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A comparison of the effects of reading from a VDU and from paper as measured in terms of reading speed and comprehension

Elizabeth Payumo
Edith Cowan University

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**A Comparison of the Effects
of Reading from a VDU and from Paper
as Measured in terms of Reading Speed
and Comprehension.**

Elizabeth Calilung Payumo

A thesis submitted in fulfilment of the
requirements for the degree of
Master of Applied Science (Computer Studies)
at the Edith Cowan University,
Perth, Western Australia.

January 1992

ABSTRACT

**A Comparison of the Effects
of Reading from a VDU and from Paper
as Measured in terms of Reading Speed and Comprehension**

Elizabeth C. Payumo

This study investigates the legibility and visual effects of eight combinations of font and colour on VDU and two different fonts on paper. Forty subjects, sixteen females and twenty-four males, were exposed to three of the ten different conditions, one in each of the set of readings, on either VDU or paper. They were asked to read different sets of stories in each condition on different days where each condition lasted for approximately two hours. Reading speed and comprehension scores were measured in every story read in the set of stories. The change of mood and physical symptoms states of the subjects were measured at the beginning and end of each conditions. Subjective ranking of the combinations of font and colour in the VDU environment were elicited from the subjects.

Subjects read at approximately the same speed on both VDU and paper media; however, there was a tendency

to read faster in the following order of the presentation medium: paper, VDU white/blue and VDU yellow/black. The subjects read 0.66% and 1.88% faster from the paper medium than the VDU white/blue and VDU yellow/black presentation media, respectively. Comprehension scores were not statistically affected by font and presentation medium, although the VDU white/black combination was associated with better performance. The time required to refresh the VDU screen with Helvetica font was 45.16% (2.8 seconds) faster than a screen with Chicago font; however, the difference was not statistically significant.

The subjects' font and colour combination preferences seem to be correlated with their reading speed performance. It was observed, however, that rankings were generally based on the colour combinations and that font had little influence on ranking.

Fatigue (as measured by the POMS and Physical Symptoms Questionnaires) was evident after reading for the maximum period of 2 hours and was found to be induced by the presentation medium and reading duration. In general, extreme fatigue and visual discomfort were associated with the VDU white/black and VDU black/green colour combinations. On the other hand, VDU yellow/black and the paper media induced the least fatigue upon the subjects.

Declaration by Candidate

I certify that this thesis does not incorporate, without acknowledgement, any material previously submitted for a degree or diploma in any institution of higher education and that, to the best of my knowledge and belief, it does not contain any material previously published or written by another person except where due reference is made in the text.

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Special Thanks are also extended to my fellow master's student, Mr Winston Tabada, for his assistance in the programming of the fonts and the screen displays which served as the screen stimuli.

I also wish to express my genuine appreciation to the students who participated as subjects in this research.

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E. C. Payumo

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1. RATIONALE FOR THE STUDY

1.1. Introduction

In the 1990s, more and more information is presented to human users on some form of computer based system. A typical example is a library environment where information about books, periodicals, and other resources is accessed via a computer. Even communications are transmitted via electronic mail and usually read from a screen or VDU. It was predicted by Guiliano (1982) that, by 1990, there would be " . . . more than 40 million VDTs in the workplace, 25 million in the home, and 7 to 8 million portable units" (Helander et al., 1984, p. 185) by 1990s. This means that a good deal of the communications will be read from VDU rather than from paper. In the educational systems, tutorial lessons are now also undertaken on computer screens where users can interactively communicate with the software being used.

Mechanisms exist whereby published information across the world may be accessed by people from the privacy of their home by using their personal computer or videotex. One possible scenario might be displaying a best-seller novel via the personal computer or home television sets attached to a computer of the subscriber. A possible question which may arise is

whether it is feasible to read text on the VDU for extended periods of time in the same way that people often read books for lengthy periods. In summary, the continued growth of the use of screen based devices for the presentation of information will continue.

Despite the fact that materials presented on paper are more permanent and are easy to transport, the use of screen displays is becoming common in private offices and work areas. With the continued increase in the use of screens for communicating information, there is a need to determine the factors which will make the user at ease and comfortable when using the screen display medium.

The use of a VDU is claimed to provide many advantages; in particular, information can be retrieved quicker, with greater flexibility, and information can be stored in a medium that is less bulky (Osborne and Holton, 1988). If these advantages offered are to be widely accepted, the comfort of using the VDU must match that of the paper medium it is to replace. To ensure that a screen based medium is accepted, reading and comprehending information from a VDU must be as easy and as efficient as when it is presented on paper.

One emerging technology today is Automatic Speech Recognition (ASR) which does not require a keyboard to

input data on the VDU screen. This technology aims to "create reports with the speed advantage of dictation with immediate inspection and correction of handwriting" (Kurzweil, 1989, p. 279). According to Kurzweil, it is four to six times faster than hunt-and-peck typing. Early implementation of ASR systems include "pathology and surgical notes in health care, law and certain financial services such as real estate and insurance" (Kurzweil, 1989, p. 279). In the meantime, their capabilities are still being improved because none of the existing ASR systems could provide more than one of the following capabilities: "(a) recognise a large vocabulary (10,000 words or more), (b) recognise continuous speech, and (c) provide speaker independence (no user training)" (Kurzweil, 1989, p. 288).

Thus, the use of a keyboard and VDU screen in storing, retrieving, and reading information will still be in demand and is likely to remain so in the immediate future.

To utilise the displayed text on the VDU it must be read and comprehended. A large amount of research in the area of human-machine interface has been conducted with the emphasis on the context of tasks rather than the reading of connected text. Because text presented on a VDU needs to be read and understood, comprehension

also needs to be measured, especially if the text presented is for tutorial or decision-making purposes. In this pursuit, it became important to understand more directly how computer displayed text affects the reading process (speed, comprehension, comfort) rather than simple scanning rates or character-recognition threshold measurements which have characterised much of the experimental research to date.

Earlier studies in this area generally reported that reading from a VDU display is significantly slower than reading from paper (Gould and Grischkowsky, 1982; 1984; 1986; Kak, 1981; Kruk and Muter, 1984; Muter, Latremouille, Treurniet and Beam, 1982; Wright and Lickorish, 1983). Only a few have reported no difference in reading speed (Cushman, 1986; Switchenko, 1984; Osborne and Holton, 1988; Gould et al., 1987c). However, no matter how small the difference is, Gould et al. (1987a) reported that "the reading speed deficit is nevertheless real" (p. 497).

Results from studies to date are inconclusive with regard to:

1. whether there is a speed difference between reading on the VDU and on paper, and
2. if there is, what are the most probable factors causing or influencing this difference.

In view of the report of Osborne and Holton (1988) that the reading speed difference in some previous studies was due to the "general lack of consistency within the experimental methods and stimuli used" (p. 4), this study has been designed to control as many variables as possible within the experimental situation. These include:

1. posture, polarity, line length, page layout;
2. the homogeneity of the respondents (familiarity with VDU and computer environment);
3. degree of difficulty of the text to be used in the study; and
4. uniformity of paper and VDU media set-up (Waern and Rollenhagen, 1983).

These variables need to be reexamined by controlling as many variables as possible so as to identify those factors that affect the reading speed on a VDU. If these variables can be identified correctly, then other measures could be taken to improve the reading environment using a VDU. One of the aims of this research is to identify factors which can improve the reading conditions from a VDU. To date, there seems no consistent evidence as to why reading from a VDU is slower compared to reading from paper.

1.2. Background and Factors Contributing to the Problem

The increasingly familiar sight and extensive use of VDUs and microcomputers in modern offices is one of the reasons why they are devices of considerable concern and study. The increasing number of VDUs being used in a workplace environment is "indicative of a growing trend toward automation of office procedure" (Dainoff et al., p. 421, 1981). It was reported by Galitz (1980) that "there are relatively large numbers of individuals involved with VDT operation who have had little or no training in, or familiarity with, the basic operation of computer systems" (Dainoff et. al., 1981, p. 421). With the increasing demand of information retrieval via a VDU, Chung et al. (1987, p. 129) reported that "as the number of CRT users increases the number of complaints increases". Several complaints were reported by office workers who were required to work with a VDU on an extensive daily basis. Prolonged exposure of a user to a VDU has been reported to produce discomfort (viz., arm, shoulder, and back pain and headache) as well as fatigue (Dainoff et al., 1981; Morrissey and Bittner, 1986).

Aside from the negative reports associated with VDU use mentioned above, it is also believed that

reading from a VDU is slower compared to reading from printed text. Despite these positions, VDUs are still gaining popularity as a means of displaying information. Thus, great attention should be given to improving the present standards of VDU presentation. The following are the reasons which provided impetus to this study.

1.2.1. The increasing Demand for VDU Use in Various Applications

The introduction of computers in the business environment has led to quick information storage and retrieval, interactive computing, word processing and database uses, and computer-aided instruction. The VDU (including microcomputer screens) has become a standard medium for displaying information. Chung and Ogino (1987) claimed that the time spent in front of a VDU has "dramatically increased" (p. 129). This is because of the flexibility in the storage and retrieval of information that the technology can offer. If these advantages are to be accepted by the user, the VDU operation must not present obstacles and must equal the ease of use and effectiveness of the medium it is supposed to replace (Osborne and Holton, 1988). This means that reading and comprehending information from a VDU should be as easy and as efficient as when it is presented on paper.

1.2.2. Feasibility of Reading Textual Material from a VDU for an Extended Period

Tutorial lessons are often presented via a VDU screen. Software package developers are now integrating tutorial lessons with the software they are producing. In some software products, particularly the "shareware" market, written manuals are no longer provided since all documentations are provided through the user's help screen. Some schools have also began introducing individualised instruction where students learn by themselves via the information presented on the VDU.

To date, there seems to be very few studies which considered the extended use of a VDU for tutorial purposes. The feasibility of having tutorial lessons for a period of less than two hours may save many people who cannot, for some reason, receive formal education in school especially those who are handicapped. This will enable them to learn at their own pace, where the bright students can have advanced lessons whereas the slow learners can have supplementary lessons if required.

1.2.3. Safety and Comfort of the User

The number of complaints from users of VDUs has increased dramatically over the last decade. Among these complaints are the following: (a) severe headaches, (b) neck pains, (c) eye strain, (d) blurred

and double vision, (e) musculoskeletal problems, and (f) postural discomfort (Smith et al., 1981) as cited by Moussaoui and Freivalds (1986, p. 267). As the VDU becomes a common medium for reading information, public concern regarding its effect to users is growing.

Some studies were undertaken to determine the cause of these complaints with a view to the improvement of the quality of VDU display. In addition to the long duration of a reading task, it was reported that poor character legibility also causes fatigue problems and that it affects user-VDU interaction in such a way that it is more difficult to discriminate between characters (Raouf and Hatami, 1985). Raouf et al. (1985) believed that more effort is exerted by the user's eye leading to fatigue. Thus in the present study, a VDU screen, with relatively high resolution that does not flicker or wobble, was used. Glare was also taken into account by using window blinds to ensure a good reading environment which was free of glare.

1.3. Importance of this Study

Based on the results of this study, it may be possible to determine if sustained reading is feasible in a reading for comprehension task. Results of this study may lead to a recommendation as to whether reading

continuous text for a maximum period of 2 hours with rest breaks of about 5 minutes every 15 minutes would be viable (without experiencing visual fatigue, eye strain, headaches, and other ergonomic problems).

Results of the present study may also identify for a reading for comprehension task the colour combinations suitable for textual presentations which enhance reading speed and comprehension performances. Moreover, the study may produce significant results which may specify the probable factors that place the VDU at a disadvantage over printed text in terms of reading speed. Based on the results, some recommendations may be made as to how to alleviate the present reading conditions on VDUs which would improve text readability as well as optimising reading speed and comprehension. As reported by earlier studies, the image quality of the characters displayed on a VDU affects reading speed whereas flicker and jitter can induce visual discomfort. The effects of these variables on extended reading might further enhance visual fatigue if not properly considered and controlled. Recommendations can be derived on how to improve character legibility in such a way that reading speed will be improved and visual fatigue may be reduced.

In addition, the findings of this study may aid people concerned with designing the layout of the text to be presented on the screen. Designers would need to consider such factors as the optimum number of characters per line, number of lines per page, polarity, screen resolution, font style, and colour coding. Adjustments in these areas could improve the quality of the image displayed on the screen and will therefore improve the character legibility and readability from the VDU.

1.4. Definition of Terms

Throughout this study reference will be made to various terms which are defined below.

Accommodation

The mechanism of keeping a sharp image on the retina of the eye necessary for discriminating different letters when reading (Moussaoui and Freivalds, 1986, p. 271).

Anti-aliasing

To enhance the perceptual goodness of the VDU characters, presumably by enhancing their perceived resolution or by increasing the screen addressability (Gould et al., 1987c, p. 8).

Asterisk (*)

An asterisk in the "Source" column of an Analysis of Variance (ANOVA) table in the Appendix signifies a source of variation due to the interaction of two or more variables surrounding it.

Bandwidth

A measure of the speed at which a monitor can redraw the screen display (Wiswell et al., 1987, p. 109).

Character descenders

The descenders for the lower case letters such as g, j, p, q and y presented below the line are referred to as "descenders below the line". On

the other hand, when letters g, j, p, q, and y are presented above the line such that they occupy the same amount of space as letter a, they are referred to as "characters without descenders" or "descenders above the line" (Mills and Weldon, 1987, p. 337).

Contrast

A term used to describe the perceived difference in colour or brightness or both of the objects within a particular field of vision or from one point in time to another (Cakir et al., 1980, p. 66).

Colour1/Colour2

Colour1 refers to the colour of the text/letter (foreground) whereas Colour2 refers to the background colour of the text/letter (background).

Fixation duration

The time spent fixating a target in order to process the information further (Kolars, Duchnick, and Ferguson, 1981, p. 523).

Fixation frequency

The number of times a reader pauses when reading a line of print (Gould, Alfaro, Barnes, Finn, Minuto and Grischowsky, 1987b, p. 282).

Fixed character width

Narrow letters such as i and l occupy the same amount of space as wide characters as m and w (Mills and Weldon, 1987, p.337).

Glare

A visual condition that occurs when the range of luminance in the visual field is too great, e.g. when bright sources of light, such as windows or their reflected images, fall within the field of vision, with the result that the processes of visual adaptation are disturbed. (Cakir et al., 1980, p. 79).

Illuminance

Illuminance is a term to describe a part of the total luminous flux that is incident on a given surface and is a measure of the quantity of light with which a given surface is illuminated (Cakir et al., 1980, p. 62).

Legibility

Concerned with perceiving letters and words, and with the reading of continuous textual material. The shapes of letters must be discriminated, the characteristic of words formed perceived, and continuous text read accurately, rapidly, easily, and with understanding (Tinker 1963). Generally measured by means of identification tasks in which single letters or a small array of letters are either presented in visual noise or briefly flashed (Mills and Weldon, 1987, p.331).

Luminance

A measure of the intensity of light which is emitted from a light source per unit surface area normal to the direction of the light flux, e.g., a lamp, a wall, or a desktop (Cakir et al., 1980, p.62).

Luminance contrast

A term used to describe the ratio between the difference in luminance of an object and its surroundings and the luminance or background luminance (Cakir et al., 1980, p. 66).

Luminance flux

This term is used to describe the quantity of light which is emitted from a light source per unit of time and is expressed in units of lumen. It is calculated in accordance with the spectral sensitivity of the 'standard eye' (Cakir et al., 1980, p. 61).

Negative contrast

Describes a situation with dark characters on a light background (Bauer and Cavonius, 1980, p. 137).

Nonproportional or fixed spacing

The complete character matrix containing descriptions of the desired letters as well as the empty columns is displayed (Muter et al., 1982, p. 501).

Polarity

The possession or exhibition of two opposite or contrasted tendencies (Refer to Contrast) (The Macquarie Dictionary, 1987, p. 1316).

Positive contrast

Describes a situation with light characters on a dark background (Bauer and Cavonius, 1980, p. 137).

Proportional spacing

The removal of the empty columns in a character matrix prior to displaying the character (Muter et al., 1982, p. 502).

Readability

Refers to the ease with which the meaning of text can be comprehended. Generally measured by means of reading comprehension and reading speed tasks (Mills and Weldon, 1987, p. 331).

Reflected glare

This is caused by the reflection of the high luminance light source external to the VDU screen. This decreases the contrast level of images and background luminance caused by the external light source (Chung and Ogino, 1987, p. 130).

Screen resolution

A measure of the number of pixels, or dots, the monitor can display horizontally and vertically on the screen (Wiswell et al., 1987, p. 118). The density and overall quality of a video display. A

high-resolution picture looks smooth and realistic. It is produced by a large number of pixels. A low-resolution picture is blocky and jagged. It is produced by a small number of pixels. (Spencer, 1983, p. 166).

Spectrum

The band of colours (red, orange, yellow, green, blue, indigo, violet) produced when white light passes through a prism (The Macquarie Dictionary, 1987, p. 1626).

Variable character width

The matrix size of each characters is variable wherein narrow letters such as i and j occupy less space than letters m and w (Mills and Weldon, 1987, p.337).

Weary

A physical state that refers to the reduction or exhaustion of physical strength or endurance. It also refers to state of having one's patience, tolerance, or pleasure exhausted (Webster's Third New Unabridged International Dictionary, 1971, p. 2590).

Worn-out

It refers to a feeling of being entirely exhausted in strength, energy or vitality. It also refers to a situation where an object or person is used

or worn to the extent of being nearly or completely useless or unserviceable (Webster's Third New Unabridged International Dictionary, 1971, p. 2636).

1.5. Research Objectives

One of the objectives of this research is to determine the relative effects on readability of the eight foreground and background colours (as shown in Table 1, p. 75) and font combinations presented on a VDU environment and two formats presented on paper using different fonts.

There are four independent variables used in this research; however, only three of them are of particular concern in this study namely:

1. presentation medium (five levels),
2. font (two levels), and
3. time of administration of fatigue questionnaire (two levels).

One level of the presentation medium is based on paper while the remaining four are based on VDU with varying colour combinations. The fourth independent variable is the set of stories which was introduced by the experimental design used. Colour combinations with

varying font rankings provide an ordered list of most to least preferred colour combinations with the associated font. The participant's pretest reading speed, age, and length of computer experience serve as covariates in the analysis of the dependent variable, Total Reading Speed. On the other hand, the participant's pretest comprehension score and age are the covariates used in determining the dependent variable, Total Comprehension Score.

The subjects were allowed to adjust the VDU contrast for them to suit their visual needs. This may produce optimal effects on their reading performances when engaged in reading text from a VDU in a real world setting. Contrast adjustment may provide evidence as to whether performance in terms of speed and comprehension is affected by the luminance contrast of the VDU. In addition, the study aimed to determine whether reading text on a preferred choice of colours would improve legibility which, in effect, may lead to the enhancement of reading speed and comprehension performances.

Another aim of this study is to discover whether prolonged exposure to a VDU produces degrading effects of fatigue. The presence of fatigue is determined by using the Profile of Mood States (Pace, 1984) and

the Physical Symptoms questionnaires (Gould and Grischkowsky, 1984). The specific concern is to determine whether any form of physical and mental stress is induced when the reading task is performed for approximately 2 hours.

The purpose of this study is focused on resolving the following specific objectives:

1. To determine whether the four (4) colour combinations significantly affect reading speed and comprehension score;
2. To determine whether there is a significant difference in reading speed and comprehension performances between reading from a VDU and from paper stimuli;
3. To discover if text colour interacts with the character font;
4. To determine whether the time required to refresh the VDU screen affects reading speed;
5. To determine the effects of the five (5) presentation media on reading speed and comprehension score;
6. To determine which of the two (2) fonts (Helvetica and Chicago) is associated with better reading and comprehension performances;

7. To identify which among the ten (10) presentation stimuli, presented on both VDU and paper, will exhibit better performance in terms of speed and comprehension score;

8. To identify the preferred foreground and background colour combinations;

9. To determine whether the participant's satisfaction in performing the reading for comprehension task is affected by the different presentation media as well as to compare their reading speed performances in other tasks (i.e., text-editing, input and search tasks); and

10. To determine the presence of fatigue, as measured by the different POMS and Physical Symptoms categories, when the participants are exposed to the VDU and paper displays for approximately 2 hours as well as to identify the presentation stimuli that are associated with greater amount of fatigue.

1.6. Statement of Hypotheses

Although all objectives listed above are of interest in this study, the main concern is with the effects of the independent variables font and presentation medium on reading speed and comprehension.

The following are the null hypotheses which will be tested in this study:

1. The four colour combinations (white/black, yellow/black, black green, white/blue) will not significantly affect reading comprehension score in a reading for comprehension task as measured by the pretest and posttest reading speeds.

2. The four colour combinations (white/black, yellow/black, black green, white/blue) will not significantly affect reading speed in a reading for comprehension task as measured by the pretest and posttest reading speeds.

3. There will be no significant difference in comprehension score between reading on paper and VDU as measured by the pretest and posttest comprehension scores.

4. There will be no significant differences between reading on paper or VDU medium in terms of reading speed regardless of fonts and colour combinations used as measured by the pretest and posttest reading speeds.

5. There is no interaction between the two VDU image quality variables: character font and colour combination.

6. There will be no significant differences in reading speed between the methods of calculating reading speed: including and excluding the time required to refresh the screen for the next page.

7. The two (2) fonts (Helvetica and Chicago) will not significantly affect reading speed in a reading for comprehension task as measured by the pretest and posttest reading speeds.

8. The two (2) fonts (Helvetica and Chicago) will not significantly affect comprehension score in a reading for comprehension task as measured by the pretest and posttest reading speeds.

9. Fatigue will not be experienced after reading continuous text for a maximum period of 2 hours as measured by the Physical Symptoms and Profile of Mood States Questionnaires.

The review of the literature supports the following hypotheses:

1. It is expected that different colour combinations would exhibit different effects on reading speed in a reading for comprehension task as measured by the pretest and posttest reading speeds.

2. Reading on paper presentation medium is significantly faster than reading on VDU regardless of fonts and colour combinations used as measured by the pretest and posttest reading speeds.

3. Reading comprehension is not significantly different between reading on VDU and on paper as measured by the pretest and posttest comprehension scores.

4. Fatigue over an extended reading on the VDU will be experienced and observed using the Physical Symptoms and Profile of Mood States questionnaires.

5. Time required to refresh the screen does not affect reading speed.

1.7. Delimitations

1. The reading comprehension tasks were conducted for a maximum of approximately 2 hours with 5 minute breaks between readings during which the subjects were given comprehension tests.

2. The results of this study can be generalised on all continuous texts that do not involve any mathematical formulas.

3. The results can be generalised only to the two fonts, having variable character size matrix, used in the study.

4. The results can be generalised only to the colour combinations used in the study.

5. The study can be generalised to experienced users with at least one year of computer experience because it is the minimum length of computer experience among the subjects who participated in the study.

6. This study has been based on a reading for comprehension task. It is not certain if the result can be generalised to a proofreading task.

1.8. Limitations

1. The effects of the inherent variations or differences among the subjects on reading speed could not be measured because the subjects were not made to read on the same presentation medium throughout their entire participation in the experiment. Instead, they were made to read on three different presentation media to determine their font and colour combination preferences.

2. The subjects were not asked to participate in all 10 treatments because each treatment lasted for approximately 2 hours. The author felt that it was too much to ask of them because the task required reading continuous text.

3. The subjects were not exposed to the same treatments from replication to replication because some of the treatments were reported to induce considerable fatigue over a period of 2 hours. Subjects who may be randomly assigned to a poor colour combination may not feel like participating in the remaining two replications because of the physical symptoms they may have experienced in their first participation.

4. Sessions were scheduled at the subject's convenience, (morning, evening, weekends). No analysis was done to assess the effects of the different time of testing. The present study assumed that the differences in the time of administration did not affect the results. It is felt that the factorial design and the random assignment of subjects to treatments in every replication eliminated any systematic bias which might have been induced.

5. The results of this study depend on the reliability and validity of the comprehension tests constructed by the author.

2. REVIEW OF LITERATURE

2.1. Introduction

The use of a VDU display is now widely used in work areas and in business enterprises. The use of paper for storing and displaying information is being replaced by computer databases combined with VDU displays. Thus, there is a need to ensure that a screen-based medium is acceptable and that it should offer at least the same convenience as well as presenting no additional obstacles when reading from it.

It is generally reported in previous studies that subjects reading from a VDU display have significantly slower performance than when reading from paper (Gould and Grischkowsky, 1982; 1984; 1986; Kak, 1981; Kruk and Muter, 1984; Muter, Latremouille, Treurniet, and Beam, 1982; Wright and Lickorish, 1983). Only a few researchers have reported no significant difference in reading speed (Cushman, 1986; Switchenko, 1984; Osborne and Holton, 1988; Gould et al., 1987c).

Nevertheless, Gould et al. (1987b) reported that no matter how small the difference is, the reading speed difference is significant. To test their hypothesis, they conducted a series of 10 experiments in which they attempted to isolate a single variable with the aim of determining how much of the reading speed difference was

accounted for by each variable. Among the variables included in their series of experiments were (a) display orientation, (b) familiarity with a VDU display, (c) character size, (d) font, (e) polarity, (f) aspect ratio, (g) contrast, and (h) different VDU displays resolutions. Results of their investigation showed that no single variable by itself significantly accounted for the difference. As a result, they tentatively suggested that the difference might be due to a combination of variables centering on the image quality (viz., polarity, contrast, colour, scale, width, line spacing) of the characters themselves rather than task or personal (user) variables (i.e., age, sex, familiarity with VDU). This was supported by the visual-angle experiment which showed that subjects read significantly slower on photographs of the IBM 3277 VDU display than when they read photographs of paper with Letter Gothic characters. According to Gould et al. (1987b), " . . . the associated differences in image quality, font, color, and polarity contribute to the reading-speed difference independent of any contribution that the CRT terminal itself might make" (p. 297).

Earlier reading research reviews on typeset materials (Paterson and Tinker, 1980; Tinker, 1963) reported that most physical variables (viz., line width,

line spacing, margin size, print size and font type) studied separately showed only a modest effect on reading speed of 10% or less even when varied over a large range. However, Gould et al. (1987b) argued that by integrating "several 'non-optimal' but 'reasonable' " (p. 297) display variables, reading speed was reduced by 20%. Gould et al. (1987b), believed that the effects of the display variables are "generally cumulative, sometimes less and sometimes more than additive" (p. 298).

Gould et al. (1987b) categorised the possible variables which may have been contributing to the reading speed difference between the two media as follows: (a) personal variables, (b) task variables, and (c) display variables.

2.2. Personal Variables

2.2.1. Familiarity with a VDU Screen

These are the variables inherent in the participants such as viewing experience with the VDU, age, and sex (Gould et al., 1987b).

Familiarity or experience with the VDU display was directly studied by Gould et al. (1987b) by asking 12 participants, six with no experience at all, and six heavy and long time VDU users, to proofread for

misspelled words. They found that experience is not associated with faster proofreading. In addition, results showed that both groups read slower on a VDU compared to the paper condition. However, they suggested that experienced VDU users are better readers and this seems to reduced the reading speed difference between the two media. The earlier study of Gould and Grischkowsky (1984) is consistent with this finding. In their study, none of the 24 participants worked regularly with a VDU making the familiarity with the VDU variable uncontrolled in their experiment. The analysis of the data they collected provided little evidence to conclude that nonfamiliarity with a VDU explains faster reading on paper.

2.2.2. Age and Sex

Although age and sex were not directly studied by Gould et al. (1987b), results of their analysis suggested that neither variable clearly affects proofreading speed. In their experiment, the participants were divided into two age groups, one with a mean age of 23 (ranging between 20-27) and the other with a mean age of 48 (ranging between 40-61). Even when the participants' ages were widely scattered, ranging from 20 to 61, it was observed that only a few

participants read faster from the VDU display than from paper (Gould et al., 1987b). In the study of Gould and Grischkowsky (1984), the older group proofread faster from both paper ($M = 221$ words per minute (wpm)) and VDU ($M = 170$ words per minute (wpm)) than the younger group with paper and VDU mean scores of 184 wpm and 152 wpm, respectively. However, the difference was not statistically significant.

This result is consistent with the report of Dillon, McKnight and Richardson (1988), who undertook a review on the nature and potential causes of reading differences between paper and VDU in earlier studies. They reported that neither age nor sex has been discovered to have significant effect on the reading speed.

2.3. Task-Oriented Variables

Gould et al. (1987b) identified the enumerated variables in this section as task-oriented variables whereas Waern and Rollenhagen (1983) described them as the factors related to the handling of text and factors related to the reading purpose.

2.3.1. Nature of Task (Proofreading versus Reading for Comprehension)

One objective of the series of experiments which Gould et al. (1987b) conducted was to determine whether

the type of task would explain the reading speed difference between VDU and paper. They noted that there is a difference between proofreading and reading for comprehension. According to them, the reader's attention is character-oriented in proofreading whereas in reading for comprehension it is word-oriented or meaning-oriented. The subjects in their study were experienced VDU users and were divided into two groups: a proofreading group and a comprehension group. Half of the 18 participants was asked to proofread an article for misspelling whereas the other half was asked to read the same article for comprehension with the misspellings removed. Each group was asked to read under three conditions: (a) paper, (b) VDU display, and (c) paper-rotated. In the paper-rotated condition, the background and aspect ratio were made similar to the VDU display but had the same format as the paper condition.

Results showed that subjects read significantly faster from paper than from the VDU display regardless of the nature of task. They further reported that reading for comprehension is significantly faster than proofreading. This is consistent with the result reported by Kak (1981). Other studies also concluded that people tend to read faster on paper than on VDU in a reading for comprehension task (Kruk and Muter, 1984;

Muter et al., 1982; Wright and Lickorish, 1983). Levy (1983) reported that " 'higher order' semantic and syntactic processes are involved in proofreading" as cited by Gould et al (1987b, p. 279). In addition, the reader needs to scan the words character by character to search for misspelled words when proofreading. Aaronson and Scarborough (1976) reported that the reading for comprehension task is more concerned with the semantic content of the text than with the syntactic structure. On the other hand, recall and proofreading tasks are more concerned with the syntactic structure of the text.

2.3.2. Reading Duration

Visual problems related to prolonged use of VDU screens have been reported in the literature and are now the target of considerable concern and study because they are one of the means used for displaying information to be read. Muter et al. (1982) investigated the feasibility of reading continuous texts on 32 subjects for 2 hours on a videotex, with a 10 minute break after an hour. Half of the 32 subjects in that study were required to read texts displayed both proportionally and nonproportionally on the screen whereas the other half read the same texts on paper with the same format as those texts displayed on the VDU.

Their results showed that it is indeed feasible to read continuous texts on videotex for 2 hours or longer because the subjects reported only a small amount of dizziness, fatigue, and eye strain which were approximately the same for the two presentation media. Results also showed that videotex subjects read 28.5% slower than the subjects who read from a book. Muter et al. (1982) believed that the following may have accounted for the difference in proofreading speed in their study (p. 507):

1. familiarity of some subjects with reading from a VDU;
2. time (9 seconds to refill the screen) required to refresh the screen, however, a follow-up study by Kruk et al. (1984) reported that delays in presentation does not significantly affect reading speed and comprehension in the VDU;
3. different reading distances between the two presentation media;
4. different number of characters per line between the two presentation media; and
5. the variable posture of the subjects in the book condition.

However, their study concentrated on the effects of character spacing on a line and not on the colour and font of the text displayed on the VDU. In addition, with the advent of faster microprocessors (i.e., 386) refresh rate of displaying a screen of text has been considerably improved and optimised.

Oborne and Holton (1988) reported that there was no significant reading speed difference between reading from paper and from VDU when the following variables were controlled: (a) subject's posture, (b) distance from the screen, (c) image polarity, (d) line length, and (e) page layout. In their study, only 3 of the 16 subjects who participated in the experiment were familiar with the VDU. In contrast with the study of Muter et al. (1982), the subjects in the study of Oborne and Holton (1988) were asked to read a set of short stories consisting of eight passages always taken from the beginning of a story. Subjects read each passage for an average of 12 minutes and a comprehension test followed after each passage was read. Therefore, the subjects read for shorter periods and with breaks in between. For this reason, Oborne and Holton (1988) suspected that any VDU-paper reading speed difference could have been associated only with longer reading periods. This observation was supported by the studies

of Switchenko (1984) and Askwall (1985) who also employed short reading periods.

This result contradicts the study of Moussaoui and Freivalds (1986) who asked 32 subjects to read short text passages. These passages were generally read for less than 60 seconds. Results showed that there was a significant reading speed difference between the two presentation media used in favour of paper even when the subjects were required to read only short text passages. According to these researchers, the difference might not have been caused by visual fatigue but by the *accommodation mechanism* during the reading process. They suggested that this might be due to the lack of geometric and "high spatial frequencies" (Moussaoui and Freivalds, 1986, p. 273) of the character's display which made it hard for the eyes to pick up the finest reading details.

VDU characters are formed by dot matrices where each dot presents a curved luminance profile (Moussaoui et al., 1986). According to Moussaoui et al. (1986), this makes the " . . . transition form [sic] [from] light to dark gradual as opposed to the very sharp edges of printed characters" (p. 268). The sharp edges in printed characters is the reason why they contain high spatial frequency which is reported to be a stimulus for accommodation whereas the gradual change of luminance at

the corner of VDU characters makes the presence of high spatial frequency unlikely (Moussaoui et al., 1986). According to Gould et al. (1987c) a high resolution VDU screen improves the geometric and spatial stability of the characters displayed. High resolution screens also enhance the appearance of the characters displayed which in effect reduces the reading speed.

The prolonged use of a VDU for viewing over a continuous period of 3 hours was also investigated by Morrissey and Bittner (1986) on 20 computer-experienced students. Their study was aimed at determining the effects of the work-rest cycle and display contrast on prolonged use of a VDU. Performance was measured by means of a simple search task on an IBM colour graphics monitor having 640 x 200 resolution. The experiment was conducted in a work environment adjusted to minimize glare and with healthy subjects.

Morrissey et al. (1986) reported that low display contrast led to an increase in constellation signs (a number of stimulus conditions or factors affecting behaviour and personality) and motion sickness syndrome such as dizziness, mental depression, drowsiness, and fatigue. It was also reported that there was a significant decrease in perceptual capabilities after 3 hours of continuous reading. In addition, the

adjustment of the display contrast and the incorporation of rest periods in the reading duration did not significantly improve the decrements in perceptual capabilities.

Morrisey and Bittner (1986) identified the general sources of fatigue problems to be:

1. improper lighting that results in direct or indirect glare;
2. improper contrast on the VDU screen and with the surrounding environment; and
3. poorly designed VDU characters that flicker, wobble, or that have "smeary" edges (p. 260).

Similar results were supported by earlier studies of Dainoff et al. (1981), Mourant et al. (1981), Stammerjohn et al. (1981), and Moussaoui and Freivalds (1986).

Thus, it is interesting to determine the effects of prolonged VDU exposure on a less ideal task such as reading for comprehension. The current study is designed to help determine up to what point the reader can be exposed to the VDU screen without impairing comprehension due to visual fatigue and discomfort as well as to determine whether reading long texts with breaks in between eliminates the reported reading speed difference between the paper and the VDU display.

2.3.3. Display Orientation (Horizontal versus Vertical Paper Orientation)

Gould et al. (1987b) investigated whether the differences between paper orientation (generally laid horizontally) and VDU orientation (laid vertically) could have contributed to slower reading on the VDU. The 12 subjects were asked to proofread an article on the following three conditions: (a) VDU display, (b) paper which was laid horizontally on a table, and (c) paper which was held in a vertical position by a copy holder attached to the face plate of an IBM 3277 VDU display. The paper and the VDU conditions had the same format in the sense that they contained the same words per line as well as the same number of lines per page. Results indicated that subjects proofread faster from the paper conditions than from the VDU display condition. This suggests that the display orientation does not affect proofreading speed since the VDU display was also in a vertical position.

2.3.4. Visual Angle

Gould et al. (1986) investigated the effects of the visual angle of a line of text in a proofreading task. The subjects in their research were presented two sets of reading materials: coloured photographs (greenish characters on a dark background) shown on the

IBM 3277 VDU screen and black-and-white photographs of the same articles printed on paper in Letter Gothic font. Both sets were printed in six different sizes and when viewed from 52 cm, produced the six visual angles (viz., 6.7, 10.6, 16.0, 24.3, 36.4, 53.4) used in that study. Two fonts or character sets (IBM 3277 and Letter Gothic) were used to determine whether font might have an interactive effect with the visual angle. Moreover, polarity, colour, and line spacing were also varied to assess if each of them would interact with the visual angle. A forehead rest was used to hold the participants' head in order to fix their line of vision. Results indicated that extreme visual angles (beyond 16 and 36.4 degrees) had reduced the proofreading speed and accuracy of the subjects. Gould et al. (1986) conjectured that at lower visual angles, subjects might have found it hard to discriminate between the characters. On the other hand, very large visual angles may have required "more eye fixations [frequency] and head movements" (Gould et al., 1986, p. 170). Therefore, it is likely that fewer characters were perceived peripherally, thus reducing the proofreading speed. Based on these results, they suggested that visual angles between 16 to 36.4 degrees do not affect proofreading speed and accuracy.

They further declared that variations in the visual angles used on VDU and printed text by previous studies could not have accounted for the reading speed difference between the two presentation media because the visual angles used were within the 16 to 36.4 degrees range. They believed that the inferior reading speed on a VDU as compared to paper might have resulted from the colour, polarity, and line spacing associated with the character font, not from the visual angle.

2.4. Display Variables

Gould et al. (1987b) defined display variables as the factors which are dynamic in the VDU display and may "include flicker, jitter, scrolling and movement of character lines, or associated luminance changes during page changes" (p. 285) together with contrast, including the factors related to the text such as character width/height, font, colour, and line spacing.

2.4.1. Dynamic Characteristics of a VDU Screen

Gould et al. (1987b) investigated whether some particular dynamic factor in a VDU causes the reading speed difference between the VDU and paper media. The subjects who participated in their experiment had more than 5 years of experience using a VDU screen and so could be considered to be experienced users. They were

required to proofread different 10-page articles under the following display conditions: (a) paper, (b) VDU screen, and (c) on good quality photographs of the IBM 3277 VDU material. The third display condition was done to eliminate the dynamic characteristics of the VDU screen such as flicker and jitter. The photographic materials had the same size as the VDU material, the same colour (greenish characters on a dark background), and the same contrast ratio of 6:1. Page layouts of the texts presented on all three display conditions were formatted in the same way. However, the photographic materials did reflect more light than the paper condition which caused glare. Their findings indicated that the participants proofread significantly faster from paper than from the other two display conditions. Proofreading in the photograph condition was slightly faster than proofreading in the VDU condition; however, the difference was not significant. According to Gould et al. (1987b), there was no strong evidence to conclude that the dynamic characteristics of the VDU screen cause the difference in reading speed since the subjects did not significantly proofread faster from the photograph condition than from the VDU condition. However, they suggested that the results might have been affected by the somewhat poor quality in photographs of the images

on the VDU screen. In addition, the subject's effort to avoid glare in the photograph condition was difficult to control and might have slightly affected their performance.

The results of Creed et al. (1987) were consistent with that of Gould et al. (1987b) who also compared the speed of 30 subjects who read on paper, VDU, and VDU photographs. They reported that reading speed on photographs did not significantly differ from either VDU and paper, although poorer performance was associated with the photographs rather than with paper. In addition, performance on a VDU was found to be the poorest among the three conditions. This suggests that the reading speed difference between the two media is unlikely to be caused by the dynamic characteristics of a VDU.

2.4.2. Time Required to Refresh the VDU Screen

The uncertainty as to when participants start reading the text during the time the screen is being refreshed might have caused the reading speed difference between the two media. Muter et al. (1982) suggested that refreshing the screen page, which took about 9 seconds, might have distracted the subjects. Their follow-up study (Kruk and Muter, 1984) compared two

video conditions (instant and delayed video conditions) and two book conditions (60 and 39 characters per line). The delayed video condition required 9 seconds to fill the screen after a key has been pressed while the instant video required 0.5 second. Results showed that the reading speeds between the two video conditions were not significantly different from each other. However, reading text speeds from the video conditions were significantly slower by 24% than reading from book conditions.

Gould et al. (1987b) reported that proofreading was faster on paper even when the geometric characteristics of the font used on both paper and VDU were the same. According to them, the proofreading time difference of about 13-15% (31 wpm) can be attributed to the two delays inherent in a VDU. The first delay was the time between when a key was pressed, to cause the next page to be displayed, and when the first line of text actually appeared. This was about 10-18 seconds depending on the response time. The second delay was the time required for a complete page to appear, once the first line was displayed, which took an average of 3.4 seconds. Since they were not sure as to when the participants began to read, they assumed that participants started reading before the screen was

filled. Even when the delay times were deducted from the proofreading speed, the paper medium was still proofread faster by 7% (29 seconds) than the VDU display.

2.4.3. Display Contrast and Polarity

Earlier research related to polarity has been conducted on paper, microfiche, photographs of the VDU display and on the VDU. Findings on the paper medium showed that black character on a white background is more readable than white character on a black background (Tinker, 1963). According to Taylor (1934), this result might have been due primarily to the greater number of eye fixations (fixation frequency) required to read white characters on a black background. It has also been reported that three-quarters of readers prefer reading black characters on white background rather than reading white characters on black background (Paterson and Tinker, 1931).

Reports concerning polarity on microfiche have yielded mixed results. Some researchers claimed no differences in performance for positive and negative contrast (Baldwin and Bailey, 1971) whereas others reported that positive contrast is better than the negative contrast (Spencer and Reynolds, 1976). Cushman (1986) suggested that some of the discrepancies in these

studies may be attributed to the type of projection screen used in their study.

Gould et al. (1987b) have investigated whether display contrast affects reading speed on a VDU by asking the subjects to proofread under the following conditions: (a) IBM 3277 CRT with green letters and dark background, (b) black letters and white background photographs of the IBM 3277 CRT, and (c) light letters and dark background photographs of the IBM 3277 CRT. They reported that proofreading from a VDU display was slower than proofreading from any of the VDU photographs; however, the difference was not significant. They concluded that polarity does not seem to affect proofreading rate, although the slight difference between the image of the VDU photographs and the VDU display itself might have affected the result.

In their follow-up study, Gould et al. (1987a) reported that faster reading is favoured by dark characters on light background when anti-aliased characters were used; however, the difference was not significant. Their evidence indicated that the VDU polarity by itself accounts for only a small percentage in the paper-VDU reading speed difference. For this reason, they suspected that polarity may have an interactive effect with other VDU display variables.

This thought seems to be reinforced by Tinker (1963) who reported that there is a " . . . dramatic interaction of polarity, type size, and font when people read from paper" as cited by Gould et al. (1987a, p. 514).

Another factor which seems to affect reading speed on a VDU screen is glare, which is thought to disturb visual adaptation (Cakir et al., 1980). In some work areas, glare cannot be avoided, especially if the environment is not ideal, thus the effect of reflected glare in a text editing task on a VDU screen with five different colour combinations was investigated by Chung and Ogino (1987). Performance was measured in terms of the time required to replace the misspelled words with the correct words in a text editing task. Participants were required to edit two short stories, one printed on paper and the other stored in a word-processor. The outcome of their study showed that replacement time is slower under the VDU glare condition than with the VDU no glare condition. In addition, subjects generally performed better with light characters or a dark background than with dark characters on a light background on the VDU. They also reported that glare caused the background colour of the VDU display to look like a blackish colour in all the colour combinations used (viz., amber/black, white/black, white/blue,

black/white, white/yellow). These researchers concluded that glare and colour affect performance on a VDU and recommended that the contrast ratio of the characters and background used should be large. Other studies (Radl, 1980; Bauer and Cavonius, 1980) contradicted this by arriving at the conclusion that negative contrast (dark characters on a light background) is better than positive contrast (light characters on a dark background). This might be due to the good illumination conditions in which the task was carried out as opposed to the study done by Chung and Ogino (1987) which was undertaken with reflected glare. Radl (1980) recommended the use of negative contrast for the following reasons:

1. The adaptation conditions for the eye are better, especially when eye movements between the VDU screen and a paper sheet often occur.

2. The sensibility for discomfort glare, which is often reduced by practically unavoidably bright optical environment, is reduced.

3. Positive presentation [negative contrast] is an effective and ergonomically ideal method for avoiding reflections on the screen (p. 134).

Cushman reported (1986) that visual fatigue is significantly greater when reading from a negative

contrast VDU screen, possibly because of the increase in flicker. According to Cushman, a possible explanation for this is that the 60 Hz frame repetition rate of the VDU display used in his study may not be fast enough to completely eliminate flicker. This may explain why his findings were inconsistent with previous studies (Bauer et al., 1980; Radl, 1980) who reported that less visual fatigue and better performance are associated with the use of negative contrast on a screen display. Bauer et al. (1980) and Radl (1980) used VDU displays with frame repetition rates greater than 60 Hz (100 Hz) and thus apparently produced less flicker. Zwahlen and Kothari (1986) argued that the previously stated studies were conducted for short periods. For this reason, they postulated that a subject's performance might not hold over a realistic full day working condition. Accordingly, their study was conducted for 2-full days in a controlled environment where a glare filter was attached to the VDU, a light placed directly above the screen to minimize glare, and with a screen refresh rate of 60 Hz.

Zwahlen and Kothari (1986) contended that the use of either negative or positive contrast can produce "very similar eye scanning behaviour, typing performance and subjective discomfort as long as a sufficient

character-background luminance contrast is provided" (p. 172). This result is supported by earlier studies which claimed that the effects of character colour and background on VDU are complicated by the interaction between colour, luminance, and luminance contrast (Konchi and Cicchella, 1980; Shurtleff, 1980; Timmers et al., 1980).

This conclusion is consistent with the study of Gould et al. (1987b) in which 15 subjects were asked to proofread on the VDU both anti-aliased and aliased characters with both positive and negative contrast. In addition, the subjects were allowed to read text on paper with the normal contrast, dark characters on a white background. In two of the display conditions, the subjects were asked to adjust the contrast knob to their preference during a trial session, before they started proofreading. On the other hand, the contrast was set to be 10:1 in the other two conditions. This was done to avoid the possibility that the 10:1 fixed contrast might have favoured one polarity over the other. Their results showed that the subjects did not significantly proofread faster on dark characters than on light characters on the VDU display; however, the trend slightly favoured dark characters on a light background. The subjects were also reported to have experienced more

fatigue after reading dark characters on a VDU than when reading light characters. The earlier study of Cushman (1984) supports this result; however, the task applied was reading for comprehension.

Mills and Weldon (1987), who reviewed studies concerning computer screen polarity, reported that the effects of polarity on VDU depends on the characteristics of the equipment being used. They recommended the following guidelines:

1. If the VDU refresher rate is relatively fast (i.e., 100 Hz cycles per second (cps) [Hz]), then dark characters on a light background may be better;

2. However, if the refresher rate is in the more common range (50-60 cps [Hz]), light characters on a dark background may be better (p. 342).

2.4.4. Colour

Radl (1980) asserted that use of coloured symbols brings an advantage in readability of information on a VDU screen. This was found to be so when the "use of colour is not connected with a decrease of the luminescence level on the display and colours are situated within the yellow-green part of the spectrum" (p. 127). Moreover, Durreit and Trezona (1982) reported that printed material presented in colour is generally

processed faster than materials presented in black and white. According to them, color can both help memory and enhance understanding when guidelines on how to use color effectively are followed (e.g., great contrast between foreground and background colours and good lighting surrounding the colour-display task).

Readability was also found to depend upon the colour combination of text and background as well as the amount of contrast (Fukuzumi et al., 1987). According to Bouma (1980), actual dissemination of information from reading depends on luminous contrast. Radl (1980) reported that brightness and contrast of symbols displayed on a VDU screen seem to have more effect on readability than the actual colour of the symbols.

