurred if there was a simple direct relationship between keyboard work and RSI such that the number of RSI cases reported in each department was a function only of the number of keyboard staff employed. The discrepancy between the expected and the actual observed frequencies

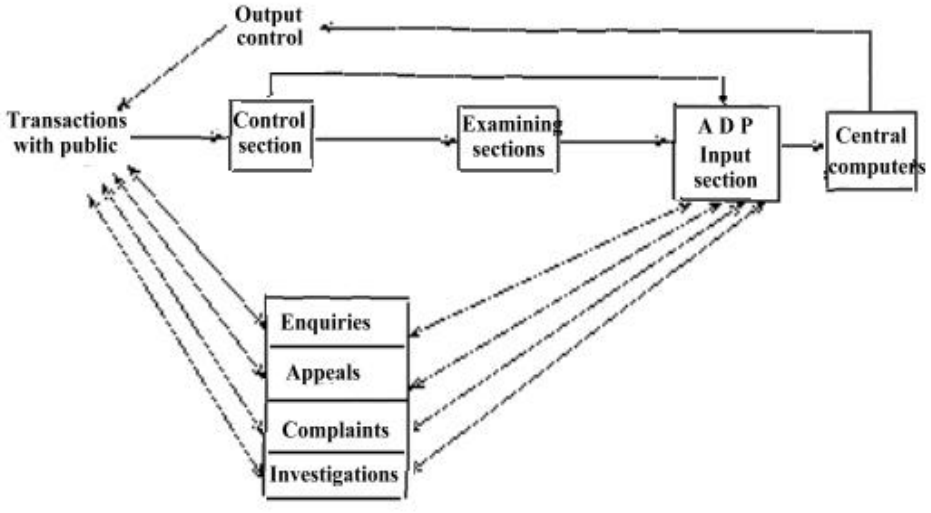
suggests that other factors may be involved, and the discrepancies are large enough to warrant further investigation.

Initially, a senior manager in each department was contacted to explain the study and seek approval and cooperation for research to proceed. Information on the main systems applications was obtained, and sections of the departments were visited to study their functions and work organization using the framework of socio-technical analysis and, where appropriate, the complementary method of role analysis.

In *Department A* there were 209 cases of reported RSI among 1221 keyboard staff, or 14.6 percent of all employees in keyboard designations. The department is responsible for the administration of a high volume of transactions with the public (Figure 2).

Figure 2

Main transactions processing operations in Department A



On a daily cycle, branch offices prepare input data that are transmitted to central computers in the national office for overnight processing, and the branches receive, print and distribute output

from the national office the next day. Transactions from the public are received and recorded by a control section that sends them either to the appropriate sections for examination prior to computer processing or directly to the Automatic Data Processing (ADP) input section, which enters data from the transactions for transmission to the central computers. An output control section receives output back from the central computers for printing and distribution within the department or to the members of the public who originated the transactions. Around this system, sections deal with inquiries, investigations, appeals and complaints and perform corporate service functions. Several sections specialize in particular categories of transactions and handle inquiries and complaints; they also receive and examine transactions before sending them to the ADP input section (via computer terminals or physical delivery) for entry into the system.

All current systems applications are based on batch processing against central data bases. The processing work is routine, and the function of the ADP input section is simply to key the entry of data into the system. Transactions are received in the section and jobbed into batches, which data processing operators collect for keying. The system automatically rejects invalid input. The operators have very little discretion and are employed full time on keyboard entry which, in practice, is now limited to five hours per day because, due to RSI, operators are restricted to 50 minutes of keying per hour. Of the 209 cases of reported RSI in the department, 134 cases, or 64 percent, involved data processing operators. An interview with management confirmed that, while RSI had occurred in other keyboard designations (notably typists), the major problem had been with the data processing operators. Due to seasonal fluctuations in ADP input staffing levels, it was not possible to obtain an accurate estimate of the percentage of all data processing operators reported as suffering from RSI. However, the situation in this

department is consistent with the general pattern in the public service. In December 1986, 17.4 percent of data processing operators had reported RSI, followed by word processing typists with 11.5 percent. The figure for data processing operators had been as high as 24 percent, and they were clearly the occupational group most at risk.

