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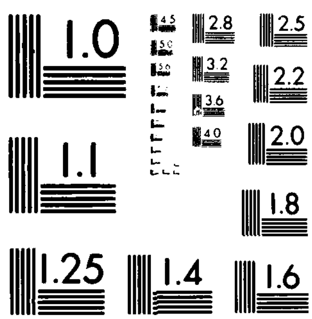

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AUSTRALIA

DEPARTMENT OF DEFENCE

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Systems Technical Memorandum 56

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J.E. GORDON

SUMMARY

Some aspects of the ergonomics of Visual Display Units (VDUs) are examined in this memorandum. Examination of specific vigilance research literature indicated that a serious deterioration of VDU user performance over time would be unlikely to occur when the users monitor and scan for critical information on a VDU screen for long periods of time. Nevertheless it is important to apply ergonomic principles to the choice of VDUs and to the design of the VDU visual environment and workstation in order to optimize the working conditions of the user.

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CONTENTS

1. INTRODUCTION

Computer peripheral devices called Visual Display Units (VDUs)* are becoming commonplace pieces of equipment in many organizations and businesses. This paper was written in reply to a request from an agency within the Department of Defence for advice about the possible influence of VDUs on analytical and vigilance performance. Specifically the question was raised whether analysts scanning large volumes of data on a VDU screen would be able to maintain their performance in recognizing and acting on significant items of information. This query arose as a result of some statements in a report by Emery and Emery (1975) of the Australian National University on the possible long-term effects of television viewing.

For the purposes of this paper, a VDU may be considered to consist of two parts: a keyboard and a display screen. The display of a VDU may be alphanumeric (alphabetic and/or numeric characters, punctuation marks and specialised symbols) or graphic (graphs or complex shapes) or both. The display screen is usually some form of cathode ray tube (CRT). In the operation of the CRT, the cathode emits a stream of electrons which are accelerated and focused in to a beam aimed at the screen centre by an electron gun assembly. The beam, after passing through a deflection system, impacts on the phosphor-coated screen surface to form a spot of light. Suitably rapid deflection of the beam allows sequential 'writing' on the screen. CRTs may differ in their capability of storing images on the screen and in their methods of focus and deflection control. The images displayed are generally monochrome but colour is being increasingly used in some applications where the extra expense is thought justified.

The following discussion will be limited generally to refreshed VDUs (in which the image must be continually refreshed a few tens of times each second to present an apparently steady image) with alphanumeric displays. The two basic beam-deflection schemes in alphanumeric display units are:

(i) raster scan in which an image is generated by an electron beam moving in line-by-line sweep across the entire display surface; and

(ii) directed beam in which the line elements of a display image are traced in any sequence given, e.g. by a computer program.

The requesting agency described one type of VDU work, namely data retrieval. However a VDU can also have other functions which differ in the degree of interaction between the user, the VDU and the computer system. Following Auerbach Publishers (1971), four basic functions of

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* an equivalent term is Visual Display Terminal (VDT).

alphanumeric VDUs are:

(i) data entry which involves entering data into the computer. The computer acknowledges the receipt of the data and the display usually shows data-entry forms or operational instructions for the operator;

(ii) data retrieval which involves the retrieval of previously stored data from a file or a system. This function typically results in a large amount of data being transmitted to the user for a small amount of input;

(iii) inquiry/response which uses two-way transmission between the user and the computer to aid the user in completing the task; and

(iv) monitoring and control which automatically informs the user when changes occur and allows him/her to interrogate the status of various aspects of the operation.

The report by Emery and Emery (1975) entitled 'A choice of futures - to enlighten or inform' was primarily concerned with the role of the media as a means of communication in society. Five main hypotheses with regard to possible adverse effects of television viewing were advanced. The Emerys attempted to establish a physiological basis for these hypotheses by describing research into the functions of the brain, but in the present author's opinion, they did not establish an adequate causal relationship between the claimed effects and specific cortical processes. Any attempt to extrapolate from these conclusions to the VDU task is inappropriate also because of the basic differences between the interactive VDU task and essentially passive television viewing.

In this paper specific literature on vigilance research is reviewed to determine if and to what extent the monitoring and scanning ability of a VDU user becomes degraded over time. Other factors which could influence operator performance and wellbeing are also discussed, namely the visual environment of VDUs, workplace design and various personal and social factors associated with the VDU task.