Among all the colours, yellow and green are the foreground colours most recommended by previous studies. Earlier studies also revealed that yellow is suitable for display (Haider et al., 1980), green letters are more suitable than blue (Fukuzumi et al., 1987), in terms of visual fatigue, and yellow and green cause less fatigue compared with red, blue, and white (Osaka, 1985). In the study of Foster and Bruce (1982), 42 foreground and background combinations were used, derived from the combinations of the following colours: white, yellow, cyan, green, magenta, red, and blue. The

54 subjects were asked to read three lines aloud for one foreground colour on six different backgrounds. Their analysis revealed that the combinations white/yellow (white letters on yellow background), yellow/cyan, yellow/white, cyan/yellow, cyan/green, green/blue, green/cyan, magenta/red, and red/magenta are associated with slow reading speed. Foster et al. (1982) also found that there is a "positive correlation between this index [index of contrast in luminance between the characters and background] and the rank ordering of the reading times for all the background colors except green" (Mills and Welton, 1987, p. 343). This implies that the contrast in luminance between characters and background is an important factor in determining the legibility and readability of coloured characters on coloured background (Ronchi and Cicchella, 1980; Shurtleff, 1980; Timmers et al., 1980; Fukuzumi et al., 1987; Bouma, 1980; Radl, 1980)

In the study by Pace (1984), 36 subjects were permitted to adjust the brightness and contrast settings on the VDU screens on both input and search tasks. Each participant viewed 8 of the 24 colour combinations used in the study. Results indicated that the different colour combinations did not significantly affect the participants' performance in either task (input or

search). According to Pace, the differences in settings might have reduced the differences in performance for the different colour combinations. This is supported by the results of Bouma (1980) who found that the legibility and readability of text displayed on a computer screen depends on the luminance contrast but not on colour. This may explain why light letters on light background and vice-versa are not very legible because they have low luminous contrast (Mills and Weldon, 1987). It was therefore theorised by Mills and Weldon (1987), on the basis of the researches they reviewed, that the adjustment of brightness-contrast settings may compensate for some of the difficulties in using certain colour combinations and that it may have " . . . reduced differences in performance for the different colour combinations" (p. 344). It is for this reason that the subjects in the present study were allowed to adjust the contrast setting on the VDU to suit their visual needs.

2.4.5. Text Justification

Another display variable associated with the readability of text is the justification of the text to the right margin. To date, no research work has been published concerning the effects of left justified

and right justified text on the VDU screen (Mills and Weldon, 1987). Nevertheless, there are a number of studies which compared the effects of reading right justified text with that of the unjustified text in printed materials. In general, these studies found no significant differences in either reading speed or comprehension (Fabrizio et al., 1967; Hartley and Burnhill, 1971; Wiggins, 1967).

Zachrisson (1965) studied the effects of right justification of text on poor readers and found that reading from a right justified text was slower; however, there was no significant difference in the comprehension performance. This is supported by the findings of Gregory and Poulton (1970) in a replication study. In addition to slower reading speeds on right justified text, comprehension scores were also significantly lower among poor readers. Right justification of text seems to have the same effect on both normal and poor readers when reading on printed material. It was also reported that reading on a right justified computer-generated printed text is significantly slower than reading from an unjustified text (Trollip and Sales, 1986); however, reading comprehension was not affected.

Since there seems to be no research published yet concerning the right justification of text on VDU

display, left justification was used in the present study. Left justified text was also used to ensure a uniform spacing between characters and words because font style is one of the variables measured in this study.

2.4.6. Line Width

Kolers et al. (1981) and Gould et al. (1987b) shared the same belief that the reading speed difference between a VDU and paper is associated with the image quality of the characters (i.e., line width, character scale, font style, and line spacing). Kolers et al. (1981) recommended the 80-character line width over the 40-character line width when they investigated the effects of eye movement on readability using 20 subjects. Both line widths generated a full width display on the screen. The 80-character width was achieved by dividing the matrix size of the 40-character width into half and increasing the number of characters per line to 80. Results showed that increasing the line width to 80 has increased the number of fixations per line from 4.82 to 8; however, the total number of fixations per passage of text read was reduced. Kolers et al. (1981) also reported that the subjects made fewer but longer fixations with the text made of smaller

characters acquiring more information from the text with each fixation, and the total reading time was reduced. This seems to suggest that smaller, densely packed characters in a line of text is read more efficiently in terms of ocular work and time than a line of text with bigger characters (Kolers et al., 1981). In addition, large characters require more screen space and more time to be read since there tends to be more fixations when reading large characters. Consequently, according to these researchers, reading large characters does not actually achieve greater comprehension because the larger the character size, the fewer words per line of text could be accommodated; thus, more time is consumed when the eyes sweep to the beginning of the next line. This result is supported by Tinker (1963) who reported that excessively short and long lines of text reduce reading speed.

Duchnicky and Kolers (1983) replicated the study of Kolers et al. (1981). They asked 10 subjects to read both on a 40-character and 80-character line text scrolled at their preferred rate. Results showed that all subjects read the 80-character line text 30% faster than the 40-character line text; however, comprehension was not affected by the line width.

The findings of Kolers et al. (1981) were also consistent with the results of Kruk et al. (1984) who replicated the reading speed experiment of Muter et al. (1982). The effects of the display format (number of characters per line, number of lines per page) and time to refresh the VDU screen were assessed. The subjects were asked to read text in all the following display conditions: (a) instant video, (b) delayed video, (c) 60-character-per-line book, and (d) 39-character-per-line book. The book condition with 60 characters per line contained approximately 400 words/page whereas the 39 characters per line condition had 130 words/page. The participants were given a comprehension test which lasted for 5 minutes related to the articles they read. Analysis showed that the subjects read slower with the 39-character-per-line than with the 60-character-per-line book. In addition, the instant and delayed video conditions were not significantly different from each other. Results also suggested that the contrast ratio, time to refresh the computer screen, and reading distance from the screen did not affect reading speed but the display format and interline spacing did (Kruk et al., 1984).

2.4.7. Font Style and Size

Gould et al. (1987a) said that, "better resolution provides the basis for better character fonts" (p. 515) and that it is nearly impossible to discuss the differences among fonts without mentioning the physical variables of the display itself such as screen addressability or resolution.

Poor font design leads to a reduction in legibility which is mainly caused by confusion between certain characters and symbols such as letters O and Q, S and 5, I and L, X and K, etc. (Knave, 1984). The study of Maddox et al. (1977) compared font designs on a 5 x 7 dot matrix. Results showed that "fonts utilising the largest number of dots per symbol produce significantly fewer errors" (Knave, 1984, p. 31). He suggested that "font designs should be simple, without seriffs, allow a variable stroke, and not be of a slanting nature" (Knave, 1984, p.32).

The study by Gould et al. (1986) reported that font style affected reading speed. In their study, they asked 20 subjects to proofread a text where the visual angle (viz., 6.7, 10.6, 16.0, 24.3, 36.4, 53.4) and font style (3277 CRT, Letter Gothic) were varied. According to them, subjects proofread about 16-20% faster on Letter Gothic font than on 3277 CRT font. Even when the

data collected on the extreme visual angles (less than 16 and beyond 36.4 degrees) were eliminated, the character font still significantly affected the proofreading speed.

However, Gould et al. (1986) pointed out that the generalization of their findings to other tasks like reading for comprehension may not hold. Thus, there is a need to investigate the effects of font characteristics on a reading for comprehension task which is undertaken in the current study. In addition, Gould et al. (1986, p. 172) pointed out that the two font styles used differed in (a) font or geometric configurations [size of matrix]; (b) polarity (3277 had light characters on a dark background, whereas Letter Gothic had dark characters on light background); (c) colour (greenish characters for 3277, black characters for Letter Gothic); and (d) blank space between rows of characters.

Due to these differences, they were not sure whether the 12-14% difference was entirely due to the font style used. According to Tinker (1963), each of the variables mentioned affects reading.

The contention of Gould et al. (1986) that font style affects reading speed on VDU is supported by their subsequent studies. In one of the series of 10

experiments conducted by Gould et al. (1987b), they aimed to determine whether font is a factor which affects reading speed. The subjects were asked to read materials on both paper and on VDU. The VDU condition was laid out in exactly the same way (number of lines per page, words per line, font) as the paper condition. The font used was Yogi 3.43 and it was proportionally spaced. The Tektronix storage-tube system printer model 4630 printed exactly what appeared on the storage-tube screen itself and this served as the paper stimuli. Results revealed that subjects had proofread faster on paper even when both presentation media had the same font. Gould et al. (1987b) suspected that this may be due to the time delays when the VDU screen is refreshed (as mentioned in Section 2.4.2.). Another possible reason might be due to the two main differences between the paper and the VDU conditions which are polarity and colour. The paper condition had black characters on white background while the VDU conditions had light green characters on dark green background.

Gould et al. (1987c) also studied the effects of font on the two display media in their follow-up study consisting of a series of four more experiments. In that experiment, they used three fonts (Press, Univers-65, and Letter Gothic) and each was displayed on the

Mitsubishi 32.5 cm high resolution screen. Their results showed that there was no significant proofreading speed difference between the two display media regardless of the font used.

According to Gould et al. (1987c), the reading speed difference was partly reduced when anti-aliasing (adding grey level to, or varying the luminance of, each character) was used. However, they observed that anti-aliasing might have only helped reduce the reading speed difference on relatively low resolution displays. This means that as the display resolution increases, anti-aliasing contributes less and less to the reading speed. They suggested that the tremendous improvement in the reading speed as compared with the earlier studies (Gould and Grischkowsky, 1984; Gould et al., 1987b) was due to the implementation and improvement of the variables mentioned above such as the use of a regeneration rate of 60 Hz and a 1024 x 1024 screen resolution. They concluded that each of the display variables may have contributed to the improvement in a small cumulative way but that, when each was studied in isolation, did not show significant effect on the reading speed difference.

In addition, Gould et al. (1987c) believed that the character font might have also contributed to the

reading speed improvement since it was also associated in their study. However, they were not able to measure its effects independently of the other variables. In addition, they believed that the display variables "probably interact, but in unknown ways" (Gould et al., 1987a, p. 9).

In summary, Gould et al. (1987c) arrived at a nonsignificant proofreading speed difference between the two presentation media when the following were implemented: (a) a polarity of dark characters on a light whitish background, (b) high resolution (1024 x 1024) VDU display, and (c) anti-aliasing the VDU characters to look like the characters printed on paper.

2.4.8. Character Width (Fixed versus Variable)

In printed materials, variable character width (character matrix) is usually used. In VDU screens, generated characters usually have a fixed dot matrix (Mills and Weldon, 1987). Muter et al. (1982) studied the effects of a 5 x 7 fixed and variable character width on 32 subjects by asking them to read short stories from either VDU or printed material for a period of 2 hours. Results showed that fixed or variable width spacing between characters does not affect the reading speed on either of the display conditions.

This result is at variance with the study of Beldie et al. (1983) who researched the effects of reading text with variable and fixed character widths. The 9 subjects were asked to perform three different tasks: (a) reading aloud, (b) error identification, and (c) line finding with both the fixed-width and variable-width characters which ranged from 1 x 7 (for letter i) to 9 x 7 (for letter w). Their results showed that the subjects read 6.1% faster with a variable matrix compared with the fixed-matrix of character size 5 x 7. In addition to faster reading on a variable-width character, the subjects were able to identify 6.4% more errors with the variable-width character (83 errors in 2 minutes) than with the fixed-matrix characters (78 errors in 2 minutes).

It is interesting that these two studies should produce inconsistent results. The difference may be attributable to the different sizes of character matrix used by the mentioned studies: one used a 5 x 7 matrix whereas the other used matrices which ranged from 1 x 7 to 9 x 7. Performance might have been improved because the " . . . characters were made wider and narrower as appropriate . . . " (Mills and Weldon, 1987, p. 338) in the study by Beldie et al. (1983), unlike the study of Muter et al. (1982) where the characters had a fixed

matrix size (Mills and Weldon, 1987). This suggests that reading on the VDU screen may be easier with variable-width characters than with fixed-width characters. For this reason, a variable-width character matrix was chosen for the current study.

2.5. Fatigue Measurements

A considerable amount of research has been devoted to exploring the effects of VDUs on the user by investigating the cause of the complaints of discomfort as well as improving the quality of the VDU screens (Moussaoui and Freivalds, 1986). Although evidence from an earlier study suggests that no physical damage results from VDU use (National Research Council, 1983), "the number of complaints from VDU users has increased dramatically" (Moussaoui and Freivalds, 1986, p. 267). This observation is supported by Chung et al. (1987) who reported that as the number of VDU users increases the number of complaints also increases. Visual discomfort is one of the discomfort complaints cited by the users.

Gould and Grischkowsky (1984) investigated the role the VDU plays with respect to the user's performance (measured in terms of proofreading speed and errors, vision and feelings) on 24 subjects. Their results showed that the VDU itself does not

significantly contribute to feelings of fatigue nor affects visual functions; however, it did lead to slower proofreading. They suggested that good quality VDU displays do not produce a significant "fatiguing" effect on the users. They believed that their results were influenced by the conditions applied in the experimental area namely: (a) the experiment was only two days in duration, (b) the task done by the participants was not their usual work (i.e., proofreading), and (c) the experiment was conducted in a "friendly environment, with good ergonomics (good lighting, seating and with a no-glare environment)" (Gould and Grischkowsky, 1984, p. 335).

Pace (1984) measured fatigue by using the Profile of Mood States (POMS) questionnaire containing six scales: anxiety (tension), dejection (depression), hostility (anger), activity (vigour), inertia (fatigue), and bewilderment (confusion). The questionnaire consisted of 65 adjectival rating scale items related to mood. Since the tasks used involved search and input tasks, all six categories were utilised to measure the changes in mood which may be induced. This instrument was administered to the 36 subjects three times: (a) before they performed either the input or search task, (b) in the middle of the task, and (c) after they had

completed the task. The POMS questionnaire was designed to measure how the subjects felt at the time of completing the questionnaire. The rating categories used ranged from worst (0) to best (4).

Dainoff et al. (1981) selected 24 items from the POMS questionnaire which include only the vigour, fatigue, and tension scales. Their POMS items were chosen and " . . . designed to be sensitive to relatively short-term fluctuations of mood and feeling rather than [co] reflect stable personality traits" (Dainoff et al., 1981, p. 425). Their result showed that workers felt more tensed and fatigued at the end of the working day than at the beginning of the day. Dainoff et al. (1981) also supplemented their 24-item POMS questionnaire with a 13-item physical symptoms test which included items selected on the basis of reports in the literature as being characteristic of VDU operators. Again, a 5-point rating scale was used, ranging from not at all (0) to extremely (4).

Dainoff et al. (1981) interviewed 121 office workers whose jobs involved the use of VDU screens. Among the 121 subjects, 19% worked in word-processing installations, 21.5% with financial operations, 29% with database maintenance, and 30.5% with data entry applications. These subjects were divided into two

groups. The first group consisted of 90 clerical workers who worked with different office organisations. A semi-structured interview was conducted on these 90 workers. The 90 clerks worked with a VDU screen from 0-100% per day with a mean response of 47%. The interview questions asked of the 90 clerks were categorised into four major classifications: (a) primary health-related symptoms, (b) ergonomic comments, (c) computer system comments, and (d) job comments. The purpose of these interviews was to obtain some assessment of the relative importance of perceived visual problems which might have been bothering the respondents relative to other aspects of their jobs such as job satisfaction, computer system efficiency, and ergonomic aspects (Dainoff et al., 1981).

The second group studied comprised 31 employees from a centralised library cataloging service whose daily activities were more involved with data entry tasks, which required working with a VDU screen for 75% of their working day on the average. This group was required to transfer bibliographic data from index cards onto a computer system for 8 days. The subjects in this group were administered the following test: (a) a visual test with the aid of a visual screening device, (b) a POMS questionnaire, and (c) a Physical Symptoms

questionnaire. These tests were administered before the working day started, before lunch, after lunch, and at the end of the working day. Results showed that there are essentially two groups of individuals. One group reported relatively high levels of job pressure and job fatigue whereas the other group, who spent a larger portion of their working day looking at a VDU, reported high levels of visual fatigue and VDU-related lighting problems. General symptoms of physical and mental stress were experienced by both groups but were more evident in the second group (Dainoff et al., 1981).

The TOMS and Physical Symptoms data indicated that the subjects in the second group were " . . . more fatigue and tense at the end of the day than upon arrival at work . . ." (Dainoff et al., 1981, p. 435). In addition, physical symptoms related to " . . . eye strain, neck, shoulder, and back pains showed considerable increase across the course of the day" (Dainoff et al., 1981, p. 435). The same researchers reported that the main contributor to generalised stress was " . . . non-visual aspects of the work environment" (Dainoff et al., 1981, p. 423) which included " . . . work pressure resulting from demands for increased productivity, feelings of loss of individual control and autonomy in a computerised work environment, or fears of

loss of jobs due to automation" (Dainoff et al., 1981, p. 423). It is thus possible that visual complaints may be used as the most acceptable excuse to express their dissatisfaction with office computerisation (Dainoff et al., 1981).

It was also reported by Dainoff et al. (1981) that working for a lengthy period with a VDU screen is related to high a level of visual fatigue and VDU related lighting problems. The complaints of visual fatigue correlate highly with stress such as tension, headaches, and mental strain. Thus in the current study, two different questionnaires were administered to the subjects twice during the course of the reading task: before the actual reading began and after the two sets of text had been read. The purpose was to determine whether fatigue is solely caused by one or by a combination of the following variables: reading duration, font style, colour combination, display medium and workplace environment.

2.6. Summary

The literature review presented above provides results which have particular relevance to the current study and have influenced the direction of this research.

The present study was designed to substantiate the reading speed result of Osborne and Holton (1988), with a different reading duration period, different VDU foreground and background combinations, and different fonts presented to the subjects. The aims are to determine the appropriate colour combination in long duration reading, to determine whether reading continuous text for 2 hours is advisable and to determine whether the findings can be generalized to apply in a reading for comprehension task with prolonged exposure to the VDU screen.

The review of related research shows that the reading speed discrepancy between the paper and the VDU display media were centred on the image quality of the display characters specifically caused by font and combinations of foreground and background colours.

3. METHODOLOGY

The objective of this study is to evaluate the combined effects of different foreground and background colours, and font on the performance in reading a continuous text. Reading speed and comprehension scores were measured to determine whether the readability and legibility of the combination of the foreground and background and font affects reading speed. Secondary measurements were gathered to determine whether fatigue would exist during the course of the reading period. Other measures, such as details about the participants and their colour combinations and font preferences, were also collected to provide evidence about their preferences.

3.1. Subjects

With the assistance of the Department of Computer Studies 40 subjects participated in the experiment, 24 males and 16 females. The subjects were students at the Western Australian College of Advanced Education, Mount Lawley in Perth, Western Australia, studying for the Bachelor of Applied Science in Information Science. Since these students were familiar with computer systems, they were allowed to adjust the distance of their ergonomic seat from the VDU screen to their most favourable visual distance. It was established from the

Subject's Profile Questionnaire (see Appendix A) that 19 of the subjects had normal vision, 6 were wearing contact lenses whereas 15 were wearing glasses. The subjects' average age was 26 and the average VDU experience was 4 years (see Appendix B for detailed description of the subjects' characteristics). One subject was replaced after participating on the first day of the experiment because of eye strain after being exposed to the black foreground and green background (black/green) colour combination.

3.2. Experimental Design

The experimental design (see Table 1) used in this study was a 5 x 2 (Presentation Medium x Font) factorial experiment having four observations per cell. A total of 10 treatments were used in this study. Each experimental treatment was replicated three times using different story sets per replication. This design was chosen because the literature suggested that there may be an interaction among the variables foreground/background colour combination and font. Since it takes an average of approximately 2 hours to read a set of texts, the participants were not made to participate in all of 10 treatment combinations. All participants were asked to read texts under three treatment conditions randomly assigned to them, one

from each of the story sets or replications. Because fatigue was also taken into consideration, requiring each participant to participate in all the treatments may produce considerable fatigue and was considered an unrealistic demand upon them. The random assignment of the 40 subjects to the three replications is shown in Table 2.

3.3. Statistical Tools Used

The effects on reading speed and comprehension of the combinations of the variables font, presentation medium, and story set were measured using a separate Analysis of Covariance.

Similarly, a Type III Sum of Squares Analysis of Variance was used to analyse the Profile of Mood States categories (viz., tension, vigour, fatigue) and Physical symptoms categories (viz., physical/mental stress, visual strain/fatigue, computer environment, general fatigue, task/job aspects, reading efficiency).

3.4. Independent and Dependent Variables

This study involved one independent task, a reading for comprehension task, and the four questionnaires (a) Subject Profile, (b) Profile of Mood States, (c) Physical Symptoms, and (d) after participation colour combination and font ranking questionnaires.

There were two dependent variables derived from the reading for comprehension task namely: reading speed and comprehension score per story set read. The computer program generated two values for reading duration per story read: one included the time to

Table 1

Experimental Layout of a 5 x 2 Factorial Experiment with 3 Replications (having four observations per cell)

Presentation Medium	Story set number		
	1	2	3
Helvetica font			
Paper (Black/White)			
White/Black (VDU)			
Yellow/Black (VDU)			
Black/Green (VDU)			
White/Blue (VDU)			
Chicago font			
Paper (Black/White)			
White/Black (VDU)			
Yellow/Black (VDU)			
Black/Green (VDU)			
White/Blue (VDU)			

Note. Colour1/Colour2 indicates Colour1 as the foreground colour and Colour2 as the background colour.

refresh the VDU screen and the other excluded the time to refresh the VDU screen. These reading durations were later converted to reading speed expressed in number of words/minute (see Appendix C for sample output). The dependent variable, Total Reading Comprehension Score, was obtained by summing all the correct answers obtained by a subject in the story set read.

Table 2

Assignment of the 40 Subjects on Each Replications

Presentation Font	Replications		
	1	2	3
PAPER Font1	6,15,19,37	5,23,25,39	1,17,27,40
PAPER Font2	8,16,18,38	3,26,28,40	7,20,21,30
CC ₁ (VDU) Font1	2,11,25,39	10,20,24,29	5,13,18,32
CC ₁ (VDU) Font2	4,12,21,40	14,22,27,34	3,28,31,36
CC ₂ (VDU) Font1	7,13,33,35	6,16,18,37	8,23,25,38
CC ₂ (VDU) Font2	1,14,20,27	4,12,19,36	2, 9,15,39
CC ₃ (VDU) Font1	9,17,30,36	7,13,21,38	10,19,29,34
CC ₃ (VDU) Font2	5,24,26,32	8,15,31,33	6,22,26,35
CC ₄ (VDU) Font1	10,22,29,31	2,11,30,35	4,12,16,37
CC ₄ (VDU) Font2	3,23,28,34	1, 9,17,32	11,14,24,33

Note. The numbers under each condition refer the subject number associated to each participant.

The analysis of variance procedure contained in the SAS package installed in an IBM AT personal computer at Mount Lawley campus, WACAE was used to analyse the main effects and interactions contained in the models of the experiment (SAS, 1988). A Type III Sum of Squares main effects model consisting of font, presentation medium (paper and VDU), and story set as the independent variables and reading speed as the dependent variable was used in the analysis of covariance. The story set variable was treated as a random variable while the other two independent variables were treated as fixed variables. The model includes the self-reported computer experience in years, age, and the measured pretest speed as covariates. The same main effects model was used to analyse the comprehension score data; however, age and pretest score were used as covariates.

The POMS and Physical symptoms questionnaires were both administered at the beginning and end of each reading session. The scales of tension, fatigue, and vigour were embedded in the POMS questionnaire. On the other hand, the physical and mental stress, visual strain, fatigue, lighting complaints due to glare, general fatigue, ergonomic aspects, computer system aspect, and the task/job categories were included in the

Physical symptoms questionnaire. The sums of all the items belonging to each of the categories were pooled together to provide a measure of change in mood and physical conditions. The dependent variables measured in the present study are summarised in Table 3.

The changes in mood states and the physical symptoms analyses used a main effects model for the ANOVA consisting of font style, presentation medium, story set, and time of administration (before and after) as the independent variables and the category scale response total as the dependent variable. This analysis aimed to determine whether reading duration of approximately 2 hours has a significant effect on the readers' feelings and behaviour (Pace, 1984). In addition, it was also desirable to verify whether certain combinations of the main effects induce more fatigue than other combinations.

The colour and font combination ranking questionnaire was presented to the subjects on the VDU screen on the last day of the experiment. The dependent variable for the rank ordering of the combinations of font and colour was the subject's preference order of the combinations of font and colour. The rank ordering measures ranged from first to fourth or from first to eighth, where first is the most preferred combination.

Table 3

Dependent Variables Listed with Each Subject Test

Test	Dependent Variables
Reading for comprehension task with presentation medium and font	<p>Reading durations for each story read. (The Total reading duration in a set of story divided by the total number of words/set times 60 provides the reading speed in words/min.)</p> <p>Number of correct answers from the comprehension test per story read. Total correct answers per set of story is the dependent variable.</p>
Rank order of font and colour combinations	Preference order ranging from first through fourth or first through eighth, where combination ranked first is the most preferred.
Profile of Mood States	Combined scale response ranging from <u>nothing at all</u> (0) to <u>extremely</u> (4) for each POMS category.
Physical Symptoms	Combined scale response ranging from <u>nothing at all</u> (0) to <u>extremely</u> (4) for each Physical Symptoms category.

3.5. Experimental Room Set-up

The paper text was directly attached to the VDU screen display making the booklet of stories parallel to the VDU screen. The participants assigned to read text on paper were instructed to press the stop clock before and after reading a page of text, thus excluding the time to turn a page. An experimental assistant was present and kept a record of the participant's reading duration page by page. The participants could sit at any distance from the VDU or the paper medium and were allowed to adjust the seat height according to their preferences (see Figures 1 and 2). In addition, the participants assigned to read from the VDU were encouraged to adjust the character luminance (contrast). Figures 3 and 4 show the photographs of a paper presentation and VDU presentation set-up, respectively.

Room illumination was provided by overhead strip lights. The lighting in the experimental room was specially designed and installed in the building to ensure that glare is minimised. The experimental room was less than 2 years old and is generally used as a computing laboratory for the computing students at WACAE, Mount Lawley campus. Window blinds were used to avoid reflection of the windows on the VDU screen as shown in Figure 5.

The chairs used were gas-filled adjustable height models and were designed to allow freedom of movement while seated (The European Foundation for the improvement of living and working conditions, 1986). The adjustable chair as shown in Figure 6 has a cushioned seat pan and an adjustable backrest centred above the seat cushion.

3.6. Software Packages Used

The short stories in the paper treatments were inputted using Microsoft Word 3.01 as a document file in a Macintosh computer and printed using a laser printer whereas the same stories presented on the VDU were inputted as a nondocument file in WordStar version 4.0. The program written in the C language reads this nondocument file when displaying a text on the screen with either Chicago or Helvetica font.

The program which generated the text displayed on the screen was written in the C language using the Quick C version 1.0 compiler because it has very good graphics facilities and built-in functions.

SAS statistical package version 6.03 was used to analyse the data that were collected from the experiment (SAS, 1988).

Figure 1. Photograph of a participant reading from a paper presentation stimuli.



Figure 2. Photograph of a participant reading from a VDU presentation stimuli.



Figure 3. Photograph of paper presentation medium set-up.

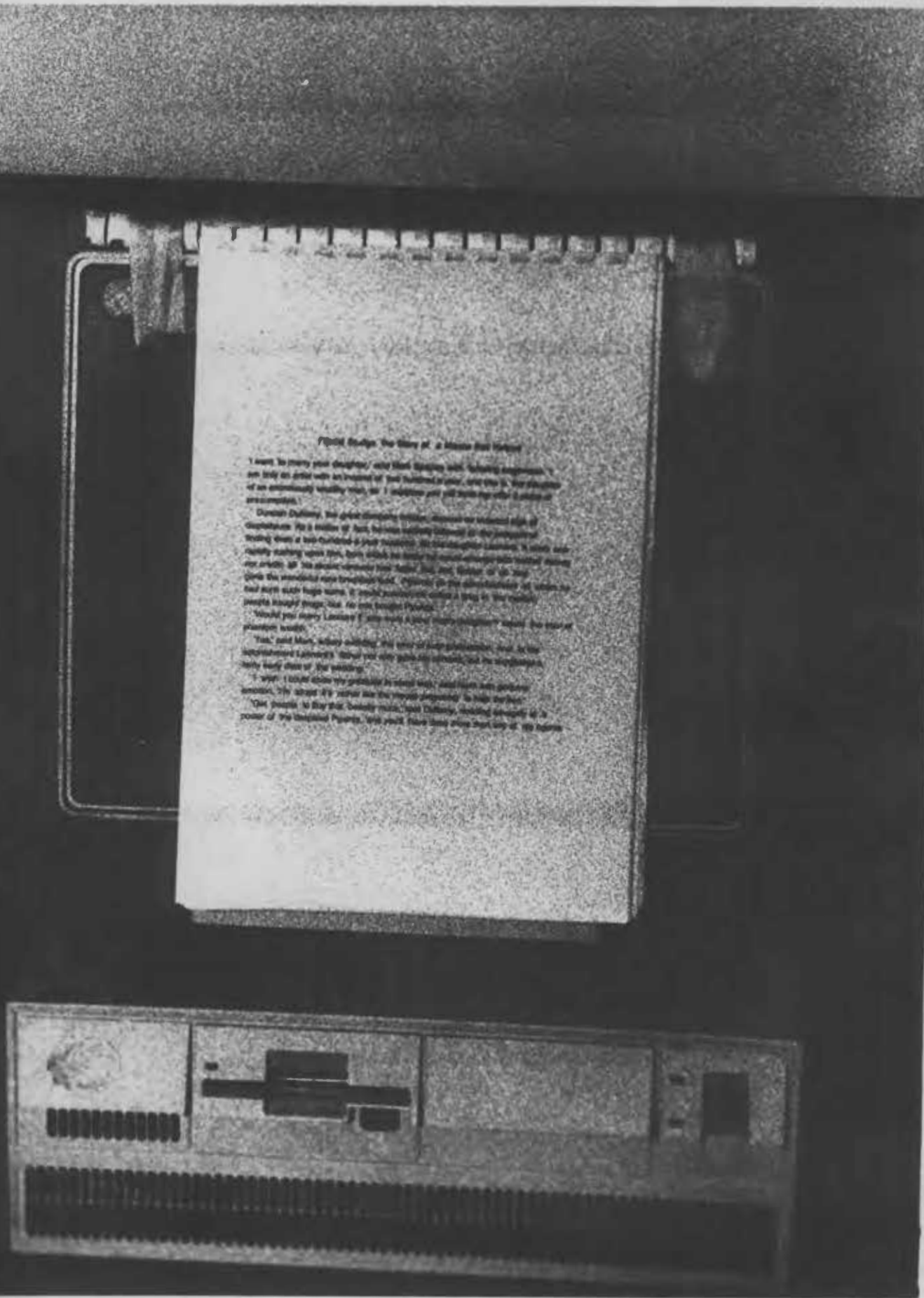




Figure 5. Photograph of the experimental room set-up.

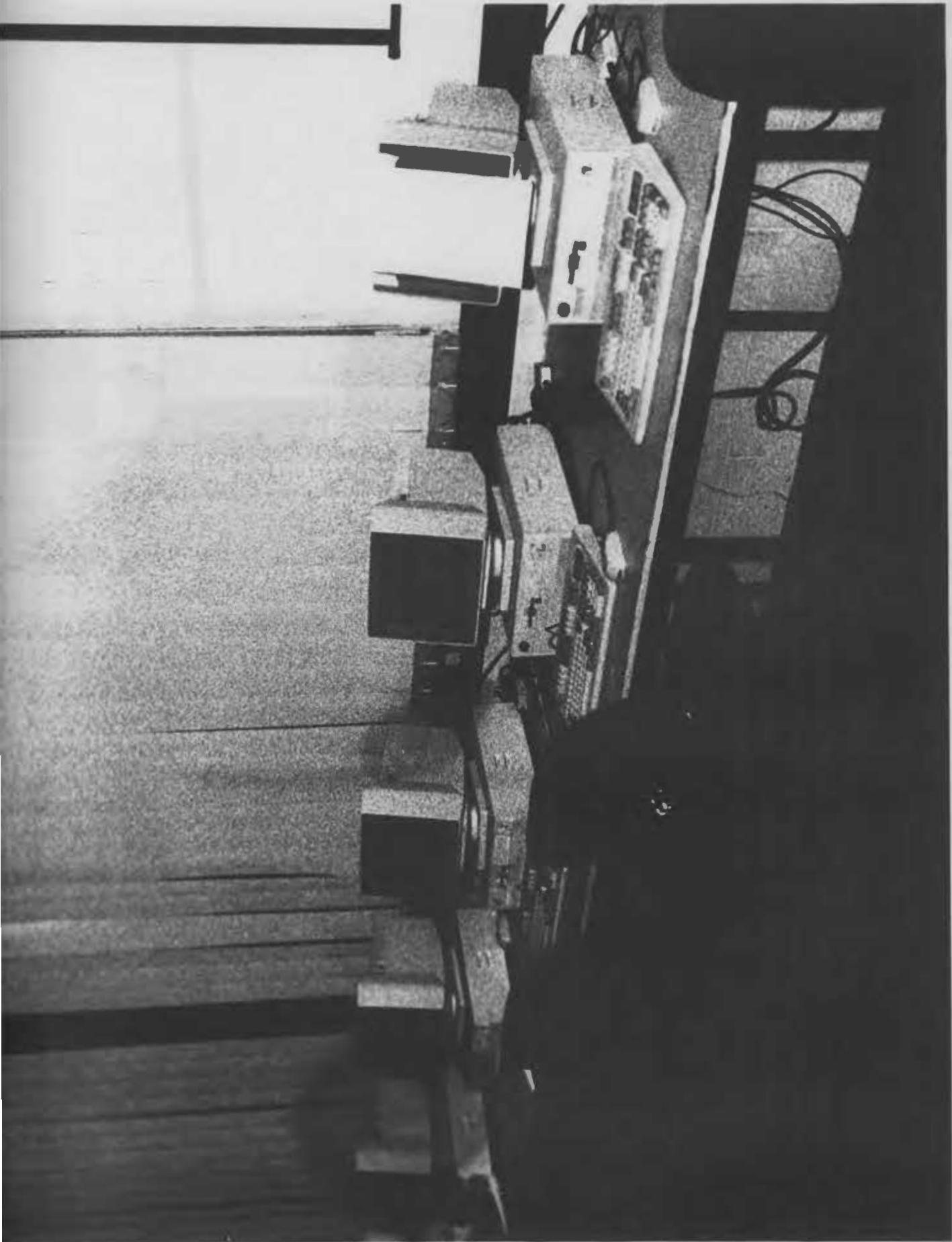


Figure 6. Photograph of an IBM PS/2 model 30 and an ergonomic chair.



3.7. Computing Equipment and Facilities

An IBM PS/2 model 30, with a 8086, 8 Mhz, microprocessor with a VGA card was used to run the computer program which displayed the text on the VDU. A resolution of 640 x 480 pixels was used to generate the characters displayed. The author has tried various ways to achieve similarity between the text presented on both media because one of the objectives of this study was to compare reading speed from paper and from VDU display.

One approach was to print on paper the texts displayed on screen using the program which displayed the text on the VDU. However, the text printed on paper was of poor quality and did not match the text displayed on the screen. This may be due to the type of printer used in printing the paper treatments which were created in graphics mode. Thus, to remove the discrepancy between the appearances of the text displayed on the VDU and that printed on paper, the short stories were inputted using Microsoft Word 3.01 as a document file in a Macintosh computer using Helvetica and Chicago fonts. The results showed that comparable layouts were achieved. This was done since the fonts displayed on the VDU were based on the word processor mentioned. A sample display of the VDU stimuli is shown in Figure 7.

The written program in C was also designed to collect input responses from the participants during the reading process by measuring the reading duration of a participant on each text read. (See Appendix C for program output). The end of reading a particular textual passage was signaled by pressing the F key on the keyboard, which produced a sound to attract the attention of the experimenter.

The paper medium was generated using a Microsoft Word version 3.01 word processor and was printed on A4 size paper using the Laser Writer II NT printer. The layout of the text on both VDU and paper was made the same with respect to the number of characters per line (maximum of 80 characters per line), number of lines per page (23 lines/page), and fonts. A sample display of the paper stimuli is shown in Figure 8.

The IBM PS/2 model 30 has a regeneration rate of at least 60 Hz which is reported to be adequate for most applications (Helander et al., 1984). In addition, it has a VGA analog screen rather than digital screens or transistor-transistor-logic (TTL) which are featured in the old IBM display standards (viz., MDA, CGA, EGA). One advantage of using an analog screen is that it can encode a virtually unlimited number of colours (262,144 colour possibilities) whereas digital screens have a

definite colour range: 16 for CGA and 64 for EGA (Rosch, 1990). The PS/2 model 30 screen has a 8 Mhz bandwidth and zero wait state which reduces flicker. No flicker was observable while a page of text was displayed on the VDU during this study.

Furthermore, the IBM PS/2 model 30 has a swivel base and tiltable screen which "minimise[s] the interference of specular (mirror-like) reflections of luminaries and other objects in the room" (Helander et al. 1984, p.191).

3.8. Reading Materials

A demonstration of the understanding of the content of text is the most important determinant of reading comprehension. "Knowledge of the topic covered by the text is of the utmost importance" (Askwall, 1985, p. 426); however, this may pose methodological problems in research because there is no universally agreed upon method to accurately assess a subject's prior knowledge of the text (Askwall, 1985). In order to eliminate some of the problems related to prior knowledge, meaningful short stories written by Saki were used. The short stories used in the present study are most probably familiar only to students of English Literature whereas the majority of computing students, the sample for the study, would be unlikely to be familiar with them.

All texts used in the present study were copied straight from the short stories of Saki (Green, 1976; Mansfield et al., 1969). The same texts were used by Osborne and Holton (1988), Kruk and Muter (1984), and Muter et al. (1982) in their studies. In the study by Osborne and Holton (1988), the passage was always taken from the beginning of the story and each passage consisted of approximately 380 words. In contrast, the subjects in the present study were asked to read a whole story, with an average of 1642 words per story, because one of the objectives of the current study is to determine if long duration reading affects reading speed.

A set of texts comprising six short stories, which were judged to be of equal difficulty, were read for a period of nearly 2 hours by normal readers. The six passages were randomly divided into two sets of approximately equal lengths. The first set was read in the first hour and the second set in the remaining hour. Administration of comprehension tests was interspersed between text passages read (Osborne and Holton, 1988). Because review of a passage of text after reading was not possible in the VDU conditions, a similar constraint was enforced in the paper conditions by printing the paper-and-pencil comprehension test on separate pages

(Kak, 1981). The order of the presentation of stories on both the VDU and paper media was the same.

Both the VDU and paper displays had exactly the same page layout. A page of text contained a maximum of 23 left justified lines with a maximum of 80 characters per line. Words were not hyphenated when the line width exceeded 80 characters because the program displaying the text was also monitoring the number of words read per page.

The VDU condition was controlled by the program written in the C language. Text was not scrolled when displayed. The subjects were instructed to press the SPACE BAR to go to the next page. The time between requesting a new page and initiating a display of that page was approximately 0.5 second. The average time required to fill the screen was approximately 3.4 seconds and 6.2 seconds for Helvetica and Chicago fonts, respectively.

3.9. Variables Under Study

3.9.1. Font Style

In this study, two fonts were used. Both the VDU and paper displays contained the same format (line width, number of lines per page) and font. These fonts, Helvetica and Chicago, were chosen from among the fonts

'You are not really dying, are you?' asked Amanda.

'I have the doctor's permission to live till Tuesday,' said Laura.

'But today is Saturday, this is serious!' gasped Amanda.

'I don't know about it being serious, it is certainly Saturday,' said Laura.

'Death is always serious,' said Amanda.

'I never said I was going to die. I am presumably going to leave off being Laura, but I shall go on being something. An animal of some kind, I suppose. You see, when one hasn't been very good in the life one has just lived, one reincarnates in some lower organism. And I haven't been very good, when one comes to think of it I've been petty and mean and vindictive and all that sort of thing when circumstances have seemed to warrant it.'

'Circumstances never warrant that sort of thing,' said Amanda hastily.

'If you don't mind my saying so,' observed Laura, 'Egbert is a circumstance that would warrant any amount of that sort of thing. You're married to him - that's different; you've sworn to love, honour, and endure him: I haven't.'

'I don't see what's wrong with Egbert,' protested Amanda.

'Oh, I dare say the wrongness has been on my part,' admitted Laura dispassionately; 'he has merely been the extenuating circumstance. He made a thin, peevish kind of fuss, for instance, when I took the collie puppies from the farm out for a run the other day.'

'They chased his young broods of speckled Sussex and drove two sitting hens

((Press SPACE BAR to go to next page))

(a) Helvetica font

Laura

'You are not really dying, are you?' asked Amanda.

'I have the doctor's permission to live till Tuesday,' said Laura.

'But today is Saturday; this is serious!' gasped Amanda.

'I don't know about it being serious; it is certainly Saturday,' said Laura.

'Death is always serious,' said Amanda.

'I never said I was going to die. I am presumably going to leave off being Laura, but I shall go on being something. An animal of some kind, I suppose. You see, when one hasn't been very good in the life one has just lived, one reincarnates in some lower organism. And I haven't been very good, when one comes to think of it. I've been petty and mean and vindictive and all that sort of thing when circumstances have seemed to warrant it.'

'Circumstances never warrant that sort of thing,' said Amanda hastily.

'If you don't mind my saying so,' observed Laura, 'Egbert is a circumstance that would warrant any amount of that sort of thing. You're married to him - that's different; you've sworn to love, honour, and endure him: I haven't.'

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'Oh, I dare say the wrongness has been on my part,' admitted Laura dispassionately; 'he has merely been the extenuating circumstance. He made a thin, peevish kind of fuss, for instance, when I took the collie puppies from the farm out for a run the other day.'

'They chased his young broods of speckled Sussex and drove two sitting hens

((Press SPACE BAR to go to next page))

(b) Chicago Font

Figure 7. Sample of VDU display stimuli with (a) Helvetica and (b) Chicago fonts.

'You are not really dying are you?' asked Amanda

'I have the doctor's permission to live till Tuesday,' said Laura.

'But today is Saturday; this is serious!' gasped Amanda.

'I don't know about it being serious; it is certainly Saturday,' said Laura.

'Death is always serious,' said Amanda.

'I never said I was going to die. I am presumably going to leave off being Laura, but I shall go on being something. An animal of some kind, I suppose. You see, when one hasn't been very good in the life one has just lived, one reincarnates in some lower organism. And I haven't been very good, when one comes to think of it. I've been petty and mean and vindictive and all that sort of thing when circumstances have seemed to warrant it.'

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'They chased his young broods of speckled Sussex and drove two sitting hens

(a) Helvetica font

Laura

'You are not really dying, are you?' asked Amanda.

'I have the doctor's permission to live till Tuesday,' said Laura.

'But today is Saturday; this is serious!' gasped Amanda.

'I don't know about it being serious; it is certainly Saturday,' said Laura.

'Death is always serious,' said Amanda.

'I never said I was going to die. I am presumably going to leave off being Laura, but I shall go on being something. An animal of some kind, I suppose. You see, when one hasn't been very good in the life one has just lived, one reincarnates in some lower organism. And I haven't been very good, when one comes to think of it. I've been petty and mean and vindictive and all that sort of thing when circumstances have seemed to warrant it.'

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'They chased his young broods of speckled Sussex and drove two sitting hens

(b) Chicago font

Figure 8. Sample of paper display stimuli with (a) Helvetica and (b) Chicago fonts.

available in the Microsoft Word version 3.01 word processor. Helvetica font was selected by the author because it has greater legibility compared with other fonts and it is also commonly used on both IBM PCs and Apple Macintosh word processors. The Chicago font, which is available in Apple Macintosh word processors, was selected for two reasons. First, its characters are bolder which enhances the character legibility compared with the characters of Helvetica font (see Appendix D for Sample characters of Helvetica and Chicago font). However, the letters u and v are somewhat alike which may produce confusion among the readers. The second reason was to determine whether it is legibly superior over the widely used Helvetica font.

The fonts generated on the two presentation media were alike because the fonts displayed on the VDU were based on the fonts available in the Microsoft Word version 3.01 word processor. All the characters of Helvetica and Chicago fonts in the MS-Word 3.01 were enlarged and printed separately to determine the size of the matrix each character uses. The size of the character matrices used in the present study varied from 1 x 11 (for i and l of both fonts) to 13 x 11 (for letter W of Helvetica font) and 11 x 11 (for letter W of Chicago font) when the descenders were excluded. (See

Appendix D for sample characters of both fonts.) With the descenders included, the character matrix varies from 1 x 19 (for letter i of both fonts) to 13 x 19 (for letter W of Helvetica font).

Variable character matrix size was used in designing the two fonts displayed on the VDU screen because the word processor used to generate the text on paper, Microsoft Word 3.01, features variable character matrix size. This was performed to maintain uniformity between the two presentation media. In addition, based on the findings of Beldie et al. (1983), Mill and Weldon (1987) suggested that " . . . reading from a computer screen may be easier with variable-matrix characters than with fixed-matrix characters" (p. 338).

3.9.2. Colour

Four different colour combinations were used in this study and were selected on the basis of their effects on a particular task. Tullis (1981) reported that the "effects of graphics and color on human performance are highly dependent on the tasks" as cited by Pace (1984, p. 8). This implies that one colour combination may produce the maximum response in one task but may not hold true in another task. One of the objectives of this study is to determine whether a

colour combination reported to be associated with good performance in a search task will have the same effect in a reading for comprehension task. Hence, the colour combinations found to produce the maximum response in search, text-editing, and input tasks by previous studies (Durrett, 1982; Chung and Ogino, 1987; Pace, 1984) were used in the current study. These are the white/black, yellow/black, and white/blue foreground and background colour combinations.

The paper treatments in this study served as control treatments and were compared with the VDU treatments. The 3 of 4 foreground and background colour combinations which were selected for the VDU presentation were all suggested by previous studies. The white characters on a black background (white/black) colour combination was shown to be effective in text-editing tasks (Durrett, 1982; Chung and Ogino, 1987). Yellow/black was recommended for a search and text editing tasks (Durrett, 1982; Pace, 1984; Chung and Ogino, 1987). Amber/black showed less replacement time in a text-editing task under a no glare condition (Chung and Ogino, 1987). White/blue was recommended for text editing and input task because this combination generated low error rates (Chung and Ogino, 1987; Pace, 1984). By contrast, the black/green combination, which

was found to be a poor colour combination in a search task (Pace, 1984; Ohlsson, Nilsson, and Ronnberg, 1981), was selected to determine whether it produces the same effect in a reading for comprehension task. In this experiment, four foreground and background colour combinations on the VDU display, two fonts, and two presentation media (VDU and paper) were considered. This study aimed at determining which of the factors interact with each other as well as to pin-point what combination of font and presentation medium would produce the maximum performance.

The significant reading speed difference between the VDU and paper is reported to be associated with the image quality (i.e., font, colour, line width, line spacing) of the characters displayed (Gould et al., 1987b; Gould et al., 1987c; Kolers et al., 1981). Thus, the current study has investigated the following factors together with their associated levels:

Factor 1 - Presentation medium

paper	-	black/white	
cc1	-	white/black	(VDU)
cc2	-	yellow/black	(VDU)
cc3	-	black/green	(VDU)
cc4	-	white/blue	(VDU)

Factor 2- Fonts

Ft1	-	Helvetica
Ft2	-	Chicago

where cc means colour combination
Ft means font

3.10. Experimental Procedure

The subjects were greeted upon their arrival to the experimental laboratory. The objectives of the study were explained to them and questions were answered before the experiment was conducted. They were informed that their reading speed and comprehension scores were important aspects of the study.