It is worth noting that, while RSI was a serious problem, particularly in the ADP input section, VDUs were used extensively in other sections of Department A where the incidence and prevalence of RSI were negligible. In sections dealing with inquiries, complaints, investigations and the like, there was no full-time keyboard entry work, and the new technology was used to support staff in their dealings with the public and to extract information from the system. However, in sections which handled specialized transactions, including on-line entry of data into the system, the logic of conventional work design may have suggested a division of work between keyboard operators doing all the data entry and clerical staff dealing with the public and updating information for entry into the system.

In one large section, the temptation to adopt this form of work organization was resisted, and an alternative work design was deliberately developed. The section was created in the early 1980s to deal with certain members of the public who may apply to the section for exemption or special treatment. A form is sent to the person who completes and returns it. The returned form is examined, and the person may be contacted for further information or clarification. When the information on the form is completely reconciled, it is keyed into the system. Forms are processed in batches proceeding first through the clerical and then through the keyboard entry stage. Work is organized on an individual job basis, with staff collecting work from central locations and taking it to their workstations. However, the work of the section is so

arranged that each employee's duties are 50 percent clerical and 50 percent keyboard. Keyboard tasks include making corrections and updating information as well as data entry. While on keyboard work, staff may receive calls from people they have been dealing with during the clerical stage. Some staff found themselves keying their own clerical work, and this has been established as common practice. The VDUs are monitored for usage, but individual staff are not monitored and appeared to be broadly rather than closely supervised.

At the time this section was studied, RSI prevalence had reached crisis proportions in Department A, but there was only one reported case among the 131 staff in this section. The sufferer was new to the section and may have been injured previously while working as a full-time data processing operator. The variety of keyboard and clerical tasks and the scope for people to move around in their work appeared to be important factors in the virtual nonoccurrence of RSI. Formal rest breaks from keying had not been introduced, management preferring to establish a general understanding that staff should take rest breaks when they needed to. Staff were aware of RSI and appeared to have sufficient control over, and variety in, their work that they could take responsibility for avoiding injury, rather than have management attempt to avoid injury for them through imposed safety practices.

Department B had 53 reported cases off RSI among its 610 keyboard staff or a prevalence rate of 8 percent. The department had two main functions. One was to monitor developments in sectors of the economy, provide information and policy advice to the government and operate an information service for the public. The other function was to plan and implement assistance programs, which also included public information services. The first function employed a high proportion of middle to senior level staff in ongoing contact with

industries, conducting research and preparing policy information and advice. These project officers were supported by relatively small numbers of clerical and keyboard staff. Although formally employed in keyboard designations and engaged in word processing, keyboard staff generally had a range of tasks including filing, preparation and distribution of documents; handling transfers of information within and between sections; and collection of basic data. The organization of work around projects allowed support staff to relate their tasks to functions and outcomes. Most managers interviewed said that support staff were encouraged to get involved in projects although they did not do any contact work. The roles of keyboard staff contained mixtures of keyboard and clerical tasks, there was a trend toward increasing use of personal computers by project officers and keyboard staff normally spent no more than 50 percent of their time keying.

The second function employed a greater number of keyboard and more junior clerical staff and required more routine keyboard entry into central information banks. This function was more decentralized geographically, with many staff working in branch and local offices throughout the Australian states. While staff performed data entry tasks, they also had clerical work, there was considerable direct contact with the public and the work involved interrogating the information banks for assistance in their work as well as entering data into the banks. The main problems with the second function appear to have been the design of systems to meet central requirements and inadequate consultation with staff in branch and local offices who encountered difficulties in using the systems effectively. Nevertheless, reported RSI in Department B was among the lowest for keyboard staff during the crisis period.