2. OPERATOR PERFORMANCE AND WELLBEING IN VDU OPERATION

2.1 Vigilance Aspects

Vigilance research involves the study of individuals keeping watch for unexpected signals during fairly long periods, viz. more than say a half hour. The research is clearly applicable to one aspect of the VDU task, namely the monitoring and scanning of information on the screen. This could involve searching for specific items of information or even for random errors found as a result of proofreading. A small but relevant sample of the vigilance literature pertaining to the VDU task will now be discussed.

Research into visual monitoring has traditionally been associated with sonar and air surveillance Plan Position Indicator (PPI) scopes (see Baker 1962). On these displays, a target is usually represented by a small spot of light (blip) brighter than the background picture. The range and bearing of the target is indicated by the image's position on the scope. The task is often made more difficult by the presence of background 'clutter' and visual 'noise' (i.e. false signals).

An early important study of vigilance was performed by Mackworth (1944) in which an observer was required to detect a double jump of a clock hand which moved in otherwise steady increments around a dial. The 25 observers missed on average 15 percent of the signals in the first half-hour and 26, 27 and 28 percent in the following three half-hour periods respectively. Mackworth concluded with a recommendation that '... radar operators should do no more than ½ an hour at the radar set ...' at one time without a rest pause.

The visual displays of VDUs involve relatively persistent and numerous alphanumeric signals on the screen. In a series of papers, Adams and his colleagues investigated various aspects of monitoring a complex visual display. The task simulated a semi-automatic air defence system (Adams, Stenson and Humes 1961; Adams, Humes and Stenson 1962; Adams, Humes and Sieveking 1963). Alphanumeric symbols were rear-projected from a film onto a screen and the filmstrip was advanced every 4 seconds. In the 1961 experiment, subjects were exposed to either 6 or 36 symbols and the required response was to press a button whenever a particular symbol occurred. The detection latency (response time for a detection) was found to be significantly longer in the 36 symbol condition. However performance decrement (the increase in detection latency) was the same in both conditions, approximately one second over a three-hour session.

This research of Adams et al. was mainly conducted with tasks which were 'normally-off' in the sense that the display was blank except for the occasional occurrences of critical signals. However most displays in operational man-machine systems are 'normally-on' where each stimulus source has a reference value showing and the monitoring task is to detect a change in this value. The display might also be cluttered with electronic noise which may cause the reference values to wander or jitter. Webber and Adams (1964) investigated the effect of three different types of displays ('normally-on' with and without noise;

and 'normally-off') and found that the 'normally-off' display resulted in better detection performance. However the type of display had no effect on vigilance decrement (defined as a statistically significant increase in response time over the session). In fact, the amount of decrement was only 2 to 3 seconds despite the long monitoring session of six hours.

Howell, Johnston and Goldstein (1966) employed a different complex monitoring task. They used a CRT display on which subjects observed an 8 x 8 matrix of computer-generated alphanumeric signals. The appropriate response was a button press each time a signal was randomly added to or removed from the display as well as the identification (via a light pen) of the location and type of signal. Amongst the different variables investigated, four stimulus densities (4, 8, 16 and 32 stimuli per display) and two levels of signal frequency (30 and 75 per hour) were employed. Their results were in partial disagreement with Adams' (1961) work. The lower density conditions were not accompanied by significant increases in mean detection latency over the 120-minute session. However there was a significant vigilance decrement in the high density, low signal frequency condition, ranging from 8 to 22 seconds. Additionally, an increased occurrence of very long latencies which were interpreted as brief lapses of attention were noted in this condition. Similar experimental results were obtained by Thackray, Bailey and Touchstone (1979).

The phenomenon of lapses of attention has also been found in other tasks of long duration. Stave (1977) examined pilot performance (deviation from desired flight path) in a fixed-base helicopter simulator. Subjects flew the simulator for periods ranging between three and eight hours (with occasional rest periods of 4 to 8 minutes duration) while exposed to vibration and noise. Despite reports of extreme fatigue, subject performance tended to improve as environmental stress increased. However there was also evidence of attention lapses resulting in extremely poor performance of a few seconds duration which occurred unpredictably throughout the experimental session. Stave concluded that overall subject performance depended largely on motivation.