The subjects were randomly assigned an individual subject number ranging from 1 to 40. They were instructed to remember their subject number because they would be asked to write their subject number on some of the questionnaires they were asked to complete. A Subject Profile Questionnaire was then administered. This questionnaire was designed to gather relevant details about the subject including age, sex, etc., and in addition, their familiarity with the VDU. (See Appendix A for sample specimen of the Subject's Profile Questionnaire.)

The subjects were then briefed on what to expect for the duration of the experiment. The sequence of procedures was outlined and explained. The subjects were allowed to control the contrast adjustment during the trial session to suit their visual needs as well as to simulate the real world. This decision was supported by the earlier findings of Gould et al. (1987a) who

reported that " . . . there was no interaction between polarity and whether or not participants preset the display brightness . . . " (p. 508).

The subjects were also informed that they would be reading two sets of stories on the presentation medium to which they would be assigned and that their reading speed and comprehension would be measured. They were encouraged to read the stories as if reading them for pleasure and were prevented from turning to the previous page they read.

A pretest was administered on the first day of the subjects' participation by asking them to read a short story presented on paper. This was undertaken to measure their pretest reading speed, which was used as a covariate in the analysis of the dependent variable, Total Reading Speed, because it was reported that " . . . variability attributed to individual persons is always expected . . . " (Pace, 1984, p. 58).

Before the subjects were instructed to start reading a set of text, they were first asked to read the instructions presented on either the paper or VDU medium. Figures 9 and 10 show the instructions on paper and VDU display, respectively. The subjects assigned to read from the VDU displays were instructed to press the SPACE BAR to view the next page. Some subjects held

down this key too long which made the computer program continuously display the remaining pages of the text. When this happened, the subjects were asked to inform the experimenter. To return to the page which the subject was previously reading, the BACKSPACE key was pressed by the experimenter until the desired page was reached. This did not make the reading duration calculation erroneous since the timer was initiated back to zero when the display was brought back to the page the subject was reading when the error occurred. The subjects were not informed about the BACKSPACE key because that situation was anticipated to happen only occasionally and the author felt that the subjects might use it as a means to review the previous page they had already read.

A comprehension test was administered immediately after the subjects had read the story presented in the pretest. The number of correct scores was used as a covariate in the analysis of the dependent variable Comprehension Score. The subjects were then given 10 minutes to relax before the experiment resumed.

The Profile of Mood States (POMS) (Appendix E-1) and Physical Symptoms Questionnaires (PSQ) (Appendices F-1 and F-2) were then administered. These tests were administered twice: before the first story was read

=====

<<<< INSTRUCTIONS >>>>

In this experiment, you will be reading some stories written by Saki. You will be asked to read two sets of stories wherein each set consists of three stories. After reading the first set of stories, you will be given a short break of 10 minutes before reading the second set of text. Your reading speed will be monitored page by page so you will be required to press the stop clock twice in every page you read: before you start reading a page and after you finished reading it. Please wait for the experimenter to record the time displayed on the stop clock before starting to read the next page. A comprehension test will be administered right after you have finished reading one story. Although your speed and comprehension will be measured, please try to read the stories as if you were reading them for pleasure. You may pause for a few seconds once in a while.

There is, however, a restriction in this experiment. You are not permitted to turn back to the previous page at any time. It is therefore necessary to read each page of the story intently since it is not allowed to review a page that has been read.

Your participation in this research will be greatly valued. Once again, thank you very much for your cooperation.

< Please turn to next page to start reading text >

=====

Figure 9. Instructions to the subjects reading text from Paper presentation.

=====

<<<< INSTRUCTIONS >>>>

In this experiment, you will be reading some short stories written by Saki. You will be asked to read two sets of stories wherein each set consists of three stories. After reading the first set of stories, you will be given a short break of 10 minutes before reading the second set of text. A comprehension test will follow after a story is read. Your reading speed will be measured automatically by a computer program. Although your speed and comprehension will be measured, please try to read the stories as if you were reading them for pleasure. You may pause for a few seconds once in a while.

There is, however, a restriction in this experiment. You are not permitted to turn back to the previous page at any time. For those reading on the screen, you must press the Space Bar key only once to go to the next page. Please refrain from touching the Space Bar key if you do not intend to go to the next page. If you pressed it by accident, please call this to the attention of the experimenter.

Your participation in this research will be greatly valued. Once again, thank you very much for your cooperation.

< Please press any key to start reading text >

=====

Figure 10. Instructions to the subjects reading text from VDU presentation.

The Profile of Mood States (POMS) (Appendix E-1) and Physical Symptoms Questionnaires (PSQ) (Appendices F-1 and F-2) were then administered. These tests were administered twice: before the first story was read (before) and again after the last comprehension test of the second set of texts had been administered (after). The purpose of this was to determine whether the participants had experienced or developed fatigue during the reading duration.

A set of texts, consisting of six different stories, were presented to the participants to be read in a period of approximately 2 hours. Comprehension tests, consisting of multiple choice questions (generally five questions per story) created by the author, were administered after reading each text which was indicated by requiring the participants to press the F key on the keyboard. When this key was pressed, the computer was programmed to produce a sound to attract the attention of the experimenter. After the completion of the first set of texts, the participants were given 10 minutes break for them to relax their head and eyes. Another set, consisting of different texts, was administered for another hour and the same procedure followed.

On the last (third) day of the subjects' participation in the experiment, they were asked to rank the font and colour combinations (VDU treatments) presented on the VDU display from a scale ranging from most preferred (first) to least preferred (fourth) or from most preferred (first) to least preferred (eight). This ranking scale provided user preferences for combinations of font and colour. Each subject was asked to rank separately the four colour combinations with either font. In addition, they were asked to rank the four colour combinations associated with either font presented on the same screen.

It should be noted that the subjects did not experience reading text on all the conditions (both on VDU and on paper) because they were required to read from only 3 of the 10 conditions. To solve this problem, an example of each of the VDU conditions was displayed on the screen for them to see the differences among the eight VDU conditions (see Appendices G-1, G-2, and G-3). The computer program which displayed the questionnaire on the screen automatically saved the subject's order of preferences in a file.

Since all the subjects were randomly assigned to a particular treatment for every replication, the experiment was conducted on three separate days to give

them time to relax their eyes as well as to remove any sort of fatigue they may have experienced during their previous participation.

3.11. Instruments Used

3.11.1. Reading Speed Measurement

The reading duration calculation on the VDU display was built-in to the program which displayed the text. This program generated a detailed report outlining the reading duration page by page. Two reading durations were measured by the program:

1. reading duration for each story read in a set of text including the time it takes to fill the screen page, and

2. reading duration excluding the time it takes to fill the screen page.

Based on the two reading durations measured, two measures of total reading duration were calculated namely: (a) total reading duration excluding the time taken to refresh the presentation medium (Total Reading Duration - Refresh Time) and (b) total reading duration including the time taken to refresh the presentation medium (Total Reading Duration). The corresponding Total Reading Speeds calculated based on these two measures were used in the analysis of covariance to

determine whether refresh time explains the reported significant reading speed difference between the paper and VDU presentation media.

In the paper medium, a stop watch was used to monitor the subjects' reading speed. Only the reading duration excluding the time to turn a page was measured because the subjects were asked to press the stop watch before and after reading a page of text. To calculate the total reading duration including the time to turn a page, 2 seconds was added to the measured reading duration time of each page excluding the last page of the story. The 2 seconds was the measured average time needed to turn a page in the booklet of printed texts.

Reading speed per story set was calculated by summing the measured reading durations per story (calculated in seconds) dividing by the total number of words in a set of stories and multiplying by 60 to express the speed in number of words read per minute (wpm). The formula used is as follows:

$$\begin{aligned} \text{Reading speed/story set} &= \frac{\text{Total reading duration} \times 60}{\text{Total number of words/story set}} \\ &= \text{Number of words read/minute} \end{aligned}$$

An analysis of covariance was also used to determine whether there was a significant difference between the two presentation media with respect to

reading speed using the pretest reading speed, age, and length of computer experience as the covariates. The independent variables used were font, medium presentation, and story set.

3.11.2. Comprehension Score Measurement

A multiple choice test consisting of an average of five questions was administered to each subject after reading a story. An analysis of covariance was used to determine if a combination of font, presentation medium, and story set affects reading comprehension. The dependent variable used was the sum of the comprehension scores obtained in a set of texts read. The subject's self-reported age and length of computer experience obtained from the Subject's Profile Questionnaire, and their pretest score obtained from the pretest, were used as covariates.

3.11.3. Fatigue Measurement

In the present study, the Profile of Mood States (POMS) and the Physical Symptoms Questionnaires (PSQ) were administered to the subjects on two occasions: before the first story was read, and after the administration of the second set of texts. These questionnaires were designed to determine what the subjects felt at the time they were completing them.

The fatigue measurement consisted of a two-part questionnaire: 15 POMS items (see Appendix E-1) and 18 PSQ items (see Appendices F-1 and F-2). Both questionnaires were administered to the subjects on paper.

The 15 POMS items were extracted from the 65-item questionnaire used by Pace (1984) and were selected from the tension, vigour, and fatigue categories. This questionnaire was designed to measure any changes in moods of the subjects with respect to the three scales mentioned. Each category contained five related items describing that particular POMS category. The items under each POMS categories are shown in Appendix E-2.

The PSQ was designed by Dainoff et al. (1981) to measure the physical symptoms experienced by subjects when reading text for a lengthy period. This questionnaire contained items selected to measure fatigue due to: physical/mental stress, visual strain/fatigue, lighting complaints due to glare, general fatigue, ergonomic aspects, computer system aspects, and the task/job itself. The computer system and job aspects were taken into consideration in the questionnaire because fatigue might also be caused by computer system inefficiencies due to slow response time, VDU flicker and jitter, as well as by the type of

job or task performed (e.g., boring, not challenging, not interesting) by the subject with the aid of a computer (Dainoff et al., 1981). The physical symptom items included were selected on the basis of reports in the literature as being the common physical symptoms experienced in long duration reading (Dainoff et al., 1981). Item numbers under each Physical Symptoms category are shown in Appendix F-3. Appendices F-1 and F-2 show samples of Physical Symptoms Questionnaire.

An analysis of variance for all the categories on both questionnaires was employed in measuring the degree of fatigue which the subjects felt after reading each particular set of texts. The analysis took into account the variation due to administration, font, presentation medium, and story set.

3.11.4. VDU Screen Font and Colour Combinations Ranking Measurement

The subjects were asked to rank the font and colour combinations based on VDU on a computer screen. They were asked to provide rankings on three items shown on successive screens. The first display asked the subjects to rank the four different colour combinations in the following order: white/black, yellow/black, black/green, and white/blue for Helvetica font. The rank ordering measures ranged from most preferred

(first) to least_preferred (fourth). (See Appendix G-1 for sample screen display.)

The second item asked the subjects to rank the same colour combinations as the first display in combination with Chicago font. The rank ordering measures were the same as the first question displayed. (See Appendix G-2 for sample screen display.)

Finally, the third item asked the subjects to rank the combinations of the two fonts and the four colour combinations. This was accomplished by merging the two earlier displays into one screen. The rank ordering measures ranged from most_preferred (first) to least_preferred (eight) (See Appendix G-3 for sample screen display).

The relationship between participants' order of colour combination and font preferences, and the combination of different font and colours was obtained from the Contingency Coefficient and the Cochran-Mantel-Haenszel Statistics provided by the SAS statistical package. (See Appendices H-1, H-2, and H-3.)

4. RESULTS

The data obtained from the study were analysed using ANOVAs to evaluate the null hypotheses, chi-squares, and Contingency Coefficients. Crosstabulation tables were used to provide data on the related research questions. Observations on certain aspects of subject behaviour were also analysed.

Results of the study will be addressed in the order of the list of objectives given on page 20.

4.1. Differences among Foreground and Background Colour Combinations Used on Reading Speed and Comprehension

The first analysis of the data focused on the legibility provided by the various colour combinations on a reading for comprehension task. The question was whether use of a particular colour combination leads to a significant difference in reading speed performance and comprehension scores.

An analysis of variance was used to evaluate the first and second null hypotheses in Section 1.6, that the different colour combinations would not exhibit different effects on reading speed and comprehension in a reading for comprehension task. In all of the analyses made, the story set variable was treated as a random variable whereas font and presentation medium were treated as fixed variables. The ANOVA table for comprehension score is shown in Table 4. Although the

participants who read on the white/black have scored slightly higher than those who read on the other presentation media as shown in the Duncan's Multiple Range Test (DMRT) grouping in Appendix I-1, the analysis (Table 4) indicated that comprehension score is not significantly affected by either font or presentation medium with $F(1,88) = 1.85$, $p < 0.3124$ and $F(4,88)=1.11$, $p < 0.4184$, respectively. From this result, it is evident that comprehension score is not significantly affected by the colour combinations and it can be deduced that all the colour combinations have similar effects on comprehension score.

Analysis also showed that there is no significant difference among the story sets when this variable was treated as a random variable. In other words, the differences among the comprehension scores of the participants across all treatments were not significant. However, the interaction effect of font and presentation medium approaches significance with $F(4,88) = 3.37$, $p < 0.0654$. In this analysis, the covariate pretest score accounts for most of the comprehension score variability.

When the story set variable was treated as a fixed variable (see ANOVA table in Appendix I-1), results showed that comprehension score was significantly

Table 4

Analysis of Variance for Reading Comprehension Score
(Mixed Model)

Source	DF	Type III SS	DF	Mean Square	F Value	Pr >F	
Font	1	5.97132	1.91	3.23074	1.85	0.3124	
Medium	4	8.43468	7.83	7.63502	1.11	0.4184	
Font x Medium	4	30.25707	8.30	8.99136	3.37	0.0654	
Set	2	93.17093	0.15	1.87067	49.81	0.6135	
Font x Set	2	3.28877	8.04	8.94309	0.37	0.7034	
Medium x Set	8	7.67034	8.10	8.95522	0.86	0.5837	
Font x Medium x Set	8	8.93601	88	13.53369	0.66	0.7248	
Pre_score	1	249.99277	88	13.53369	18.47	0.0001	***
Age	1	32.51075	88	13.53369	2.40	0.1248	
<hr/>							
<u>Note.</u>	*	= significant at 0.05 level					
	**	= significant at 0.01 level					
	***	= significant at 0.001 level					

affected by the differences among the sets of stories. As shown in the DMRT grouping, Story Set 1 is significantly different to both Story sets 2 and 3. This shows that Story Set 1 was found by the participants to be relatively easier to understand ($M = 27.80$) than Story Set 2 ($M = 25.90$) and Story Set 3 ($M = 24.73$).

The reading speeds for the different presentation media are shown graphically in Figure 11. From this figure, it appears that the participants read faster from the VDU with white characters on blue background ($M = 208.05$ words/min), followed by the yellow/black presentation medium ($M = 204.45$ words/min).

Colour Combinations
(Text/Background)

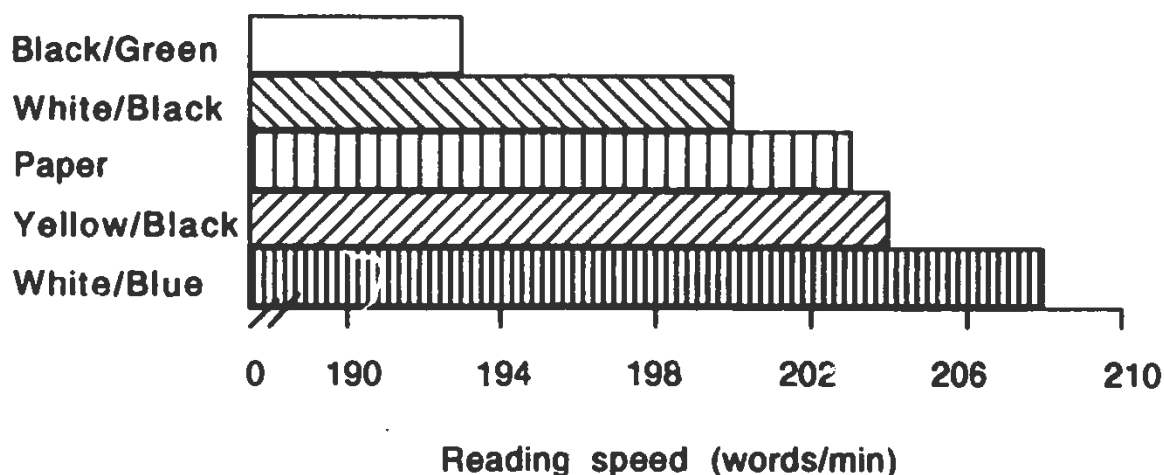


Figure 11. Reading speed as a function of presentation media.

Participants read poorly on the black on green colour combination ($M = 192.89$ words/min). However, the five presentation media failed to differ significantly with

$F(4,87) = 0.20$, $p < 0.9325$ as shown in Table 5 (Mixed Model). The existence of a significant interaction between the presentation medium and story set may have accounted for some of the reading speed difference, with $F(8,87) = 3.86$, $p < 0.0353$. Analysing the means of the interaction of these two main effects (see Appendix I-2) shows that the combination of Story Set 3 with any presentation medium seems to be associated with faster reading speed compared with the other story sets. Based on the analysis of covariance, it appears that the covariates, length of experience with computers and pretest reading speed, account for a great deal of the variability in reading speed among the presentation media and font styles.

4.2. Differences between the Paper and VDU Media in terms of Reading Speed and Comprehension

Another objective of this study is to test null hypotheses 3 and 4 in Section 1.6, that is, the differences between the paper and VDU media do not significantly affect reading speed and comprehension regardless of font style and colour combinations used. To assess the validity of the null hypotheses, a three-way analysis of variance with three replications over the factors font, presentation medium, and story set was used. The covariates, pretest reading speed, age, and

Table 5

Analysis of Variance for Reading Speed (Mixed Model)
(Excluding Time to Refresh the Presentation Medium)

Source	DF	Type III SS	DF	Mean Square	F Value	Pr > F
Font	1	0.23	1.98	4845.52	0.00	0.9951
Medium	4	1369.54	7.89	6922.91	0.20	0.9325
Font x Medium	4	1606.51	8.36	1756.96	0.91	0.4985
Set	2	2263.09	5.43	10076.22	0.23	0.8059
Font x Set	2	4803.77	8.07	1755.97	2.74	0.1239
Medium x Set	8	6787.02	8.17	1756.33	3.86	0.0353 *
Font x Medium x Set	8	1755.71	87	1815.30	0.97	0.4670
Pre_speed	1	184522.20	87	1815.30	101.65	0.0001 ***
Age	1	627.72	87	1815.30	0.35	0.5580
Experience	1	14021.79	87	1815.30	7.72	0.0067 **

Note. * = significant at 0.05 level
 ** = significant at 0.01 level
 *** = significant at 0.001 level

length of computer experience, were included in the analysis of the dependent variable Total Reading Speed (TRS). On the other hand, pretest score and age were used as covariates in the analysis of the dependent variable Total Reading Comprehension Score (TRCS). Referring back to Table 4, reading comprehension is not

affected by both main effects, font and presentation medium. This implies that the number of questions answered correctly does not significantly differ when reading either from paper ($M = 26.08$) or from VDU ($M = 26.16$), regardless of font style and colour combinations used.

Time taken to read a story set was analysed using the same method. The analysis of variance for Total Reading Speed (excluding the time to refresh the presentation medium) as shown in Table 5, indicated a nonsignificant reading speed effect from the different presentation media, $F(4,87) = 0.20$, $p < 0.9325$. In addition, the font style effect has contributed minimal effects on reading speed, $F(1,87) = 0.00$, $p < 0.9951$.

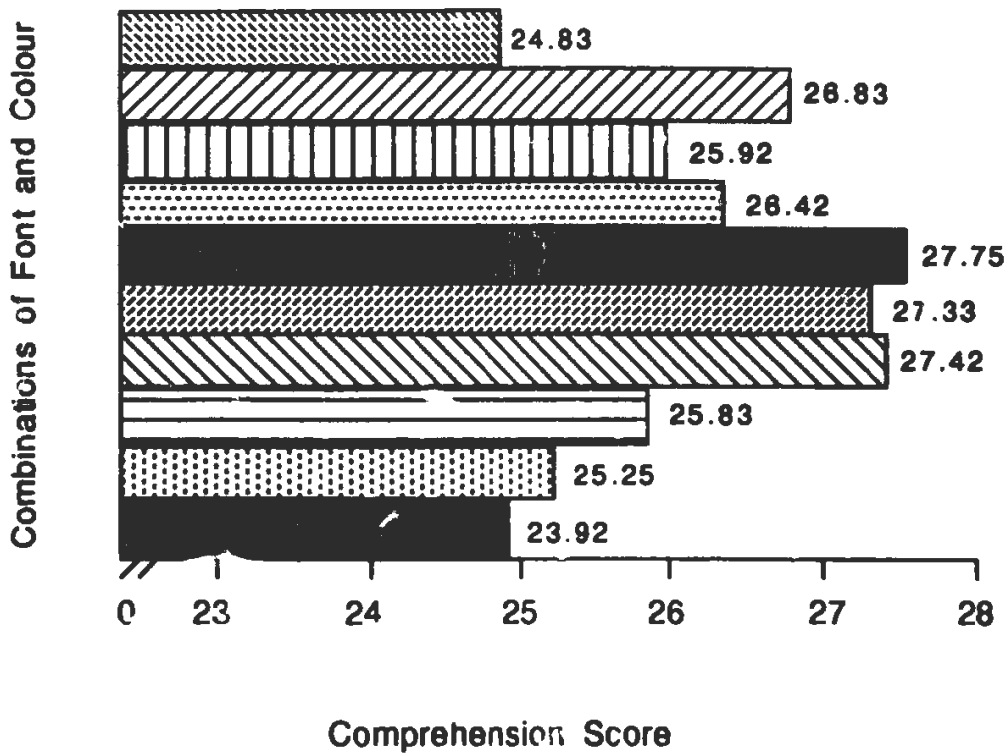
Related to these analyses is to test null hypothesis 5, that there is no significant interaction that exists between the two VDU image variables, font and colour combination. Contrary to the earlier belief, the interaction between these two variables contributed very little to the differences in reading speed, $F(4,87) = 0.91$, $p < 0.4985$ (see Table 5). However, their interaction nearly approached significance in the analysis for reading comprehension $F(4,87) = 3.37$, $p < 0.0654$ as shown in Table 4. As shown in Figure 12 (see also Table 11, p. 154), the white/blue presentation medium with Helvetica font is associated with the

highest comprehension score (27.75) followed by the white/black with Chicago font (27.42). When the average comprehension performance on the five (5) presentation media was taken (Table 10, p. 152), results showed that the participants comprehended better when reading on the white/black colour combination with an average of 27.125 followed by the paper medium with an average comprehension score of 26.08.

Taken together, results in this study indicate that the subjects were able to read and comprehend text on both paper and VDU screen equally well regardless of the font style and colour combinations used in the VDU medium. The analysis also indicates that the covariate pretest score accounts for most of the variability in comprehension scores. On the other hand, the covariates, pretest reading speed and length of computer experience, account for most of the variability in reading speeds among presentation media and font styles.

4.3. Effects of Time Required to Refresh the VDU Screen on Reading Speed

One of the objectives, objective number 4, of this study is to determine whether the time required to refresh the screen in displaying the next page affects reading speed. This is evaluated by testing null hypothesis 6 in Section 1.6. Two reading duration calculations were undertaken. The first calculation did



LEGEND:

Font		Presentation Medium	
	Chicago	Paper	
	Chicago	White/Black (VDU)	
	Chicago	Yellow/Black (VDU)	
	Chicago	Black/Green (VDU)	
	Chicago	White/Blue (VDU)	
	Helvetica	Paper	
	Helvetica	White/Black (VDU)	
	Helvetica	Yellow/Black (VDU)	
	Helvetica	Black/Green (VDU)	
	Helvetica	White/Blue (VDU)	

Figure 12. Reading comprehension as a function of presentation medium and font.

not include the time to refresh the screen (VDU) or time to turn the page (paper) whereas the other reading duration computation included the time to refresh the presentation medium. Two separate analyses of variance were undertaken to determine whether the time required to refresh the VDU accounts for some of the reading speed difference between reading from paper and VDU. The analysis of variance, excluding the time to refresh the presentation medium, is shown in Table 5 and has already been discussed in Section 4.2. Table 6 shows the analysis of variance (Mixed Model) for reading speed when the time to refresh the presentation medium was included (ANOVA Fixed Model is shown in Appendix H-3). Comparing Tables 5 and 6 reveals similar results. There is, however, a slight difference noted; the variation due to font increased from $F(1,87) = 0.00, p < 0.9951$ (see Table 5) to $F(1,87) = 0.05, p < 0.8434$ (see Table 6) although both failed to meet a required level of significance. This could be attributed to the fact that it took slightly longer to refresh the screen using Chicago font ($M = 6.2$ seconds) compared with using Helvetica font ($M = 3.4$ seconds). As indicated on both tables, most of the variability in reading speed is accounted for by the covariates of pretest reading speed and participant's computer experience, and not by the

time required to refresh the presentation medium in relation to font style. Both tables also show that a significant interaction exists between presentation medium and story set, $F(8,87) = 4.48$, $p < 0.0229$ (Table 6). It can be inferred that this significant interaction occurred only by chance because the main effects of font and story set failed to differ significantly.

Table 6

Analysis of Variance for Reading Speed (Mixed Model)
(Including Time to Refresh the Presentation Medium)

Source	DF	Type III SS	DF	Mean Square	F Value	Pr > F
Font	1	189.299	1.97	3753.012	0.05	0.8434
Medium	4	1838.817	7.89	5766.732	0.32	0.8577
Font x Medium	4	1496.849	8.50	1266.662	1.18	0.3846
Set	2	1800.061	5.87	8314.463	0.22	0.3115
Font x Set	2	3709.359	8.19	1263.089	2.94	0.1093
Medium x Set	8	5656.861	8.25	1263.767	4.48	0.0229 *
Font x Medium x Set	8	1260.810	87	1490.494	0.85	0.5651
Pre_speed	1	155027.072	87	1490.494	4.01	0.0001 ***
Age	1	585.157	87	1490.494	0.39	0.5326
Experience	1	11371.375	87	1490.494	7.63	0.0070 **

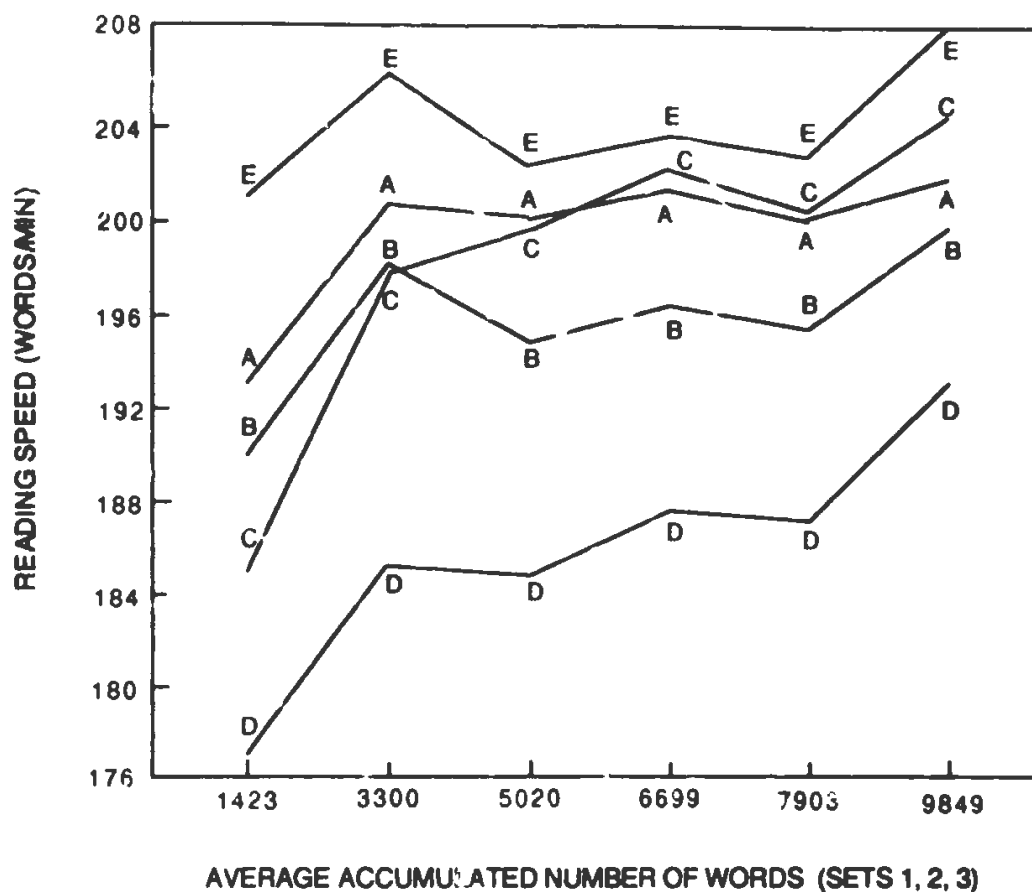
Note. * = significant at 0.05 level
 ** = significant at 0.01 level
 *** = significant at 0.001 level

4.4. Effects of the five (5) presentation media on Reading Speed and Comprehension Score

Majority of the discussion in this section is based on graphical examination of the order effects in a story set on reading speed and comprehension. This section addresses objective number 5 which is to determine or identify the presentation media that affect reading speed performance and comprehension scores.

The reading speed trend based on presentation medium by sets of stories is shown in Appendix J. As indicated in the three figures, there appears to be no presentation medium superior to any other because there are times that a particular medium is superior to the rest in a particular story set while there are also times that this particular medium is inferior compared with the other presentation medium in a certain story set.

Only the effects of the presentation medium on reading speed is given emphasis because the story set factor is not of particular interest in this study. The average reading speed across all treatments in the three story sets is shown in Figure 13. The reading speed data reveal a general increase in reading speed from the first to second story read, a decrease from second to third, an increase from third to fourth, a decrease



Legend: Presentation medium

- A - Paper
- B - White text on a Black background (VDU)
- C - Yellow text on a Black background (VDU)
- D - Black text on a Green background (VDU)
- E - White text on a Blue background (VDU)

Figure 13. Summary of reading speed as a function of presentation medium by story set.

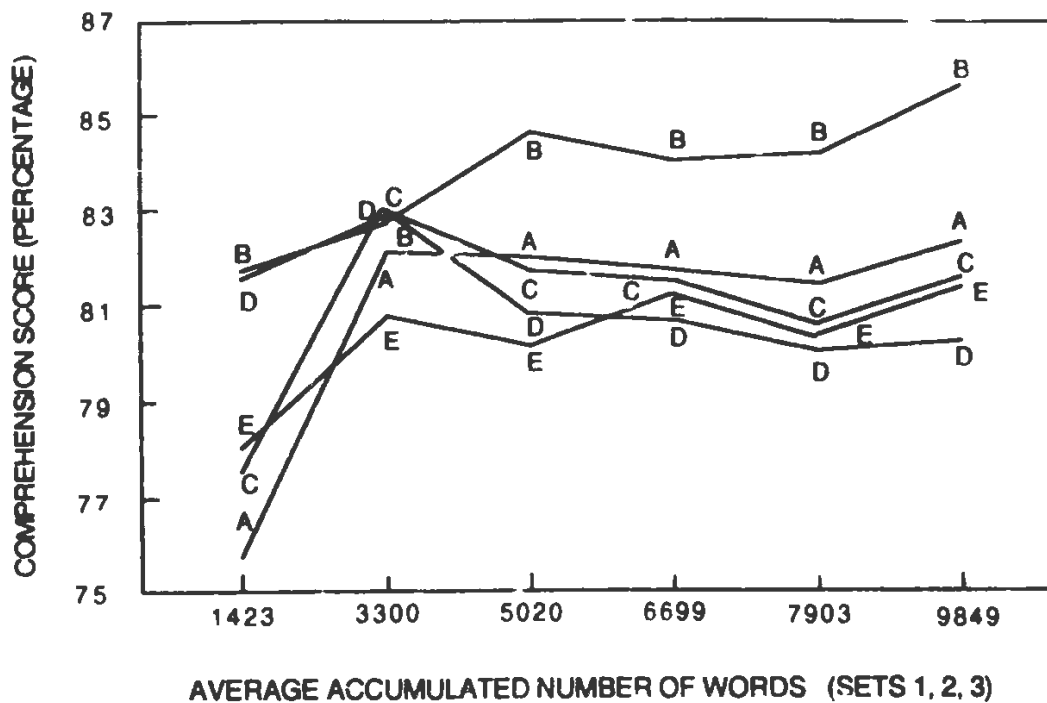
from fourth to fifth, and an increase from fifth to the last story. The increase in reading speed from stories 3 and 4 needs some explanation. The subjects were given 10 minutes break after they finished reading the first three stories. This may have been the reason why reading speed generally increased from stories 3 and 4. Reading speed from stories 2 and 3 and from stories 4 and 5 generally decreased, possibly because of the fatigue that they may have been experiencing. As depicted in the figure, there is an increase in reading speed from stories 5 and 6. An explanation for this might be "perhaps the subjects developed a more successful reading strategy near the end of the experiment" (Pace, 1984, p. 59). According to Pace (1984), industrial studies reported that subjects "experienced a resurgence of energy as the experiment neared the end" (p. 59). However, in this study, the subjects were not informed that they were reading the last story in a set.

Reading from the white/blue combination generated highest reading speed across the six stories read by the participants. The paper presentation initially ranked second in the first three stories read but was surmounted by the combination yellow/black which continued to increased until the fourth story read. The

participants generally read slower in the combination black/green across the three sets of stories. The slow reading speed for the black/green combination might have been due to the poor colour combination contrast. Participants who read with this combination reported that they experienced a greater degree of fatigue compared with those who read with the other presentation media used. Although the white/blue combination seems to have generated the greatest reading speed among the presentation media, no significant differences exist among them, as shown in Table 5.

The effects on reading comprehension of the order of short stories as a function of presentation medium by sets of stories are shown graphically in Appendix M. The intent is to determine whether the participants' reading comprehension level is affected as the six stories are read to completion. Based on the three figures shown in Appendix M, no presentation medium seems to be associated with high comprehension score because none of them showed consistent superiority over the rest in the three sets of stories read.

When the average comprehension score was calculated across the sets of stories, as shown in Figure 14, the combination white/black generated the highest comprehension score followed by the paper



Legend: Presentation medium

A - Paper

B - White text on a Black background (VDU)

C - Yellow text on a Black background (VDU)

D - Black text on a Green background (VDU)

E - White text on a Blue background (VDU)

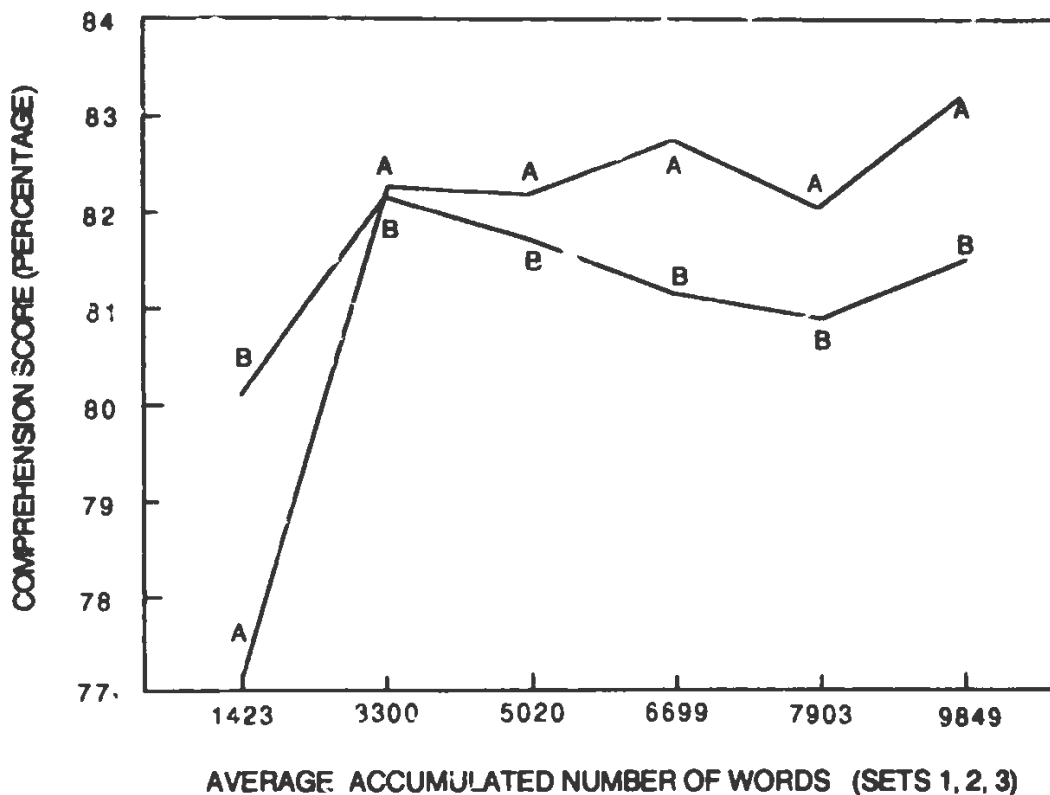
Figure 14. Summary of comprehension score as a function of presentation medium by story set.

medium. The comprehension score in the black/green combination diminished from the third to the fifth story read with a slight recovery in the last story. The same is true with the yellow/black combination although the decrease is not as large. Participants who read on the black/green presentation medium might have suffered more fatigue compared with the participants who read in the other presentation media. In effect, it is possible that participants who read on the black/green medium had lost their concentration while reading.

4.5. Effects of the two (2) fonts on Reading Speed and Comprehension Score

The results of the analysis of variance shown in Table 4 indicate no significant differences that exists in comprehension scores between reading from the two fonts. However, mixed results were obtained when the effects of font on comprehension score were drawn for each story set as shown in Appendix N. The three figures indicate that both fonts seem to have the same effect on the participants' level of comprehension because neither showed a consistently increasing comprehension score across a story set.

As depicted in Figure 15, higher comprehension scores seem to be associated with Helvetica font when the average comprehension score in the three story sets associated with font was taken. However, it was not



Legend : A - Helvetica font B - Chicago font

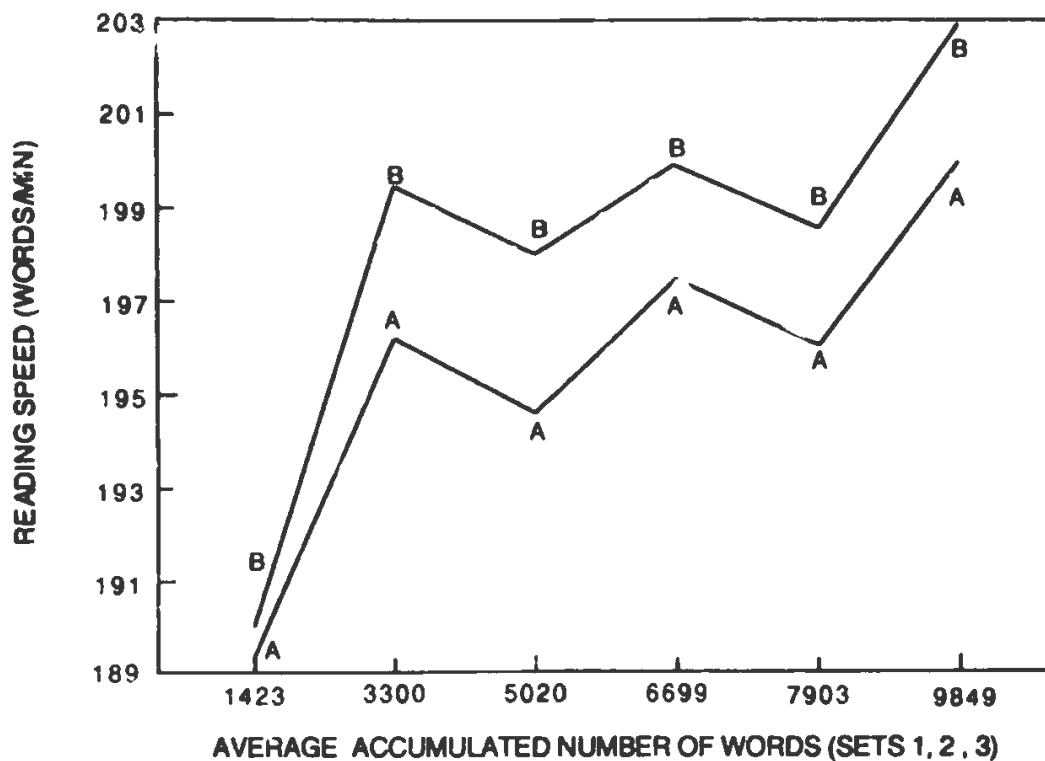
Figure 15. Summary of comprehension score as a function of font by story set.

statistically significant (see Table 4). Another observation is the fluctuation of comprehension scores across the reading duration. One possible reason is a lack of concentration experienced by the participants which might have been caused by the emerging presence of fatigue.

Similarly, reading speed is not significantly affected by the type of font used as shown in Table 5, with $F(1,87) = 0.0$, $p < .0051$. Results also reveals that the two fonts, Helvetica and Chicago, do not significantly account for some of the variations in the reading speed difference between VDU and paper.

Figure 16 shows the average reading speed of all the three story sets administered to the subjects. On the average, the subjects seems to have read faster when they read stories from a presentation medium with Chicago font than from a presentation medium with Helvetica font.

However, when the effects of the story sets on reading speed were graphed individually, as shown in Appendix K, mixed results were observed. The participants generally read faster from a presentation medium with Helvetica font in the first set of stories (Set 1). On the contrary, reverse result was obtained when the participants read the third set of stories. Pictorial inspection of the three figures in Appendix K suggests that no font is consistently associated with faster reading speed, an observation consistent with the analysis of variance shown in Table 5.



Legend : A - Helvetica font B - Chicago font

Figure 16. Summary of reading speed function of font by story set.

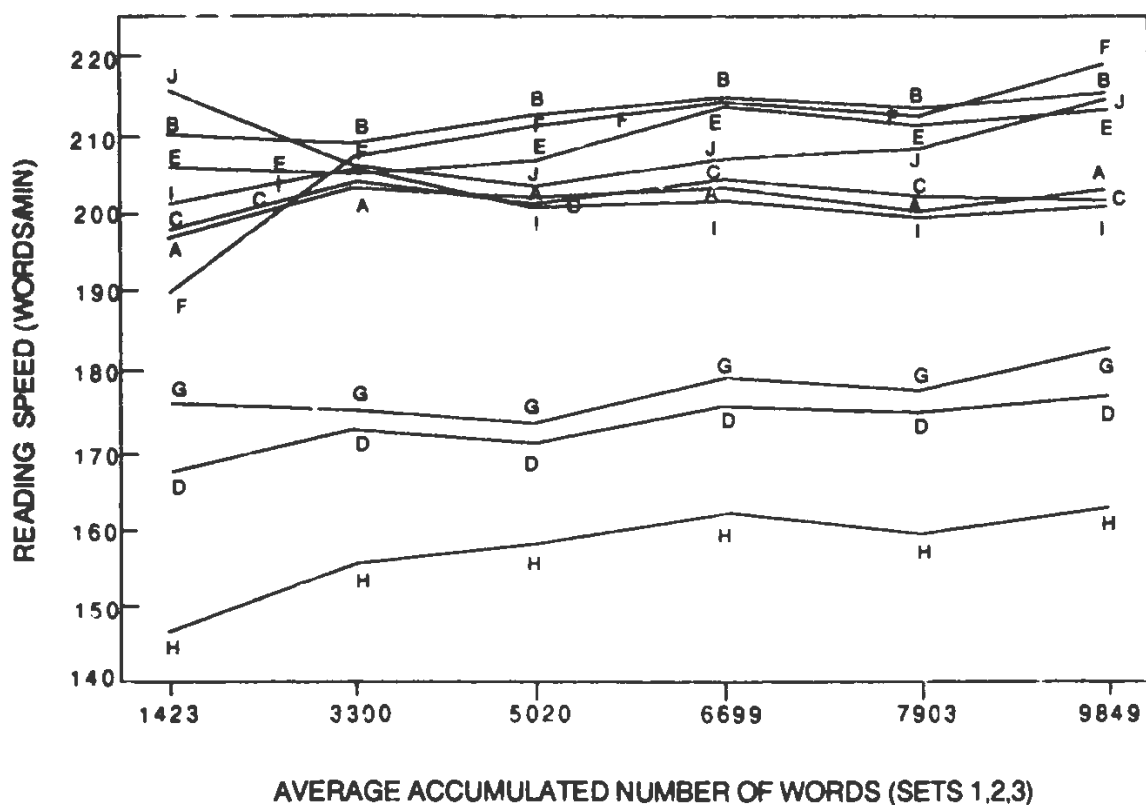
4.6. Effects of the Ten Presentation Stimul. on Reading Speed and Comprehension Score

Objective number 7 in Section 1.5 aimed to determine the effects of the 10 treatments on reading speed during the reading duration of approximately 2

hours. To pin-point which treatment is associated with faster reading, the average reading speed per story read was plotted against the average accumulated number of words per story in a story set. As shown in Figure 17, the paper medium associated with Chicago font is consistently at the top for the entire reading duration except the last story read where the yellow/black with Chicago font yielded the highest reading speed.

This figure also reveals that the black/green combination associated with both font styles is the presentation medium generating the lowest reading speed in addition to white/black associated with Chicago font. Examining the figure closely, it appears that the treatments with Chicago font are associated with better reading performance (i.e., Yellow/Black (F), Paper (B), and White/Blue (J)). The effects on reading speed of the combination of font and presentation medium per story set are shown in Appendix L.

The effects of the 10 treatments on reading comprehension for a reading period of approximately 2 hours are shown in Figure 18. The average comprehension score for the three story sets indicates that the white/blue presentation medium with Helvetica font generates the highest average comprehension score



Legend: Font/Presentation medium

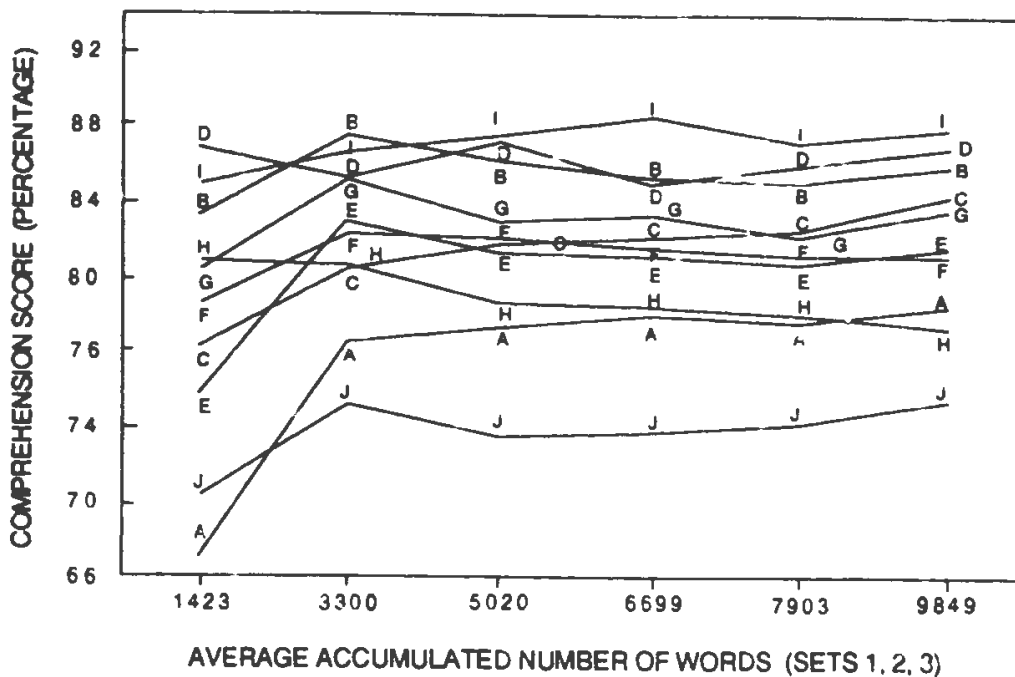
- A - Helvetica font/Paper
- B - Chicago font/Paper
- C - Helvetica font/White text on a Black background
- D - Chicago font/White text on a Black background
- E - Helvetica font/Yellow text on a Black background
- F - Chicago font/Yellow text on a Black background
- G - Helvetica font/Black text on a Green background
- H - Chicago font/Black text on a Green background
- I - Helvetica font/White text on a Blue background
- J - Chicago font/White text on a Blue background

Figure 17. Summary of reading speed as a function of font and presentation medium by story set.

followed by the white/black and paper presentations associated with Chicago font. No inference can be made as to which treatment enhanced reading comprehension because no specific font or presentation medium is associated with high comprehension scores across the reading duration. This observation is consistent with their interaction effect which is not statistically significant as shown in the analysis of variance in Table 4. The effects on reading comprehension score of the combination of font and presentation medium per story set are shown in Appendix O.