Reported keyboard RSI in the public service has been declining for some time, as

shown in Table 2; comparable figures for Departments A and B are given in Table 3. In response to the emergence of RSI as a serious occupational health problem, departments implemented a variety of measures. These were surveyed by Crawford (1987) and, although confined to the Australian Capital Territory, her findings provide some indication as to the pattern of departmental responses (Table 4).

Table 2

	Dec 1985	Mar 1986	Mar 1987	Change (%)
Typist	577	588	378	- 34.5
Secretary	373	271	150	- 59.8
DP operator	593	545	380	- 35.9
Word processing typist	441	372	260	- 41.0
Other keyboard	43	25	22	- 48.8
TOTAL keyboard	**2027**	**1771**	**1190**	**- 41.3**

Table 3

Decline in RSI by Department

	Department A				*Department B*			
	Dec 1985	*Mar 1986*	*Mar 1987*	*Change (%)*	*Dec 1985*	*Mar 1986*	*Mar 1987*	*Change (%)*
Typist	49	55	43	-12.2	34	37	32	-5.9
Secretary	2	3	2	0.0	16	13	2	-87.5
Data processing operator	147	128	121	-17.7	1	1	0	0.0
Word processing typist	13	19	13	0.0	17	16	8	-52.9
Other keyboard	6	5	7	1.7	0	0	0	0.0
Total keyboard	217	210	186	-14.3	68	67	42	-38.2

Table 4
Remedies for RSI

Measure	*Yes*		*No*	
	N	%	*N*	%
RSI reporting system	42	100	—	—
Ergonomic advice	39	93	3	7
Officer responsible	38	90	4	10
Counseling	37	81	5	12
External consultants	34	81	8	19
Education, training	34	81	8	19
Exercise programs	32	76	10	24
Rest breaks	29	69	12	29
Job design	27	64	15	36
RSI policy	27	64	15	36
Workplace investigations	23	55	19	45

The general impression is that departments responded with a variety of measures but that some measures were more likely to be adopted than others. All departments had established some form of RSI reporting procedure: 75 percent or more sought ergonomic advice on equipment and furniture; had appointed officers responsible for RSI management; provided counseling for RSI-affected staff; introduced education and training in RSI prevention; employed external consultants (mainly medical practitioners, physiotherapists and ergonomists); and had introduced rest breaks and exercise programs. Departments were less likely to have conducted

workplace investigations where staff were diagnosed as suffering from RSI or to have made changes in work design. Workplace investigations, where undertaken, were more likely to result in changes to equipment and furniture than to work design.

Crawford's findings suggest that critically examining and changing the design of work organization was the least preferred alternative in departments' responses to RSI. It must be acknowledged that the incidence and prevalence of RSI in all employment designations have declined and that the measures most widely adopted appear to have contributed to this general reduction of occupational injury. At the end of the reporting period, RSI remained an occupational health problem affecting more than 1,000 keyboard staff in the public service (Table 2). In the case of Department A, it is evident from Table 3 that there had been relatively modest improvement in the most seriously affected employment designation of data processing operators. In the ADP input section, furniture and keyboard equipment were of an advanced standard, boards displayed the times of scheduled rest breaks and the physical environment was pleasant and comfortable, but RSI among the department's processing officers declined by only 17.7 percent, while it had been reduced by 35.9 percent in the public service as a whole (Table 2). This is consistent with the contention that measures such as rest breaks and improved operator training, equipment, furniture and physical working environment can help to reduce occupational injury but, in themselves, are not sufficient to eliminate the problem.

In the area of activities where Department A had the most serious prevalence of RSI, the characteristics of bureaucratic/batch socio-technical design were clearly evident. The systems application was based on linear sequential work flows broken down into discrete processing steps. The work organization and the technical design allowed operators little

discretion in their task performance, and the tasks were simple and repetitive. Within Department A, the greater task variety and operator control over task performance and the virtual nonoccurrence of RSI in the special transactions section provides one point of contrast. This might be described as a participative/batch socio-technical design. Department B also had a significantly lower prevalence of RSI throughout its keyboard designations and areas of operation. There was no full-time keyboard entry work; keyboard staff had a range of tasks and a substantial proportion of their work enabled them to identify their efforts with meaningful projects and outcomes. These findings are consistent with the central hypothesis that departments with relatively high prevalence of RSI were more likely to have adopted bureaucratic/batch socio-technical designs and that departments with relatively low RSI were more likely to display participative work-unit characteristics.