The tentative conclusion to be drawn from this research is that a performance decrement with concomitant occasional lapses of attention might be found in operational monitoring tasks under conditions of high target density which we might interpret as a heavy perceptual workload. (This conclusion is applicable to the case where the subject is motivated to perform the task and the subject's normal sleep-work-rest diurnal cycle is undisturbed (see Craig, Wilkinson and Colquhoun 1981)). It is generally accepted in human performance literature, for example Cumming and Croft (1973), that at low rates of task loading, an individual's task performance can be proportional to the load demand. However as the demand increases, performance increases only up to some maximum value after which it decreases with further increases in demand. The Yerkes-Dodson law, derived from some experiments performed in 1908, is also relevant to the present discussion. In essence this law states that as task difficulty increases, an individual's optimum anxiety or arousal level decreases. Thus one could hypothesize that a new, unpracticed VDU operator with a high level of arousal would perform adequately on VDU tasks with a low perceptual workload and less ably on VDU tasks with a high workload. As the operator gained experience and approached the VDU task with a lower anxiety level, one would expect that the individual would handle both simple and difficult tasks more efficiently.

Specifically with reference to the VDU task, these studies suggest that a VDU operator might show a deterioration of monitoring performance if scanning a full VDU display for long periods of time. However it is the opinion of the present author that the performance decrement and attention lapses of a VDU user would be unlikely to be as serious as that found in the vigilance experiments described above for several reasons. Firstly a VDU screen is not necessarily kept full with data; in many tasks the operator may request or control the amount of information required for viewing. Generally, with the exception of proofreading work, the data appearing on the VDU screen has a more ordered and predictable format than the random stimuli used in the vigilance experiments. Moreover, the VDU operator's work is usually more varied than simply monitoring a screen for signals and pressing one or two response buttons. The VDU user's activities include reading source documents, monitoring the screen and communicating with the computer system and there are often opportunities for rest pauses. Vigilance performance can be greatly improved when short periods of rest (see Stave 1977), conversation, and/or mild physical or mental exercise are introduced into the vigilance situation (Stroh 1971).

2.2 The Visual Environment

The efficacy and well being of a VDU user is closely related to the VDU visual environment and workplace design. Over the last ten years there has been an increasing awareness of complaints of fatigue and visual fatigue from VDU operators. Ostberg (1975) distinguished four types of symptoms giving rise to these complaints:

(i) ocular symptoms - eye discomfort and sensations that the eyes are tense, heavy, dry, burning, aching, throbbing or tender;

(ii) visual symptoms - perceptual difficulties which may be unpleasant without actually causing pain, for example fixation or focusing problems;

(iii) systemic symptoms - usually headaches or general aches in the neck and arms; and

(iv) behavioural symptoms - a conglomerate of voluntary and involuntary actions taken by the individual to overcome other problems; for example a certain posture may be taken up to make a visual task easier or to avoid glare from light sources or reflections in the visual field.

The condition of visual fatigue (largely covered by (i) and (ii) in the above list) is termed asthenopia by the ophthalmic professions and is loosely called eye strain. The one defining characteristic of asthenopia is that the symptoms are always associated with visual work and are alleviated by cessation of the visual task (Cole 1979).

The poor quality of the images on a VDU screen is recognised as one of the major causes of visual fatigue. The image quality is dependent, inter-alia, upon the luminance of the images on the screen, their contrast with the screen background luminance, and the spacing, shape, size and colour of the characters. General recommendations about the desirable level of image quality are given, for example, in the 'The VDT Manual' by Cakir et al. (1979).

The characters on a VDU display are quantized and intermittent. In a raster scan, the characters are usually 'written' on the screen by an electron beam as it scans across the phosphor-covered surface of the CRT screen. It is only on the raster scan lines that the dots or small stripes are written and these marks together form the character (usually formed from a dot or segment matrix of 7 x 5 or 9 x 7). The result is an image which is slightly 'blurred' compared to its printed equivalent. As soon as an image is formed on a CRT screen, it starts to fade at a rate which is dependent on the persistence of the screen phosphor. In order to maintain the appearance of a steady image, the character has to be refreshed continually, otherwise the display will fade, perhaps at a rate perceived as instantaneous. The refresh rate (alternatively referred to as regeneration rate, update time or frame rate) is the frequency (in hertz) with which a displayed image is reproduced.

Ross (1979) stated that the best way to present this quantized character display '... may well be not as close as can be, not as bright as can be, not at the highest contrast that might be achievable, but at a combination of conditions. This allows the interpretive part of the visual system to receive the information that it requires for recognition and allows it to ignore ... that information which complicates the process of recognition' (Ross 1979, pp49, 50).