4.7. Subject Preferences Results

One of the objectives of this study was to determine the participants' preferred foreground and background colour combination on the VDU. Subjects provided rankings of the four colour combinations displayed on the VDU screen associated with Helvetica font, with Chicago font, and with the combinations of the two fonts. Rankings were made on the VDU display allowing the participants to refer to the actual colour combination and font displayed on the screen. No statistical tests of significance were made except for the Contingency Coefficient, which is a measure of association, generated by the SAS package, because no



Legend: Font/Presentation medium

A - Helvetica font/Paper

B - Chicago font/Paper

C - Helvetica font/White text on a Black background

D - Chicago font/White text on a Black background

E - Helvetica font/Yellow text on a Black background

F - Chicago font/Yellow text on a Black background

G - Helvetica font/Black text on a Green background

H - Chicago font/Black text on a Green background

I - Helvetica font/White text on a Blue background

J - Chicago font/White text on a Blue background

Figure 18. Summary of reading comprehension score as a function of font and presentation medium by story set.

relationship between font style and colour combination preference on performance was hypothesized. A set of crosstabulation tables was constructed for these variables and preferences to examine only the distribution of the percentages within the cells of the tables.

Appendix H-1 shows that of the 40 participants, 21 preferred reading from the white/blue presentation with Helvetica font as their first choice, 17 ranked the yellow/black as second whereas 18 ranked it as their third choice and the majority (31) least preferred the black/green combination. The Contingency Coefficient of 0.64, and the Cochran-Mantel-Haenszel Statistics row mean scores differ significantly from each other with a value of 13.08, $p = 0.004$, with 3 degrees of freedom. This implies that the rankings of the participants over the different presentation media on the VDU display differ significantly from VDU presentation to presentation. Similar results were obtained when the four presentation media associated with the Chicago font were ranked as shown in Appendix H-2.

From Appendices H-1 and H-2, the subjects preferred reading from VDU in the following presentation medium order: white/blue, yellow/black, white/black, and black/green regardless of font style used. This is

consistent with the subjects' reading speed performance measures as shown in the DMRT grouping in Appendix I-2. This seems to indicate that the VDU presentation medium preferences of the subjects correlate with their reading speed performance, although no statistical test was done.

Appendix H-3 shows the subjects' responses when they were asked to rank the sample display shown in Appendix G-3 which consists of the presentation medium combined with either the Helvetica or Chicago font. As shown in Appendix H-3, 12 participants ranked the white/blue (Helvetica) font as their first choice, 11 ranked yellow/black (Helvetica) as second, 12 ranked white/black (Chicago) as third, and 26 ranked black/green (Helvetica) as their least preferred presentation medium.

Based upon the font and colour combination preferences of the participants, it appears that their order of preferences is consistent with their reading speed performance (see Table 10 and Appendix H-4).

4.8. Participants' Satisfaction with Job/Task

Factors related to the task or job itself were embedded in the PSQ to find out if presentation medium affects job or task performance. Participants were

asked to rate the set of stories as to whether they found them interesting, enjoyable, and engrossing. An analysis of variance was used to determine whether the participant's satisfaction in performing the reading for comprehension task is affected by the different presentation media. (See Mixed Model ANOVA table for Task/Job Comments in Appendix S.) The factors font, presentation medium, and story set were used as the independent variables whereas the sum of the items under the job/task category was used as the dependent variable. The Story set factor was treated as a random variable whereas the other factors were treated as fixed variables. Results indicate that both font and story set do not significantly differ from each other. There is, however, significant variation among the presentation media, $F(4.90) = 4.66$, $p < 0.0309$. This implies that the presentation medium has somehow influenced the rating by the participants of the story sets they read. The DMRT grouping shows that the participants who read on white/blue and white/black found the story sets less interesting and enjoyable than those who read on the paper medium. The visual discomfort experienced by the participants who read on the VDU might have affected their concentration when reading the short stories, thus losing their

appreciation of the story. The author believes that the presentation medium alone does not explain all the variations in the analysis of variance and that some of the variations might have been caused by the participants' individual differences inherent in each of them (Pace, 1984).

4.9. Profile of Mood States/Physical Symptom Data Results

The POMS and PSQ data were derived by obtaining the sum of the items belonging to the same category and were analyzed to discover any differences in scores due to the time of administration, font, and presentation medium. Analysis of variance was used to evaluate the null hypothesis that any form of fatigue will not be experienced by the participants after reading text for approximately 2 hours.

4.9.1. Profile of Mood States Results

Results, as shown in Appendix P, reveal that among the three POMS scales, only the vigour scale is not significantly affected by the presentation medium, $F(4,220) = 1.57$, $p < 0.1827$. Tension ($F(4,220) = 4.69$, $p < 0.0012$) and fatigue ($F(4,220) = 3.08$, $p < 0.0169$) are significantly induced by the presentation medium.

In addition, the participants reported significantly greater fatigue ($F(4,220) = 30.92, p < 0.0001$), more tension ($F(4,220) = 7.42, p < 0.007$), and less vigour ($F(4,220) = 30.70, p < 0.0001$) after they finished reading a set of text than before they commenced reading.

It is surprising to find that the paper medium ($M = 4.875$) induced as much fatigue on the subjects as the white/black ($M = 6.437$) and black/green ($M = 5.896$) colour combinations as shown in the DMRT grouping in Appendix M (see Analysis of Variance for Fatigue). The colour combinations which induced less fatigue on the subjects are yellow/black ($M = 4.25$) and white/blue ($M = 3.75$).

Further analysis of the POMS data, shown in Table 7, was performed by calculating the means of the 15 POMS items obtained before and after a story set was read. Results indicate that participants felt more terrified and tensed at the end of the reading session than when they began reading a story set in the Tension-Anxiety scale. In the Vigour-Activity scale, there was a bigger decrease in the participants' level of alertness and relaxation. Subjects also experienced a greater degree of helplessness and fatigue at the end of the reading session compared with other items under the Fatigue-

Table 7

Profile of Mood States (POMS) Item Means Before and After Reading a Set of Texts

POMS Items	Before	After	Increase/ (Decrease)
<u>Tension-Anxiety scale</u>			
Shaky	0.19	0.40	0.21
Nervous	0.18	0.71	0.53
Uneasy	0.29	0.91	0.62
Tense	0.46	1.52	1.06
Terrified	0.09	1.37	1.28
<u>Vigour-Activity scale</u>			
Lively	1.90	1.52	0.38
Vigorous	1.18	1.66	0.48
Active	2.00	1.49	0.51
Alert	2.03	0.22	1.81
Relaxed	2.33	0.15	2.18
<u>Fatigue-Inertia scale</u>			
Worn out	0.88	0.21	(0.67)
Weary	0.69	0.73	0.04
Fatigued	0.83	1.45	0.62
Exhausted	0.82	1.74	0.92
Helpless	0.23	1.28	1.05

Note. Scores ranged from not at all (0) to extremely (4).

Inertia scale. This scale also indicated that participants generally felt less physically worn out: from 0.88 before they commenced reading compared with 0.21 at the end of the reading session. One possible explanation might be the short breaks which lasted for about 5 minutes when they were completing a comprehension test after reading a story. These short breaks might have reduced the tiredness they were experiencing while reading the texts.

Participants appear to have experienced a greater amount of fatigue (Fatigue-Inertia scale), rising from 3.46 to 6.63, after a reading session as shown in Table 8. They also reported a considerable decrease in vigour (Vigour-Activity scale) from 9.44 to 6.70. This suggests that participants experienced more fatigue which is related to the decrease in vigour at the end of the reading session. On the other hand, there was a much smaller increase in the Tension-Anxiety scale (0.79) which suggests that participants felt only a slight increase in tension when they had finished reading a set of text.

A graphical presentation of the three POMS categories (Appendix Q) indicates a definite trend across administrations. There is a consistent decrease in the Vigour-Activity scale in all the presentation

Table 8

Profile of Mood States (POMS) Category Means Before and After Reading a Set of Texts

POMS Scales	Before	After	Increase/ (Decrease)
Tension-Anxiety scale	0.24	0.40	0.16
Vigour-Activity scale	1.89	1.34	(0.55)
Fatigue-Inertia scale	0.69	1.27	0.58

Note. Scores ranged from not at all (0) to extremely (4).

media during the 2 hour reading duration (see Vigour-Activity Scale in Appendix Q). However, the participants who were exposed to the white/black presentation medium lost more strength whereas those who read on paper lost less.

There is also a consistent increase in fatigue across all the presentation media (see Fatigue-Inertia Scale in Appendix Q). Participants reported to be fatigued after reading from a presentation medium with white/black colour combination. On the other hand, only minimal fatigue was reported at the end of the 2 hours reading duration for the white/blue colour combination.

In the Tension-Anxiety scale data (see Tension-Anxiety Scale in Appendix Q) there is also a consistent increase in tension at the end of the reading period. As in the other two POMS scales, participants who read in the white/black medium felt more tense followed by the participants who read on the black/green medium. Participants who read on the paper medium experienced only a slight increase in tension followed by the white/blue medium readers.

The effects of the combination of font and presentation medium are illustrated in Appendix R. Participants who read on white/black and black/green media (regardless of the font used) felt more tense after reading a story set (see Tension-Anxiety Scale figure in Appendix R) whereas those who read on the paper medium with Helvetica font felt less tense at the end of the reading period than when they commenced reading a story set. In addition, there is also a consistent decrease in the participants' strength across the 10 treatments (see Vigour-Activity Scale figure in Appendix R). However, participants exposed to the black/green colour combination with Chicago font lost the most strength whereas those who read on the paper medium with the Chicago font experienced only a slight amount of weakness after the reading session.

A consistent increase in fatigue across all treatments (see Fatigue-Inertia Scale figure in Appendix R) is also evident after the reading session. Participants who read on white/blue combination with Helvetica font reported less fatigue compared with the other treatments. As in the Tension-Anxiety scale, white/black and black/green combination with Chicago font induced more fatigue on the participants than the other presentation media.

4.9.2. Physical Symptoms Items Result

The presence of physical symptoms were analysed using an analysis of variance. The analyses were done for the following categories: physical stress, mental stress, visual strain, workplace environment, and reading efficiency (see ANOVA tables in Appendix S). The time of administration, presentation medium, and font were the independent variables. Results reveal that participants felt more physically stressed ($F(1,220) = 14.62, p < 0.0002$), experienced more mental stress ($F(1,220) = 20.51, p < 0.0001$), and experienced more visual strain ($F(1,220) = 39.05, p < 0.000$) after the reading session than before they started reading a story set. Results also indicate that visual strain ($F(4,220) = 3.82, p < 0.0050$) and mental stress

($F(4,220) = 7.69, p < 0.0001$) are induced by the medium. As shown in the DMRT grouping in Appendix S (see ANOVA for Mental Stress), yellow/black induced less mental stress on the subjects, followed by white/blue and then paper medium. On the other hand, the paper medium caused the least visual strain, followed by yellow/black and white/blue combinations (see ANOVA for Visual Strain).

Item number 14 in the PSQ questionnaire ascertained from the subjects how they assessed their reading before and after they finished reading a story set (e.g., My reading is proceeding easily, efficiently). Analysis shows that the subjects' reading efficiency from the time they commenced reading to their finishing time is affected by the presentation medium ($F(4, 220) = 2.54, p < 0.0405$), by the reading duration of nearly 2 hours ($F(1, 220) = 9.38, p < 0.0025$), and by the interaction of the two factors mentioned ($F(4, 220) = 2.61, p < 0.0366$). (See ANOVA table for Reading Efficiency in Appendix S.) The DMRT grouping shows that participants read more efficiently on the white/blue presentation followed by the paper medium.

Other items embedded in the PSQ covered the effects of the workplace environment such as amount of glare, quality of lighting, and size of the reading

place. Analysis shows that none of these independent variables significantly affects the subjects' reading speed. (See ANOVA table for Workplace Environment in Appendix S.)

Further analysis of the physical symptoms data is illustrated in Table 9. As shown in the table, the largest increase in the physical symptom item complaints over the 2 hours reading duration are caused by visual strain, fatigue problems, focus problems, mental stress, and neck and shoulder pains. There is also a decrease in the reading efficiency of 0.45 (from 2.28 to 1.83). However, participants appear to have been barely affected by the experimental room set-up and environment because there is only a decrease of 0.03 (from 0.73 to 0.70) in discomfort reported after they had finished reading a story set.

The effects of the presentation medium on the different physical symptoms categories are presented graphically in Appendix T. There is a consistent increase in discomfort across the following four categories: general fatigue, mental stress, physical stress, and visual strain, with the white/black presentation medium inducing a greater amount of discomfort in all the first three mentioned categories followed by the black/green medium. The black/green

Table 9

Physical Symptoms Item Means Before and After Reading a
Before and After Reading a Set of Texts

POMS Symptoms Items	Before	After	Increase/ (Decrease)
Workplace poorly laid out, cramped	0.73	0.70	(0.03)
Upset stomach	0.11	0.20	0.09
Fingers, wrist, or arms hurt	0.13	0.23	0.10
Can see coloured fringes around objects	0.35	0.53	0.18
Glare	0.64	0.95	0.31
Lower back hurts	0.18	0.50	0.32
Dizzy	0.17	0.50	0.33
Headache	0.33	0.69	0.36
Tense, anxious, or uneasy	0.37	0.74	0.37
Neck and shoulders hurt	0.24	0.72	0.48
Mental stress	0.42	0.92	0.50
Blurry and hard to focus vision	0.18	0.75	0.57
Wearry, bushed, fatigued	0.75	1.48	0.73
Eyes feel strained, hurt, uncomfortable	0.46	1.42	0.96
Read easily, efficiently	2.28	1.83	(0.45)

Note. Scores ranged from not at all (0) to
extremely (4).

presentation medium appears to have induced greater visual strain than the white/black presentation medium (see Visual Strain figure in Appendix T). These findings are consistent with the verbal complaints of some participants after reading on the black/green presentation medium.

As depicted in the first five figures of Appendix T, the paper and yellow/black presentation media generally induced minimal discomfort on the participants whereas the white/blue presentation medium induced a slightly greater amount of discomfort as compared with the paper and yellow/black media.

In the Reading Efficiency analysis (see Reading Efficiency figure in Appendix T), those participants exposed to the paper presentation medium showed consistently increasing reading speed from the time they began reading a story set to completion. On the other hand, the participants who read on the VDU presentation media were less efficient as they read the text to completion than when they first started reading a set of texts. Those who read on the yellow/black presentation medium showed only a slight decrease in their reading speed and those who read on the black/green medium showed a drastic decrease.

In terms of the effects of the workplace environment on the presentation media (see Workplace Environment figure in Appendix T), the black/green and white/black media seemed to have an interactive effect with the workplace environment (glare) whereas the white/blue and yellow/black did not seem to be affected. Participants who read on the paper medium reported a slight discomfort on the experimental set-up which may be attributed to the comment that the environment was somewhat cramped.

The effects of the 10 treatments, combination of font and presentation medium on the physical symptom categories across the administration time are shown in Appendix J. Results are consistent with the figures presented in Appendix T. It is evident from the figures that font style does not contribute significantly to the physical discomfort felt by the subjects but the colour combination itself appears to be the major contributor to physical discomfort. The white/black and black/green colour combinations are consistently associated with greater degrees of discomfort across the following physical symptom categories: physical stress, mental stress, visual strain, general fatigue, and workplace environment. On the other hand, the paper and the yellow/black presentation media consistently induced the

least discomfort across the mentioned Physical Symptoms categories with the white/blue medium generating more discomfort than the paper and yellow/black media.

Results also indicate that participants experienced less eye strain when they read from paper regardless of the font style used (see Visual Strain figure in Appendix U). However, reading from either black/green (Chicago font) or white/black (Chicago font) presentation medium was associated with severe visual strain.

Among the physical symptoms categories, only reading efficiency did not show a consistent trend. As shown in the Reading Efficiency figure (Appendix U), participants who read on paper (both fonts) and yellow/black (Chicago font) showed an increase in reading efficiency as they read the story set to completion. In contrast, the participants who read on the black/green (both fonts) medium reported a drastic decrease in their reading efficiency as they read the text to completion.

5. DISCUSSION

This chapter will review and discuss the results of the present study. One of the major concerns was to investigate whether there is a significant reading speed difference between the VDU and paper media as well as to identify the possible factors contributing towards the improvement of reading speed. Another question addressed was whether the four different colour combinations produce different results when used in the same task. In addition, the question of whether, after reading for a period of approximately 2 hours, fatigue will be significantly evident as measured by the two questionnaires.

This study has analysed the reading speed and comprehension performances of the 40 subjects who participated in the experiment. Participants were asked to read a story set, consisting of six different short stories, for a period of less than 2 hours. There were two methods used to calculate the reading speed based on the measurement taken from the participants: the reading speeds excluding and including the time to refresh the presentation medium. The comprehension test was administered immediately after each story was read.

The different colour and font combinations were ranked by the participants on their final participation in the study from the most to the least preferred.

Changes in the participants' mood were measured using the POMS questionnaire and the presence of fatigue in the participants was measured by the Physical Symptoms Questionnaire.

5.1. Presentation Medium

This section will discuss the results of objective number 1, 5 and 7. The effects of the different presentation media on reading speed and comprehension performances in the present study did not reach the required level of significance. Comprehension level did not seem to be affected by a wide range of variables and this is consistent with some earlier studies (Duchnick et al., 1983 ; Kolers et al., 1981; Muter et al., 1982; Kruk et al., 1984; Osborne et al., 1988). Comprehension score was affected neither by font nor presentation medium. Mean scores for the different colour combinations and the 10 treatments are shown in Tables 10 and 11, respectively. As mentioned earlier, the white/black colour combination seems to be associated with better comprehension performance as compared with the other colour combinations (see Table 10). This result is consistent with the findings of Pace (1984). Likewise, reading speed is also found to

Table 10
Summary of Reading Speed and Comprehension Performances
as a Function of Presentation Medium

Presentation medium	Average reading speed (words/min)	Comprehension score (mean score)
White/Blue (VDU)	208.05	25.83
Yellow/Black (VDU)	204.45	25.88
Black/White (Paper)	202.56	26.08
White/Black (VDU)	199.10	27.12
Black/Green (VDU)	192.89	25.79

Note. Maximum possible comprehension score is 30.

be not significantly affected by the different presentation media. This implies that the subjects read as fast on VDU as they read on paper. The adjustment of the brightness-contrast settings might have compensated for some of the difficulties in using certain colour combinations (Pace, 1984). This is justified by the result of Radl (1980) who reported that brightness and contrast of symbols displayed on a VDU screen seem to have more effect on readability than the actual colour of the symbols. Furthermore,

Fukuzumi et al. (1987) reported that readability was also found to depend upon the colour combination of text and background as well as the amount of contrast.

Although the 5 presentation media were not statistically different from each other, it appears that some colour combinations are associated with higher reading speed than others. Results shown in Table 10 reveal that the subjects tend to read faster in the following presentation medium order: white/blue combination (VDU), yellow/black (VDU), and paper regardless of font style used.

Shurtleff (1980) reported that white text on a dark background had favoured identification rates over blue, green, yellow, and red letters. Pace (1984) also concluded that white text on a dark background produces good performance. This seems to hold true in the present study because the white/black colour combination is associated with relatively high comprehension scores, but not in reading speed, as shown in Tables 10 and 11. The overall performance of the participants in terms of reading speed and comprehension score associated with the yellow/black colour combination is generally better than the white/black combination which is consistent with the results of Pace (1984) for search and input

Table 11

Summary of Reading Speed and Comprehension Performances
as a Function of the Font and Presentation Medium

Presentation medium with font	Average reading speed (words/min)	Comprehension score (mean score)
Paper (Helvetica font)	183.93	24.83
Paper (Chicago font)	211.20	27.33
White/Black (Helvetica font)	199.94	26.83
White/Black (Chicago font)	176.84	27.42
Yellow/Black (Helvetica font)	191.32	25.92
Yellow/Black (Chicago font)	196.40	25.83
Black/Green (Helvetica font)	186.02	26.42
Black/Green (Chicago font)	179.82	25.17
White/Blue (Helvetica font)	198.44	27.75
White/Blue (Chicago font)	194.10	23.92

Note. Maximum possible comprehension score is 30.

Muter et al. (1982) reported that reading white text on a blue background was 28.5 % slower than reading from a book. However, in this study, results showed that reading on the white/blue combination was only 0.66% slower than reading on paper. This

discrepancy may be attributed to the differences in the number of characters per line and to the size of the character matrix used by Muter et al. (1982) and those used in the present study. Firstly, the line widths on both the book and the VDU conditions in their study were not uniform, with the book condition having a maximum of 60 characters per line whereas the VDU condition had a maximum of 39 characters per line. The present study used a maximum of 80 characters per line which was recommended by Kolars et al. (1981). Secondly, Muter et al. (1982) used a slightly smaller character matrix of fixed size (5 × 8) as opposed to the variable character matrix with a maximum of 13 × 11 (Helvetica) and 11 × 11 (Chicago) used in this study. This is postulated to have made the characters more legible.

The yellow/black combination used in the current study was also found to generate good performance in terms of reading speed as did the white/blue colour combination. Furthermore, the yellow/black combination was found to have induced the least fatigue as measured by the Physical Symptoms categories. Pace (1984) reported that this colour combination generated low error rates in the address task but not in the search task.

As expected, the black/green colour combination generally generated the poorest reading speed performances of all 10 treatments (see Table 11). However, the reading speed difference with the other colour combinations was not significant. One explanation might be due to the adjustment of the VDU contrast which suited the participants' individual preferences as well as moderating the effects of the colour combination contrast thereby enhancing the legibility of the black/green colour combination. Nevertheless, black/green colour combination was found to induce more fatigue and physical symptoms than the other colour combinations because of its inherently poor colour combination contrast. This result is consistent with the study of Pace (1984) and Ohlsson et al. (1981) who reported that black/green is a poor colour combination.

5.2. Paper and VDU Reading Speed Difference

In this section, objectives number 2 and 3 will be discussed. One of the interesting results in this study is that not only was there no reading speed difference found between the two presentation media but results (shown in Table 11) also revealed that some VDU presentation media such as the white/blue, and

yellow/black combinations associated with either fonts, performed better than the paper medium associated with Helvetica font.

The belief (Kolers et al., 1981; Gould et al., 1987b) that the reading speed difference is associated with the image quality of the characters (viz., font, colour, polarity, line width) led to some of the research questions in the present study. One of these is whether there is a significant interaction effect between font and colour combination. Results showed no significant interaction between the font and presentation medium factors which implies that their interaction did not affect reading speed. Because the main effects of either font or presentation medium did not affect reading speed, it can be postulated that text colour and its background does not have an interactive effect with the text font style.

One possible explanation for why no significant reading speed difference existed between the two presentation media (paper and VDU) might be the tremendous improvement in the computers used in the current study in terms of speed and screen resolution as compared with the machines used in the earlier studies (Gould et al., 1987c). The improved reading speed on the VDU might also have been attributed to the

variable character matrix used on both fonts controlled through software. The legibility of the displayed characters might have been enhanced because the size of each character matrix was made proportional to the character. Performance may have been improved because the characters were made narrower and wider as appropriate (Beldie et al., 1983).

It should be noted that the participants in this study read a set of text for a period of approximately 2 hours with breaks of 5 minutes between stories read. Each story was read by the participants for less than 15 minutes on average. In effect, the participants actually read for short periods with short breaks in between. These short breaks, when the comprehension test was administered, may have lessened the fatigue experienced by the participants when they continued reading the rest of the short stories. Thus reading speed was not severely affected by fatigue that may have been induced by the colour combination or by the reading duration. This result seems to be consistent with the hypothesis of Osborne and Holton (1988) who reported that the reading speed difference between the two media might only be associated with continuous reading for longer periods without short breaks in between (Osborne and Holton, 1988). This observation

seems to be consistent with the results of previous studies which also employed short breaks in between the reading periods (Switchenko, 1984; Askwall, 1985). In contrast, Muter et al. (1982) asked the participants to read continuously for 2 hours and reported a significant reading speed difference between the two media.

Uniform posture was ensured in this study when the participants read on either paper or VDU. This is one of the differences between the previous studies (Muter et al., 1982; Kruk and Muter, 1984) and the present study. The paper stimuli in the present study were attached to the VDU screen which made the layout of the two media the same instead of allowing participants to hold the paper stimuli in any position that suited them. Some of the disadvantages associated with the screen in earlier studies may have been associated with the participants' posture because while reading from paper they were free to vary the distance of the paper medium to their eyes, and adjust the paper to avoid the reflection of the light falling on the paper. This hypothesis is supported by the results of Bhatnagar et al. (1985) who reported that the performance of workers changed for the better when their posture was altered. The workers error rates increased from 4% in the optimum conditions to 6% in poorer conditions.

The adjustment of the display contrast which was not undertaken in some previous studies might have moderated the effects of colour combinations on the participants as well as reducing the differences in the reading speed performance of the different colour combinations. This might be the reason why there were no significant differences among the colour combinations used despite the fact that the black/green combination was categorised as a poor colour combination (Pace, 1984; Ohlsson, Nilsson, and Ronnberg, 1981).

Lastly, it appears that the length of computer experience of the subjects may have reduced the reading speed difference. This is supported by the analysis of covariance (see Tables 5 and 6) which showed that both the subjects' length of computer experience and pretest reading speeds accounted for most of the differences in reading speed. According to Gould et al. (1987a), participants with more computer experience are better readers than the inexperienced participants; however, the difference is not statistically significant. All the participants in this study had at least one year of experience with computer screens, with an average computer experience of four years. This may also be one of the factors that contributed to the finding of no reading speed difference between the two media.

5.3. Refresh Time

The uncertainty of when the participants started reading the text when the VDU is refreshed was one of the questions posed by Muter et al. (1982). The result of the current study is consistent with their findings which indicated that the extra time required to refresh the screen when turning to the next page does not significantly affect reading speed.

The improved refresh time of a screen page using the two fonts might have been lessened because of the machine used (IBM PS/2 Model 30) which uses the 30286 microprocessor. However, there was a slight difference noted in the refresh time of the two fonts used. The refresh time of a VDU screen page with Helvetica font was on the average 45.16% (2.8 seconds) faster than the screen page with Chicago font. This statistically not significant difference is due to the fact that it takes longer to display a Chicago character than a Helvetica character because the former font is bolder. This explains the slower refresh time of a screen page using Chicago font. Since there was no significant reading speed difference between reading on either Helvetica or Chicago font, it is assumed that the subjects commenced reading before the whole screen page was filled up.

5.4. Font Style

Results of the analysis indicate that the effects of the two font styles, Helvetica and Chicago, did not significantly differ. Likewise, font style did not affect the reading speed performance. This is consistent with the findings of Tinker (1963) who compared 10 printed fonts on paper and only found a maximum of 5% reading speed difference among the nine best fonts. This is reinforced by the belief of Gould et al. (1987a) who stated that "better resolution [screen addressability] provides the basis for better character fonts" (p. 515). This implies that the reading speed improves as the display resolution increases.

The font style results in this study contradict the earlier study of Gould et al. (1986). In that study, there were a number of differences between the two fonts used such as geometric configuration, polarity, colour, and blank space between rows of characters. Due to these differences, they were unsure whether the 12-14% reading speed difference between the VDU and paper was due to the font style used.

In the present study, the only variable which differed in the two fonts used was the size of the character matrices because a variable character width

was adopted instead of a fixed character width. All the other variables were kept constant across all the 10 treatments. Gould et al. (1987b) used a proportionally spaced character set called Yoga 3.43. However, their results showed that reading on paper was still significantly faster compared with reading on VDU even when the same font style was used on both media. This implies that reading speed difference was not due to the font style used but due to other factors.

The latest study of Gould et al. (1987c) also supports the result of the present study. They reported that no reading speed difference existed between the two media regardless of the font style used. Further study (Gould et al., 1987a) indicated a "strong evidence that font (within reason) has little effect on reading rate from paper [and] this may be extrapolated to CRT displays as well" (p. 515).

There were some differences in the methodology of the present study and that employed by Gould et al. (1987c). Their study used a very high VDU resolution of 1024 x 1024 whereas the present study used a 640 x 480 screen resolution. Furthermore, to achieve the same character appearance on both media in this research, the character sets displayed on the VDU were patterned, created, and programmed to look like the two

fonts available in the Microsoft Word processor in the Macintosh computer. On the other hand, Gould et al. (1987c) used anti-aliasing to achieve the same goal. Their results showed that there was no significant proofreading rate difference when the participants proofread on either aliased or anti-aliased characters (Gould et al., 1987a). According to them, anti-aliasing (adding grey level, or variations in luminance, to each character) might have only helped improve legibility when using relatively low resolution VDUs. This means that as the screen resolution increases, anti-aliasing contributes less and less to the improvement in the reading speed on the VDU.

Although the present study did not use a VDU of the same resolution employed by Gould et al. (1987c), a 640 x 480 resolution is one of the more commonly available and affordable VDU screens in the standard commercial marketplace. Furthermore, it is generally suitable for most computer applications. The author believes that a screen resolution of 640 x 480 is an adequate resolution for the purpose of reading text on the VDU.

One possible explanation for the reduction in the reading speed difference between the two media was the use in the current study of a variable character matrix

which may have helped the characters to be recognised more easily. This might have reduced the difference in performance between the two fonts used. The participants read 1.52% faster on the Chicago font than on the Helvetica font; however, the difference was not found to be significant. This could have been due to the fact that Chicago font is bolder than Helvetica which seems to make it more legible. (See Appendix D for sample font characters.)

5.5. Subject Preferences

Investigation of the participants' order of colour combination and font preferences displayed on the VDU in this study showed that the white/blue combination followed by the yellow/black combination were the most preferred colour combinations regardless of the font used (see Appendix H-4). This finding appears to be consistent with the participants' reading speed performance as shown in Figure 11 and Table 10. One possible reason why the participants performed better on the colour combinations they preferred most may be because they felt more comfortable and relaxed while reading than they did with the colour combinations they least preferred, so less fatigue was induced.

Another observation arising from colour and font combination ranking is that the participants seemed to have based their rankings more on the colour combinations and paid little notice to the fonts associated with the text colour (see Appendix H-4). The participants did not seem to favour any particular font style because the first two most preferred presentation media, white/blue and yellow/black, are associated with Helvetica font whereas the third most preferred medium, white/black, is associated with Chicago font. On the contrary, the least preferred medium (black/green) is related to the Helvetica font. This appears to indicate that the subjects based their rankings mainly on the colour combinations rather than the type of font used.

This is consistent with the author's observations during the subjects' completion of the Font and Colour Combination Ranking Questionnaire. Most of the participants did not notice whether they were ranking the different colour combinations with Helvetica (see Appendix G-1) or with Chicago font (Appendix G-2). The majority of them distinguished the difference only when they started answering the questionnaire shown in Appendix G-3. This appears to indicate that the participants were not really influenced by the fonts

used, possibly because the effects of the two fonts on reading speed were minimal.

In addition, the font preferences of the participants also seem to be associated only with specific colour combinations. Most of the subjects preferred the white/blue with Helvetica font presentation medium. Conversely, Helvetica font with the black/green colour combination was least preferred by the participants.

5.6. Rating of the Subjects on Task Performed

Results of the study indicated that the presentation medium has somehow affected the ratings made by the participants on the story sets they read. The DMRT grouping shows that the participants who read on white/blue and white/black found the story sets less interesting and less enjoyable than those who read on the paper medium. The visual discomfort experienced by the participants who read on the VDU might have affected their concentration when reading the short stories, thus losing their appreciation of the story.

Based on the results of previous studies (Pace, 1984; Durrett, 1982; Chun, and Ogino, 1937) and this study, it can be substantiated that certain colour combinations associated with better performance in a

certain task may also produce good performance on another task. This is exemplified by the result of Pace (1984) who reported that the colour combination yellow/black was one of the combinations associated with better performance on both the input and the search tasks.

It is therefore possible to infer that the yellow/black combination not only enhances a text-editing task but can also generate good reading speed performance in a reading for comprehension task. This combination was found to induce less fatigue compared to the other combinations used.

Likewise, the white/blue combination, which was recommended for both text-editing tasks and input tasks, due to low error rates associated with it, was also found to perform better for a reading for comprehension task in terms of speed, and visual and physical comfort. The white/black combination, also recommended for a text-editing task, generated good comprehension performance. However, it was found to cause more fatigue than the yellow/black and white/blue colour combinations. The black/green combination showed the poorest effect on reading speed and was found to have caused more visual strain and fatigue than the other colour combinations.

It is also important to stress that a colour combination may produce maximum response in one task but may not produce the same effect in another task (Tullis, 1981). This is true in the case of the white/black combination which cannot be recommended to be used for long duration reading because of the intense visual strain and fatigue it may induce in the reader when exposed for a long period.

5.7. Subjective Measures in the Changes in Mood and Discomfort

Reading for a period of less than 2 hours produced physical discomfort and changes in mood as measured by the POMS and PSQ questionnaires. Specifically, a decrease in vigour among the participants was recorded between the first and the last administration of the POMS questionnaire; however, it did not reach a level of statistical significance. Likewise, the presence of fatigue and tension were also evident between the two administrations. The smallest degree of visual strain was experienced by the paper readers followed by the participants who read on the yellow/black and white/blue presentation media. This was expected because the paper medium did not produce any glare at all.

Of all the text colours used in this study, yellow is the most suitable text colour (Haider et al., 1930). According to Csaka (1985), it caused less fatigue compared with the white text and this is supported by the results of this study.

Results also indicated that the participants were more fatigued and tense after reading for approximately 2 hours than when they started reading. In addition, specific symptoms relating to visual strain, fatigue, mental stress, neck and shoulder pains demonstrated a larger increase across the reading duration. According to Dainoff et al. (1981), the longer a reader views the VDU, the more likely that visual strain will be experienced. The Physical Symptoms data used in this study appear to support this view. (See ANOVA table for Visual Strain in Appendix S.)

It was also discerned that the paper conditions induced as much discomfort as the yellow/black and white/blue presentations (see Tables 12 and 13). This is consistent with the result of Muter et al. (1982) who reported that reading from either paper or VDU (white text and blue background) generated approximately equal feelings of discomfort. Among the presentation media used, the paper, white/blue, and yellow/black generally produced the least discomfort

Table 12

Comparative Summary of the Effects of the Different Presentation Media on POMS Categories (Mean scores Before/(After) Administration)

Presentation Medium	Vigour	Tension	Fatigue
Black/White (Paper)	1.98 A (1.70)	0.22 B (0.23)	0.81 A B C (1.14)
White/Black (VDU)	1.79 B (1.19)	0.38 A (0.68)	0.95 A (1.65)
Yellow/Black (VDU)	1.91 A B (1.38)	0.14 B (0.27)	0.49 B C (1.21)
Black/Green (VDU)	1.84 A B (1.22)	0.25 A B (0.55)	0.80 A B (1.56)
White/Blue (VDU)	1.92 A B (1.22)	0.23 B (0.28)	0.43 C (1.07)

Note. Presentation medium having the same letters are not significantly different from each other. Scores ranged from not at all (0) to extremely (4).

across the different measures of discomfort (physical symptoms categories) and changes in mood used in this study. On the other hand, the white/black and black/green colour combinations (regardless of font used) were found to induce the most discomfort in the participants.

Table 13

Comparative Summary of the Effects of the Different
Presentation Media on Selected Physical Symptoms
Categories (Mean scores Before/(After) Administration)

Presentation Medium	Physical Stress		Mental Stress		Visual Strain	
Black/White (Paper)	0.21 (0.30)	B	0.17 (0.44)	B	0.33 (0.50)	B
White/Black (VDU)	0.32 (0.83)	A	0.40 (0.83)	A	0.43 (1.19)	A
Yellow/Black (VDU)	0.15 (0.37)	B	0.14 (0.29)	B	0.26 (0.72)	B
Black/Green (VDU)	0.16 (0.63)	A B	0.40 (0.78)	A	0.38 (1.32)	A
White/Blue (VDU)	0.19 (0.55)	A B	0.14 (0.33)	B	0.24 (0.76)	B

Note. Presentation medium having the same letters are not significantly different from each other. Scores ranged from not at all (0) to extremely (4).

Another indication of the presence of fatigue is evident when the reading speed of the participants per story in a given set of stories was drawn against the different presentation media (see Appendix J). A general trend from the three figures in Appendix J

reveals that there is an observed increase in reading speed from the first to the second story read, a decrease from second to third, an increase from third to fourth, a decrease from fourth to fifth, and an increase from the fifth to the last story read. This implies that as early as the second story, participants began to experience some physical symptoms such as visual strain, fatigue, mental stress, neck and shoulder pains. Another observation made was the rise and fall of the participants' reading speed for every other story read. One possible explanation might be because of the short breaks in between the stories read. These short breaks might have given the participants enough rest to have contributed to the apparent improved reading speed.

6. CONCLUSIONS

The primary purpose of this research is to determine whether there is a significant difference in reading speed and comprehension performances between reading on paper and on a VDU screen. In addition, this study has aspired to discover which colour and font combination can be recommended to be used on a VDU screen for the provision of an environment which contributes to a better user performance in terms of reading speed and comfort. It also sought to determine whether the subjects' font and colour combination preferences relate to their reading speed performance. The present study investigated 10 combinations of font and presentation media, two of which were based on paper.

The results of this study are valid for college/university affiliated students who have at least one year of computer experience. Furthermore, results may be generalised only to reading continuous text for a period of at approximately most 2 hours with short breaks. Likewise, the VDU contrast was adjusted according to the participants' visual preferences to simulate the real world setting. For this reason, it is doubtful whether the same results would be obtained if the contrast was not able to be adjusted.

The findings of no significant differences between reading from a VDU and from paper is consistent with the results of Osborne and Holtor. (1988). This favourable result might have been due to the proper control of the experimental variables listed on page 5 which were perceived by the above-mentioned researchers to be improperly controlled in earlier studies.

A summary of conclusions based on experimental results is given below.

1. The different presentation media, fonts, and their interaction do not significantly affect the reading speed and comprehension performances. Most of the variations are attributable to the participants' computer experience and pretest reading speed.

2. Reading from a VDU medium is as fast as reading from a paper medium. Likewise, comprehension performance between the paper and VDU medium is not significantly different.

3. The time required to refresh the VDU medium to the next page does not disrupt the participants' reading speed. It is believed that they commenced reading before the VDU medium was completely filled with text.

4. Reading speed tends to be faster in the following order of the presentation media: paper, white/blue, and yellow/black. This result, however, is not conclusive because the difference is not statistically significant. In addition, the white/black combination is associated with good comprehension performance. Again, the variability of the performance measured did not reach a required level of significance.

5. Reading speed tends to be faster with presentation media associated with Chicago font in the following order: paper, yellow/black, and white/blue. Again, this observation is not conclusive because the effects of the 10 treatments are not statistically significant.

6. Colour combination and font preferences of participants appear to be related with their reading speed performance. However, the experimental design used did not allow this observation to be statistically tested.

7. Changes in mood states and physical symptoms are evident after reading for a duration of 2 hours maximum as measured in the POMS and PSQ questionnaires. This is induced by the presentation medium and task

duration. In general, the white/black and black/green colour combinations cause the most visual discomfort and fatigue whereas the yellow/black and paper media are associated with the least visual discomfort and fatigue.

7. RECOMMENDATIONS

The results in this study support the recommendation of Muter et al. (1982) that it is feasible to read continuous text on the VDU screen for approximately 2 hours. However, from this study, it is recommended that short breaks be interspersed during the reading process. It is believed that these short breaks may give the readers enough time to recover from possible fatigue and weariness which may develop during the reading period of around 2 hours.

Secondly, for prospective buyers of computer machines, it is recommended that they purchase VDUs which have contrast adjustment to alleviate any undesirable effects of colour combination. In addition, they should buy a VDU that has a screen resolution of at least 640 x 480 because, when reading continuous text on a VDU, speed dramatically improves as the display resolution increases.

This study has also confirmed that certain VDU colour combinations produce good reading performance and the same combinations are generally preferred by readers. In view of this, either yellow/black or white/blue colour combinations could be made as the default colour setting since both induced minimal

fatigue and visual strain upon the reader. On the other hand, since there are always people who deviate from the norm, it is recommended that software should provide the reader or user with the option to alter the default colour setting. In this case, the reader can be more productive because it was discovered that readers tend to read faster on the colour combination they preferred. It is also proposed that the colour combination white/black should only be used for short duration reading whereas the black/green combination should be avoided.

Future research could investigate whether the colour combinations used in this study would exhibit the same results on routine jobs such as text-editing, data encoding, or proofreading tasks in a workplace environment. In such cases, the reader would have some idea as to what colour to choose when performing a particular task. This would minimise the discomfort which may arise when exposed to a VDU screen for longer durations.

Since this study used a variable character matrix across all the treatments, it is questionable if it really contributed to the reading speed improvement on the VDU screen. Thus, it is recommended that the effects of fixed and variable character matrices be

investigated further in future studies. This would identify which one is associated with better reading performance. In addition, it could also determine whether using a variable character matrix can significantly enhance character legibility.

Although earlier studies reported that familiarity with a VDU does not influence reading speed, the findings in this study indicated that most of the differences in reading speed were accounted for statistically by the participants' length of computer experience. The participants' length of computer experience in this study was variable and ranged from 1 to 10 years. It is therefore recommended for future studies to test both experienced and novice VDU users. The duration of experience should be made uniform to be able to accurately assess the influence of VDU familiarity on reading speed. This would make the result applicable to a wider population of users.

The subjects who participated in this study were all volunteers. Asking them to read on the same presentation medium during the entire experiment (three replications) was believed to be unreasonable because some participants who read on the black/green and white/black colour combinations experienced extreme visual strain and fatigue after reading a story set.

Due to this consideration, the participants were not asked to read on the same presentation medium for each story set read. This consideration did not allow the experimental design used to measure the variation inherent in the subjects. To determine whether feelings of discomfort also depend on the individual and not only on the presentation medium and task duration, the subjects should be assigned to the same treatment for the entire experiment (three replications).

The rank ordering of the participants' colour combination and font preferences seems to be correlated with their reading speed performance. However, because the subjects in the present study did not experience reading on all the 10 conditions due to long reading durations per treatment, performing a correlation analysis on the subjects' reading performance and preferences was not allowed by the design used. A solution would be to assign all the subjects in all the conditions for shorter reading periods so that they can truly base their rating and ranking on all the conditions based from their reading experiences.

Evidence is contradictory as to whether the use of either positive (dark letter/light background) or negative (light letter/dark background) contrast affects reading speed. The present study failed to analyse this

because the number of colour combinations belonging to the two contrasts were unequal: one positive and three negative contrasts were used. To shed light on this area, it is recommended that an equal number of colour pairs belonging to both contrasts be used in future studies to be able to test whether one is better than the other.

Lastly, the results of this study confirmed that fatigue was evident after reading for a maximum period of 2 hours since there was a consistent decrease in the different physical symptoms and change of mood states. However, it is not known how the subjects felt in the middle of the task. In the study of Pace (1984), only two of the six categories used showed a steady decrease or increase. There were slight recoveries noted in the middle of the task on the remaining categories. It would thus be interesting to know whether the same trend would be obtained in a reading for comprehension task. Therefore, it is recommended that both the POMS and PSQ questionnaires be administered in the middle as well as at the beginning and end of the reading process.