Comparisons between two organizations do not, of course, provide unequivocal confirmation of the hypothesis. If the findings held for a larger number of departments with more nearly similar functions and operations, this would provide a somewhat stricter and more comprehensive test. However, the Australian government's concern about new technology and the design of work organization has gone beyond the initial preoccupation with RSI to encompass a wider range of issues in public sector performance and the quality of working life available to government employees. The government's current policy on work design is stimulating work organization innovations throughout the public service, which do not require further empirical evidence concerning RSI for their justification. Improving occupational health and safety is one objective of the government's Office Structures Implementation (OSI) program, but the program is also intended to provide employees with greater responsible autonomy,

variety, opportunities to attain higher levels of skills and knowledge, job satisfaction and career prospects. The original research focus on new technology, work organization and worker disablement has also shifted to the broader question of relationships between new technology and the democratization of work.

From Occupational Health to Industrial Democracy

Following lengthy consultation with departments and unions, the broad change intended by the OSI program is the integration of the previously separate keyboard designations, clerical assistant grades and the bottom five grades of the clerical administrative structure into a single structure within which jobs will contain mixtures of keyboard and clerical skills and career paths will be more open to all staff. More than 70,000 office staff employed in 48 different, and often narrow, classifications will be integrated in one structure with five levels, in which traditional work divisions are supposed to disappear along with long-standing barriers to career mobility (Australian Public Service Board, 1987).

For Department B, the integration of keyboard and clerical tasks does not represent a radical departure from its existing work organization. The main problem for Department B arises from the gap between the senior grades of the project officers and the junior grades of support staff. Although there are no strict formal educational requirements, many project officers have tertiary qualifications, and they all have considerable experience in both analytical work and high-level industry contact. Some support staff have attained more senior positions, but the qualitative differences between analytical and contact work and support tasks currently present a barrier to advancement from lower to higher positions, which the department

will have to develop strategies to remove.

In Department A, the work organization conformed closely to the traditional public service office structure and was a more typical object of the changes required by OSI. The department established an OSI implementation team nationally and in each branch, which initially concentrated on reviewing existing job classifications and resolving anomalies created by moving to the new five-level structure. Next, OSI working parties were set up to examine the existing work organization of sections; develop alternatives which were presented to and discussed with the staff who would be affected; and propose agreed changes to management through the OSI implementation team that now had a coordinative role in the planning and implementation of change. A working party usually included management and union representatives, employees working in the section and a member of a services section concerned with matters such as industrial democracy or equal employment opportunity. At this stage the department also commenced keyboard training for clerical employees.

The main transactions processing operation, which was the principal source of RSI in the department, was selected as one of the first target areas for change under the RSI program. Four sections previously described (p.20) were involved in the operation, each performing a discrete part of the process. The whole operation entailed 31 manual or machine processing tasks and seven filing and storage tasks. These tasks were divided between the four sections with further subdivisions within sections such that staff each performed one or a small number of tasks repeatedly on a succession of transactions.

The working party identified several alternative arrangements, one of which was preferred by the great majority of staff in the existing sections. The preferred work design

integrates the four sections into one section with each employee completing the entire processing cycle on transactions.

The new work organization was tried initially in a pilot unit operated by 17 employees from the existing sections and a supervisor. These employees were volunteers and, prior to the pilot unit, received training in keyboard operation or clerical processing depending on which designations they had worked in before. Although the broad intention was that each employee would perform the entire processing cycle on transactions, this was qualified in two main ways. First, some types of transactions required different levels of knowledge and experience, and there was a division of work between more junior staff processing the simpler transactions and staff in higher-grade classifications processing the more complex transactions. Peak work loads for these different transactions varied, and there were periods when junior staff were unable to share the work of senior staff, whereas in other peak periods senior staff were able to process some of the simpler transaction types. The simpler transactions comprised the bulk of the processing with the result that employees at different seniority and pay levels spent considerable periods doing the same work. This caused some friction between members of the pilot unit, with junior staff questioning the status differences and higher-level staff resenting the perceived erosion of their seniority.