The contrast (C) of the characters on the screen is primarily affected by the symbol and background luminances. The ambient illumination of the workplace also interacts with the intrinsic contrast of the image in the following manner:

$$C = \frac{L_s - L_b + L_a}{L_b + L_a}$$

where L_s = internally produced symbol luminance

L_b = internally produced background luminance, and

L_a = luminance of reflected ambient light.

Positive contrast (light characters on dark background) is almost universally used on VDUs rather than negative contrast (dark characters on light background) which is used primarily for 'hard copy' (like this document). It is generally found that because of the 'soft' outline of VDU images, the actual image contrast achieved is generally less than that recommended by researchers for optimum viewing. In order to achieve an increase in perceived contrast one can either reduce L_b or L_a or increase L_s. Currently the most common method of enhancing CRT contrast is to reduce the reflected ambient illumination by decreasing the room lighting or by fitting some sort of polarizing or absorbing (maybe even spectrally selective) filter or fine mesh over the screen which reduces L_a more than L_s and L_b. Cakir et al. (1979) recommended an illuminance of 300 to 500 lux as appropriate for reading of source documents in the VDU workplace. The aim should be to provide a visual environment such that there are not severe differences in the luminance levels of the VDU, the desk area and the room, so that there is a practical limit to the increase of contrast that can be gained from reducing L_a.

Prominent and distracting reflections on the CRT screen are a common but undesirable result when VDUs are introduced into an environment not specifically designed to avoid this problem. A partial solution is to ensure that there is adequate glare shielding on a VDU to minimise glare arising from specular and diffuse reflections from the screen surfaces (viz. phosphor, face plate, cover glass and filter surfaces). Glare, more precisely disability glare and discomfort glare, is caused by extensive and/or bright light sources (glare sources) in the visual field. The distinction is that disability glare degrades the ability to perform a visual task whereas discomfort glare only causes visual discomfort. Often the two go together, however. Spotlighting with a directional baffle attachment to reduce stray illumination may also be a solution for the lighting of VDU workstations (see Anderson and Clark 1980).

Glare shielding the surface of the display screen can be accomplished by the use of the filters or mesh mentioned above or by applying an anti-reflective (interference) coating. However, the simplest and most effective solution to reduce the luminance of specular reflections is to adjust the position of the VDU in relation to the sources of the reflections, that is, relocate the VDU in the workplace. In a similar vein the wearing of dark clothing by VDU users is sometimes useful in reducing the effect of reflections.

An appropriate refresh rate for VDU screens is necessary to reduce visual fatigue (Cole 1979). At low refresh rates, the display can be seen flickering. If the refresh rate is increased to the critical fusion frequency (CFF) the flicker is no longer visible. Therefore to eliminate flicker, the refresh rate must be equal to or greater than the CFF. The CFF itself depends on factors such as the display luminance, the ambient illuminance, the screen phosphor, the visual angle subtended by the display, and the location of the stimulus on the retina (Meister and Sullivan 1969). Barmack and Sinaiko (1966) pointed out that '... flicker is likely to be a problem only when the stimulation is very intense and a large area of the retina is affected. Further, there are wide individual differences among viewers in response to intermittent [visual] stimulation'.

In practice, the phosphor characteristics are an important determinant of the required refresh rate but the raster scan sequence is also a consideration. Dill and Gould (1970) systematically varied phosphor persistence and raster scan sequence in order to try and achieve a flicker-free CRT display. They found that the pseudorandom*, random** and dot-line interlace*** scan orders reduced the disturbing effects of flicker but did not substantially reduce the rate at which the flicker occurred except for the long persistence phosphors. It should be noted that the most commonly used phosphors are in the short to medium persistence range and that long persistence phosphors usually have a shorter tube life (Poole 1966). Gould (1968) and Stewart, Ostberg and Mackay (1974) recommended that for the commonly used short to medium persistence phosphors (P4, P31, etc.), the refresh rate should be approximately 50 to 60 hertz to provide a flicker-free display.

Definitions from Dill and Gould (1970):

* Pseudorandom scanning of CRT displays consisted of dividing the display into a matrix of cells in which the electron beam scanned one or more points in one cell and then jumped randomly to a different cell.

** The random scan order referred to one in which raster lines were scanned in random order.

*** The dot-line interlace scan order consisted of each horizontal row of dots being scanned progressively. However only one of every four consecutive dots in each row was illuminated during a single scan. A different one-quarter of the dots was illuminated during each of four successive progressive scans.

The type of phosphor also determines the colour of characters on the screen. Little research has been performed in this area but anecdotal second-hand evidence from radar operators indicates that orange phosphors (such as P7, P28 and P33) are viewed unfavourably and that green-coloured phosphors (such as P31) are more acceptable to the observer.