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Appendix A

Sample Form of the Instrument to Obtain Information About the
Participants**SUBJECT'S PROFILE QUESTIONNAIRE****SUBJECT NO. :** _____

(Please tick (✓) or supply your answer)

1. Age: _____

2. Sex: _____

3. Course: _____

4. Eye condition : (Tick the one applicable to you)

_____ a. Normal or 20/20 vision

_____ b. Wearing eyeglasses

_____ c. Wearing contact lenses

5. Familiarity with computers (Please tick all applicable answers)

_____ a. Use for programming

_____ b. Use for reading information on screen

_____ c. Use for playing Video games

_____ d. Never used at all

6. How long have you been using the computer?

(years) _____ and (months) _____

7. Have you had speed reading lesson before? (Y/N) _____.

Appendix B

Detailed Summary of Participants' Characteristics

Age	Frequency	Percentage
19	3	7.5
20	4	10.0
21	6	15.0
22	3	7.5
23	2	5.0
24	1	2.5
25	6	15.0
26	5	12.5
27	1	2.5
30	1	2.5
32	1	2.5
33	2	5.0
34	2	5.0
38	1	2.5
44	1	2.5
51	1	2.5

Sex	Frequency	Percentage
Male	23	57.5
Female	17	42.5

Eye condition	Frequency	Percentage
Normal vision	19	47.5
Wearing eyeglasses	15	37.5
Wearing contact lenses	6	15.0

Experience on Computers

Number of years	Frequency	Percentage
1	4	10.0
2	9	22.5
3	14	35.0
4	2	5.0
5	4	10.0
6	2	5.0
7	1	2.5
8	1	2.5
9	1	2.5
10	2	5.0

Type of Task where Subjects used Computer

Type	Frequency	Percentage
Programming	37	92.5
Reading information	29	72.5
Playing video games	24	60.0
Never used at all	0	0.0

Frequency Distribution of Subjects' Pretest Reading Speed

Pretest reading speed	Frequency
88 - 138	5
139 - 189	5
190 - 240	14
241 - 291	10
292 - 342	3
343 - 393	1
394 - 445	1
446 - 496	1

Appendix C

Sample Reading Duration Output of the Program Written in C

Subject Code : s40 - Day1

Date Conducted : 12/05/90

***** Text # 1 *****

Text Filename : bull.doc

Time Started : 23:41:05

Time Ended : 23:56:27

Page	No. of Words	Reading Duration	- Generation Time	= Difference
1	306	189.0000	4.0000	185.0000
2	310	161.0000	5.0000	156.0000
3	268	170.0000	4.0000	166.0000
4	308	177.0000	6.0000	171.0000
5	298	124.0000	5.0000	119.0000
6	219	101.0000	3.0000	98.0000
Total	1709	922.0000	27.0000	895.0000

***** Text # 2 *****

Text Filename : fur.doc

Time Started : 23:58:20

Time Ended : 00:13:08

Page	No. of Words	Reading Duration	- Generation Time	= Difference
1	269	166.0000	4.0000	162.0000
2	290	155.0000	5.0000	150.0000
3	274	150.0000	5.0000	145.0000
4	248	118.0000	5.0000	113.0000
5	300	117.0000	4.0000	113.0000
6	306	118.0000	5.0000	113.0000
7	94	64.0000	1.0000	63.0000
Total	1781	888.0000	29.0000	859.0000

***** Text # 3 *****

Text Filename : laura.doc
 Time Started : 00:15:53
 Time Ended : 00:30:30

Page	No. of Words	Reading Duration	- Generation Time	= Difference
1	252	181.0000	4.0000	177.0000
2	256	128.0000	4.0000	124.0000
3	244	122.0000	5.0000	117.0000
4	275	105.0000	5.0000	100.0000
5	241	117.0000	4.0000	113.0000
6	256	140.0000	5.0000	135.0000
7	144	84.0000	2.0000	82.0000
Total	1668	877.0000	29.0000	848.0000

***** Text # 4 *****

Text Filename : wolves.doc
 Time Started : 00:32:15
 Time Ended : 00:47:04

Page	No. of Words	Reading Duration	- Generation Time	= Difference
1	253	207.0000	4.0000	203.0000
2	293	140.0000	5.0000	135.0000
3	288	170.0000	5.0000	165.0000
4	281	144.0000	4.0000	140.0000
5	259	110.0000	4.0000	106.0000
6	286	90.0000	4.0000	86.0000
7	37	28.0000	1.0000	27.0000
Total	1697	889.0000	27.0000	862.0000

***** Text # 5 *****

Text Filename : tiger.doc

Time Started : 00:48:25

Time Ended : 00:58:51

Page	No. of Words	Reading Duration	- Generation Time	= Difference
1	263	133.0000	5.0000	128.0000
2	281	139.0000	5.0000	134.0000
3	274	126.0000	5.0000	121.0000
4	299	138.0000	5.0000	133.0000
5	213	90.0000	3.0000	87.0000
Total	1330	626.0000	23.0000	603.0000

***** Text # 6 *****

Text Filename : tactics.doc

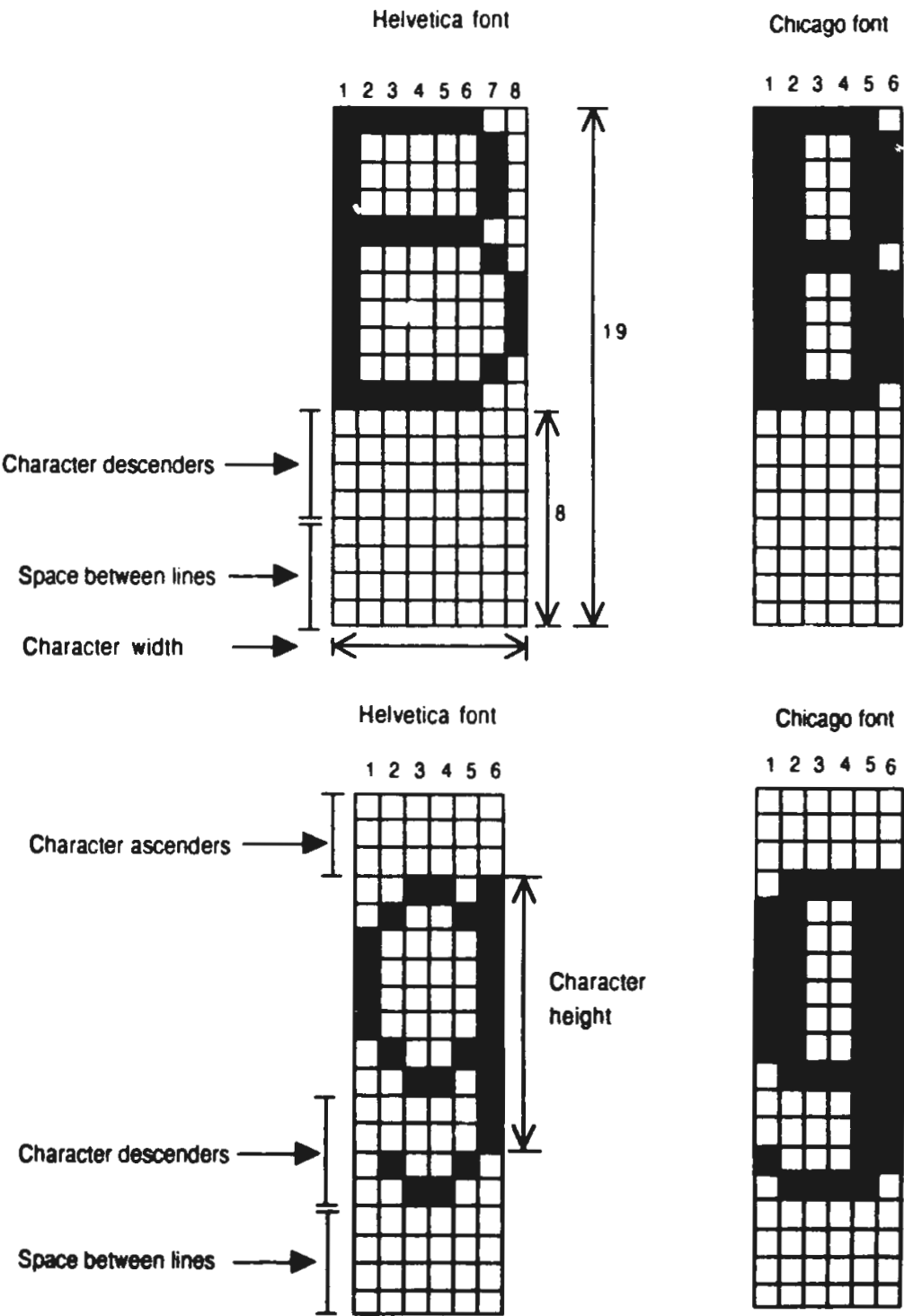
Time Started : 00:59:59

Time Ended : 01:12:44

Page	No. of Words	Reading Duration	- Generation Time	= Difference
1	242	141.0000	4.0000	137.0000
2	239	94.0000	4.0000	90.0000
3	271	92.0000	5.0000	87.0000
4	224	120.0000	4.0000	116.0000
5	260	97.0000	5.0000	92.0000
6	259	111.0000	4.0000	107.0000
7	239	101.0000	4.0000	97.0000
8	18	9.0000	1.0000	8.0000
Total	1752	765.0000	31.0000	734.0000

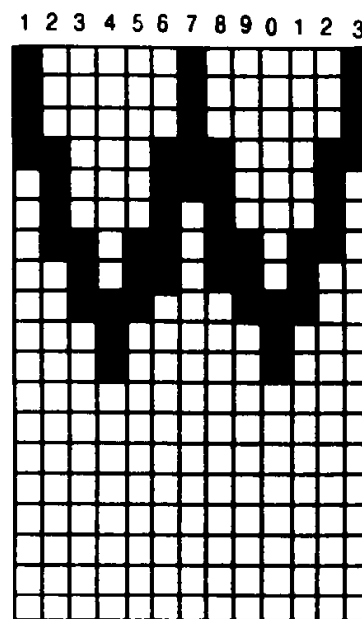
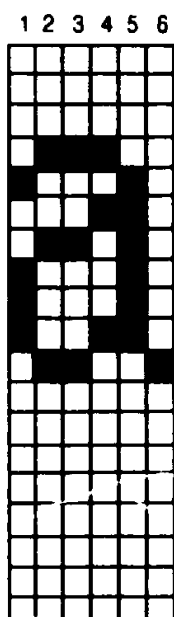
Appendix D

Character Matrix Components and Sample Characters of
Helvetica and Chicago Fonts



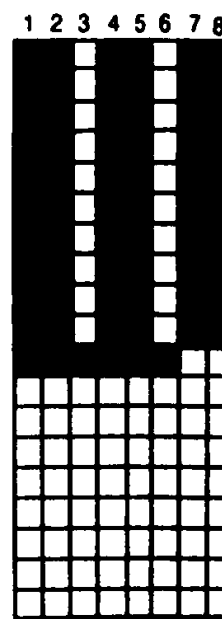
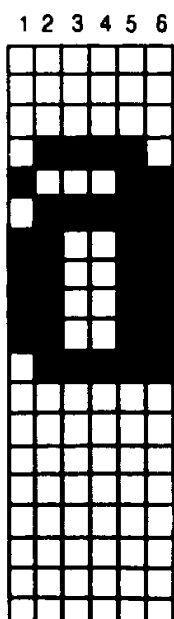
Helvetica fonts

Capital letter I



Chicago fonts

Capital letter I



Appendix E-1

Sample Form of the Profile of Mood States Questionnaire

Below is a list of words that describe feelings people have.

Please read each one carefully. Then, encircle the number

which best describe **HOW YOU FEEL RIGHT NOW**

The numbers refer to these phrases:

0 = Not at all

2 = Moderately

4 = Extremely

1 = A little

3 = Quite a bit

1. Tense	0 1 2 3 4	6. Relaxed	0 1 2 3 4	11. Helpless	0 1 2 3 4
2. Worn out	0 1 2 3 4	7. Uneasy	0 1 2 3 4	12. Alert	0 1 2 3 4
3. Lively	0 1 2 3 4	8. Fatigued	0 1 2 3 4	13. Terrified	0 1 2 3 4
4. Shaky	0 1 2 3 4	9. Nervous	0 1 2 3 4	14. Vigorous	0 1 2 3 4
5. Active	0 1 2 3 4	10. Exhausted	0 1 2 3 4	15. Weary	0 1 2 3 4

MAKE SURE YOU HAVE ANSWERED EVERY ITEM

Appendix E-2

POMS Questionnaire Categories and Items Under Each Category

Category	Item
Tension - Anxiety scale	Tense Shaky Uneasy Nervous Terrified
Vigour - Activity scale	Lively Active Relaxed Alert Vigorous
Fatigue - Inertia scale	Worn out Fatigued Exhausted Helpless Weary

Appendix F-1

Physical Symptoms Questionnaire (Before)

Please read each sentences listed below carefully. Place a number that best describes how you feel right now on the blank provided. The number refers to the following phrases:

- | | |
|----------------|-----------------|
| 1 = Not at all | 4 = Quite a bit |
| 2 = A little | 5 = Extremely |
| 3 = Moderate, | |

- | | |
|-------------------|----------------------------------------------------------------------|
| _____ | 1. My workspace (where I'm reading) seems poorly laid out, cramped |
| _____ | 2. I'm experiencing mental stress |
| XXXXXX | 3. The set of texts is engrossing, demanding; I think of little else |
| _____ | 4. The lighting (where I'm reading) is not very good or has glare |
| XXXXXX | 5. The selection of texts is enjoyable |
| _____ | 6. I'm feeling weary, bushed, fatigued |
| _____ | 7. My eyes feel strained, uncomfortable, or hurt |
| _____ | 8. My head aches |
| _____ | 9. My vision is blurry, hard to focus |
| XXXXXX | 10. The selection of texts is interesting |
| _____ | 11. I'm feeling tense, anxious, or uneasy |
| _____ | 12. My neck or shoulders hurt |
| _____ | 13. My lower back hurts |
| _____ | 14. My reading is proceeding easily, efficiently |
| _____ | 15. My fingers, wrist, or arms hurt |
| _____ | 16. I feel dizzy |
| _____ | 17. I can see coloured fringes around objects |
| _____ | 18. My stomach is upset |

MAKE SURE YOU HAVE ANSWERED EVERY SENTENCE

Administered :

Before ☒
 After ☐

Taken from: Doing the Same Work with Hard Copy and with Cathode-Ray Tube (CRT)
 Computer Terminals by John Gould and Nancy Grischkowsky

Set story #: _____

Treatment #: _____

Appendix F-2

Physical Symptoms Questionnaire (After)

Please read each sentences listed below carefully. Place a number that best describes how you feel right now on the blank provided. The number refers to the following phrases:

- | | |
|----------------|-----------------|
| 1 = Not at all | 4 = Quite a bit |
| 2 = A little | 5 = Extremely |
| 3 = Moderately | |

- 1. My workspace (where I'm reading) seems poorly laid out, cramped
- 2. I'm experiencing mental stress
- 3. The set of texts is engrossing, demanding; I think of little else
- 4. The lighting (where I'm reading) is not very good or has glare
- 5. The selection of texts is enjoyable
- 6. I'm feeling weary, bushed, fatigued
- 7. My eyes feel strained, uncomfortable, or hurt
- 8. My head aches
- 9. My vision is blurry, hard to focus
- 10. The selection of texts is interesting
- 11. I'm feeling tense, anxious, or uneasy
- 12. My neck or shoulders hurt
- 13. My lower back hurts
- 14. My reading is proceeding easily, efficiently
- 15. My fingers, wrist, or arms hurt
- 16. I feel dizzy
- 17. I can see coloured fringes around objects
- 18. My stomach is upset

MAKE SURE YOU HAVE ANSWERED EVERY SENTENCE

Administered :

Before _____
After ✓

Taken from: Doing the Same Work with Hard Copy and with Cathode-Ray Tube (CRT)
Computer Terminals by John Gould and Nancy Grischowsky

Set story #: _____

Treatment #: _____

Appendix F-3

Physical Symptoms Questionnaire Categories and Items
Under Each Category

Category	Item Numbers in Questionnaire
Physical stress	12, 13, 16, 18
Mental stress	2, 8, 11
Visual strain	7, 9, 17
Computer environment	1, 4
General fatigue	6
Task/job comments	3, 5 , 10
Reading efficiency	14

Appendix G-1

Ranking Questionnaire for Helvetica Font with Four Different
Colour Combinations

For Helvetica font, rank the colour combinations you most preferred

(a) White foreground with Black background

(b) Yellow foreground with Black background

(c) Black foreground with Green background

(d) White foreground with Blue background

First = []

Second = []

Third = []

Fourth = []

Type the letter of the colour combination to its corresponding rank.
Use left and right arrow keys to edit and press <ENTER> when finished.

Appendix G-2

Ranking Questionnaire for Chicago Font with Four Different
Colour Combinations

For Chicago font, rank the colour combinations you most preferred

(a) White foreground with Black background

(b) Yellow foreground with Black background

(c) Black foreground with Green background

(d) White foreground with Blue background

First = []

Second = []

Third = []

Fourth = []

Type the letter of the colour combination to its corresponding rank.

Use left and right arrow keys to edit and press <ENTER> when finished.

Appendix G-3

Ranking Questionnaire for Helvetica and Chicago Fonts
with Four Different Colour Combinations

Rank the following font and colour combinations
 according to your preferences

(a) White foreground with Black background

(b) Yellow foreground with Black background

(c) Black foreground with Green background

(d) White foreground with Blue background

(a) White foreground with Black background

(b) Yellow foreground with Black background

(c) Black foreground with Green background

(d) White foreground with Blue background

First = []

Second = []

Third = []

Fourth = []

Fifth = []

Sixth = []

Seventh = []

Eight = []

Type the letter of the colour combination to its corresponding rank.
 Use left and right arrow keys to edit and press <ENTER> when finished.

Appendix H-1

Crosstabulation Table for Participants' Ranking by
Combination of Helvetica Font and Colour

TABLE OF RANK BY COLOR (Helvetica font)

RANK					
Frequency/ Expected Percent Row Pct Col Pct	COLOUR COMBINATION WITH HELVETICA FONT				
	A	B	C	D	Total
1ST	15	3	1	21	40
	10	10	10	10	
	9.38	1.87	0.63	13.13	25.00
	37.50	7.50	2.50	52.50	
	37.50	7.50	2.50	52.50	
2ND	10	17	3	10	40
	10	10	10	10	
	6.25	10.63	1.87	6.25	25.00
	25.00	42.50	7.50	25.00	
	25.00	42.50	7.50	25.00	
3RD	12	18	5	5	40
	10	10	10	10	
	7.50	11.25	3.12	3.12	25.00
	30.00	45.00	12.50	12.50	
	30.00	45.00	12.50	12.50	
4TH	3	2	31	4	40
	10	10	10	10	
	1.87	1.25	19.37	2.50	25.00
	7.50	5.00	77.50	10.00	
	7.50	5.00	77.50	10.00	
Total	40	40	40	40	160
	25.00	25.00	25.00	25.00	100.00

Note.

- A - White letter/Black background
- B - Yellow letter/Black background
- C - Black letter/Green background
- D - White letter/Blue background

STATISTICS FOR TABLE OF RANK BY COLOR

<u>Statistic</u>	<u>DF</u>	<u>Value</u>	<u>Prob</u>
Chi-Square	9	108.200	0.000
Contingency Coefficient		0.635	

SUMMARY STATISTICS FOR RANK BY COLOUR COMBINATION

Cochran-Mantel-Haenszel Statistics (Based on Table Scores)

<u>Statistic</u>	<u>Alternative Hypothesis</u>	<u>DF</u>	<u>Value</u>	<u>Prob</u>
1	Nonzero Correlation	1	0.195	0.659
2	Row Mean Scores Differ	3	13.078	0.004
3	General Association	9	107.524	0.000

Appendix H-2

Crosstabulation Table for Participants' Ranking by
Combination of Chicago Font and Colour

TABLE OF RANK BY COLOR (Chicago font)

RANK		COLOUR COMBINATION WITH CHICAGO FONT				
Frequency	Expected					
Percent	Row Pct					
Col Pct		A	B	C	D	Total
		11	3	2	24	40
		10	10	10	10	
1ST	6.87	1.87	1.25	15.00	25.00	
	27.50	7.50	5.00	60.00		
	27.50	7.50	5.00	60.00		
		8	17	5	10	40
		10	10	10	10	
2ND	5.00	10.63	3.12	6.25	25.00	
	20.00	42.50	12.50	25.00		
	20.00	42.50	12.50	25.00		
		14	17	6	3	40
		10	10	10	10	
3RD	8.75	10.63	3.75	1.87	25.00	
	35.00	42.50	15.00	7.50		
	35.00	42.50	15.00	7.50		
		7	7	27	3	40
		10	10	10	10	
4TH	4.37	1.87	16.87	1.87	25.00	
	17.50	7.50	67.50	7.50		
	17.50	7.50	67.50	7.50		
Total		40	40	40	40	160
		25.00	25.00	25.00	25.00	100.00

Note.

- A - White letter/Black background
- B - Yellow letter/Black background
- C - Black letter/Green background
- D - White letter/Blue background

STATISTICS FOR TABLE OF RANK BY COLOR

<u>Statistic</u>	<u>DF</u>	<u>Value</u>	<u>Prob</u>
Chi-Square	9	91.400	0.000
Contingency Coefficient		0.603	

SUMMARY STATISTICS FOR RANK BY COLOUR COMBINATION

Cochran-Mantel-Haenszel Statistics (Based on Table Scores)

<u>Statistic</u>	<u>Alternative Hypothesis</u>	<u>DF</u>	<u>Value</u>	<u>Prob</u>
1	Nonzero Correlation	1	3.343	0.067
2	Row Mean Scores Differ	3	17.689	0.001
3	General Association	9	90.829	0.000

STATISTICS FOR TABLE OF RANK BY COLOR

<u>Statistic</u>	<u>DF</u>	<u>Value</u>	<u>Prob</u>
Chi-Square	49	248.000	0.000
Contingency Coefficient		0.661	

SUMMARY STATISTICS FOR RANK BY COLOUR COMBINATION

Cochran-Mantel-Haenszel Statistics (Based on Table Scores)

<u>Statistic</u>	<u>Alternative Hypothesis</u>	<u>DF</u>	<u>Value</u>	<u>Prob</u>
1	Nonzero Correlation	1	0.836	0.361
2	Row Mean Scores Differ	7	9.038	0.250
3	General Association	49	247.225	0.000

Note.

- A - White letter/Black background (Helvetica)
- B - Yellow letter/Black background (Helvetica)
- C - Black letter/Green background (Helvetica)
- D - White letter/Blue background (Helvetica)
- E - White letter/Black background (Chicago)
- F - Yellow letter/Black background (Chicago)
- G - Black letter/Green background (Chicago)
- H - White letter/Blue background (Chicago)

Appendix H-4

Distribution of the Participants' Font and Colour
Combination Preferences

HELVETICA FONT WITH VARYING COLOUR COMBINATIONS

RANK	White/ Black	Yellow/ Black	Black/ Green	White/ Blue
1ST	15	3	1	21
2ND	10	17	3	10
3RD	12	18	5	5
4TH	3	2	31	4

CHICAGO FONT WITH VARYING COLOUR COMBINATIONS

RANK	White/ Black	Yellow/ Black	Black/ Green	White/ Blue
1ST	11	3	2	24
2ND	8	17	5	10
3RD	14	17	6	3
4TH	7	3	27	34

FONTS WITH VARYING COLOUR COMBINATIONS

RANK	Wht/ Blck (H)	Yel/ BlckK (H)	Blck/ Green (H)	Wht/ Blue (H)	Wht/ Blck (C)	Yel/ Blck (C)	Blck/ Green (C)	Wht/ Blue (C)
1ST	11	0	1	12	3	2	2	9
2ND	2	11	0	7	2	4	4	10
3RD	4	6	1	5	12	7	0	5
4TH	5	2	1	5	10	8	4	5
5TH	5	9	3	7	4	6	5	1
6TH	3	9	3	1	7	9	3	5
7TH	8	2	5	2	0	4	16	3
8TH	2	1	26	1	2	0	6	2

Note.

H - Helvetica font
C - Chicago font

Blck - Black
Wht - White

Yel -Yellow

Appendix I-1

Analysis of Variance for Reading Comprehension (Fixed Model)

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Font	1	5.97132	5.97132	0.44	0.5083
Medium	4	33.73871	8.43468	0.62	0.6471
Font*Medium	4	121.02828	30.25707	2.24	0.0716
Set	2	186.34186	93.17093	6.88	0.0017 **
Font*Set	2	6.57755	3.28877	0.24	0.7848
Medium*Set	8	61.36276	7.67034	0.57	0.8024
Font*Medium*Set	8	71.48808	8.93601	0.66	0.7248
Pre_score	1	249.99278	249.99278	18.47	0.0001 ***
Age	1	32.51075	32.51075	2.40	0.1248

Note. * = significant at 0.05 level

** = significant at 0.01 level

*** = significant at 0.001 level

Duncan's Multiple Range Test for variable: TOTAL_SCORE

Means with the same letter are not significantly different

Duncan Grouping	Mean	N	FONT
A	26.350	60	Helvetica
A			
A	25.933	60	Chicago

Duncan Grouping	Mean	N	SET
A	27.800	40	Set of Story 1
B	25.900	40	Set of Story 2
B			
B	24.725	40	Set of Story 3

Duncan Grouping	Mean	N	PRESENTATION MEDIUM
A	27.125	24	White/Black
A			
A	26.083	24	Black/White (Paper)
A			
A	25.875	24	Yellow/Black
A			
A	25.833	24	White/Blue
A			
A	25.792	24	Black/Green

Appendix I-2

Analysis of Variance for Reading Speed (Fixed Model)
(excluding time to refresh the Presentation Medium)

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Font	1	0.23	0.23	0.00	0.9910
Medium	4	5478.15	1369.54	0.75	0.5578
Font*Medium	4	6426.03	1606.51	0.88	0.4765
Set	2	4526.18	2263.09	1.25	0.2925
Font*Set	2	9607.54	4803.77	2.65	0.0766
Medium*Set	8	54296.18	6787.02	3.74	0.0008 ***
Font*Medium*Set	8	14045.71	1755.71	0.97	0.4670
Pre_speed	1	184522.20	184522.20	101.65	0.0001 ***
Age	1	627.72	627.72	0.35	0.5580
Experience	1	14021.79	14021.79	7.72	0.0067 **

Note. * = significant at 0.05 level

 ** = significant at 0.01 level

 *** = significant at 0.001 level

Duncan's Multiple Range Test for variable: TOT_SPD

Means with the same letter are not significantly different

Duncan Grouping	Mean	N	FONT
A	202.952	60	Chicago
A			
A	199.867	60	Helvetica

Duncan Grouping	Mean	N	SET
A	209.545	40	Set of Story 3
A			
A	200.350	40	Set of Story 2
A			
A	194.334	40	Set of Story 1

Duncan Grouping	Mean	N	PRESENTATION MEDIUM
A	208.05	24	White/Blue
A			
A	204.45	24	Yellow/Black
A			
A	202.56	24	Paper
A			
A	199.10	24	White/Black
A			
A	192.89	24	Black/Green

Level of MEDIUM	Level of SET	N	TOTAL SPEED		PRETEST SPEED	
			Mean	Std. Dev.	Mean	Std. Dev.
0	1	8	194.6161	37.1176	221.9825	58.8517
0	2	8	174.1528	42.5752	211.4071	71.8101
0	3	8	238.9064	98.8877	216.7454	73.2124
1	1	8	199.6205	88.3982	234.8262	113.6228
1	2	8	228.1005	83.4685	245.7774	67.7865
1	3	8	169.5864	48.9886	208.9485	77.4807
2	1	8	218.3764	74.6457	229.7800	82.7463
2	2	8	181.4455	41.5732	203.9210	63.5134
2	3	8	213.5253	64.8583	248.0714	112.0670
3	1	8	168.1577	52.3835	195.0251	72.1093
3	2	8	229.3689	61.7418	261.8756	71.2414
3	3	8	181.1318	57.1484	240.1731	89.0556
4	1	8	190.8997	31.0688	253.4488	71.8487
4	2	8	188.6848	71.0953	235.7249	116.2458
4	3	8	244.5728	80.7015	233.9965	43.7725

Appendix I-3

Analysis of Variance for Reading Speed (Fixed Model)
(including time to refresh the Presentation Medium)

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Font	1	189.30	189.30	0.13	0.7224
Medium	4	7355.27	1838.82	1.23	0.3026
Font*Medium	4	5987.40	1496.85	1.00	0.4098
Set	2	3600.12	1800.06	1.21	0.3038
Font*Set	2	7418.72	3709.36	2.49	0.0889
Medium*Set	8	45254.89	5656.86	3.80	0.0007 ***
Font*Medium*Set	8	10086.48	1260.81	0.85	0.5651
Pre_speed	1	155027.07	155027.07	104.01	0.0001 ***
Age	1	585.16	585.16	0.39	0.5326
Experience	1	11371.38	11371.38	7.63	0.0070 **

Note. * = significant at 0.05 level

 ** = significant at 0.01 level

 *** = significant at 0.001 level

Duncan's Multiple Range Test for variable: TOT_SPD

Means with the same letter are not significantly different

Duncan Grouping	Mean	N	SET
A	199.287	40	Set of Story 3
A			
A	190.610	40	Set of Story 2
A			
A	185.508	40	Set of Story 1

Duncan Grouping	Mean	N	FONT
A	191.931	60	Helvetica
A			
A	191.672	60	Chicago

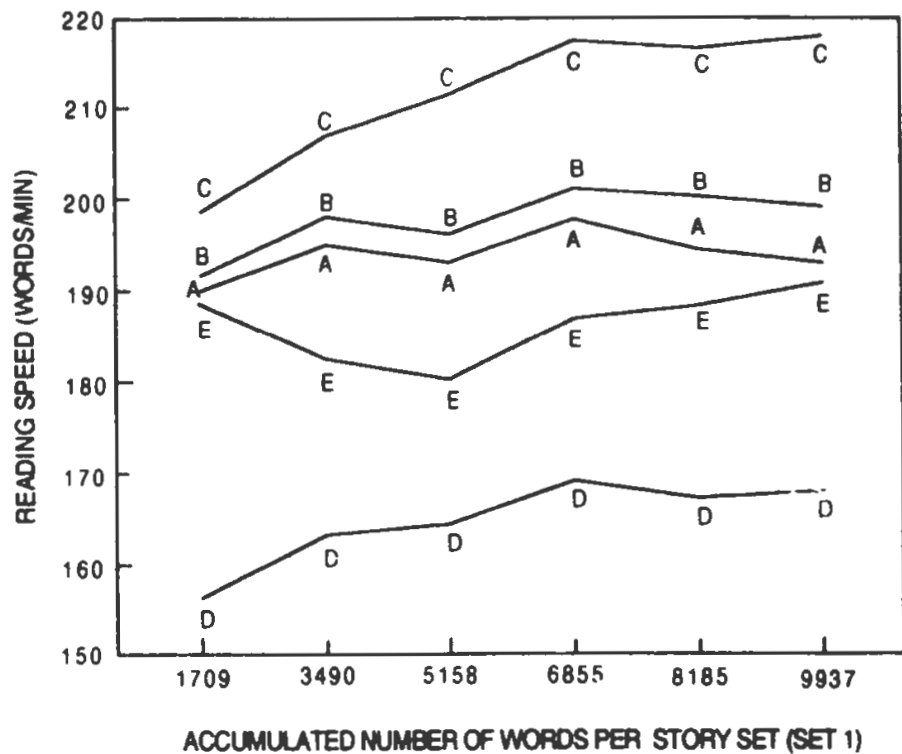
Duncan Grouping	Mean	N	PRESENTATION MEDIUM
A	197.57	24	Paper
A			
A	196.27	24	White/Blue
A			
A	193.86	24	Yellow/Black
A			
A	188.39	24	White/Black
A			
A	182.92	24	Black/Green

Level of MEDIUM	Level of SET	N	TOTAL SPEED		PRETEST SPEED	
			Mean	Std. Dev.	Mean	Std. Dev.
0	1	8	190.2617	35.4412	221.9825	58.8517
0	2	8	170.6240	40.9375	211.4071	71.8101
0	3	8	231.8171	92.6498	216.7454	73.2124
1	1	8	189.0331	81.0178	234.8262	113.6228
1	2	8	214.5483	74.9437	245.7774	67.7865
1	3	8	161.5912	44.8812	208.9779	77.4623
2	1	8	206.1865	68.2541	229.7800	82.7463
2	2	8	172.7281	37.4541	203.9210	63.5134
2	3	8	202.6700	59.6112	248.0714	112.0670
3	1	8	160.7319	48.8347	195.0251	72.1093
3	2	8	215.9701	55.4182	261.8756	71.2414
3	3	8	172.0613	52.6701	240.1731	89.0556
4	1	8	181.3267	28.5602	253.4488	71.8487
4	2	8	179.1819	65.6335	235.7249	116.2458
4	3	8	228.2942	68.8470	233.9965	43.7725

Appendix J

Graphical Presentation of Reading Speed as a Function
of Presentation Medium by Story Sets

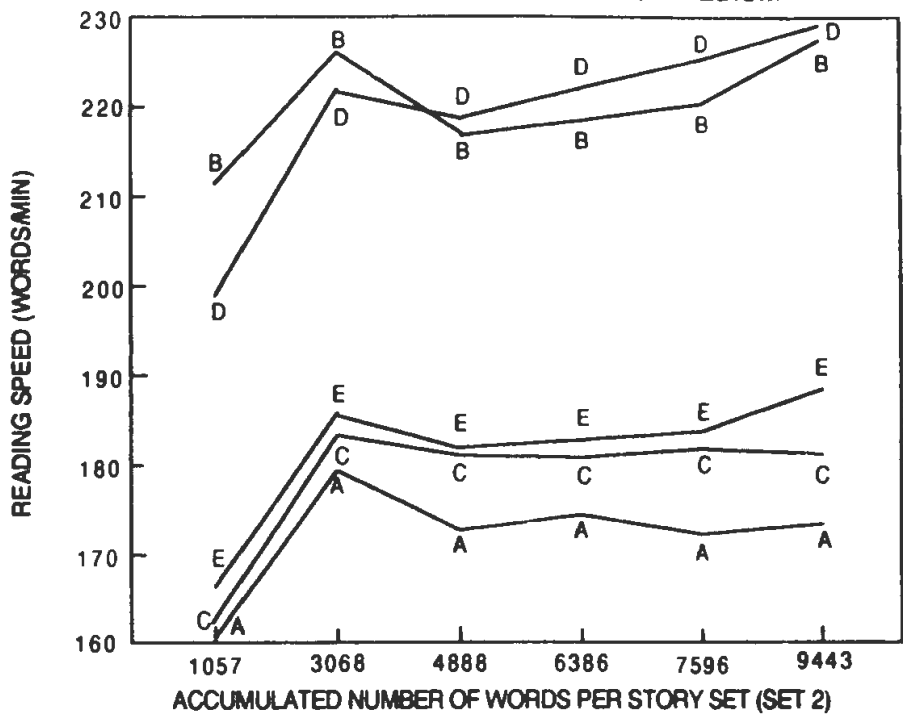
**READING SPEED VERSUS ACCUMULATED NUMBER
OF WORDS BY PRESENTATION MEDIUM**



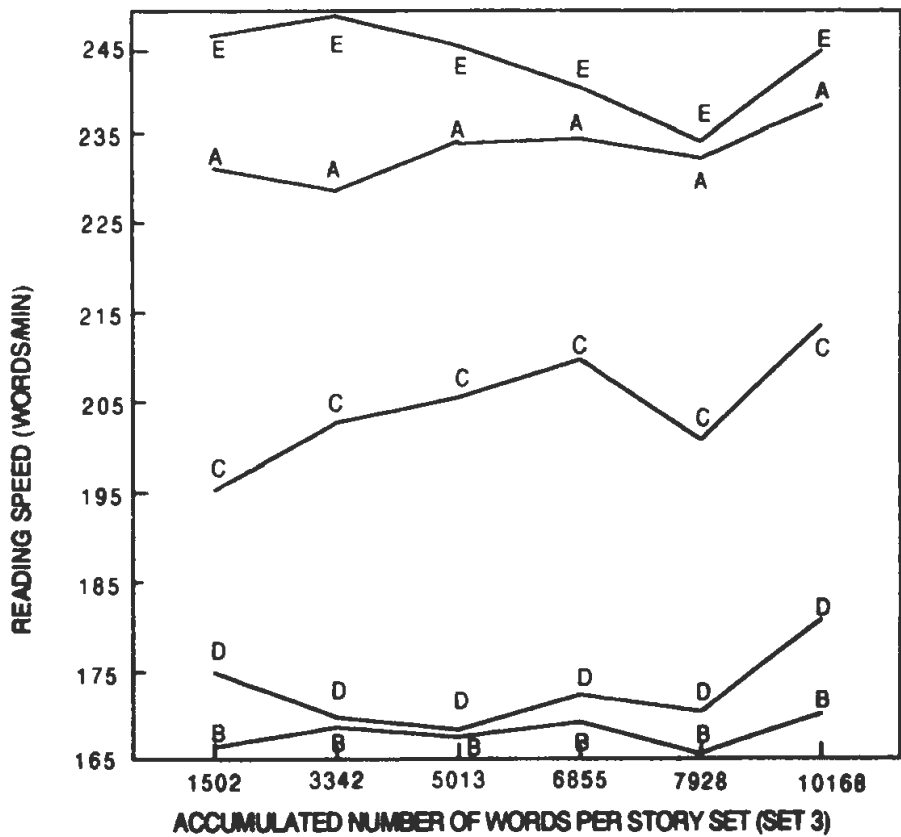
Legend: Presentation medium

- A - Paper
- B - White text on a Black background (VDU)
- C - Yellow text on a Black background (VDU)
- D - Black text on a Green background (VDU)
- E - White text on a Blue background (VDU)

READING SPEED VERSUS ACCUMULATED NUMBER
OF WORDS BY PRESENTATION MEDIUM

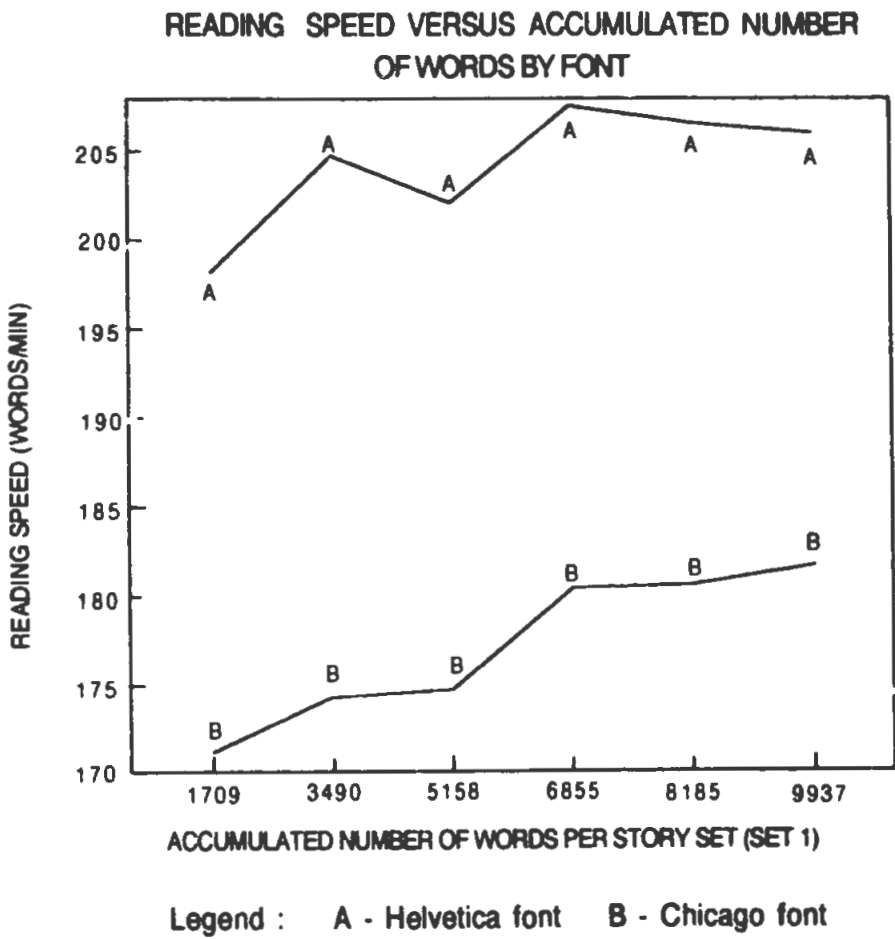


READING SPEED VERSUS ACCUMULATED NUMBER
OF WORDS BY PRESENTATION MEDIUM

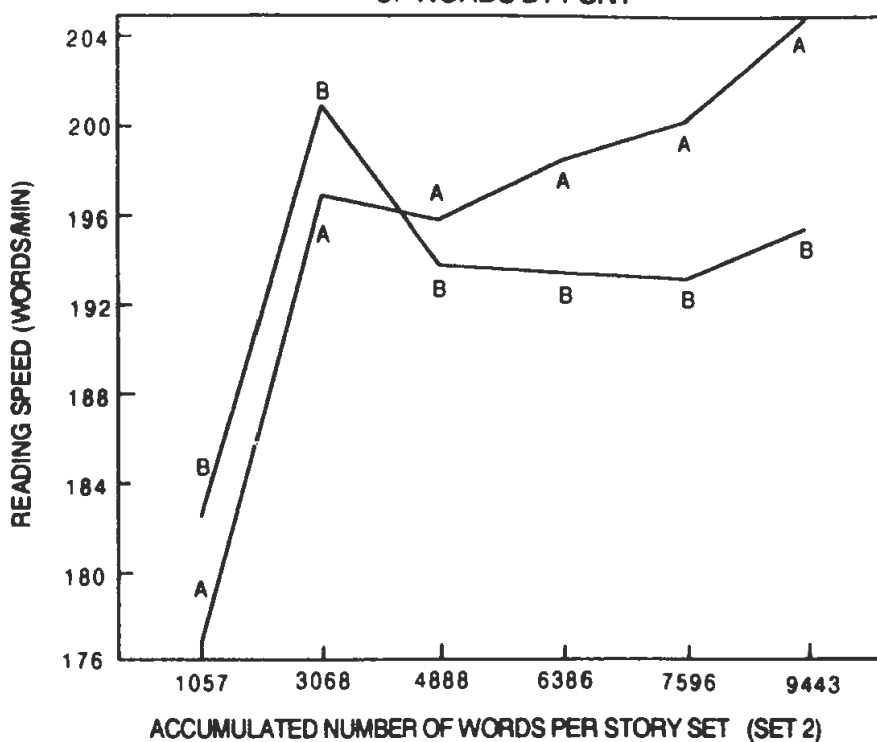


Appendix K

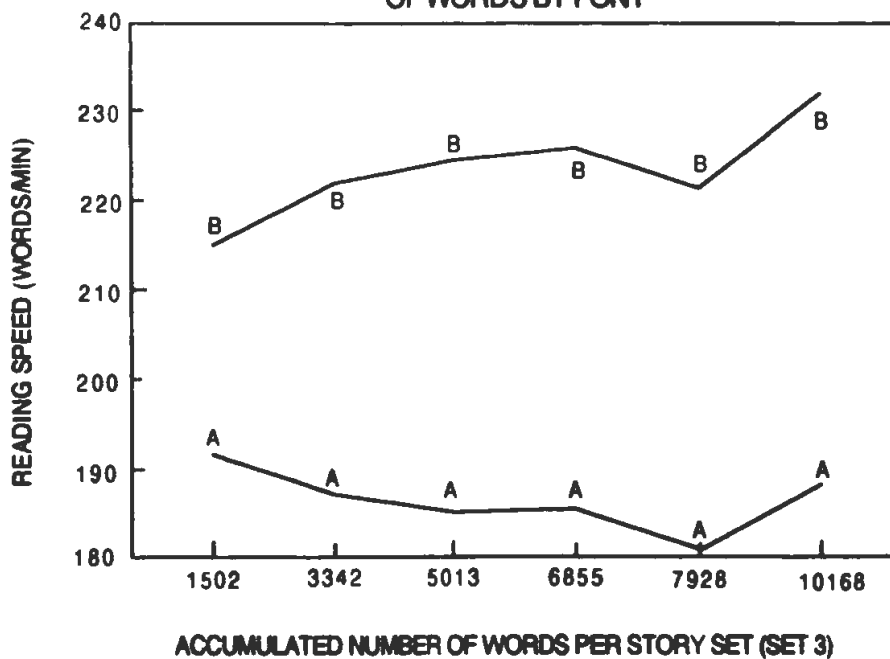
Graphical Presentation of Reading Speed as a Function
of Font by Story Sets



READING SPEED VERSUS ACCUMULATED NUMBER
OF WORDS BY FONT

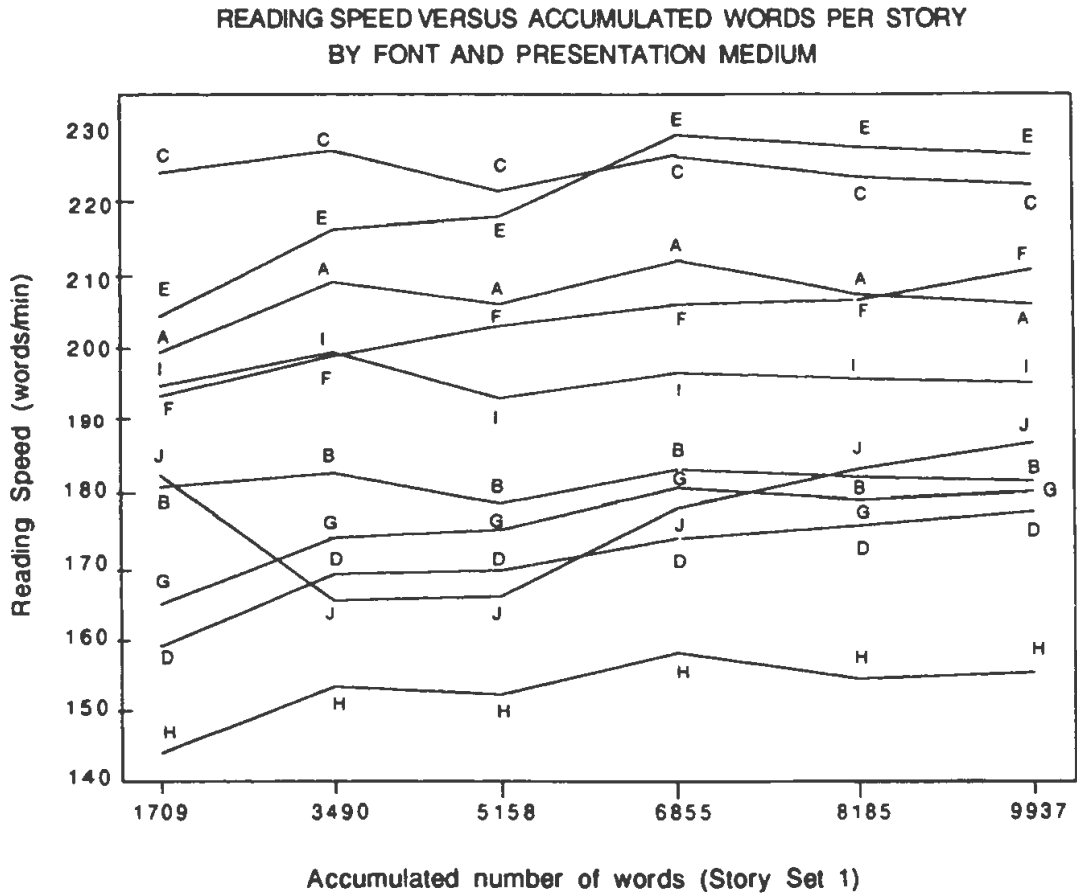


READING SPEED VERSUS ACCUMULATED NUMBER
OF WORDS BY FONT



Appendix L

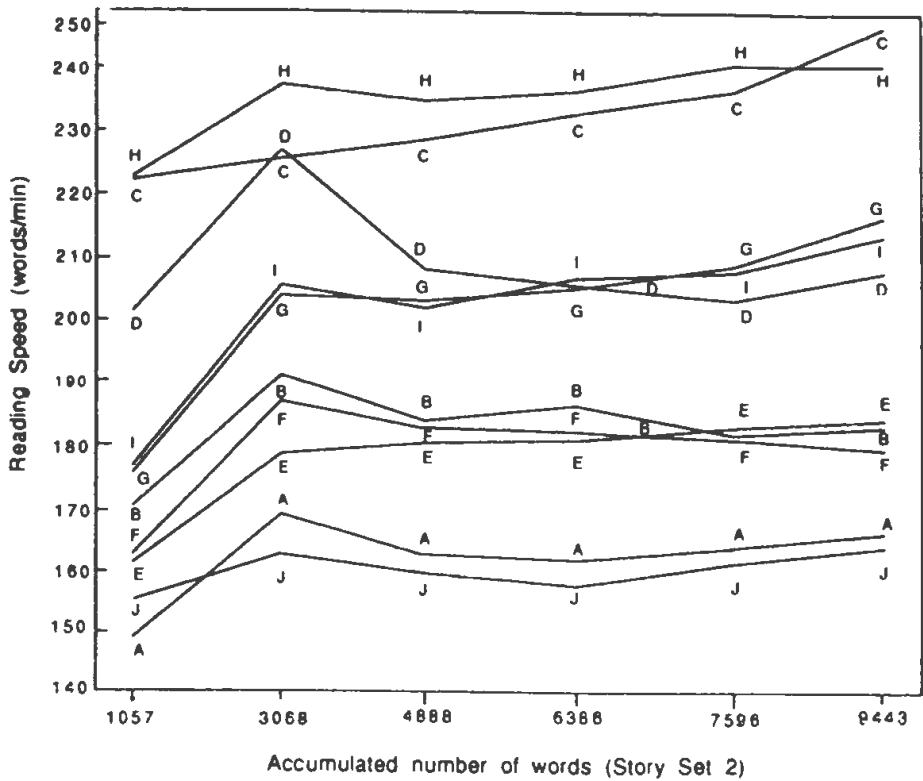
Graphical Presentation of Reading Speed as a Function of Font
and Presentation Medium by Story Sets