Second, while employees were involved in the entire processing cycle, they did not complete the cycle for each transaction that they handled. Rather, one employee performed all tasks entailed in receiving a transaction through to entering it into the system for processing, but it was likely that another employee would deal with the checking, reconciliation and distribution of the processed transaction. At least in part, this was

> due to the pilot unit's inability to control the flow of output from the central computers, in the national office. Staff collected batches of processed transactions as they came back from the central computers, and it would have been coincidental if the same person who performed the input tasks on those transactions also performed the output tasks on the same transactions. The work redesign in the pilot unit was providing staff with greater variety of tasks and increased opportunities for learning and advancement based on acquiring new knowledge and skills. However, branch office dependence on the central computers was a factor which inhibited staff identification with the whole transaction as the object of their task performance. The pilot unit's lack of control over the entire cycle also affected its performance. The cycle was taking between 10 and 30 days to complete, but the unit only took three days to complete its work on each transaction. The unit supervisor thought that most transactions could be processed in one day if all of the processing was done within the unit.

The pilot unit was not given any production objectives. Its purpose was to try the new work organization design and to improve and refine procedures. Within the scope of the unit's control over its operation, this is being achieved, for example, by eliminating tasks made redundant when employees perform sequences of related tasks previously performed separately by different people. Initially, error rates were high while staff were learning new tasks. Average

keyboard speeds were 40 percent slower than in the ADP input section, but staff in the unit were productive for whole work periods whereas ADP operators only worked five hours per day due to rest breaks. Despite the tension between different seniority levels, employees in the unit have remained enthusiastic about the new work design and have successfully tackled the learning challenges involved. In time, this should reduce or eliminate the division of work between staff based on the types of transactions they deal with.

Early in 1989, the first of several processing modules commenced operation with 75 employees, including the 17 who participated in the pilot unit. Three further modules will be established during the year and the old sections phased out, but several issues remain. Beginning with the staffing of the pilot unit, transfer of employees to the new work design has been voluntary. This continues to be the case, but there is some concern about whether all staff in the old sections will be attracted to the new work organization. Because the pilot unit was located in close physical proximity to the sections, staff in the unit continued to interact with their workmates in the sections, and there was a continuing flow of information about the pilot unit's experiences, which may have helped to reduce anxiety.

Employee demand for places in the new processing modules is very strong at present, but this may be for reasons which are problematic. It appears that more staff are attracted to the new work design because of the opportunities to acquire skills and knowledge which can be used to seek promotion and pay increases than are attracted by the prospect of more interesting and challenging work. There is no public service or departmental objection to rewarding employees for attaining higher performance capabilities, but the processing modules are already having difficulty in meeting the expectations of staff (supported by their unions) that

they will be promoted as soon as they have acquired the new skills and knowledge. In the longer term, this has important implications for the department's and the public service's employment structure. The immediate problem for Department A is that employees are transferring to the processing modules to gain new skills and knowledge and then seeking further transfer to higher-level positions elsewhere if their promotional expectations are not met immediately within the modules.

Other issues concern constraints on the new work design. The effects of branch office dependence on central computers may be reduced or eliminated through a major computer reequipment program. Department A is exploring the possibility that a significant proportion of transactions could be entered into the system directly from outside private computers or public access terminals. This could substantially reduce transactions processing within the department. A more radical but feasible step would be to abolish the department's ongoing transactions with the public in their present form and to replace them with onetime determinations of transaction status, which would change only in accordance with changes in actual status or in government policy. If the current technological change program does not go this far, increasing the control that the processing modules in branch offices have over the processing cycle would seem to require the provision of local computing facilities to perform the same functions for the modules as are currently performed by the central computers, with records of transactions being transmitted to central computers rather than having them involved in the actual processing cycle. Other sections of branch offices could have access to the national system, local systems or both.