The perceptually undesirable effects of the intermittency of the VDU images can thus be controlled but a potential problem does arise if the intermittency is in combination with image instability (for instance, jitter or drift of the images). Ross (1979) explained this situation in terms of our visual system. As the characters are 'painted' point by point at a refresh rate of say 50 hertz, then each point should come up precisely in the same spot. However if there is instability in the system and the point comes up in a slightly different spot, a quite different part of our interpretive system says '... I see movement, I want to interpret this picture in a different way' (Ross 1979). Thus it is important to reduce any perceptible image instability by identifying the source and fixing the problem. A common cause is mains interference in the VDU d.c. supply which can be minimised by careful screening and positioning of the components in the VDU.

Scrolling is a useful VDU option which eases the task of reading large amounts of displayed information. In this mode of display, the screen is used as if it were a continuous roll of paper with the top or oldest line disappearing from the screen as the newest line appears at the bottom, all intervening lines moving up one position. This technique maintains the continuity of reading a block of information. Various degrees of scrolling smoothness are also available. This mode contrasts with the paging technique in which one page of information is displayed at a time and the framing mode in which a skeleton of a document page is displayed ready for the operator to fill in.

2.3 Workplace Design

The working posture of a VDU user can cause or aggravate visual fatigue because 'people will adopt postures which improve matters in the short term but cause them fatigue and strain in the longer term' (Stewart 1979, p13). Muscular discomfort associated with sustained postures is known as static loading and may involve interference with the circulatory functioning of some part of the body (Komoike and Horiguchi 1971).

Various recommendations can be made with the intention to optimize a VDU user's posture in the workplace:

(i) The keyboard of the VDU should be separate from the VDU screen and the screen should be adjusted for viewing angle at approximately near normal incidence. Non-fixed equipment is generally a minimum requirement to allow operators from a population with a range of physical dimensions sufficient flexibility to achieve both keying and viewing comfort. Stewart (1979) stated that at the optimum keyboard height, the forearms are approximately horizontal, and that at the optimum screen height, the line of sight of the operator is 35° to 40° below the horizontal.

(ii) Document holders of a simple lectern variety should be provided so that the operator can avoid twisting or bending to read a source document. There should also be sufficient work surfaces for the study or sorting of whatever documents the operator has to deal with, especially if they are large documents such as computer printouts.

(iii) The operator's chair should be adjustable for height (preferably 440 mm to 520 mm), rake and lumbar support. The chair should be of a swivel type with a sturdy base. A footrest should be used as necessary (e.g. in the case of short individuals) to avoid undue pressure at the back of the thigh near the knee.

(iv) There should be a minimum knee clearance of 200 mm between the seat cushion (compressed) and the underside of the desk top so that the operator can freely move his/her legs under the table.

Attention should also be given to general environmental factors which are likely to affect VDU user performance. There should be visual relief areas in the room (for example, indoor plants or paintings on the wall) which would provide the opportunity to rest the accommodation and convergence muscles of the eye by viewing relatively distant objects. Air conditioning of the room may be required, depending on the circumstances, because computer peripheral equipment unavoidably emits heat when operating. Also the noise level of the VDU room should be measured. Cakir et al. (1979) recommended a noise level of less than 55 dB(A) in task areas requiring a high level of concentration and less than 65 dB(A) in routine task areas.

2.4 Personal and Social Factors

It was emphasized in the 1979 'Ergonomics and Visual Display Units' Conference (McPhee and Howie 1979) that the health and age of a VDU operator can largely determine the likelihood, severity and consequences of 'eye strain' for the operator.

VDU operation typically involves work at near visual distances. Cole (1979) pointed out that operators with a visual acuity of less than 6/9* or who have unstable binocular co-ordination or convergence insufficiency were likely to suffer visual discomfort after prolonged VDU use. Moreover if the VDU employs colour coding in its display, colour-defective operators may be disadvantaged. The progressive and inevitable loss with age of the eye's automatic focusing capacity (called accommodation) is also an important consideration. The critical age for this loss is about 45 years for the majority of the population by which time accommodation is just sufficient to enable objects at usual working distances to be seen clearly but with discomfort after long working sessions.

A need therefore exists for prospective and current VDU operators to have regular eye examination in order to check for uncorrected or inadequately corrected visual defects. This need is certainly not confined to VDU jobs but is applicable in many other visually demanding tasks as well.