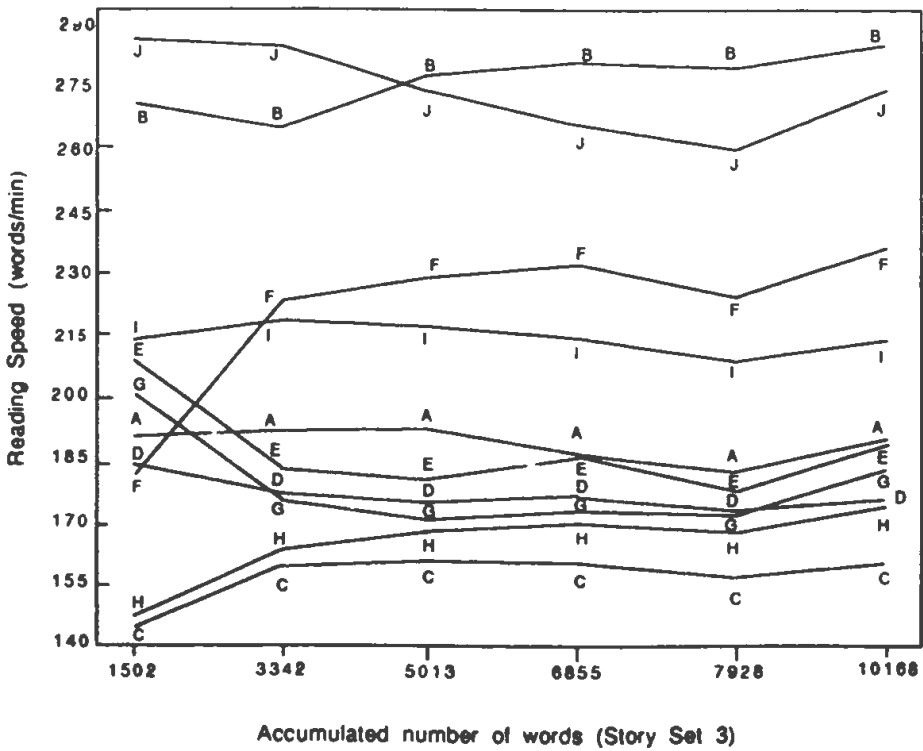
Legend : Font/Presentation medium

- A - Helvetica font/Paper
- B - Chicago font/Paper
- C - Helvetica font/White text on a Black background (VDU)
- D - Chicago font/White text on a Black background (VDU)
- E - Helvetica font/Yellow text on a Black background (VDU)
- F - Chicago font/Yellow text on a Black background (VDU)
- G - Helvetica font/Black text on a Green background (VDU)
- H - Chicago font/Black text on a Green background (VDU)
- I - Helvetica font/White text on a Blue background (VDU)
- J - Chicago font/White text on a Blue background (VDU)

READING SPEED VERSUS ACCUMULATED WORDS PER STORY
BY FONT AND PRESENTATION MEDIUM



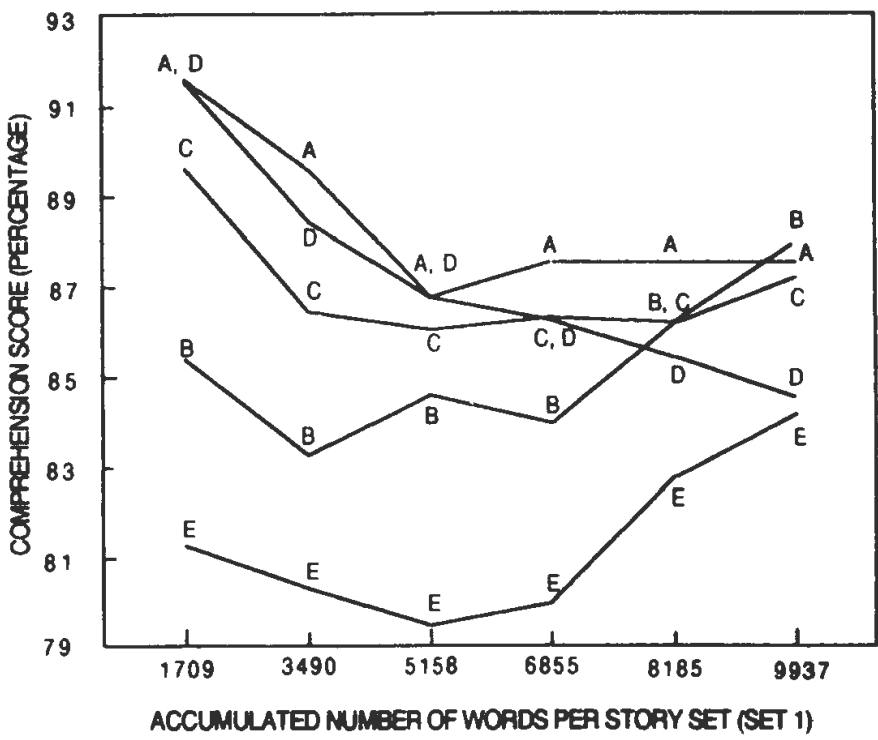
READING SPEED VERSUS ACCUMULATED WORDS PER STORY
BY FONT AND PRESENTATION MEDIUM



Appendix M

Graphical Presentation of Reading Comprehension Score
as a Function of Presentation Medium by Story Sets

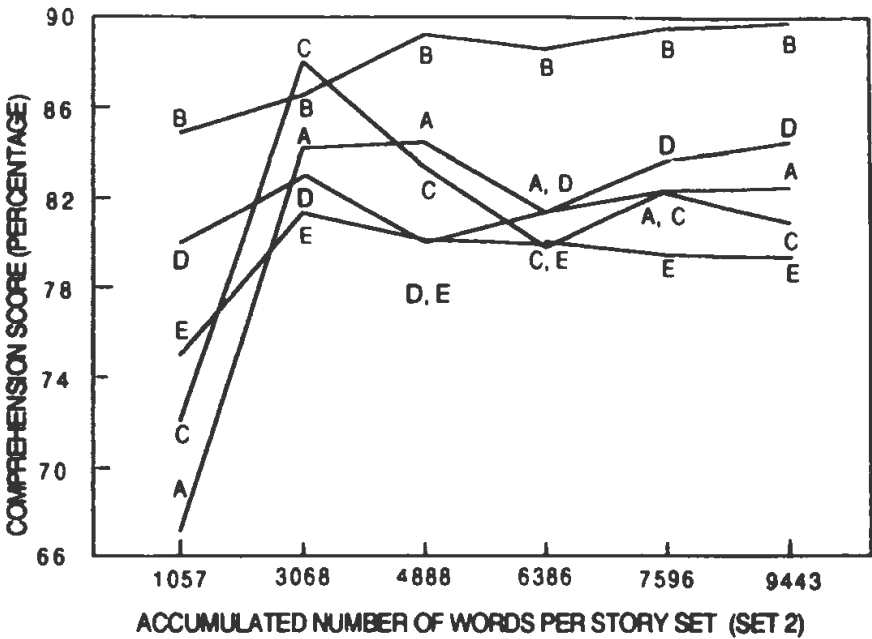
COMPREHENSION SCORE VERSUS ACCUMULATED NUMBER
OF WORDS BY PRESENTATION MEDIUM



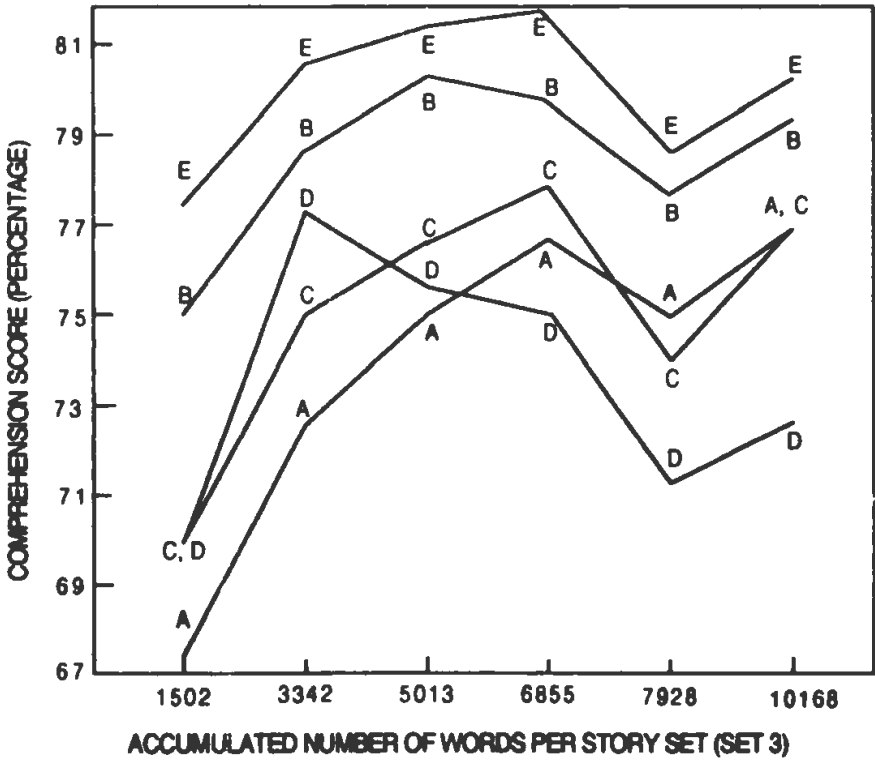
Legend : Presentation medium

- A - Paper
- B - White text on a Black background (VDU)
- C - Yellow text on a Black background (VDU)
- D - Black text on a Green background (VDU)
- E - White text on a Blue background (VDU)

COMPREHENSION SCORE VERSUS ACCUMULATED NUMBER
OF WORDS BY PRESENTATION MEDIUM

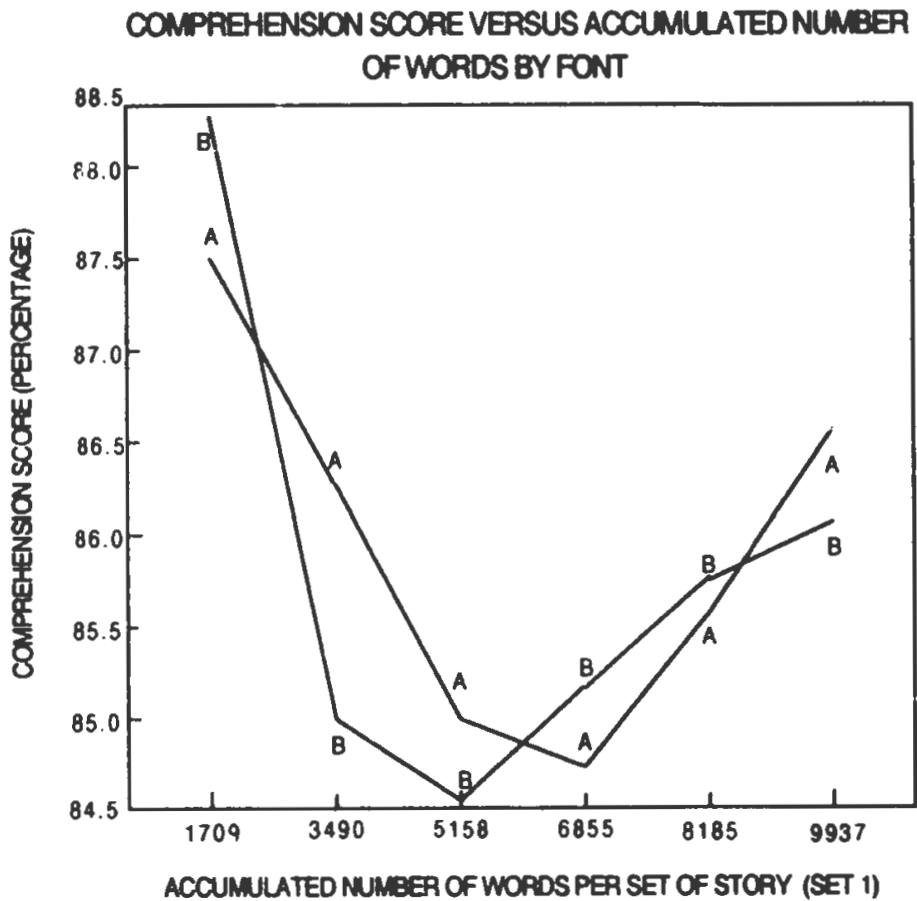


COMPREHENSION SCORE VERSUS ACCUMULATED NUMBER
OF WORDS BY PRESENTATION MEDIUM



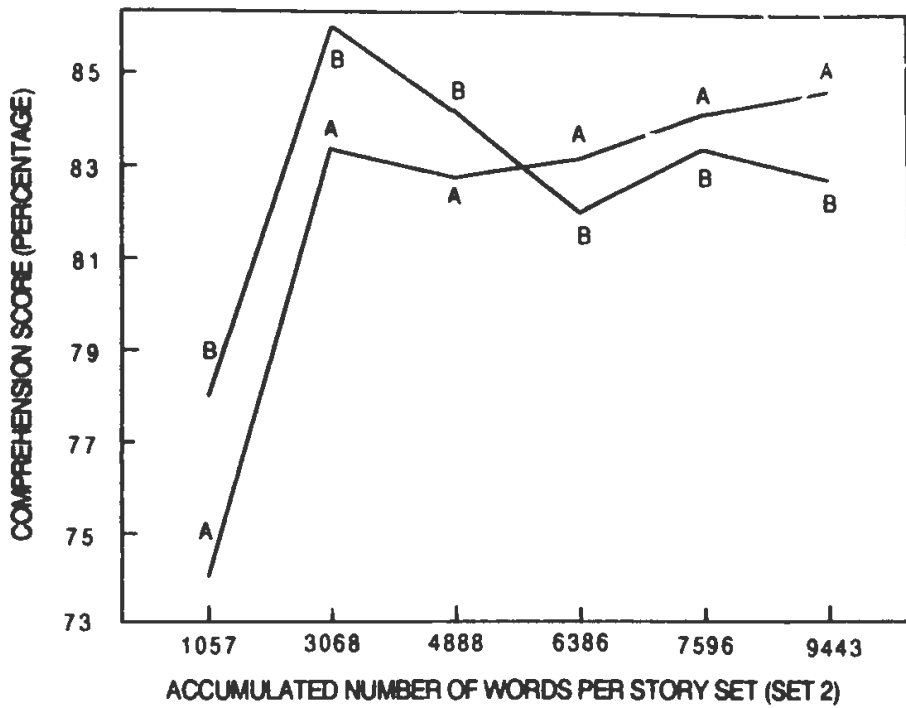
Appendix N

Graphical Presentation of Reading Comprehension Score
as a Function of Font by Story Sets

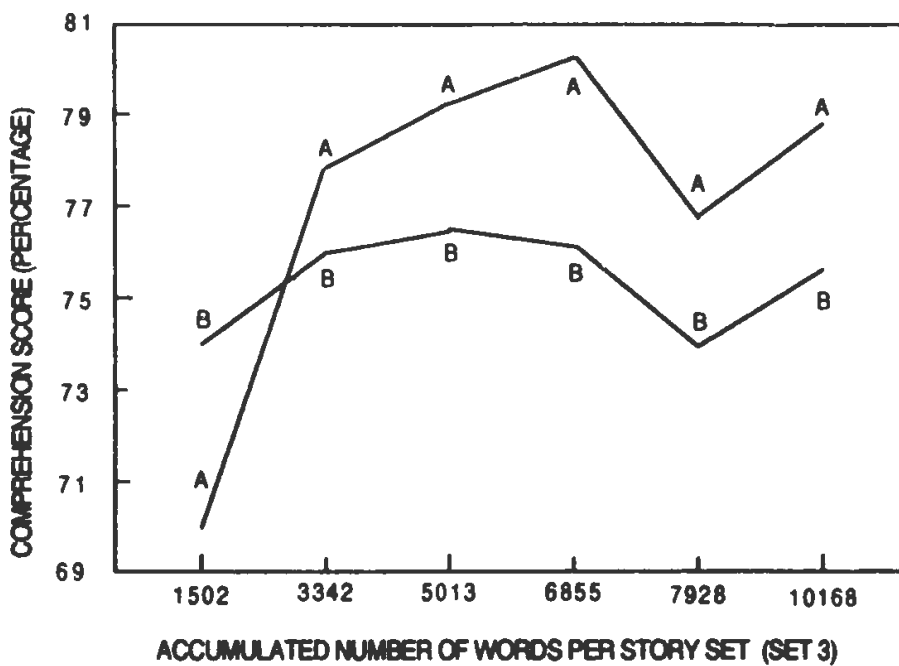


Legend : A - Helvetica font B - Chicago font

COMPREHENSION SCORE VERSUS ACCUMULATED NUMBER
OF WORDS BY FONT

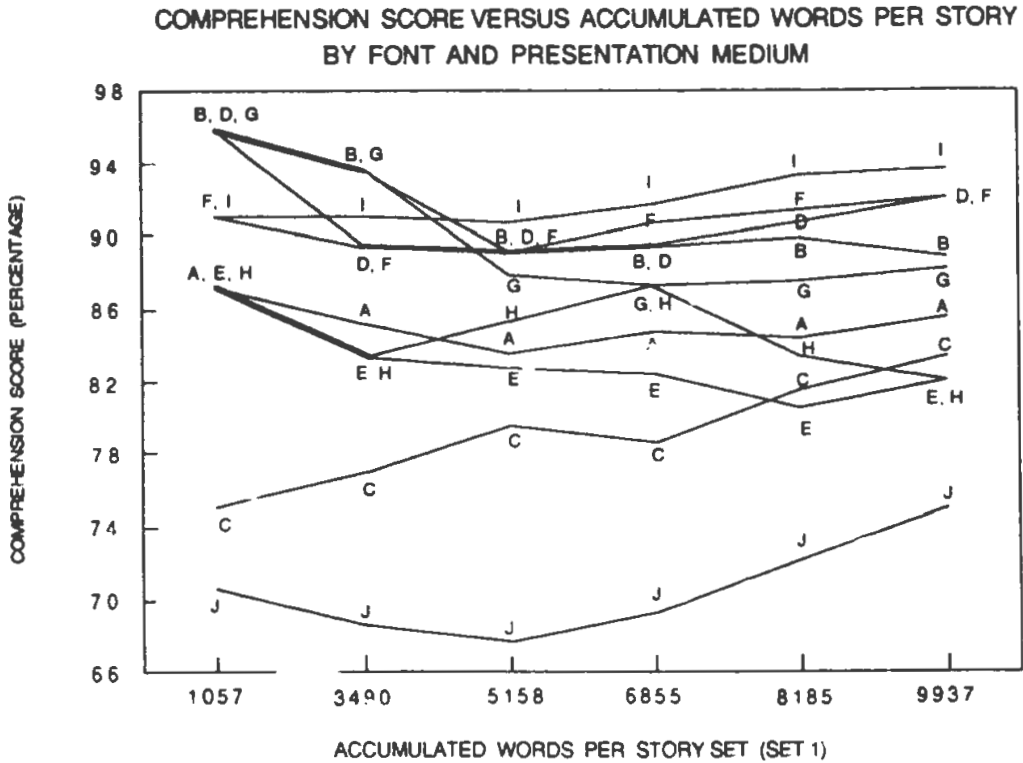


COMPREHENSION SCORE VERSUS ACCUMULATED NUMBER
OF WORDS BY FONT



Appendix O

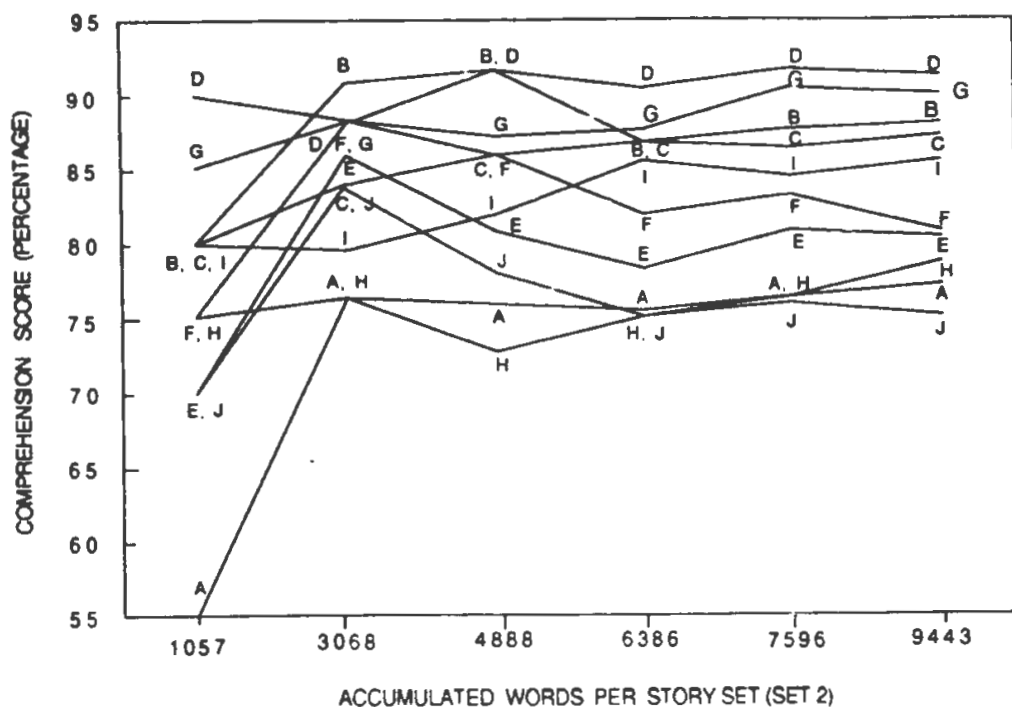
Graphical Presentation of Reading Comprehension Score as a
Function of Font and Presentation Medium by Story Sets



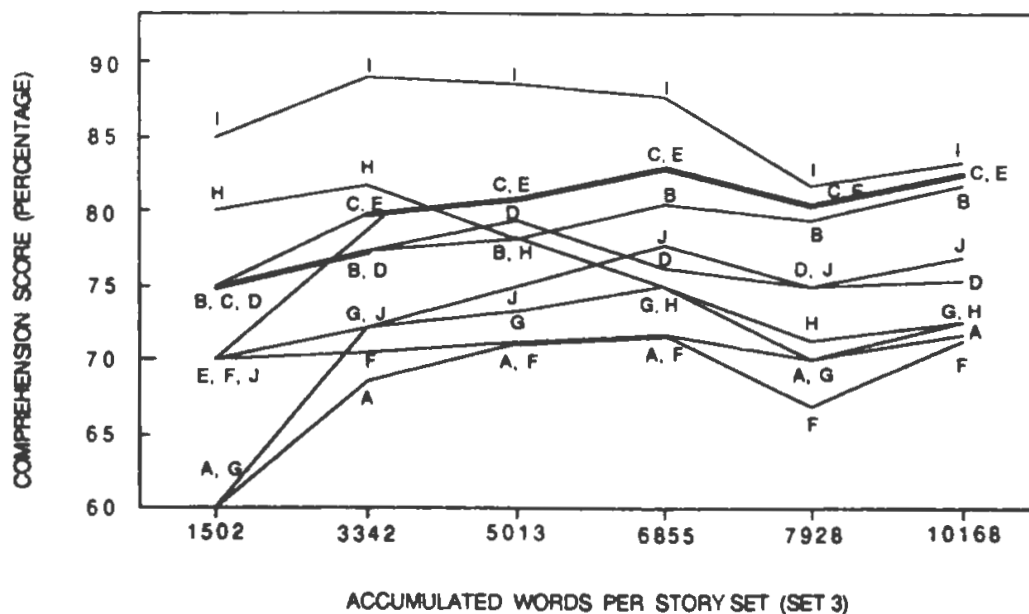
Legend : Font/Presentation medium

- A - Helvetica font/Paper
- B - Chicago font/Paper
- C - Helvetica font/White text on a Black background (VDU)
- D - Chicago font/White text on a Black background (VDU)
- E - Helvetica font/Yellow text on a Black background (VDU)
- F - Chicago font/Yellow text on a Black background (VDU)
- G - Helvetica font/Black text on a Green background (VDU)
- H - Chicago font/Black text on a Green background (VDU)
- I - Helvetica font/White text on a Blue background (VDU)
- J - Chicago font/White text on a Blue background (VDU)

COMPREHENSION SCORE VERSUS ACCUMULATED WORDS PER STORY
BY FONT AND PRESENTATION MEDIUM



COMPREHENSION SCORE VERSUS ACCUMULATED WORDS PER STORY
BY FONT AND PRESENTATION MEDIUM



Appendix P

Analysis of Variance for the POMS Categories

Analysis of Variance for Tension (Fixed Model)

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Font	1	0.50417	0.50417	0.10	0.7527
Medium	4	95.06667	23.76667	4.69	0.0012 ***
Font*Medium	4	7.51667	1.87917	0.37	0.8293
Admin	1	37.60417	37.60417	7.42	0.0070 **
Font*Admin	1	6.33750	6.33750	1.25	0.2646
Medium*Admin	4	21.91667	5.47917	1.08	0.3666
Font*Medium*Admin	4	1.26667	0.31667	0.06	0.9928

Note. * = significant at 0.05 level
 ** = significant at 0.01 level
 *** = significant at 0.001 level

Duncan's Multiple Range Test for variable: TENSION

Means with the same letter are not significantly different.

Duncan Grouping	Mean	N	FONT
A	1.658	120	Chicago
A			
A	1.567	120	Helvetica
Duncan Grouping	Mean	N	PRESENTATION MEDIUM
A	2.667	48	White/Black
A			
B	2.000	48	Black/Green
B			
B	1.250	48	White/Blue
B			
B	1.125	48	Paper
B			
B	1.021	48	Yellow/Black
Duncan Grouping	Mean	N	ADMINISTRATION
A	2.008	120	After
B	1.217	120	Before

Analysis of Variance for Fatigue (Fixed Model)

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Font	1	6.01667	6.01667	0.31	0.5787
Medium	4	240.04167	60.01042	3.08	0.0169 *
Font*Medium	4	39.35833	9.83958	0.51	0.7316
Admin	1	601.66667	601.66667	30.92	0.0001 ***
Font*Admin	1	0.60000	0.60000	0.03	0.8608
Medium*Admin	4	36.29167	9.07292	0.47	0.7604
Font*Medium*Admin	4	80.94167	20.23542	1.04	0.3874

Note. * = significant at 0.05 level
 ** = significant at 0.01 level
 *** = significant at 0.001 level

Duncan's Multiple Range Test for variable: FATIGUE

Means with the same letter are not significantly different.

Duncan Grouping	Mean	N	FONT
A	5.200	120	Chicago
A			
A	4.883	120	Helvetica

Duncan Grouping		Mean	N	PRESENTATION MEDIUM	
	A	6.437	48	White/Black	
	A				
B	A	5.896	48	Black/Green	
B	A				
B	A	C	4.875	48	Paper
B		C			
B		C	4.250	48	Yellow/Black
		C			
		C	3.750	48	White/Blue

Duncan Grouping	Mean	N	ADMINISTRATION
A	6.625	120	After
B	3.458	120	Before

Analysis of Variance for Vigour (Fixed Model)

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Font	1	3.03750	3.03750	0.21	0.6498
Medium	4	92.40000	23.10000	1.57	0.1827
Font*Medium	4	105.90000	26.47500	1.80	0.1294
Admin	1	451.00417	451.00417	30.70	0.0001 ***
Font*Admin	1	0.20417	0.20417	0.01	0.9063
Medium*Admin	4	30.60000	7.65000	0.52	0.7206
Font*Medium*Admin	4	58.56667	14.64167	1.00	0.4103

Note. * = significant at 0.05 level
 ** = significant at 0.01 level
 *** = significant at 0.001 level

Duncan's Multiple Range Test for variable: VIGOUR

Means with the same letter are not significantly different

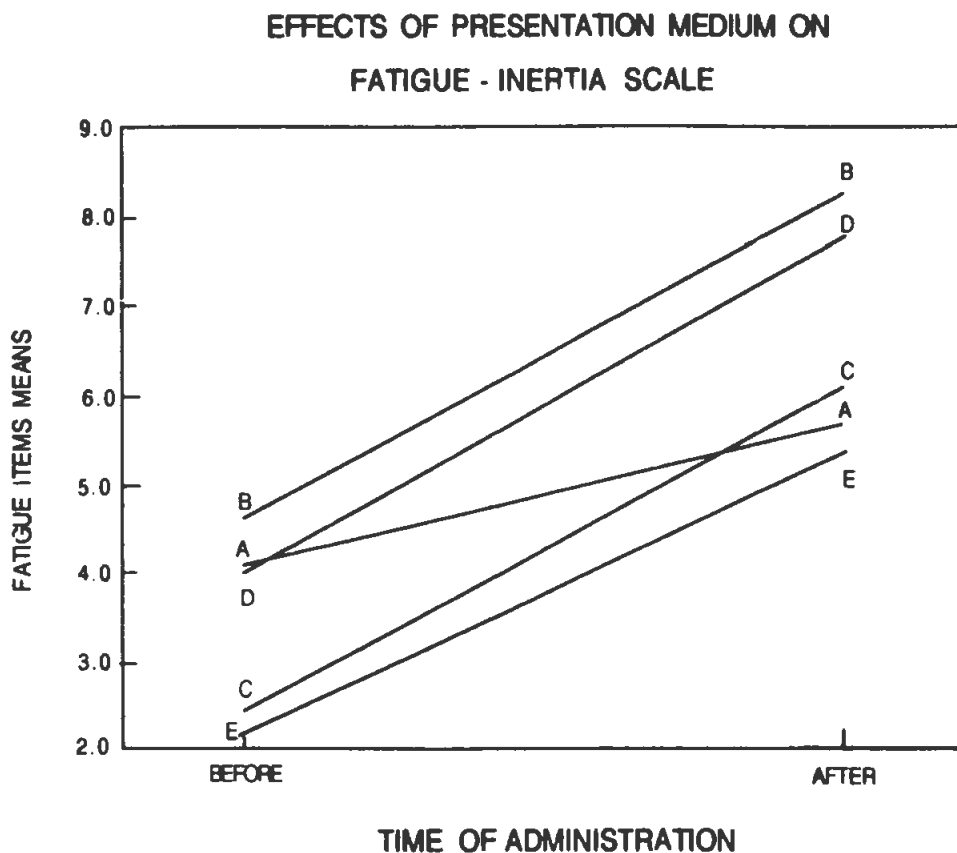
Duncan Grouping	Mean	N	FONT
A	8.183	120	Chicago
A			
A	7.958	120	Helvetica

Duncan Grouping	Mean	N	PRESENTATION MEDIUM
A	9.208	48	Paper
A			
B	8.208	48	Yellow/Black
B			
B	7.833	48	White/Blue
B			
B	7.646	48	Black/Green
B			
B	7.458	48	White/Black

Duncan Grouping	Mean	N	ADMINISTRATION
A	9.442	120	Before
B	6.700	120	After

Appendix Q

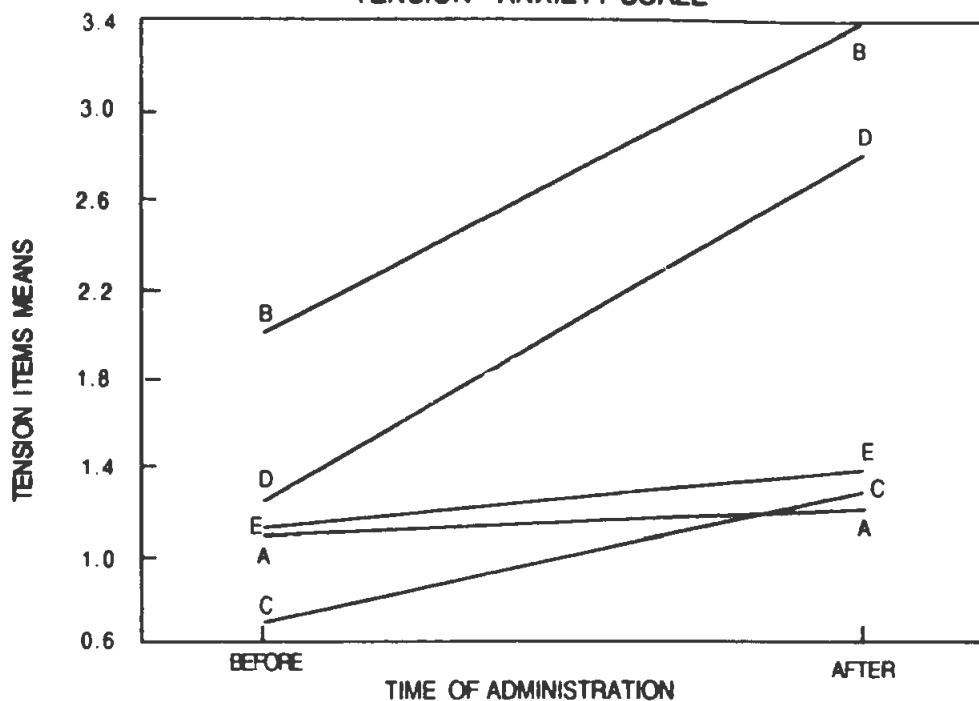
Graphical Presentation of POMS Categories as a Function
of Presentation Medium Across Administration Time



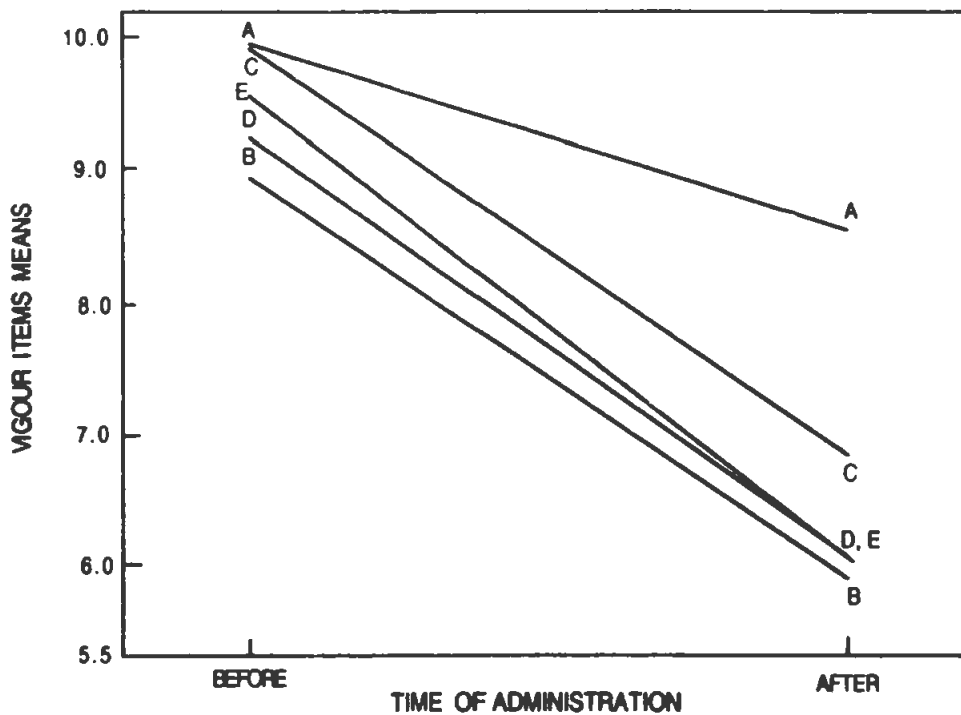
Legend : Presentation medium

- A - Paper**
- B - White text on a Black background (VDU)**
- C - Yellow text on a Black background (VDU)**
- D - Black text on a Green background (VDU)**
- E - White text on a Blue background (VDU)**

EFFECTS OF PRESENTATION MEDIUM ON TENSION - ANXIETY SCALE

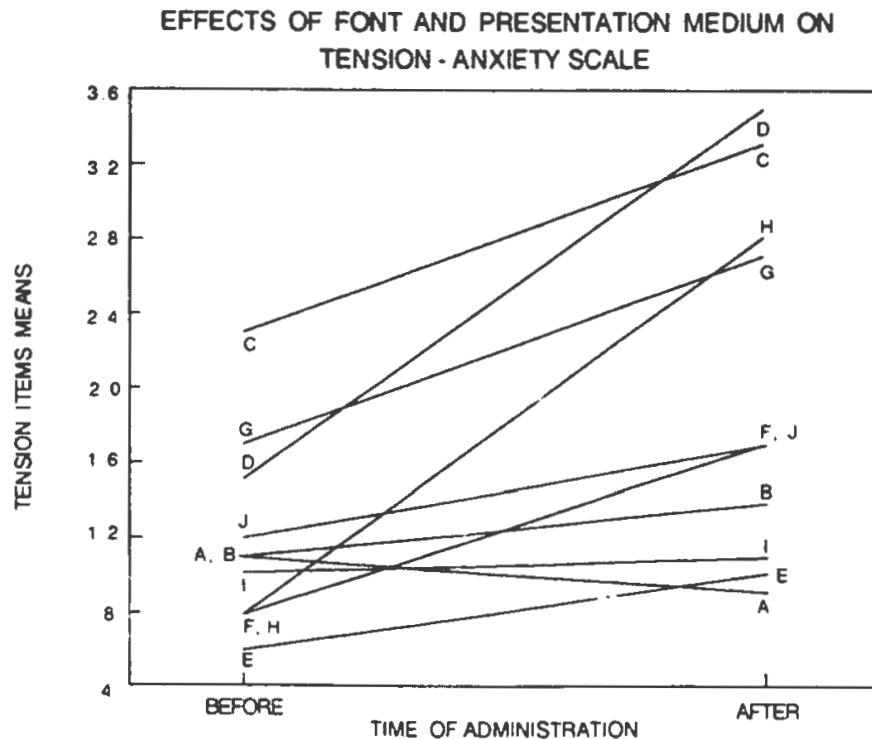


EFFECTS OF PRESENTATION MEDIUM ON VIGOUR - ACTIVITY SCALE



Appendix R

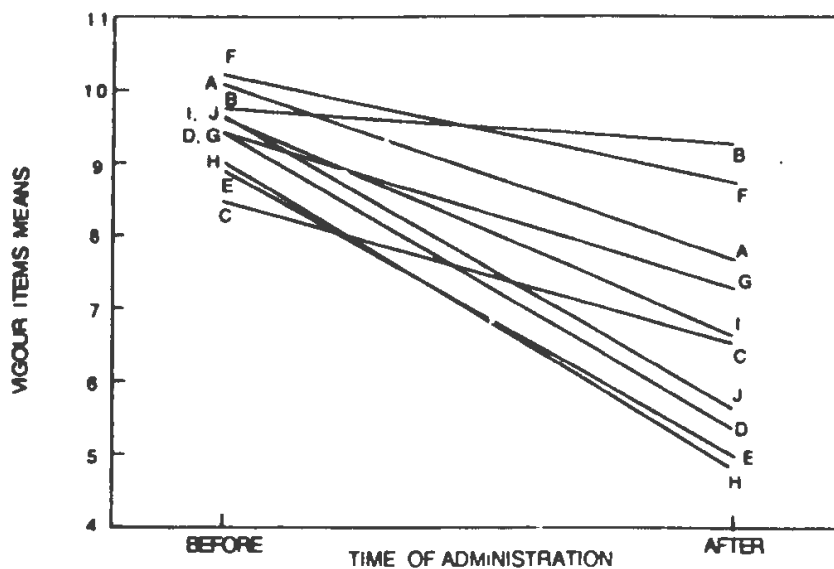
Graphical Presentation of POMS Categories as a Function of Font
and Presentation Medium Across Administration Time



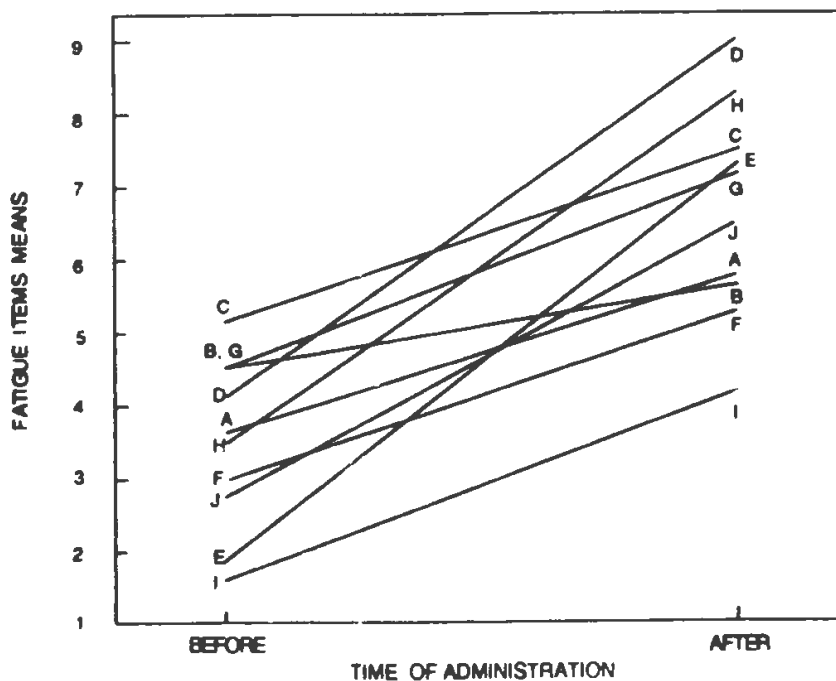
Legend : Font/Presentation medium

- A - Helvetica font/Paper
- B - Chicago font/Paper
- C - Helvetica font/White text on a Black background (VDU)
- D - Chicago font/White letter on Black background (VDU)
- E - Helvetica font/Yellow letter on Black background (VDU)
- F - Chicago font/Yellow letter on Black background (VDU)
- G - Helvetica font/Black letter on Green background (VDU)
- H - Chicago font/Black letter on Green background (VDU)
- I - Helvetica font/White letter on Blue background (VDU)
- J - Chicago font/White letter on Blue background (VDU)

EFFECTS OF FONT AND PRESENTATION MEDIUM ON VIGOUR - ACTIVITY SCALE



EFFECTS OF FONT AND PRESENTATION MEDIUM ON FATIGUE - INERTIA SCALE



Appendix S

Analysis of Variance for the Physical Symptoms Categories

Analysis of Variance for Physical Stress (Fixed Model)

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Font	1	0.70417	0.70417	0.10	0.7548
Medium	4	53.83333	13.45833	1.87	0.1170
Font*Medium	4	55.73333	13.93333	1.93	0.1058
Admin	1	105.33750	105.33750	14.62	0.0002 ***
Font*Admin	1	0.33750	0.33750	0.05	0.8288
Medium*Admin	4	23.26667	5.81667	0.81	0.5216
Font*Medium*Admin	4	7.76667	1.94167	0.27	0.8974

Note. *** = significant at 0.001 level

Duncan's Multiple Range Test for variable: PHYSIC

Means with the same letter are not significantly different.

Duncan Grouping	Mean	N	FONT
A	1.533	120	Chicago
A			
A	1.425	120	Helvetica
Duncan Grouping	Mean	N	PRESENTATION MEDIUM
A	2.313	48	White/Black
A			
B	1.562	48	Black/Green
B			
B	1.479	48	White/Blue
B			
B	1.021	48	Yellow/Black
B			
B	1.021	48	Paper
Duncan Grouping	Mean	N	ADMINISTRATION
A	2.142	120	After
B	0.817	120	Before

Analysis of Variance for Mental Stress (Fixed Model)

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Font	1	0.00417	0.00417	0.00	0.9650
Medium	4	66.27500	16.56875	7.69	0.0001 ***
Font*Medium	4	11.47500	2.86875	1.33	0.2592
Admin	1	44.20417	44.20417	20.51	0.0001 ***
Font*Admin	1	1.83750	1.83750	0.85	0.3568
Medium*Admin	4	5.94167	1.48542	0.69	0.6001
Font*Medium*Admin	4	1.47500	0.36875	0.17	0.9530

Note. *** = significant at 0.001 level

Duncan's Multiple Range Test for variable: MENTAL STRESS

Means with the same letter are not significantly different.

Duncan Grouping	Mean	N	FONT
A	1.183	120	Chicago
A			
A	1.175	120	Helvetica

Duncan Grouping	Mean	N	PRESENTATION MEDIUM
A	1.854	48	White/Black
A			
A	1.771	48	Black/Green
B	0.917	48	Paper
B			
B	0.708	48	White/Blue
B			
B	0.646	48	Yellow/Black

Duncan Grouping	Mean	N	ADMINISTRATION
A	1.608	120	After
B	0.750	120	Before

Analysis of Variance for Visual Strain (Fixed Model)

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Font	1	6.66667	6.66667	1.47	0.2263
Medium	4	69.27500	17.31875	3.82	0.0050 **
Font*Medium	4	30.37500	7.59375	1.68	0.1563
Admin	1	176.81667	176.81667	39.05	0.0001 ***
Font*Admin	1	8.06667	8.06667	1.78	0.1833
Medium*Admin	4	38.30833	9.57708	2.12	0.0799
Font*Medium*Admin	4	6.30833	1.57708	0.35	0.8451

Note. ** = significant at 0.01 level

*** = significant at 0.001 level

Duncan's Multiple Range Test for variable: VISUAL STRAIN

Means with the same letter are not significantly different.

Duncan Grouping	Mean	N	FONT
A	2.008	120	Chicago
A			
A	1.675	120	Helvetica

Duncan Grouping	Mean	N	PRESENTATION MEDIUM
A	2.542	48	Black/Green
A			
A	2.438	48	White/Black
B	1.500	48	White/Blue
B			
B	1.479	48	Yellow/Black
B			
B	1.250	48	Paper

Duncan Grouping	Mean	N	ADMINISTRATION
A	2.700	120	After
B	0.983	120	Before

Analysis of Variance for Workplace Environment (Fixed Model)

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Font	1	0.41667	0.41667	0.17	0.6822
Medium	4	8.06667	2.01667	0.81	0.5177
Font*Medium	4	19.33333	4.83333	1.95	0.1032
Admin	1	4.81667	4.81667	1.94	0.1647
Font*Admin	1	1.35000	1.35000	0.54	0.4613
Medium*Admin	4	16.93333	4.23333	1.71	0.1493
Font*Medium*Admin	4	5.73333	1.43333	0.58	0.6787

Duncan's Multiple Range Test for variable: WORKPLACE

Means with the same letter are not significantly different.

Duncan Grouping	Mean	N	FONT
A	1.550	120	Chicago
A			
A	1.467	120	Helvetica

Duncan Grouping	Mean	N	PRESENTATION MEDIUM
A	1.708	48	Black/Green
A			
A	1.583	48	White/Blue
A			
A	1.583	48	White/Black
A			
A	1.500	48	Yellow/Black
A			
A	1.167	48	Paper

Duncan Grouping	Mean	N	ADMINISTRATION
A	1.650	120	After
B	1.367	120	Before

Analysis of Variance for Task/Job Comments (Fixed Model)

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Font	1	12.03333	12.03333	1.49	0.2256
Medium	4	73.63333	18.40833	2.28	0.0670
Font*Medium	4	16.96667	4.24167	0.52	0.7178
Set	2	20.21667	10.10833	1.25	0.2913
Font*Set	2	25.01667	12.50833	1.55	0.2184
Medium*Set	8	31.61667	3.95208	0.49	0.8612
Font*Medium*Set	4	34.48333	4.31042	0.53	0.8286

Analysis of Variance for Task/Job Comments (Mixed Model)

Source	DF	Type III SS	DF	Mean Square	F Value	Pr > F
Font	1	12.03333	2	12.50833	0.96	0.4301
Medium	4	18.40833	8	3.95208	4.66	0.0309 *
Font*Medium	4	4.24167	8	4.31042	0.98	0.4680
Set	2	10.10833	1.8	12.15000	0.83	0.5553
Font*Set	2	12.50833	8	4.31042	2.90	0.1128
Medium*Set	8	3.95208	8	4.31042	0.92	0.5473
Font*Medium*Set	8	4.31042	90	8.08333	0.53	0.8286

Note. * = significant at 0.05 level

Duncan's Multiple Range Test for variable: JOB/TASK COMMENTS

Means with the same letter are not significantly different.