The future of the transactions processing modules is affected by current uncertainty about the future of the transactions processing function in Department A. If the

function continues to be performed as at present, or with a reduced volume of work due to direct entry of transactions from outside terminals, it will be necessary to resolve the issues raised by the present division of work among different transaction types; the lack of control by the modules over the processing cycle; and employee expectations of advancement. There are other issues concerning access to high security areas of the department that also constrain the new work design at present. However, considerable progress has been made in the directions intended by the OSI program. There are an increasing number of OSI work redesign initiatives in the department, but it was in the main transactions processing area that traditional work organization and the application of new office technology had interacted to create the most pressing problems and need for change.

Conclusions

The Australian experience with, and response to, RSI has several ramifications. First, an important development may have occurred in the "appreciative system" of the society, or the way in which the phenomenon is collectively perceived, evaluated and acted upon (Vickers, 1965). The disorders known generally as RSI (or occupational overuse syndrome) in Australia are present and prevalent in other countries although known by different names, but Australia is unusual in the extent to which RSI has been recognized as probably or definitely related to work involving VDUs. There has, of course, been a general trend in industrial countries toward greater emphasis on occupational health and safety (Corlett and Richardson, 1981), and this may partly account for the Australian response to RSI. Other factors have been suggested as more peculiar to Australia, e.g., VDUs may have been introduced there more rapidly compared with other

countries. It is more clearly the case that the recognition of worker disablement from VDUs is an achievement for the individuals and groups who sought to have it recognized. This recognition is due also to the strength and attitudes of Australian trade unions which took a leading role in gaining acceptance of RSI cases as legally compensable. The unions have rejected negotiating danger money for keyboard work and, while demanding medical services for their members who work with VDUs, have insisted that the ultimate aim must be to eliminate RSI from the workplace. Although there are suspicions of RSI as mass malingering, these carry little credibility among most employers. The association between VDUs and worker disablement may be disputed for a long time, but it has become an important social and political reality.

The human and economic costs of RSI created strong pressures for rapid effective resolution of the problem. What was known medically and ergonomically about the problem pointed to work organization as an important factor. Several measures have been increasingly adopted by organizations to counter the evident disabling effects of VDUs. The most commonly introduced measures are ergonomic design; susceptibility assessments; operator training; discontinuation of work incentives; rest and exercise periods; and providing mixtures of keyboard and nonkeyboard tasks. Such measures can have some effect in reducing worker disablement, but there is a more fundamental issue. Most Australian organizations adopted visual display technology while retaining bureaucratic work organization design. This increased the repetitiveness of the work and the control imposed on workers, making them vulnerable to injury. When measures were then introduced to prevent disablement, the same bureaucratic work organization design limited the effectiveness of these measures. Management was trying to prevent and control injury <u>for</u> workers without changing the basic characteristics of work

organization that were contributing to the occurrence of injury in the first place.

Effective and stable prevention of worker disablement requires more fundamental redesign of work organization. The high prevalence of RSI particularly among data processing operators in Department A, where traditional bureaucratic work organization had been retained while introducing new technology, is consistent with the contention that bureaucratic/batch designs increase the risk of occupational injury and also constrain the effectiveness of attempted countermeasures. The virtual nonoccurrence of RSI in the special transactions section in Department A and its low prevalence in Department B are associated with socio-technical systems in which task variety and employee control over work are considerably greater.

The Australian government's Office Structures Implementation (OSI) program is broadening the public service's approach to new technology and work design. The OSI is a vehicle for the government as an employer to put into practice the kinds of work organization initiatives which it advocates. These policies encompass not only formal consultative procedures but also workplace issues including work design and employee participation in decisions about their work. While the main transactions processing operation in Department A provided a case where bureaucratic/batch design was associated with comparatively high worker disablement, the new work organization design (in addition to making the work less hazardous) is establishing directions for the democratization of work and for the design of new technical systems to support democratic work.

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