Many of the psychological and social factors associated with VDUs were described in an evaluation of a computer-based system for aviation flight service specialists in Atlanta and Macon Flight Service Stations (FSS) in Georgia, USA (Milligan and Rosenberg 1979). An automated system of providing aviation weather and Notice to Airmen (NOTAM) information via VDUs was introduced in the late 1970s. Subjective opinions from the users were collected concerning the acceptance of the automated system. The Atlanta users were generally

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* Tests of visual acuity or resolving power of the eye involve the discrimination between spatial configurations that lead to differing sensations only if details of a given angular subtense are resolved, for example the legibility of letters on a Snellen chart. The convention that visual acuity tests are carried out with objects or charts at 6 m or 20 ft is the origin for designating 1' of arc (accepted as 'normal' visual acuity) as 6/6 (or 20/20) visual acuity. Thus a letter with a stroke width subtending 1' of arc at 6 m can then be resolved at 6 m. A visual acuity ratio of smaller than 6/6 (for example 6/9) represents a resolving capacity somewhat poorer than 'normal'. The converse is true for a ratio larger than 6/6 (for example 6/4).

impressed with the improvement in the quality of service and the morale level. Eyestrain was considered a problem. The Macon users, in contrast, were dissatisfied with the automated system mainly due to the slow response time of the computer at Macon FSS. The response time at Atlanta FSS was significantly faster. Over a period of a year's experience with the new system, the attitudes of the users became increasingly less critical, particularly with regard to eyestrain, as work experience was gained and ergonomic improvements were implemented.

3. DEFINITION OF SYSTEM REQUIREMENTS

It is important that employers should carefully consider the type of work which their VDU users are required to perform. In common with microfiche viewing devices, VDUs have advantages such as rapid access to compact data storage and no material waste if the screen content is erased or stored away because the information is no longer of immediate interest. However VDU images (usually single page) can generate frustration in a user who needs to annotate or underline items, or compare items on separate pages of the source documents(s). The use of suitable hard-copy printers for any work of this nature would seem to be essential from the point of view of avoiding a major source of job dissatisfaction and the likely accompanying signs of physical and psychological disorders. In other words, VDUs should only be used to advantage and not used as a substitute for more suitable methods of information display in misguided attempts at economy.

4. RECOMMENDATIONS

General recommendations can be made to optimize the choice, implementation and use of VDUs:

(i) the visual environment of VDUs should avoid excessive luminance ratios;

(ii) adequate VDU glare shielding as well as workplace layout factors should be considered to reduce any glare problems in the VDU environment;

(iii) the source of any VDU image instability should be carefully investigated and the instability eliminated;

(iv) the keyboard of a VDU should be separate from the VDU screen and there should be adjustability for screen angle;

(v) the chair of a VDU user should be adjustable for height, rake and lumbar support, with separate footrests to be used as necessary (e.g. in the case of shorter users);

(vi) document holders of a simple lectern variety and sufficient work surfaces should be provided;

(vii) a VDU user's work should be a mix of different activities and regular rest pauses in order to assist in the maintenance of job performance and satisfaction; and

(viii) the smooth scrolling of displayed information on VDU screens can ease the task of reading large amounts of material.

5. CONCLUSIONS

Examination of the report by Emery and Emery (1975) on the role of the media in society leads to the conclusion that their report is of questionable relevance to the request for advice on the effects of using VDUs. Emery and Emery failed to establish an adequate causal argument for the claimed adverse effects of television viewing.

In this memorandum, specific vigilance research was reviewed to determine the possible influence of monitoring information on a VDU screen for long periods of time on user performance. It appears unlikely that there would be a serious deterioration of performance over time in the course of a working day when analysts scan for critical information on a VDU screen under self-paced information presentation rates. However the VDU user's work should involve a mix of activities and regular rest pauses, and VDUs should not be used for tasks in which hard copy printers or other computer peripherals are more effective. Attention should also be given to apply ergonomic principles to the choice of VDUs and the design of the VDU visual environment and workstation in order to optimize the working conditions of the user.

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16.Abstract

Some aspects of the ergonomics of Visual Display Units (VDUs) are examined in this memorandum. Examination of specific vigilance research literature indicated that a serious deterioration of VDU user performance over time would be unlikely to occur when the users monitor and scan for critical information on a VDU screen for long periods of time. Nevertheless it is important to apply ergonomic principles to the choice of VDUs and to the design of the VDU visual environment and workstation in order to optimize the working conditions of the user.

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