Duncan Grouping	Mean	N	FONT
A	5.750	60	Helvetica
A			
A	5.117	60	Chicago

Duncan Grouping		Mean	N	SET OF STORY
	A	5.850	40	Set 1
	A			
	A	5.575	40	Set 2
	A			
	A	4.875	40	Set 3
Duncan Grouping		Mean	N	PRESENTATION MEDIUM
	A	6.833	24	Paper
	A			
B	A	5.708	24	Yellow/Black
B	A			
B	A	5.125	24	Black/Green
B				
B		4.792	24	White/Black
B				
B		4.708	24	White/Blue

Analysis of Variance for Reading Efficiency (Fixed Model)

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Font	1	3.75000	3.75000	2.89	0.0903
Medium	4	13.18333	3.29583	2.54	0.0405 *
Font*Medium	4	1.16667	0.29167	0.23	0.9242
Admin	1	12.15000	12.15000	9.38	0.0025 **
Font*Admin	1	0.15000	0.15000	0.12	0.7340
Medium*Admin	4	13.51667	3.37917	2.61	0.0366 *
Font*Medium*Admin	4	2.26667	0.56667	0.44	0.7815

Note. * = significant at 0.05 level

** = significant at 0.01 level

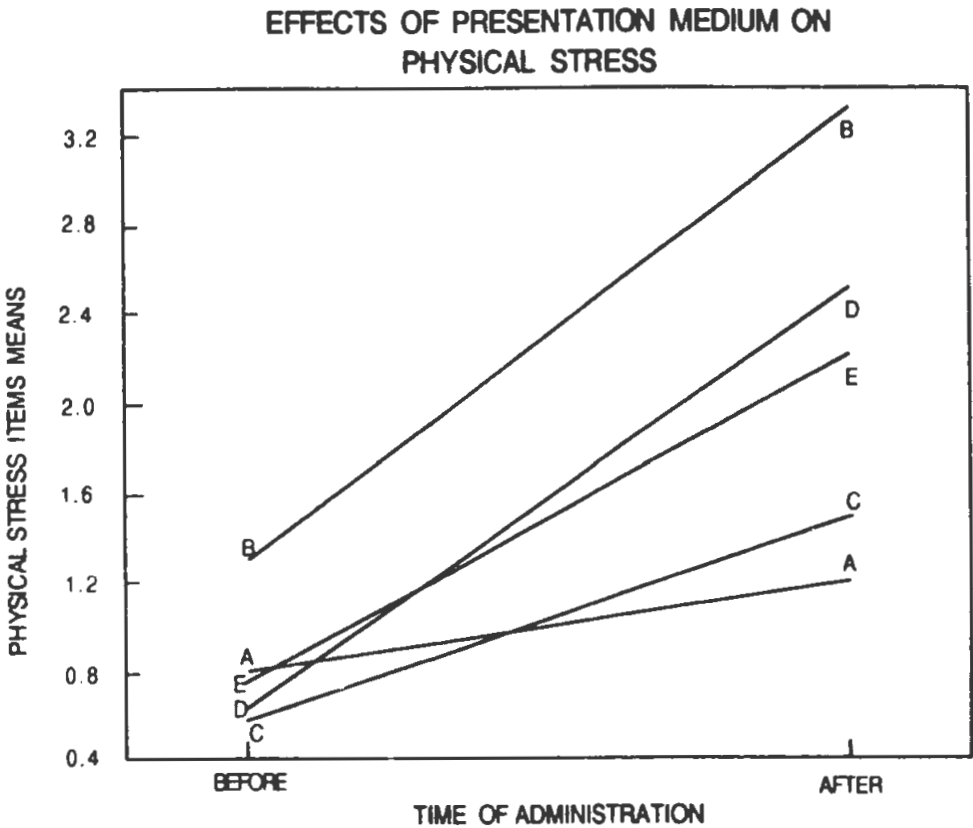
Duncan's Multiple Range Test for variable: READING EFFICIENCY

Means with the same letter are not significantly different.

Duncan Grouping	Mean	N	FONT
A	2.183	120	Helvetica
A			
A	1.933	120	Chicago
Duncan Grouping	Mean	N	PRESENTATION MEDIUM
A	2.479	48	Yellow/Black
A			
B	2.146	48	Black/Green
B			
B	1.937	48	White/Black
B			
B	1.875	48	Paper
B			
B	1.854	48	White/Blue
Duncan Grouping	Mean	N	ADMINISTRATION
A	2.283	120	Before
B	1.833	120	After

Appendix T

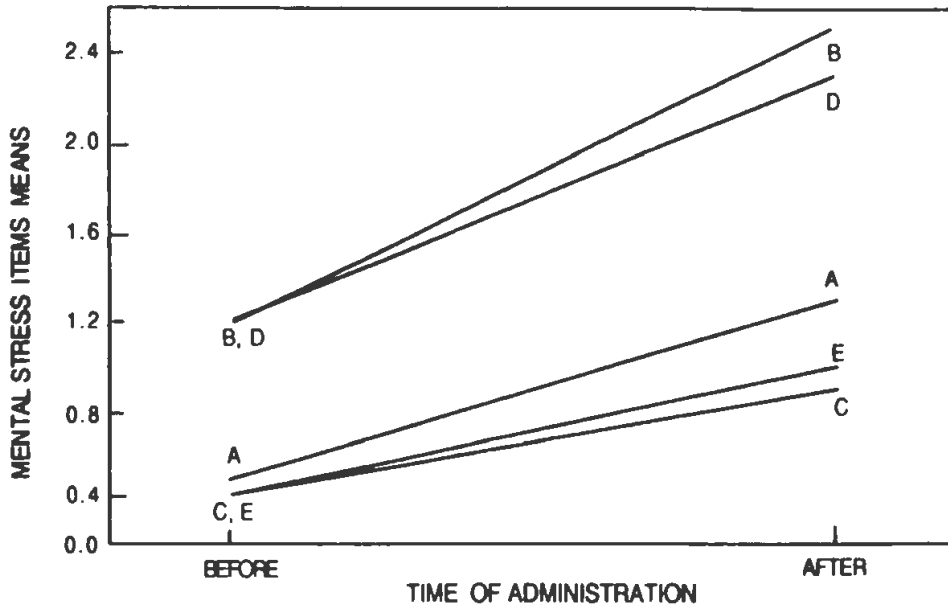
Graphical Presentation of Physical Symptoms Categories
as a Function of Presentation Medium
Across Administration Time



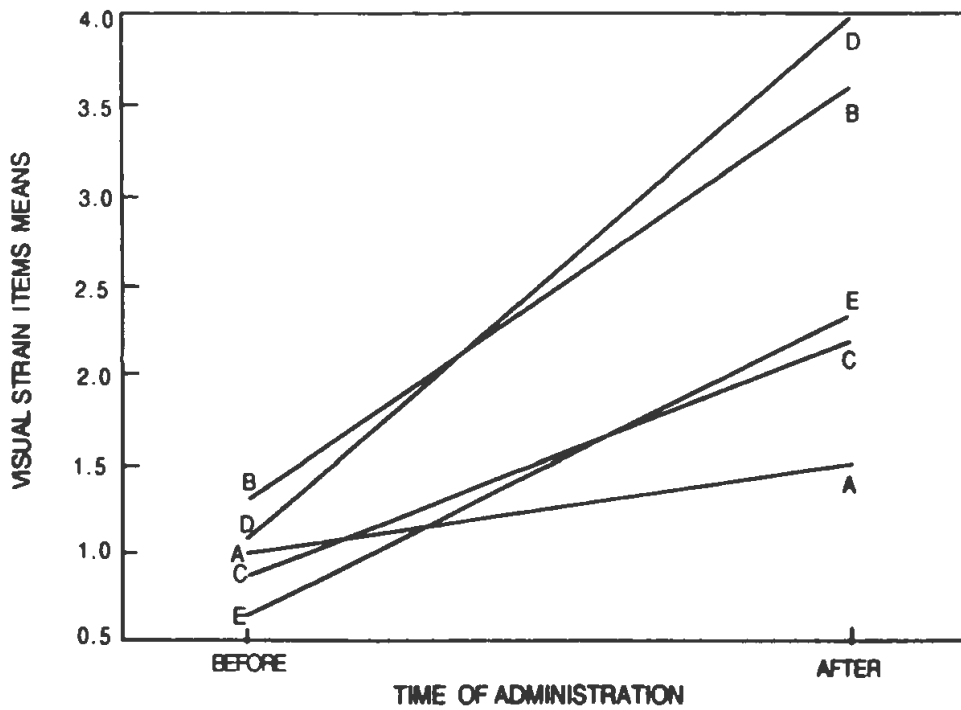
Legend : Presentation medium

- A - Paper
- B - White text on a Black background (VDU)
- C - Yellow text on a Black background (VDU)
- D - Black text on a Green background (VDU)
- E - White text on a Blue background (VDU)

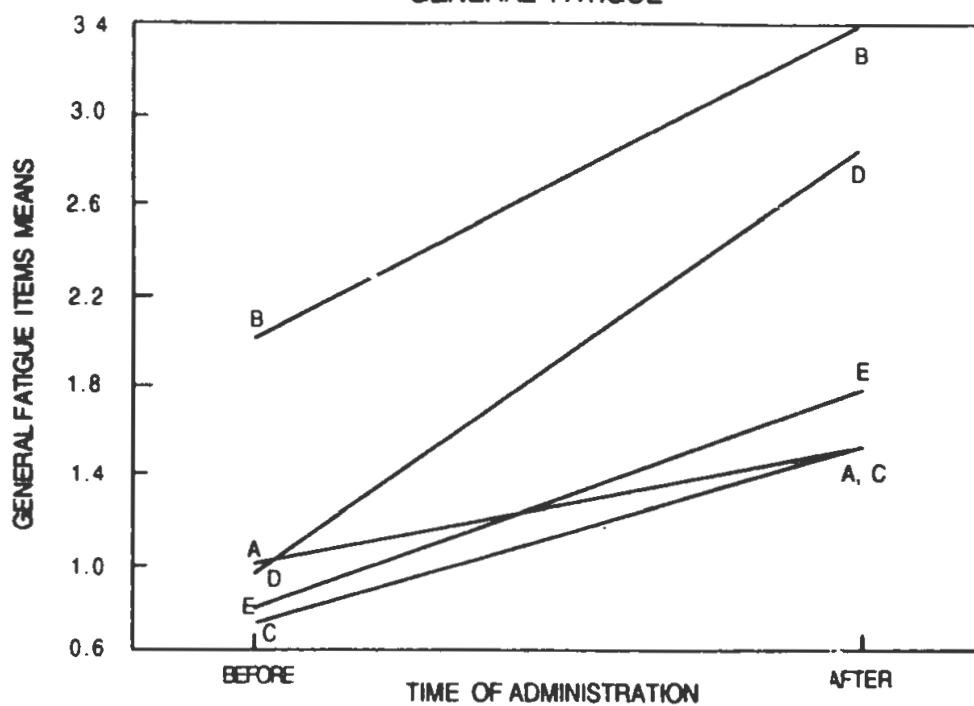
EFFECTS OF PRESENTATION MEDIUM ON MENTAL STRESS



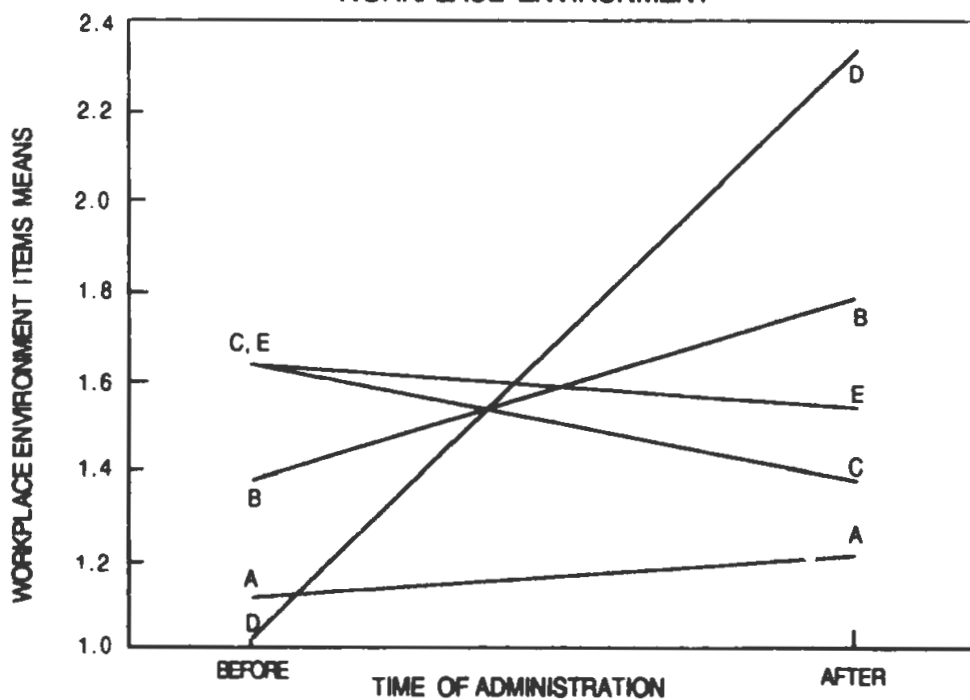
EFFECTS OF PRESENTATION MEDIUM ON VISUAL STRAIN



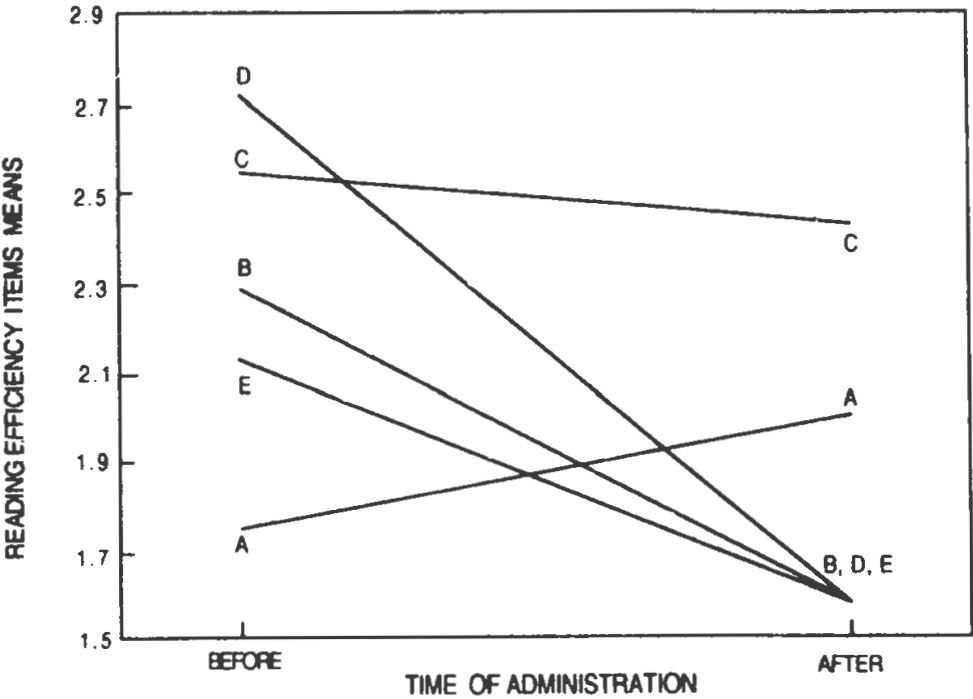
EFFECTS OF PRESENTATION MEDIUM ON GENERAL FATIGUE



EFFECTS OF PRESENTATION MEDIUM ON WORKPLACE ENVIRONMENT

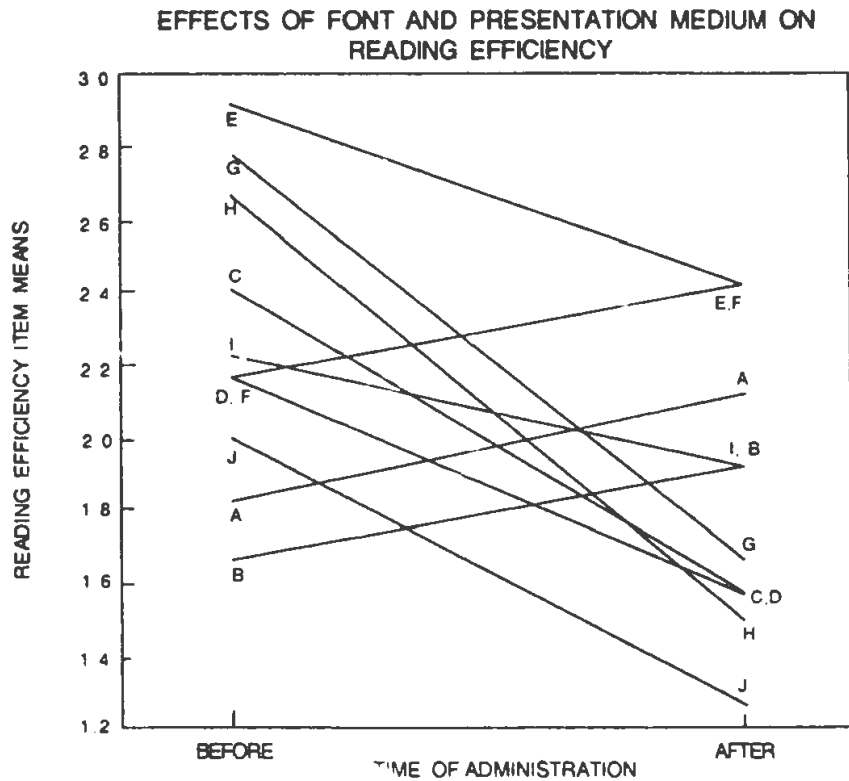


EFFECTS OF PRESENTATION MEDIUM ON
READING EFFICIENCY



Appendix U

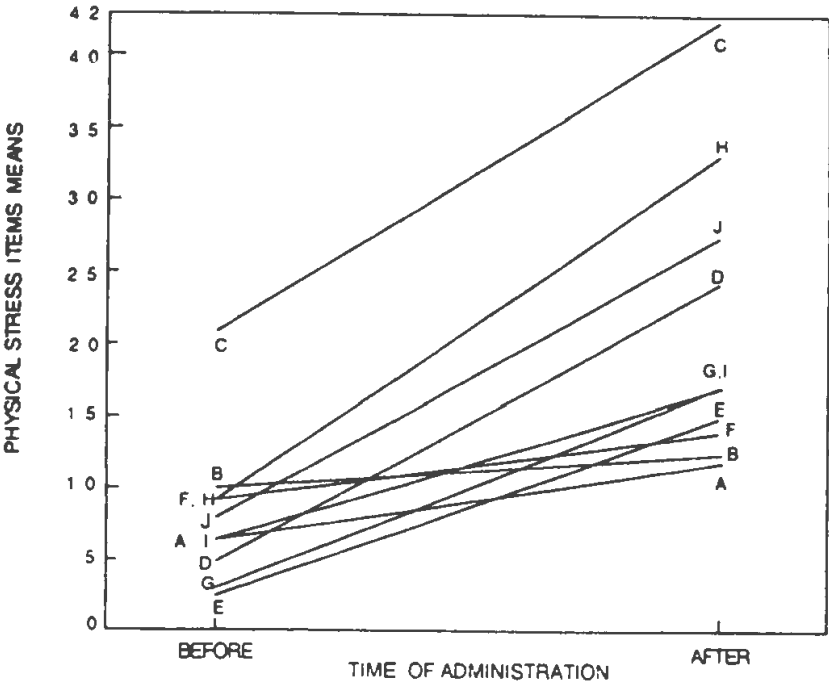
Graphical Presentation of Physical Symptoms Categories as a Function
of Font and Presentation Medium Across Administration Time



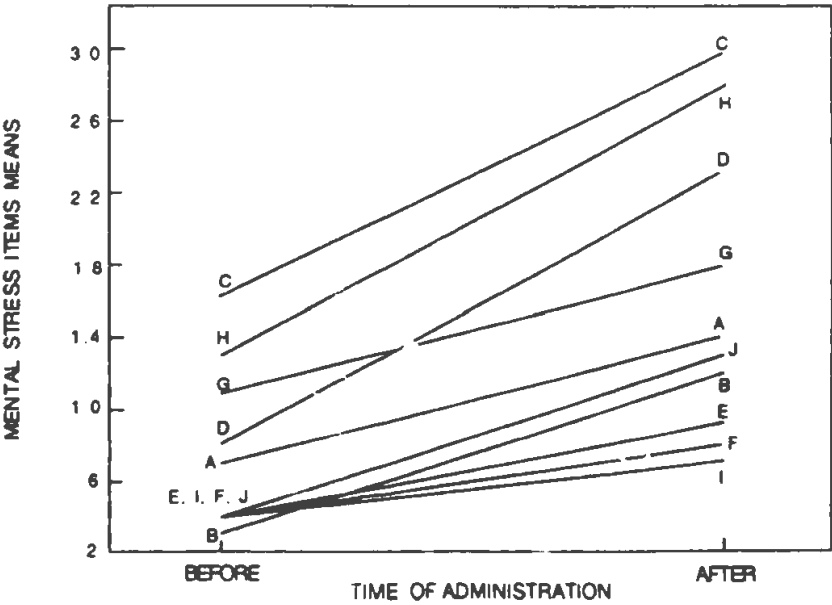
Legend : Font/Presentation medium

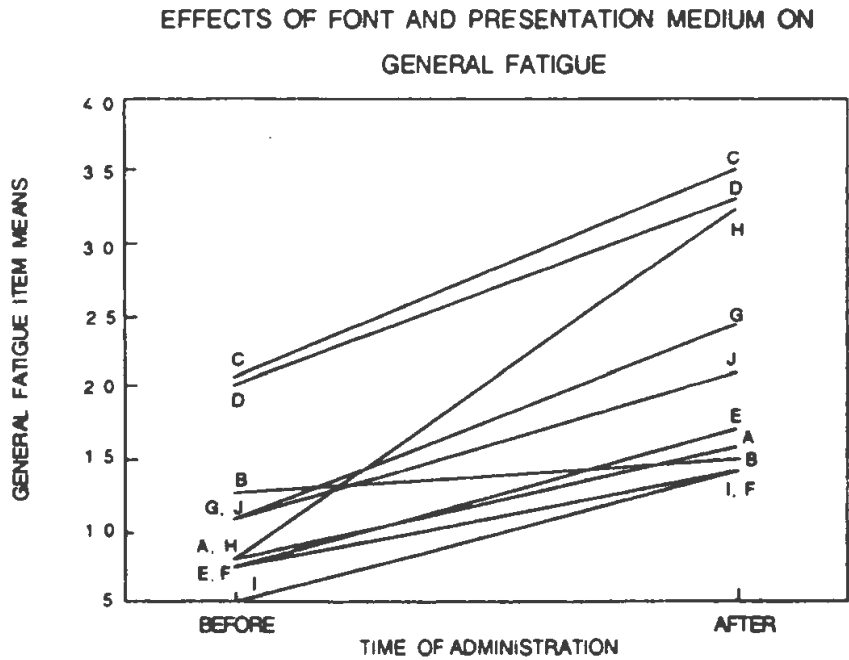
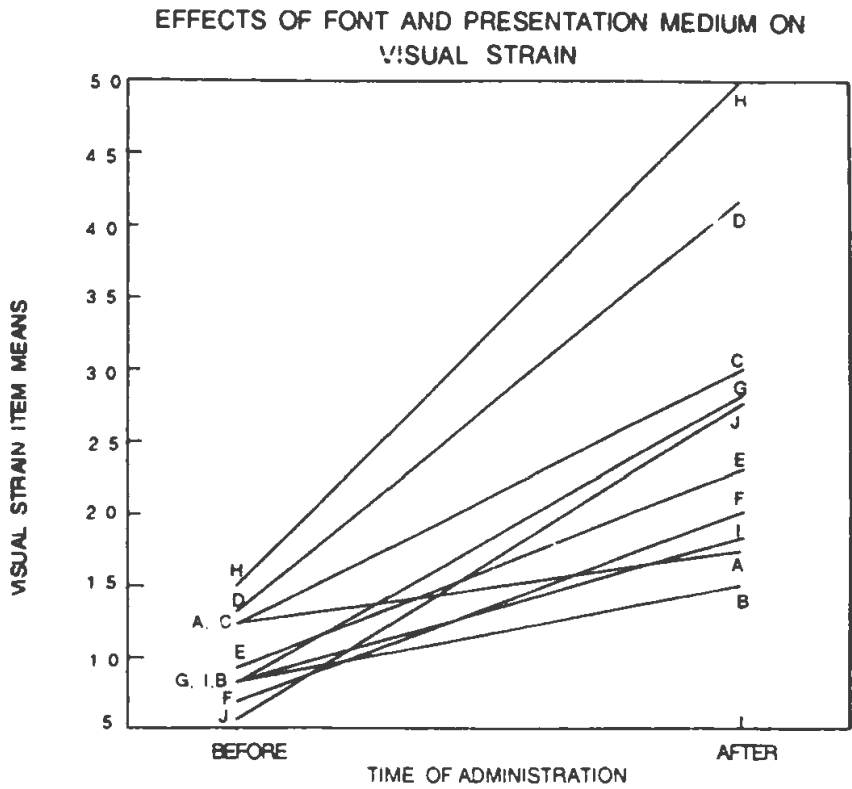
- A - Helvetica font/Paper
- B - Chicago font/Paper
- C - Helvetica font/White text on a Black background (VDU)
- D - Chicago font/White text on a Black background (VDU)
- E - Helvetica font/Yellow text on a Black background (VDU)
- F - Chicago font/Yellow text on a Black background (VDU)
- G - Helvetica font/Black text on a Green background (VDU)
- H - Chicago font/Black text on a Green background (VDU)
- I - Helvetica font/White text on Blue a background (VDU)
- J - Chicago font/White text on a Blue background (VDU)

EFFECTS OF FONT AND PRESENTATION MEDIUM ON
PHYSICAL STRESS

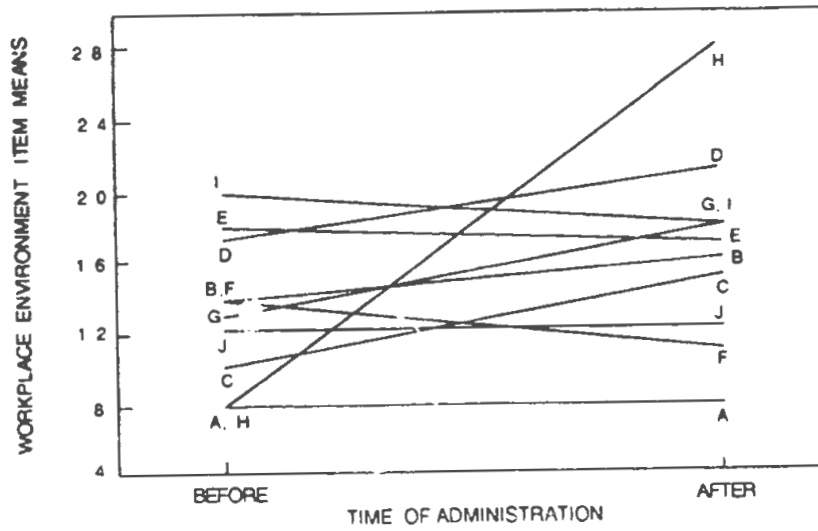


EFFECTS OF FONT AND PRESENTATION MEDIUM ON
MENTAL STRESS





EFFECTS OF FONT AND PRESENTATION MEDIUM ON WORKPLACE ENVIRONMENT



Appendix V

Pretest Reading Comprehension Questionnaire**The Story-Teller****(Please encircle the correct answer)**

1. An aunt together with her nieces and a nephew were on board on a
 - a. bus
 - b. plane
 - c. carriage
 - d. none of the above
2. While on board, the aunt was obliged to relate them _____ to keep them quiet
 - a. an uninteresting story about a little girl who was very good
 - b. an interesting story about a little girl who was very bad
 - c. a story about Cinderella
 - d. none of the above
3. The aunt was _____ in keeping the children occupied when she related them a story.
 - a. successful
 - b. moderately successful
 - c. unsuccessful
 - d. none of the above
4. The aunt and the children were traveling in the same compartment with
 - a. a couple and their child
 - b. a helor
 - c. an old lady
 - d. none of the above
5. One of the nieces of the aunt was _____ while on board
 - a. singing the same line of a song over and over again
 - b. reciting a particular line of a poem a thousand times which she knew by heart

Do not fill below the dotted line

Subject #: _____

Treatment #: _____

Day#: _____

- c. playing with the stranger seated in their compartment
 - d. none of the above
6. Due to the failure of the aunt to keep the children quiet, the stranger related them a story about
- a. a girl who was awarded three medals: one for obedience, one for punctuality, and one for good behaviour
 - b. a girl who was invited by the Prince to visit the Palace garden once a week
 - c. a girl, due to her goodness, was eaten by a wolf at the Prince's garden
 - d. all of the above
7. The children rated the story related to them by the stranger as the
- a. most beautiful story they ever heard
 - b. most uninteresting story they ever heard
 - c. most improper story to be told to young children
 - d. none of the above
8. There were no flowers in the Prince's garden because
- a. he has an allergy on flowers
 - b. they were all destroyed by the flood
 - c. they were all eaten by the pigs grazing in the palace garden
 - d. none of the above
9. The reason why the Prince does not keep some sheep in his palace garden is because
- a. he does not like the smell of the sheep
 - b. there is no space to accommodate them in the palace garden
 - c. his mother once had a dream that he will be killed by a sheep or by a falling clock
 - d. none of the above

Do not fill below the dotted line

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Subject #: _____

Treatment #: _____

Day#: _____

10. The wolf that was chasing Bertha, the good girl who was permitted to walk in the Prince garden, was already moving away to find a little pig instead when
- a. he spotted Bertha hiding a tree
 - b. he heard the sound of medals worn by the nervous Bertha clinking with one another
 - c. he saw the very clean white dress of Bertha in a nearby tree from where she was hiding
 - d. none of the above

Do not fill below the dotted line

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Subject #: _____

Treatment #: _____

Day#: _____

Appendix W

Posttest Reading Comprehension Questionnaires

The Hen

(Please encircle the correct answer)

1. The friendship of Dora Bittholz and Jane Martlet became sour because of:

a. Mrs. Sangrail	c. a hen
b. Clovis	d. a pig
2. Dora gave the animal mentioned in the above question to Jane

a. at a very low price	c. for free as a sign of friendship
b. at a very high price	d. none of the above
3. The reason why Jane got mad with Dora is because the animal she sold to her

a. doesn't lay egg	c. doesn't produce good breed
b. died after she bought it	d. none of the above
4. What was the reason why Clovis, the son of the inn owner, was trying to scare Jane about the butler's mental condition?

a. Jane doesn't pay her bills promptly	c. to make Jane cut her self-allotted fortnight visit short
b. Jane is a very fussy customer	d. to make Jane's and Dora's visit to overlap so they could see each other
5. What did Clovis asked the butler, Sturridge, to bring to Jane in the morning room?

a. a glass of water	c. a towel
b. breakfast	d. a venerable weapon that hangs in the wall

Do not fill below the dotted line

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Subject #: _____

Treatment #: _____

Day#: _____

The Bull

(Please encircle the correct answer)

1. Laurence is the _____ of Tom Yorkfield.
 - a. father
 - b. cousin
 - c. brother-in-law
 - d. half-brother
2. Laurence is a _____ while Tom is a _____.
 - a. farmer, painter
 - b. painter, lawyer
 - c. painter, farmer
 - d. farmer, accountant
3. Tom _____ Laurence.
 - a. envies
 - b. dislikes
 - c. likes
 - d. none of the above
4. How much did Laurence sell his bull painting?
 - a. half a thousand pounds
 - b. three hundred pounds
 - c. hundred pounds
 - d. none of the above
5. What was the reason why Tom and Laurence fought?
 - a. Laurence admired the bull of Tom
 - b. Tom got mad with Laurence because the latter's paintings are selling much more than his dairy animals
 - c. Laurence said to Tom that the older his paintings will become, the bigger the value he can get from it, unlike Tom's bull which will eventually die and will get few shillings from it
 - d. all of the above

6. During the fight of Tom and Laurence, what did the bull pet of Tom do?
- a. watch the two men fighting
 - b. was not bothered by the commotions going on and continued playing
 - c. went to the rescue of Tom by tossing Laurence over one shoulder and prod him in the ribs while still in the air
 - d. was disturbed and petrified so it ran away

Do not fill below the dotted line

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Subject #: _____

Treatment #: _____

Day#: _____

Shock Tactics

(Please encircle the correct answer)

1. What did Bertie gave to Ella as a birthday present?
 - a. a box of chocolate
 - b. handkerchief
 - c. a bottle of perfume
 - d. none of the above
2. What spoilt Ella's pleasure upon receiving the gift from Bertie?
 - a. She was not happy about the content of the gift
 - b. She didn't like the colour of the gift given to her
 - c. She wasn't able to send a "thank you note" to the sender
 - d. none of the above
3. Bertie was very much displeased with the bad habit of his mother, opening letters that are not addressed to her, so he confided this to his
 - a. sisters
 - b. neighbour
 - c. friend, Clovis
 - d. none of the above
4. What made the mother of Bertie to promise not to read anyone's letter again?
 - a. Bertie placed a small snake inside a letter addressed to himself in the letter box
 - b. Bertie threatened to call the doctor because his mother got very excited and disturbed the whole household for reading the phony letters addressed to Bertie
 - c. her friends advised her to respect the privacy of her children
 - d. none of the above
5. Who was the person who sent the phony letters addressed to Bertie?
 - a. Ella
 - b. Clovis
 - c. Bertie's sister
 - d. none of the above

Do not fill below the dotted line

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Subject #: _____

Treatment #: _____

Day#: _____

Laura

(Please encircle the correct answer)

1. What form does Laura want to reincarnate into when she dies?
 - a. an angel
 - b. an otter
 - c. a bird
 - d. none of the above

2. Laura was a very
 - a. kind, considerate, and charming person
 - b. petty, mean, and vindictive person
 - c. hard-working and intelligent person
 - d. none of the above

3. What was the reason why Laura wanted to make a revenge on Egbert, the husband of Amanda?
 - a. Laura took the puppies for a walk which destroyed the flower beds of Egbert
 - b. the puppies chased Egbert's young brood of Speckled Sussex
 - c. the puppies drove 2 hens out of their nest
 - d. Egbert got mad with her for letting the puppies loose in the farm that caused a lot of destruction
 - e. all of the above

4. After Laura's death, she reincarnated into
 - a. an otter
 - b. an angel
 - c. a Nubian boy
 - d. none of the above

5. The second form that Laura has reincarnated into was
 - a. an otter
 - b. an angel
 - c. a Nubian boy
 - d. none of the above

Do not fill below the dotted line

Subject #: _____

Treatment #: _____

Day#: _____

Fur

(Please encircle the correct answer)

1. Who's going to celebrate her birthday in the coming week?
 - a. Eleanor
 - b. Bertram
 - c. Suzanne
 - d. none of the above

2. What does the birthday celebrant want as a birthday present from her cousin?
 - a. a fan
 - b. a fur made up of silver-fox
 - c. A Dresden figure
 - d. none of the above

3. The wealthy distant cousin of the birthday celebrant is
 - a. Suzanne
 - b. Bertram
 - c. Eleanor
 - d. none of the above

4. What strategy did the 2 friends, Suzanne and Eleanor, used to hint to Bertram what his cousin wants as a birthday present?
 - a. Suzanne asked her friend to tell Bertram directly what she likes as a birthday present
 - b. Suzanne and Eleanor intentionally meet Bertram in the street with the plan of asking him to go with them in the fur shop where they will implicitly hint to him what Suzanne wants as birthday present
 - c. Suzanne frankly told Bertram what she likes as a birthday present
 - d. none of the above

5. Why did Eleanor get mad with Suzanne which made her change her mind about telling Bertram what Suzanne really wishes as a birthday present?
 - a. Eleanor is very jealous because her friend is always getting the best from everybody every time she celebrates her birthday
 - b. Suzanne totally ignored her presence while they were strolling in the street

Do not fill below the dotted line

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Subject #: _____

Treatment #: _____

Day#: _____

- c. Eleanor asked Suzanne a favour to replace her in the bridge game because she wants to talk to somebody privately
- d. none of the above

6. Who received a fur as a birthday present?

- | | |
|------------|----------------------|
| a. Suzanne | c. Bertram |
| b. Eleanor | d. none of the above |

Do not fill below the dotted line

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Subject #: _____

Treatment #: _____

Day#: _____

Mrs Packletide's Tiger

(Please encircle the correct answer)

1. The reason why Mrs Packletide wants to kill a tiger is because
 - a. she loves hunting them
 - b. she hates them and wants to reduce the wild beast population
 - c. she wants to give a tiger-claw brooch to her rival, Loona Bimberton
 - d. none of the above

2. Mrs Packletide paid the sum of 1,000 rupees to _____ for their/his/her cooperation in killing the tiger without over much risk or exertion

a. the village people	c. Louisa Mebbin
b. Clovis	d. none of the above

3. A _____ is the animal they used to bait the tiger.

a. Cow	c. Sheep
b. Lion	d. Goat

4. The cause of death of the tiger was due to

a. bullet-wound	c. poison
b. heart-failure	d. none of the above

5. Louisa Mebbin has persuaded Mrs Packletide to buy her a cottage-house because she threatened her to expose the truth that :
 - a. the village people were the one who killed the tiger
 - b. Mrs Packletide missed the tiger and accidentally shot the goat instead
 - c. she, Louisa Mebbin, was the one who actually killed the tiger, not Mrs Packletide
 - d. none of the above

Do not fill below the dotted line

Subject #: _____

Treatment #: _____

Day#: _____

The Mouse

(Please encircle the correct answer)

1. Theodoric Voler was brought up by his mother from childhood to adulthood
 - a. with a silver spoon on his mouth
 - b. shielded from the coarse and hard realities of life
 - c. exposed with the realities in life
 - d. none of the above
2. On Theodoric's way to the train station, what misfortune did he experience?
 - a. the pony carriage that was supposed to take him to the train station met an accident
 - b. the pony carriage he booked did not arrive
 - c. the handy-man with whom he booked the pony carriage was nowhere to be found, thus, no carriage was made available for him
 - d. none of the above
3. The companion of Theodoric in the train compartment is a
 - a. wealthy woman of his age
 - b. an elderly woman 10 years his senior
 - c. a blind woman of his age
 - d. none of the above
4. The mouse that went into Theodoric's clothing came from the
 - a. train compartment where he was in
 - b. train station
 - c. stable where he took the pony carriage that brought him to the train station
 - d. none of the above

Do not fill below the dotted line

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Subject #: _____

Treatment #: _____

Day#: _____

5. What did Theodoric do to free himself from the crawling mouse inside his clothing?
- a. shake himself until the mouse came out
 - b. ask his fellow-traveller in the compartment to remove the mouse from his clothing
 - c. undress himself in an improvised dressing room while his fellow-traveller was asleep
 - d. none of the above

Do not fill below the dotted line

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Subject #: _____

Treatment #: _____

Day#: _____

The Lumber Room

(Please encircle the correct answer)

1. Nicholas was not permitted to go with the group that went to Jagborough sands,organised by his distant aunt, because
 - a. he was sick
 - b. he was in disgrace, by deliberately placing a frog in his bread-and-milk at breakfast
 - c. he has a phobia with deep water
 - d. none of the above
2. While the group was away, Nicholas had originally planned to
 - a. make his aunt believe that he went to the forbidden gooseberry garden without actually doing it
 - b. go explore the forbidden gooseberry garden and find out what's in there
 - c. stay in his room and do his assignments
 - d. none of the above
3. Nicholas was able to get access to the lumber room by
 - a. seeking the help of the gardener
 - b. using the key kept in the library to open one of the doors of the lumber room
 - c. passing through the underground tunnel leading to the lumber room
 - d. none of the above
4. Nicholas discovered that the lumber room is a
 - a. store house containing treasures such as framed tapestry picture, teapot, candle stick etc.
 - b. library containing banded books such as sex magazines
 - c. store house containing prohibited drugs
 - d. none of the above

Do not fill below the dotted line

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Subject #: _____

Treatment #: _____

Day#: _____

5. While Nicholas was inside the lumber room, his aunt became suspicious of his long absence so she started looking for him. Along the way, she fell into the empty rain-water tank , where she was detained for about 35 minutes, and was rescued by _____ .
- a. Nicholas
 - b. the gardener watering the flowers
 - c. the kitchen maid looking for parsley
 - d. none of the above

Do not fill below the dotted line

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Subject #: _____

Treatment #: _____

Day#: _____

The Wolves of Cernogratz

(Please encircle the correct answer)

1. The chorus howling of the dogs and wolves in the village are heard when
 - a. any person living in the castle dies
 - b. any one of the Cernogratz family that lives in the castle dies
 - c. any one in the village dies
 - d. none of the above

2. _____ descends from the Cernogratz family.
 - a. The Baroness
 - b. The Baron
 - c. Amalie Schmidt
 - d. Conrad

3. What happens, according to Amalie, when the soul of the dying one left its body
 - a. There will be lightning and thunder.
 - b. A tree would crash down or fall in the park.
 - c. The dogs and wolves will howl in unison.
 - d. none of the above

4. The Baron and Baroness have planned to _____ after the New Year festivities are over.
 - a. give Amalie a holiday for her loyalty
 - b. give her a pay rise for efficiency
 - c. give Amalie a notice to leave after she claimed to be a Cernogratz descendant
 - d. none of the above

5. During the last hour of Amalie, all here stories were proven to be proven
 - a. all lies
 - b. true
 - c. half-true
 - d. none of the above

Do not fill below the dotted line

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Subject #: _____

Treatment #: _____

Day#: _____

The Open Window

(Please encircle the correct answer)

1. The reason why Mr. Nuttel went to the rural area was
 - a. to improve his nerve problem
 - b. to start a new life out there
 - c. to meet some of the old friends of his sister in that place
 - d. none of the above
2. The sister of Mr. Nuttel gave him _____ before he went to the rural area.
 - a. money to finance his vacation
 - b. medicines to stabilise his nerves
 - c. introductory letters to some of the nice people she used to know there
 - d. none of the above
3. Vera, the niece of Mrs. Sappleton, tried to entertain Mr. Nuttel while her aunt was still in her room by
 - a. making-up a story about the "tragedy" of her aunt's husband and two brothers during one of their shooting spree
 - b. telling him a legend in that place
 - c. by playing her favourite piece in the piano
 - d. none of the above
4. The french window at Mrs. Sappleton's house is always left open every evening till dusk so as to
 - a. let the fresh air enter the lounge or drawing room
 - b. serve as an entry to their cat into the house
 - c. let her husband and two brothers pass through it after their day's shooting to avoid messing the carpet with mud
 - d. none of the above

Do not fill below the dotted line

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Subject #: _____

Treatment #: _____

Day#: _____

5. According to the "made-up" story of Vera, the cause of the death of her aunt's husband and two brothers was due to
- a. a big tree that fell over them while searching for birds to shoot
 - b. a sudden strong hurricane that washed them away
 - c. the unstable shooting place which gave way and engulfed them inside
 - d. none of the above

Do not fill below the dotted line

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Subject #: _____

Treatment #: _____

Day#: _____

The Reticence of Lady Anne

(Please encircle the correct answer)

1. The caused of misunderstanding between Egbert and his wife, Lady Anne, was due to
 - a. a dispute over their newly acquired house
 - b. an academic dispute over lunch which was given personal significance by Lady Anne
 - c. a dispute over what to name to give to their newly acquired pet
 - d. none of the above
2. Because of the prolonged silence of Lady Anne, Egbert thought that she might _____. However, he abandoned that thought.
 - a. be feeling sick
 - b. feeling sleepy
 - c. want to be left alone
 - d. none of the above
3. Egbert and Lady Anne had a company in the drawing room which were
 - a. Don Tarquinio, their dog pet, and the parrot
 - b. Don Tarquinio, their cat pet, and the bullfinch
 - c. Don Tarquinio, their dog pet, and the bullfinch
 - d. none of the above
4. The reason why Lady Anne was silent while Egbert was trying to make peace with her at the drawing-room was
 - a. she fell asleep
 - b. she wants to continue the fight with her husband
 - c. she was already dead for two hours
 - d. none of the above
5. Egbert couldn't see Lady Anne's facial expression in the drawing-room because
 - a. it was a gloomy December afternoon
 - b. there were no lights on in the drawing-room
 - c. she was seated in the dark corner of the drawing-room
 - d. none of the above

Do not fill below the dotted line

Subject #: _____

Treatment #: _____

Day#: _____

The Philanthropist and the Happy Cat

(Please encircle the correct answer)

1. Jocantha desired to act as a _____ by wishing to bring a gleam of pleasure and interest into the life of one or two wistful-hearted, empty-pocketed workers.

a. guardian	c. Santa Claus
b. Fairy godmother	d. none of the above

2. Jocantha, on the spur of the moment, decided to purchase a _____ with the intention of giving it to a lone-looking girl eating a cheap meal by herself.

a. plane ticket	c. theatre ticket
b. train ticket	d. none of the above

3. Jocantha went to search for a _____ with the aim of finding the lucky person to whom she will award the ticket

a. tea shop	c. ice cream house
b. restaurant	d. none of the above

4. The first person that Jocantha intended to award the ticket was to

a. Bertie	c. a lady friend of Bertie
b. an old woman	d. none of the above

5. Jocantha was hesitant to approach the person whom she finally decided to award the ticket for etiquette reasons, thus she thought of other means to attract his attention, by

a. joining him in his table and informing him that she couldn't go to the movie because of a sudden commitment that came up	
b. asking the waitress to hand the ticket to the person she wishes to give it	
c. making up an argument with a waitress, making loud inquiries about something, and intentionally spilling a milk-jug	
d. none of the above	

Do not fill below the dotted line

Subject #: _____

Treatment #: _____

Day#: _____

6. After all the tricks that Jocantha resorted to, she was not able to attract the attention of the person to whom she had wished to give the ticket because
- a. he was busy talking with his lady friend
 - b. he was on his way out from to the shop at the time Jocantha was making a scene
 - c. he was very much engrossed in the pocket book he was reading, thus was not aware of the happenings in his surroundings
 - d. none of the above

Do not fill below the dotted line

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Subject #: _____

Treatment #: _____

Day#: _____

The Lull

(Please encircle the correct answer)

1. Mrs. Durmot invited Latimer Springfield to spend Sunday night with them with the intent to
 - a. draw away Latimer's mind from politics for that particular evening
 - b. befriend him
 - c. match him with Vera
 - d. none of the above

2. Latimer Springfield is
 - a. the animal caretaker of Mrs. Durmot
 - b. a politician
 - c. the boyfriend of Vera
 - d. none of the above

3. Latimer spent the night in Mrs. Durmot house with _____ in his room.

a. a pig and a rooster	c. a pig and a dog
b. a pig and a cat	d. a pig and a bird

4. Vera was successful in making Latimer forget his political worries that night by
 - a. accompanying him in his room all night
 - b. making him drunk during dinner
 - c. making up a story that there was a flood and had asked him to let some animals stay in his room for that evening
 - d. none of the above

5. Vera is a _____ of Mrs. Durmot.

a. daughter	c. niece
b. daughter-in-law	d. none of the above

Do not fill below the dotted line

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Subject #: _____

Treatment #: _____

Day#: _____

Filboid Studge, the Story of a Mouse that Helped

(Please encircle the correct answer)

1. Mark Spayley, who is a/an _____, proposes to marry the daughter of Duncan Dullamy who is believed to have enormous wealth.
 - a. ordinary government employee
 - b. businessman of equally huge wealth himself
 - c. poster designer of very little earning
 - d. none of the above

2. Duncan Dullamy gave Mark Spayley his consent to marry his daughter with the proposition to
 - a. hold their wedding with grand festivity
 - b. make his new breakfast food product, called Pipenta, to make sales
 - c. uplift his position in the society
 - d. none of the above

3. Mark Spayley was able to accomplish what was required from him by Duncan Dullamy by
 - a. changing the name of the product to Filboid Studge as well as creating new poster designs for the advertisement of the product that depicts torment if the breakfast food is not eaten
 - b. giving the suggestion to improve the taste of the product
 - c. giving suggestion to make the product easy to prepare and ready to eat
 - d. none of the above

4. The poster created by Mark Spayley
 - a. has improved the popularity of the breakfast product, thus generating more sales
 - b. did not improve the sales of the breakfast product at all
 - c. was the factor that made him a well-sought after poster designer
 - d. none of the above

Do not fill below the dotted line

Subject #: _____

Treatment #: _____

Day#: _____

5. Mark Spayley was _____ after producing the wonder-working poster that saved Mr Dullamy's company from bankruptcy
- a. given the permission to marry Mr Dullamy's daughter
 - b. no longer permitted to marry Mr Dullamy's daughter
 - c. offered high position in Mr Dullamy's company
 - d. none of the above

Do not fill below the dotted line

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Subject #: _____

Treatment #: _____

Day#: _____

The Disappearance of Crispina Umberleigh

(Please encircle the correct answer)

1. The disappearance of a world famous picture from the walls of Louvre in Vienna brought the topic of conversation between _____ who are boarded on a first class train.
 - a. two journalists
 - b. a journalist and a wine businessman
 - c. two businessmen
 - d. none of the above

2. The _____ is a nephew of the wealthy and dominant Crispina Umberleigh
 - a. journalist
 - b. Edward Umberleigh
 - c. wine businessman
 - d. none of the above

3. Crispina Umberleigh disappeared without a trace because she
 - a. was kidnapped for a ransom money
 - b. had a sudden and complete lost of memory
 - c. was murdered by her enemies
 - d. none of the above

4. The disappearance of Crispina Umberleigh _____
 - a. had caused deep bereavement and unhappiness on her family
 - b. gave her husband and children the freedom they never experienced when she was there
 - c. was planned by her embittered husband because of her domineering nature
 - d. none of the above

5. During the eight (8) years of disappearance of Crispina Umberleigh, she
 - a. remained a captive of her kidnappers
 - b. wandered somewhere abroad and found steady employment as a chambermaid
 - c. had gone to a nursing home for a treatment
 - d. none of the above

Do not fill below the dotted line

Subject #: _____

Treatment #: _____

Day#: _____

The Guests

(Please encircle the correct answer)

1. Matilda's unexpected visitor was a Bishop who turned out to be
 - a. a friend of her family
 - b. her distant relative
 - c. her uncle
 - d. none of the above

2. The family of Matilda and her guest's family had a dispute over a
 - a. piece of land
 - b. money
 - c. Crown Derby dessert service
 - d. none of the above

3. Matilda and her guest were scarcely on speaking terms because
 - a. her guest had rake up the incidents of the old quarrel
 - b. Matilda gave her cook an unnecessary holiday
 - c. Matilda had asked the emergency cook to do the cooking
 - d. all of the above
 - e. none of the above

4. During the Bishop's stay at Matilda's place, an unfortunate event happened, _____, which aggravated the friction between the two distant relatives.
 - a. hurricane
 - b. fire
 - c. a prolonged rain which resulted to the overflowing of the Gwadlipichee bank
 - d. none of the above

5. As a result of that calamity, a _____ was/were found in the Bishop's room
 - a. hen and her chickens
 - b. a leopard eating a goat
 - c. pony
 - d. none of the above

Do not fill below the dotted line

Subject #: _____

Treatment #: _____

Day#: _____

The Quest

(Please encircle the correct answer)

1. Mrs. Momeby created a commotion at Villa Elsinore because her baby was
 - a. found dead
 - b. eaten by hyaena
 - c. missing
 - d. none of the above

2. Clovis' theory about the vanishing of the Momeby's child, Erik, in the lawn was the child was
 - a. kidnapped for a ransom money
 - b. eaten by a wild beast or eagle
 - c. just playing somewhere in the lawn
 - d. none of the above

3. Miss Gilpet from Villa Peterholf came to hear the details of Mrs.Momeby's bereavement. During their exchange of ideas she voiced out that
 - a. baby Erik was not eaten by a hyaena
 - b. the Momebys don't have sufficient faith to find their missing baby
 - c. rheumatism does not exists
 - d. all of the above
 - e. none of the above

4. During Miss Gilpet's search for the baby, she found a baby in the
 - a. lawn of Villa Elsinore playing
 - b. middle of the highway playing with dust and faded buttercups
 - c. lawn of Villa Charlottenburg playing with dust and faded buttercups
 - d. none of the above

Do not fill below the dotted line

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Subject #: _____

Treatment #: _____

Day#: _____

5. The suggestion to give the baby, found by Miss Gilpet, a ride in the roly-poly led to the discovery of the genuine Erik when the roly-poly was set into motion. This
- a. caused baby Erik to cry loud who was inside the roly-poly
 - b. caused the encounter between the two babies, baby Erik and baby Precy, in the roly-poly
 - c. awakened baby Erik from his deep sleep under a tree in the lawn
 - d. none of the above
6. The baby found by Miss Gilpet turned out to be baby Precy that comes from
- a. Villa Elsinore
 - b. Villa Charlottenburg
 - c. Villa Peterholf
 - d. none of the above

Do not fill below the dotted line

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Subject #: _____

Treatment #: _____

Day#: _____

A Holiday Task

(Please encircle the correct answer)

1. During the interval of waiting for the lunch to be served at Golden Galleon Hotel, Kenelm Jerton directed his attention to the
 - a. contents of the flower-vase on his table
 - b. Lady seated on the next table
 - c. to people entering the restaurant
 - d. none of the above

2. The lady sitting next to Jerton's table, who supplied the name of the rose in response to his query to the waiter

a. has partially lost her memory	b. is an expert on roses
c. has an amnesia	d. none of the above

3. When the porter asked the woman that Jerton met at the hotel about her luggage in the train station, she formulated that she had a dressing-case and a dress-basket with her and supplied her name to the porter as

a. Stroope	c. Jerton
b. Smith	d. none of the above

4. The woman that Jerton met had forgotten who she is, however she recalled that she has the title of a

a. Princess	c. Lady
b. Duchess	d. none of the above

5. The woman that Jerton met finally decided to establish her identity by
 - a. trying little tests to rule out who she is not to be able to narrow down the list of the House of Lords
 - b. asking Jerton to help her uncover her identity
 - c. planning to ask the porter of the Pivot Club, where she thinks she's a member, any letters or messages for her and if none, ask him who she is
 - d. none of the above

Do not fill below the dotted line

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Subject #: _____

Treatment #: _____

Day#: _____

6. Jerton later discovered that the woman she met was
- a. Lady Ulwight who doesn't give tip to waiters
 - b. Lady Mousehilton who flirts with every man she meets
 - c. Lady Starping who never eats shell-fish at all
 - d. Mrs. Stroope who is good at golf but always loses her memory every now and then

Do not fill below the dotted line

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Subject #: _____

Treatment #: _____

Day#: _____

Appendix X

Quick-C Program that Displays the Font and Colour Combination
Ranking Questionnaire on the VDU Screen

```

/* ===== */
/* Quick C computer program to generate the font and colour */
/* ranking questionnaire. It collects the subject's ranking */
/* and stores it into a file */
/* ===== */
/* Quick C libraries included in the program and global */
/* initialisation of variables */
/* ===== */
#include <stdio.h>
#include <conio.h>
#include <graph.h>
#include <time.h>
#include <malloc.h>
#include <stdlib.h>
#include <string.h>
#include <ctype.h>
#define WIDTH 400 /* 448 60 characters by 8 */
#define HEIGHT 25 /* good for two rows */
#define TAB_VALUE 2
#define NULL 0
#define TAB '\t' /* tab */
#define SPACE 32 /* ascii code for space bar */
#define NEWLINE '\n' /* end of line */
#define TEXT_LENGTH 23
#define F_KEY 70 /* if F key is pressed */
#define IBM '3'
#define CHICAGO '2'
#define HELVETICA '1'
#define BACKSPACE 8
#define LEFT_MARGIN 20
/* ===== */
/* === GLOBAL VARIABLES and their initial values === */
int Current_X = LEFT_MARGIN; int Current_Y = 0;
int Char_Width = 1; /* width 80 */
char FONT_TYPE = IBM;
int Foregrnd_Color = 14; /* yellow foreground */
long Backgrnd_Color = 5; /* magenta background color */
struct font_rec
{
    int no_col;
    int *bit_array;
}
typedef struct font_rec FONT_REC;
FONT_REC FONTS[95];
char *fontname[] = { "helv.fnt", "chicagol.fnt", "IBM.fnt" };
int *alloc_integer(int *integers, int n)
{
    integers = (int *) malloc(n*2);

```

```

    return integers;
}

/*=====
                                Copy an array of integers
=====*/
int *copy_integer(int *dest, int *src, int n)
{register int i;
    dest = alloc_integer(dest,n);
    for (i=0; i<n; i++)
        dest[i] = src[i];
    return dest;
}

/*=====
/*      Sets the screen mode to either TEXT 40 or TEXT 80      */
/*=====
void set_videomode(int width)
{
    if ( width == 1)
        _setvideomode(_TEXT80); /* sets the videomode to text m
        */
    else
        _setvideomode(_TEXT40); /* sets the videomode to text m
        */
}

/*=====
/*      Initialise the screen and sets it to TEXT mode      */
/*=====
void initialise_screen(int i)
{
    _clearscreen(_GCLEARSCREEN);
    set_videomode(Char_Width);
    _settextcolor(Foregrnd_Color);
    _setbkcolor(Backgrnd_Color);
}

/*=====
/*      Displays the text to be displayed at row and      */
/*      column position      */
/*=====
void at(int row, int col, char *text)
{
    _settextposition(row,col);
    _outtext(text);
}

/*=====
/*      Free the memory allocated to the FONTS array      */
/*=====
void free_fonts(char font)
{
    register int i;
    for (i= 0; i < 95 ; i++)
        free(FONTS[i].bit_array);
}

/*=====
/*      Loads a font table from the file      */
/*=====
int load_fonts(char *filename)
{ static int row[15];

```

```

register int i, j, k;
char c;
FILE *fp;
if ( (fp = fopen(filename,"r")) == NULL)
{
    printf("\t\t\t\t File < %s > does not exist\n",
           filename);
    exit(0);
}
for (i = 0; i < 95; i++)
{
    fscanf(fp, "\n%c", &c);
    fscanf(fp, "\n%d\n", &FONTS[i].no_col);
    for (j=0; j < FONTS[i].no_col; j++)
        fscanf(fp, "%d ", &row[j]);
    FONTS[i].bit_array = copy_integer(FONTS[i].bit_array,
                                     row, FONTS[i].no_col);
}
fclose(fp);
return(1);
}
/*=====
   Scan an integer that represent a line column downward
   =====*/
void disp_scan(int col)
{
    register int i, scan = col, j= Current_Y, k= Current_X;
    for (i=0; i<15; i++)
    {
        if (scan == 0)
        {
            Current_Y = j+15-i;
            return;
        }
        if (scan & 0x0001)
        {
            _setpixel(k,j);
        }
        j++;
        scan >>= 1;
    }
    Current_Y = j;
}
/*=====
   Display the whole character bit column by bit column
   =====*/
void scan_all_col(int letter_code[], int n_size)
{ register int column=0, i;
  if (n_size == 0)
  {
      Current_X += 5*Char_Width;
      return;
  }
  Current_X++;
  for (i = 0; i < n_size; i++)
  {   disp_scan(letter_code[i]);
      Current_X++;
  }
}

```

```

        Current_Y += 15; }
    Current_X++;
}
/*=====*/
/*    Display a character of a text given an ASCII code    */
/*=====*/
void disp_char (char letter)
{
    register char scan;
    register int let_position, column=0, i;
    if (Current_X > 632)
    {
        Current_X = LEFT_MARGIN;
        Current_Y += 19;
    } /* if line number is > 25, clear the screen */
    if (Current_Y >= 480)
        Current_Y = 0;
    switch (letter)
    {
        case TAB:
            Current_X += 8* TAB_VALUE;
            return;
        case SPACE:
            Current_X += 6* Char_Width;
            return;
        case NEWLINE:
            return;
        default :
            if ( (let_position = letter - 32) < 0)
                return;
            scan_all_col(FONTS[let_position].bit_array,
                        FONTS[let_position].no_col);
            break;
    } /* switch end */
}
/*=====*/
/*    Display a string on screen with the chosen Font    */
/*=====*/
void display_string(char *string)
{
    while (*string != '\0')
        disp_char(*string++);
}
/*=====
    Draw the template (rectangle) of a string
=====*/
void template(int fore, int back,int top_x, int top_y,
             char *text,int height, int y_inc)
{
    _setcolor(back);
    _rectangle( _GFillInterior, top_x,top_y, top_x+WIDTH,
                top_y+height);
    Current_X = top_x + 16;
    Current_Y = top_y + y_inc;
    _setcolor(fore);
    _rectangle( _GBorder, top_x, top_y, top_x+WIDTH, top_y+height)
    display_string(text); }
/*=====

```



```

    Display the text color combination inside the template
===== */
int disp_combination(int top_y, int top_x, int letter,
                    int bar_space, int height, int y_inc)
{ static char combination[4][42] =
    {" White foreground with black background \0",
      " Yellow foreground with black background\0",
      " Black foreground with green background \0",
      " White foreground with blue background  \0"};
  static int cc[4][2] = { {15,0}, {14,0}, {0,2}, {15,1} };
  register int i;
  char *string;
  string = (char *) malloc(80);
  strcpy(string,"( ) ");
  for (i=0; i<4; i++)
  {
    strcpy(string,"( ) ");
    *(string+1) = (char) (letter+i);
    strcat(string,&combination[i][0]);
    template(cc[i][0], cc[i][1],top_x, top_y,
             string,height,y_inc);
    top_y += height + bar_space;
  }
  free(string);
  return top_y;
}
/*=====
                                Displays a question and options
===== */
void display_q(int q_type)
{
  static char tail[4][69] =
  {"First = [ ] Second = [ ] Third = [ ] Fourth [ ] \0",
   "Fifth = [ ] Sixth = [ ] Seventh = [ ] Eight [ ] \0",
   "Type the letter of the color combination to its
    corresponding rank.\0",
   "Press left and right arrow keys to change and <ENTER>
    when finish. \0",};
  register int i, top_x, top_y;
  top_x = 78;
  if ( (q_type == 1) | (q_type ==2) )
  { load_fonts(fontname[q_type-1]);
    top_y = disp_combination(60, top_x, 97,30,40,15);
  }
  else
  {
    load_fonts(fontname[0]);
    top_y = disp_combination(60, top_x,
                             (int) 'a',14,25,5);
    free_fonts(' ');
    load_fonts(fontname[1]);
    disp_combination(top_y, top_x, (int) 'e',14,25,5);
    at(25,2,&tail[1][0]);
  }
}

```

```

free_fonts(' ');
at(24,2,&tail[0][0]);
for (i=2; i<4; i++)
    at(i+25,2, &tail[i][0]);
}
/*=====
                                Get a key
    75 -left arrow key          77 -right arrow key
    72 - up arrow key          80 -down arrow key
=====*/

int get_key(int k)
{register int key,i,j, mask = 0x0100;
 i = getch();
 if (i==0)
 {switch (j = getch())
 {
 case 75:
 case 77:
 case 72:
 case 80:
 i = j | mask;
 break;
 default :
 break;
 }
 }
 else
 i = tolower(i);
return i; }
/*=====
                                Get the choice from the screen
=====*/

char *get_the_answer(int query, int col, int inc)
{ register int key, position=0, row=0, start=24, flag=1;
 char *answer, *cursor, *choices, *d;
 answer = (char *) malloc(9);
 cursor = (char *) malloc(2);
 choices= (char *) malloc(9);
 if (query > 2)
 { strcpy(answer, "_____");
   strcpy(choices,"abcdefgh");
 }
 else
 { strcpy(answer, "_____");
   strcpy(choices,"abcd");
 }
 strcpy(cursor, "_");
 do
 {
 _settextcolor(14);
 *cursor = *(answer+position + row*4);
 at(start+row,col+inc*position,cursor);
 at(start+row,col+inc*position,"");
 switch ( key = (int) get_key(1) )

```

```

{
case 27 : flag = 0;
case 13 : /* check if there is a blank */
    if ( (d=strchr(answer, 95)) == NULL)
        flag = 0;
    else
        { position = d - answer;
          if ( (position > 3) && (query == 3) )
              { position -= 4;
                row = 1;
              }
          else
              row = 0;
        }
    break;
case 0x14d : /* right arrow key */
    if (position == 3)
        {if ( (query == 3) && (row == 0) )
            { row++;
              position = 0;
            }
        }
    else
        position++;
    break;
case 0x14b : /* left arrow key */
    if (position == 0)
        { if ( (query == 3) && (row == 1) )
            { row--;
              position = 3; } }
    else
        position--;
    break;
case 0x148 : /* up arrow key */
    if ( (query == 3) && (row == 1) )
        row--;
    break;
case 0x150 : /* down arrow key */
    if ( (query == 3) && (row == 0) )
        row++;
    break;
default :
    if ( strchr(choices, key) != NULL)
        {if ( (d = strchr(answer, key)) == NULL)
            {*cursor = *(answer+position + row*4) =
              (char) key;
             at(29,5,"
                                ");
            }
        }
    else
        {if ( *(answer+position + row*4) == (char) key )
            break;
          at(29,5,"There is a duplication. Type a new
              letter at the cursor");
          putchar(7);
          *cursor = *(answer+position + row*4) = (char) key;
          at(start+row,col+inc*position,cursor);
          at(start+row,col+inc*position,"");
          position = d - answer;
        }
}

```

```

        if ( (position > 3) && (query == 3) )
        {
            position -= 4;
            row = 1;
        }
        else
        {
            row = 0;
            *(answer+position + row*4) = (char) 95; }
        }
        else
        {
            at(29,5," Letter entered not among the choices
              Try again..... ");
            putchar(7); }
        break;
    }
}
while (flag);
free(cursor);
free(choices);
return answer;
}
/*=====
    Saves ranking of Subjects to a file
=====*/
void save_to_file(FILE *quest_file,char *answer, int q_no)
{
    static char rank[8][8] =
        {"First \0","Second \0","Third \0","Fourth \0",
         "Fifth \0","Sixth \0","Seventh\0","Eight \0"};
    register int i, max;
    max = (q_no == 3) ? 7 : 3;
    fprintf(quest_file,"\n\n\t\tAnswer to Question #&d:
                        \n",q_no);
    for (i=0; i<=max; i++)
        fprintf(quest_file,"\t\t\t %s : %c\n", &rank[i][0],
            *(answer+i));
}
/*=====
    Display a question on screen
=====*/
char *question(int query)
{
    static char head[] =
"font, rank the color combination you most preferred\0";
    char *string, *font_name, *answer, *result;
    register int i=0, top_x, top_y, font_type;
    _setvideomode(_VRES16COLOR);
    string = (char *) malloc(100);
    _setcolor((short) 15);
    if (query == 1)
    {
        sprintf(string,"For HELVETICA %s",head);
    }
    else if (query == 2)
    {
        sprintf(string,"For CHICAGO %s",head);
    }
}

```



```

/*=====
Store subjects#, time, date, and answer to file
=====*/
void query(char *date_taken,char *time_taken)
{
    FILE *quest_file;
    register int i=0;
    int s_no=13;
    char *answer, *string;
    char *p, *strng;
    string = (char *) malloc(20);
    s_no = (int) get_subject_no(1);
    sprintf(string,"q_file%d",s_no);
    quest_file = fopen(string, "w");
    if (quest_file == NULL)
    {
        printf("\n No input file that exist %s\n", quest_file);
        exit(1);
    }
    fprintf(quest_file,"\n\n    Date:  %s\n",date_taken);
    fprintf(quest_file,      "    Time:  %s\n",time_taken);
    fprintf(quest_file,"\n    Preferences of Subject#
                        %d\n",s_no);
    for (i=1; i<=3;i++)
    {
        answer = question(i);
        save_to_file(quest_file,answer,i);
    }
    _setvideomode(_TEXT80);
    fclose(quest_file);
    free(string);
}
/*=====
Displays thank you message
=====*/
void display_end(int i)
{
    _setvideomode( (short) _VRES16COLOR);
    _settextcolor( (short) 11); /* set color to light cyan */
    at( 4,30,"End of survey..... ");
    at( 9,30,"Thank you very much..");
    at(11, 8,
        "We appreciate your support and participation in this
        research.");
    at(12, 8,
        "If you wish to know the result of this experiment,
        just let us know.");
    at(25,40,"Yours sincerely,");
    at(27,40,"Elizabeth Payumo - Student Researcher");
    at(28,40,"Anthony Watson - Supervisor");
    getch();
}

```

```

/*=====
      Main Program of the Font and Colour combination
      Ranking Questionnaire
=====*/
int main(void)
{
    char *time_taken, *date_taken;
    _setvideomode(_DEFAULTMODE);
    initialise_screen(1);
    date_taken = (char *) malloc(9);
    time_taken = (char *) malloc(9);
    _strdate(date_taken);
    _strtime(time_taken);
    query(date_taken,time_taken);
    free(date_taken);
    free(time_taken);
    display_end(1);
    _setvideomode(_DEFAULTMODE);
    return 0;
}

```

Appendix Y

Quick-C Program that Generates and Displays the VDU Screen-Based Stimuli

```

/*=====*/
/* Quick C computer program that displays the screen based */
/* stimuli. It generates the Helvetica and Chicago font by */
/* reading the two font tables on different files. It also */
/* monitors the reading duration of the subject per screen */
/* of text read. See program output for details.          */
/*=====*/
/*      Quick C libraries included in the program          */
/*=====*/
#include <stdio.h>
#include <conio.h>
#include <graph.h>
#include <time.h>
#include <malloc.h>
#include <stdlib.h>
#include <string.h>
#include <ctype.h>
/*=====*/
/*      Global definitions of variables                      */
/*=====*/
#define TAB_VALUE 2
#define NULL 0
#define TAB '\t' /* tab */
#define SPACE 32 /* ascii code for space bar */
#define NEWLINE '\n' /* end of line */
#define TEXT_LENGTH 23
#define F_KEY 70 /* if F key is pressed */
#define IBM '3'
#define CHICAGO '2'
#define HELVETICA '1'
#define BACKSPACE 8
#define LEFT_MARGIN 20
/*=====*/
/* ===== GLOBAL VARIABLES and their initial values ===== */
int Current_X = LEFT_MARGIN; int Current_Y = 0;
int Char_Width = 1; /* width 80 */
char FONT_TYPE = IBM;
struct font_rec
{ int no_col;
  int *bit_array;
}
/* ----- Font table array ----- */
typedef struct font_rec FONT_REC;
FONT_REC FONTS[95];
/* ----- Text File buffer ----- */
struct text_rec
{ char *Line_Text;
  struct text_rec *Prev_Line, *Next_Line;
}
typedef struct text_rec TEXT_REC;

```



```

/* Stores the address of the first line of the text file */
TEXT_REC *Text_Start;
/*=====*/
/* Stores the address of the number of words and reading */
/*time for one whole screen */
/*=====*/
struct scrn_rec
{ int no_of_words, no_of_lines;
  double dt;
  TEXT_REC *Starting_Line;
  struct scrn_rec *Next_Scrn, *Prev_Scrn;
}
typedef struct scrn_rec SCR_N_REC;
SCR_N_REC *Scrn_Start;
/*=====*/
/* Color combinations : foreground/background
   low intensity white (7) / black (0)
   yellow (14) / black (0)
   black (0) / low intensity green (2)
   blue (9) / low intensity white (7) */
/*=====*/
int Foregrnd_Color= 14; /* yellow foreground */
long Backgrnd_Color = 5; /* magenta background color */
FILE *fp;
char *fontname[] = { "helv.fnt", "chicagol.fnt", "IBM.fnt" };
char *filename= "IBM.fnt";
char Text_Name[] = "text.doc";
char Sub_Code[14]; /* --- Subject code ----- */
char pause_text[] = "Press any key to continue";
/*=====*/
/* Allocate a memory space for integers */
/*=====*/
int *alloc_integer(int *integers, int n)
{ integers = (int *) malloc(n*2);
  return integers;
}
/*=====*/
/* Copy an array of integers */
/*=====*/
int *copy_integer(int *dest, int *src, int n)
{ register int i;
  dest = alloc_integer(dest,n);
  for (i=0; i<n; i++)
    dest[i] = src[i];
  return dest;
}
/*=====*/
/* Sets the screen mode to either TEXT 40 or TEXT 80 */
/*=====*/
void set_videomode(int width)
{
  if ( width == 1) /* sets the videomode to text mode */
    _setvideomode(_TEXTC80);
  else /* sets the videomode to text mode */
    _setvideomode(_TEXTC40);
}

```

```

/*=====*/
/*      Initialise the screen and sets it to TEXT mode      */
/*=====*/
void initialise_screen(int i)
{ _clearscreen(_GCLLEARSCREEN);
  _set_videomode(Char_Width);
  _settextcolor(Foregrnd_Color);
  _setbkcolor(Backgrnd_Color);
}
/*=====*/
/* Clears the screen and sets up the screen foreground and */
/* background colour                                     */
/*=====*/
void set_display_screen(int fore, long int back)
{ int i;
  _clearscreen(_GCLLEARSCREEN); /* clears the screen */
  _settextcolor(fore);          /* sets foreground color */
  _setbkcolor(back);            /* sets the background color */
  for (i = 0; i<24; i++)
    _outtext("\n                ");
}
/*=====*/
/*      Displays the text and to be diplayed at row and    */
/*                      column position                      */
/*=====*/
void at(int row, int col, char *text)
{ _settextposition(row,col);
  _outtext(text);
}
/*=====*/
/* Gets a character inputted in the keyboard until it is   */
/* equal to SPACE                                           */
/*=====*/
void in_key(char value)
{ char c;
  while ( (c= (char) getch()) != value);
}
/*=====*/
/*      Gets the choice inputted from the keyboard          */
/*=====*/
char get_choice(char max, char min)
{ int answer;
  while ( ((answer = getch()) < min) || (answer >max));
  return( (char) answer);
}
/*=====*/
/* Displays the graphics text to the displayed at row and */
/*                      column positions                     */
/*=====*/
void at_char(int row, int col, char c)
{ char *t;
  *t = c;
  *(t+1) = '\0';
  at(row,col,t); }

```

```

/*=====*/
/*          Set the Foreground Color          */
/*=====*/
void set_background_color(short Background)
{ _setcolor(Background);
  _rectangle(_GFillInterior, (short) 0, (short) 0,
              (short) 639, (short) 479);
}
/*=====*/
/*      Clears a GRAPHICS mode screen display and reset      */
/*              the colors                                     */
/*=====*/
void clear_graphics_display(int fore, long int back)
{ _clearscreen(_GCLEARSCREEN); /* clears the screen */
  set_background_color((short) Backgrnd_Color);
  _setcolor(Foregrnd_Color);
}
/*=====*/
/*      Clears TEXT mode screen display and resets the colors */
/*=====*/
void cls_non_graphics(int fore, long int back)
{ _clearscreen(_GCLEARSCREEN);
  _setbkcolor(back);
  _setcolor(fore);
}
/*=====*/
/*      Clears a GRAPHICS mode screen and resets the screen   */
/*              to top of page                                 */
/*=====*/
void top_page(int i)
{ clear_graphics_display((short) Foregrnd_Color,
                          (long) Backgrnd_Color);
  Current_X = LEFT_MARGIN;
  Current_Y = 0;
}
/*=====*/
/*      Scan an integer that represent a line column downward */
/*=====*/
void disp_scan(int col)
{ register int i, scan = col, j= Current_Y, k= Current_X;
  for (i=0; i<15; i++)
  {
    if (scan == 0)
    {
      Current_Y = j+15-i;
      return;
    }
    if (scan & 0x0001)
      _setpixel(k,j);
    j++;
    scan >>= 1;
  } /* for */
  Current_Y = j;
}
/*=====*/
/*      Display the whole character bit column by bit column */
/*=====*/
void scan_all_column(int letter_code[], int n_size)

```

```

{ register int column=0, i;
  if (n_size == 0)
  {
    Current_X += 5*Char_Width;
    return;
  }
  Current_X++;
  for (i = 0; i < n_size; i++)
  {
    disp_scan(letter_code[i]);
    Current_X++;
    Current_Y -= 15;
  }
  Current_X++;
}
/*=====*/
/*      Display a character of a text given an ASCII code      */
/*=====*/
void disp_char (char letter)
{ register char scan;
  register int let_position, column=0, i;
  if (Current_X > 632)
  {
    Current_X = LEFT_MARGIN;
    Current_Y += 19;
  }
  if (Current_Y >= 480) /* if line number is > 25, clear the
screen */
    top_page((int) 1);
  switch (letter)
  { case TAB:
    Current_X += 8* TAB_VALUE;
    return;
    case SPACE:
    Current_X += 6* Char_Width;
    return;
    case NEWLINE:
    return;
    default :
    if ( (let_position = letter - 32) < 0)
      return;
    scan_all_column(FONTS[let_position].bit_array,
                    FONTS[let_position].no_col);
    break;
  } /* switch end */
}
/*=====*/
/*      Display a string on screen with the chosen Font      */
/*=====*/
void display_string(char *string)
{ while (*string != '\0')
  disp_char(*string++); }
/*=====*/
/*      Displays a prompt (text) on screen in GRAPHICS mode  */
/*=====*/
void graphics_prompt(char *text)
{ int col;
  col = strlen(text)/2;

```

```

    col = (40 + 40*(Char_Width % 2) )/2 - col;
    Current_X = col*8;
    display_string(text);
}
/*=====*/
/*          Produce a sound when the F key is pressed          */
/*=====*/
void produce_sound(int w)
{ int i, f_key;
  do
    f_key = getch();    /* if key pressed if letter F */
    while ( (toupper(f_key) ) != F_KEY);
    for (i=0; i < 2; i++)
      putc(7, stdout);  /* produce a sound 2 times */
}
/*=====*/
/*          Displays a prompt (text) on screen in TEXT mode          */
/*=====*/
void prompt(char *text, int row)
{ int col;
  col = (40 + 40*(Char_Width % 2)) /2 - strlen(text) / 2;
  _settextposition(row, col);
  _outtext(text);
}
/*=====*/
/*          Draws a blank line on screen in GRAPHICS mode          */
/*=====*/
void blank_line(int i)
{ Current_X = LEFT_MARGIN;
  Current_Y +=19;
}
/*=====*/
/* Displays a prompt (text) on screen in either TEXT mode          */
/* or GRAPHICS mode after when the last screen page of a          */
/* story has been displayed.                                          */
/*=====*/
void display_end_text_message(int row)
{
  if ( ( row == 24) && (FONT_TYPE != IBM) )
    top_page((int) 1);
  if ( ( 25 - row) < 3 )
  {
    if (FONT_TYPE == IBM)
    { prompt(pause_text, 25);
      in_key(' ');
      initialise_screen((int) 1);
      set_display_screen(Foregrnd_Color , Backgrnd_Color);
      row = 1;
    }
    else
    { graphics_prompt(pause_text);
      getch();
      top_page((int) 1);
    }
  }
}
if (FONT_TYPE == IBM)
{ prompt(".....END OF TEXT.....", ++row);
  prompt("Press <F> key when finish", ++row);
}

```

```

    }
    else
    { graphics_prompt(".....END OF TEXT.....");
      blank_line((int) 1);
      graphics_prompt("Press <F> key when finish");
    }
    produce_sound((int) 1);
}

/*=====*/
/*      Find the bit value at the given column position      */
/*=====*/
int bit_value(char byte, int position)
{ register int mask = 1;
  mask <= position-1;
  return ( (int) (mask & byte) );
}

/*=====*/
/*      Set the bit of an integer at the given position      */
/*=====*/
int set_bit(int byte_2, int position)
{ register int result, mask=1;
  mask <= position-1;
  return result = byte_2 | mask;
}

/*=====*/
/* ----- Loads a font table from the file ----- */
/*=====*/
int load_fonts(char *filename)
{ static int row[15];
  register int i, j, k;
  char c;
  if ( (fp = fopen(filename,"r")) == NULL)
  { printf("\t\t\t File < %s > does not exist\n", filename);
    exit(0);
  }
  for (i = 0; i < 95; i++)
  { fscanf(fp, "\n%c", &c);
    fscanf(fp, "\n%d\n", &FONTS[i].no_col);
    for (j=0; j < FONTS[i].no_col; j++)
      fscanf(fp, "%d ", &row[j]);
    FONTS[i].bit_array = copy_integer(FONTS[i].bit_array,
                                     row, FONTS[i].no_col);
  }
  fclose(fp);
  return(1);
}

/*=====*/
/*      Erase a TEXT mode string displayed on the screen  */
/*=====*/
void erase_string(int length)
{ int i;
  for (i = 0; i < length+2; i++)
    at(10, 65 + i, " ");
}

```

```

/*=====*/
/*          Allocate a memory for a string          */
/*=====*/
char *alloc_str(char *text)
{ char *s;
  s = (char *) malloc(strlen(text) + 1);
  strcpy(s, text);
  return s;
}

/*=====*/
/*          Count the number of words per line of text      */
/*=====*/
int count_words(char *text)
{ register int words = 0, c;
  while ( (c = *text++) != '\0')
    { if ( (isalpha(c)) || (isdigit(c)) )
      { words++;
        while ( isalpha(c = *text++) || isdigit(c) || c == 39 );
      }
    } /* while */
  return words;
}

/*=====*/
/*  Transfer the contents of the file read to the memory  */
/*  and at the same time count the number of words      */
/*  displayed on one screen page                        */
/*=====*/
void transfer_to_buffer(FILE *ftest)
{
  register int row=0, max_width, words = 0, lines = 0;
  char *text;
  SCRN_REC *scrn_current;
  TEXT_REC *text_current;
  Text_Start = text_current = (TEXT_REC *)
  malloc(sizeof(TEXT_REC));
  Scrn_Start = scrn_current = (SCRN_REC *)
  malloc(sizeof(SCRN_REC));
  text_current->Prev_Line = NULL;
  scrn_current->Prev_Scrn = NULL;
  max_width = 42 + 40*(Char_Width % 2);
  while (fgets(text,max_width, ftest) != NULL)
  { if (++row > 23)
    { scrn_current->no_of_words = words;
      scrn_current->no_of_lines = row-1;
      scrn_current->Next_Scrn = (SCRN_REC *)
      malloc(sizeof(SCRN_REC));
      scrn_current->Next_Scrn->Prev_Scrn = scrn_current;
      scrn_current = scrn_current->Next_Scrn;
      row = 1;
      words = 0; }
    text_current->Line_Text = alloc_str(text);
    if (row == 1)
      scrn_current->Starting_Line = text_current;
    words += count_words(text);
    text_current->Next_Line = (TEXT_REC *)
    malloc(sizeof(TEXT_REC));
    text_current->Next_Line->Prev_Line = text_current;
    text_current = text_current->Next_Line;
  }
}

```

```

} /* while */
scrn_current->no_of_words = words;
scrn_current->no_of_lines = row;
scrn_current->Next_Scrn = NULL;
text_current->Next_Line = NULL;
}
/*=====*/
/*      Get the subjects code inputted from the keyboard      */
/*=====*/
void get_subcode(int w)
{
    at(10,9,"Define the SUBJECT CODE (alphanumeric) and press
    ENTER: ");
    do
    { scanf("%s",Sub_Code);
      if ( isalpha(Sub_Code[0] ) )
          break;
      at(15,29,"Wrong SUBJECT CODE.  Try again.");
      getch();
      at(15,29,"");
      erase_string( strlen(Sub_Code) );
      at(10,65,"");
    }
    while (1);
}
/*=====*/
/*      Display text line width choices either 40 or 80      */
/*      char/line                                             */
/*=====*/
void display_linewidth_menu(int w)
{ char linewidth_choice;
  at( 6,22,"<<<<<  Line Width Menu  >>>>>");
  at(12,25,"(1) 80 characters per line");
  at(14,25,"(2) 40 characters per line");
  at(20,15,"Please enter your choice and press ENTER: [ ]");
  linewidth_choice = get_choice('2','1');
  at_char(20,58, linewidth_choice);
  getch();
  clear_graphics_display(Foregrnd_Color,Backgrnd_Color);
  if (linewidth_choice == '1')
      Char_Width = 1;          /* width 80 */
  else
      Char_Width = 2;          /* width 40 */
}
/*=====*/
void display_IBM_text( char *text, int row)
{ int column = 1;
  while (*text == '\t')
  { column += TAB_VALUE;
    ++text;
  }
  _settextposition(row,column);
  _outtext(text);
}
/*=====*/
/*      After a screen of text has been displayed, screen   */
/*      pauses and waits for either SPACE BAR (to go to the  */
/*      next page) or BACKSPACE (to display previous page shown)*/

```



```

/* to be pressed */
/*=====*/
void pause_FONT_screen(int *flag)
{ blank_line((int) 1);
  graphics_prompt("(( Press SPACE BAR to go to next page ))");
  while ( ((*flag = getch()) != SPACE) && (*flag != BACKSPACE)
    );
  top_page((int) 1);
}
/*=====*/
void pause_IBM_screen(int *flag)
{ prompt("(( Press SPACE BAR to next PAGE ))",25);
  while ( ((*flag = getch()) != SPACE) &&
    (*flag != BACKSPACE) );
  initialise_screen((int) 1);
  set_display_screen(Foregrnd_Color, Backgrnd_Color);
}
/*=====*/
/*      Display reading duration and other details after      */
/*      reading a set of story                                */
/*=====*/
FILE *set_file_ptr, *sub_fp;
void display_stat(FILE *sub_fp, int text_no, char *date,
  char *buf1, char *buf2, char *fname)
{ register int ctr=0;
  long tot_words = 0;
  double tot_rt = (double) 0.0;
  SCRN_REC *cur;
  cur = Scrn_Start;
  if (text_no == 1)
    fprintf(sub_fp, "***** Subject Code :
    %s\n\n",Sub_Code);
    fprintf(sub_fp, "Date Conducted : %s\n\n",date);
  }
  fprintf(sub_fp,"      *****      Text # %d
  *****\n\n",text_no);
  fprintf(sub_fp,"Text Filename      : %s\n",fname);
  fprintf(sub_fp,"Time Started       : %s\n",buf1);
  fprintf(sub_fp,"Time Ended        : %s\n",buf2);
  fprintf(sub_fp, "\nPage      No. of Words      Reading
  Time\n");
  while (cur != NULL)
    { fprintf(sub_fp," %2d          %4d          %8.4f\n",
      ++ctr,cur->no_of_words,cur->dt);
      tot_words += cur->no_of_words;
      tot_rt += cur->dt;
      cur = cur->Next_Scrn; }
  fprintf(sub_fp,"-----\n");
  fprintf(sub_fp,"Total          %5d          ",tot_words);
  fprintf(sub_fp,"%8.4f \n\n\n",tot_rt);
}

```

```

/*=====*/
/*                      Displays a Story                      */
/*=====*/
void display_story(int w)
{ register int row;
  int scrn_flag;
  time_t start, finish;
  TEXT_REC *current_text;
  SCRN_REC *current_scrn;
  current_text = Text_Start;
  current_scrn = Scrn_Start;
  if (FONT_TYPE == IBM)
    { initialise_screen((int) 1);
      set_display_screen(Foregrnd_Color , Backgrnd_Color);
    }
  while (current_scrn != NULL)
    { time(&start);
      current_text = current_scrn->Starting_Line;
      for (row = 0; row < current_scrn->no_of_lines ; row++)
        { if (FONT_TYPE == IBM)
            display_IBM_text(current_text->Line_Text,row+1);
          else
            { display_string(current_text->Line_Text);
              Current_X = LEFT_MARGIN;
              Current_Y += 19;
            }
          current_text = current_text->Next_Line;
        } /* ----- end of FOR loop */
      if (current_scrn->no_of_lines < 23)
        { row = (FONT_TYPE == IBM) ? current_scrn->no_of_lines
                                   : Current_Y/19;
          Current_Y += 19;
          display_end_text_message(row); }
      else
        { if (FONT_TYPE == IBM)
            pause_IBM_screen(&scrn_flag);
          else
            pause_FONT_screen(&scrn_flag);
        }
      time(&finish);
      current_scrn->dt = difftime(finish, start);
      current_scrn = (scrn_flag == BACKSPACE) ?
        current_scrn->Prev_Scrn :
        current_scrn->Next_Scrn;
    } /* end of WHILE loop */
}

/*=====*/
/*                      Display the Type of Fonts available    */
/*=====*/
void display_font_menu(char *font_choice)
{ at(6,22,"<<<<<  Font Type Menu  >>>>>");
  at(10,25,"(1) Helvetica");
  at(12,25,"(2) Chicago");
  at(14,25,"(3) Normal font of IBM PCs");
  at(18,15,"Please enter your choice and press ENTER: [ ]");
  *font_choice = get_choice('3','1');
  at_char(18,58, *font_choice);
}

```

```

getch();
clear_graphics_display(Foregrnd_Color,Backgrnd_Color);
switch (*font_choice)
{ case '1':
  case '2':
  case '3':
    filename = &fontname[atoi(font_choice)-1][0];
    break;
}
}
/*=====*/
/*          Sets the foreground and background colours          */
/*=====*/
void set_fore_back(short fore, long back)
{ Backgrnd_Color=back;
  Foregrnd_Color=fore; }
/*=====*/
/*  Display the Foreground/background color combinations  */
/*=====*/
void display_color_menu(int w)
{ char choice;
at(4,15,"<<<<< Foreground/Background Color Combination Menu
>>>>>");
at( 7,20,"(1) high intensity white / black");
at( 9,20,"(2) yellow / black");
at(11,20,"(3) black / low intensity green");
at(13,20,"(4) low intensity blue / high intensity white ");
at(18,15,"Please enter your choice and press ENTER: [ ]");
choice = get_choice('4','1');
at_char(18,58, choice);
getch();
clear_graphics_display(Foregrnd_Color,Backgrnd_Color);
switch (choice)
{ case '1': /* sets the background color to black (0) and
             sets the foreground color to high intensity
             white(15) */
    set_fore_back((short) 15, (long) 0);
    break;
  case '2': /* sets the background color to black
             sets the foreground color to yellow */
    set_fore_back((short) 14, (long) 0);
    break;
  case '3': /* sets the background color to low intensity
             green sets the foreground color to black */
    set_fore_back((short) 0, (long) 2);
    break;
  case '4': /* sets the background color to low intensity
             blue sets the foreground color to high
             intensity white */
    set_fore_back((short) 15, (long) 1);
    break;
} /* switch */
}
/*=====*/
/*  Check if the set of text files are available in the  */
/*  disk                                                  */
/*=====*/
int check_set_of_text(FILE *set_file_ptr)

```

```

{ char fname[25];
  char *pos,
  FILE *dfp;
  if ( (set_file_ptr = fopen("set.dat","r")) == NULL )
    { at(25,1,"*** Error : Set file cannot be opened");
      return 0;
    }
  while (fgets(fname,25,set_file_ptr) != NULL)
    { pos = strchr(fname,'\n');
      *pos = '\0';
      if (*fname == '\0')
        continue;
      if ( (dfp = fopen(fname,"r")) == NULL)
        { at(25,1,"*** Error : Unavailable text");
          return 0;
        }
      fclose(dfp);
    }
  fclose(set_file_ptr);
  return 1;
}

/*=====*/
/*      Release the memory associated with the buffer      */
/*=====*/
void release_buffer(int w)
{ TEXT_REC *cur_text;
  SCRN_REC *cur_scrn;
  cur_text = Text_Start;
  cur_scrn = Scrn_Start;
  while (cur_text != NULL)
    { free(cur_text->Line_Text);
      cur_text = cur_text->Next_Line;
      free(cur_text->Prev_Line);
    }
  while (cur_scrn != NULL)
    { free(cur_scrn);
      cur_scrn = cur_scrn->Next_Scrn;
    }
}

/*=====*/
/*      Release the memory associated with the table of fonts      */
/*=====*/
void free_fonts(char font)
{ register int i;
  for (i= 0; i < 95 ; i++)
    free(FONTS[i].bit_array); }

/*=====*/
void display_text(char font)
{ FILE *text_ptr;
  register int ctr=0;
  char *fname, *pos, *buf1, *buf2, *date;
  if ( ! (check_set_of_text(set_file_ptr)) )
    return;
  set_file_ptr = fopen("set.dat","r");
  if (font != IBM)
    { if (FONT_TYPE != font)
      { if (FONT_TYPE != IBM)
        free_fonts(font);

```

```

        load_fonts(filename);
        /* loads the font table from a file */
    }
    _setvideomode(_VRES16COLOR);
}
FONT_TYPE = font;
sub_fp = fopen(Sub_Code,"w");
date = (char *) malloc(9);
_strdate(date);
fname = (char *) malloc(13);
while (fgets(fname,13,set_file_ptr) != NULL)
{
    pos = strchr(fname,'\n');
    *pos = '\0';
    if (*fname == '\0')
        continue;
    text_ptr = fopen(fname,"r");
    transfer_to_buffer(text_ptr);
    top_page((int) 1);
    buf1 = (char *) malloc(9);
    buf2 = (char *) malloc(9);
    _strtime(buf1);
    display_story((int) 1);
    _strtime(buf2);
    display_stat(sub_fp,++ctr, date, buf1, buf2, fname);
    free( buf1);
    free( buf2);
    release_buffer((int) 1);
    fclose(text_ptr);
    prompt(pause_text,25);
    getch();
}
free( date);
free( fname);
fclose(sub_fp);
fclose(set_file_ptr);
_setvideomode(DEFAULTMODE);
_setvideomode(_TEXT80);
}
/*=====*/
/*                      Displays the Main Menu                      */
/*=====*/
void menu_screen(int w)
{
    static char Menu_File[] = "menu.scr";
    static char Read[] = "r";
    FILE *mfp;
    char *text;
    register int i=8;
    if ( (mfp = fopen(Menu_File,Read)) == NULL)
    {
        prompt("*** File Error : Menu screen file
        unavailable",25);
        exit(-1);
    }
    text = (char *) malloc(70);
    fgets(text,70,mfp);
    at(6,25,text);
    while (i < 20)
    {
        fgets(text,70,mfp);
        at(i+=2,20,text);
    }
}

```

```

    }
    fgets(text,70,mfp);
    at(23,15,text);
    fclose(mfp);
    free(text);
}
/*=====*/
/*  Display the Instructions to the Subjects before the  */
/*  set text are displayed                               */
/*=====*/
void display_instruction(int w)
{static char Menu_File[] = "inst.scr";
  static char Read[] = "r";
  FILE *mfp;
  char *text;
  register int i=1;
  if ( (mfp = fopen(Menu_File,Read)) == NULL)
    {prompt("*** File Error : Instruction screen file
      unavailable",25);
      exit(-1);
    }
  text = (char *) malloc(80);
  fgets(text,70,mfp);
  at(2,20,text);
  while (i < 21)
    { fgets(text,80,mfp);
      at(i++,3,text);
    }
  fgets(text,70,mfp);
  at(23,18,text);
  fclose(mfp);
  free(text);
}
/*=====*/
/*  Displays the Menu for the Type of Font, Line width,  */
/*  Color combinations and Prompts for the Subject Code  */
/*=====*/
void display_menu(int i)
{ char font;
  char choice= '0';
  /* sets the videomode to text mode */
  _setvideomode(_TEXT80);
  while (choice != '6')
    { set_display_screen((short) 14, (long) 5);
      menu_screen((int) 1);
      choice = get_choice('6','1');
      at_char(23,58, choice);
      getch();
      clear_graphics_display(Foregrnd_Color,Backgrnd_Color);
      switch (choice)
        { case '1': display_color_menu((int) 1);
            break;
          case '2': display_font_menu(&font);
            break;
          case '3': display_linewidth_menu((int) 1);
            break;
          case '4': get_subcode((int) 1);
            break;
        }
    }
}

```

```

        case '5': if (strlen(Sub_Code) < 1)
                    prompt("***** Fatal error :
                           No subject code specified",25);
                else
                    display_instruction( (int) 1);
                getch();
                display_text(font);
                break;
            }
        }
    }
}

/*=====*/
/* Main Program of the Displays the Screen based Stimuli on*/
/*      Helvetica or Chicago font      */
/*=====*/
int main(void)
{
    /* sets Video mode to default value */
    _setvideomode(_DEFAULTMODE);
    display_menu((int) 1);
    /* sets Video mode to default value */
    _setvideomode(_DEFAULTMODE);
    return(0);
}

```