HUMAN FACTORS IN COMPUTING SYSTEMS - IV
AND GRAPHICS INTERFACE

Edited by JOHN M. CARROLL and PETER P. TANNER

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Designing Optimum CRT Text Blinking
for Video Image Presentation

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ABSTRACT

A reference scale has been established to assist in the determination of optimum text blinking times for portions of video image texts being presented on CRT display systems. Optimum text blinking time herein is considered to be that time which most effectively catches and holds viewer attention and quickens his understanding of message import. Three experiments involving questions of the psychology of blinking time were conducted. The first experiment examined subjects' preconceived notions of optimum blinking time, i.e. what they imagined, within their own minds, such times would be for specific text portions. The second experiment determined the gap between those preconceived notions and the subjects' changed concepts of optimum blinking times, based on their experience of visual trials. The third experiment applied a scale of blinking times, based on the experience gained in the second experiment, to a new set of subjects in order to further refine our understanding of optimum intervals. For the portions of text used here, optimum blinking times centered about 1.0 second.

Moreover, through an adaptation to the video image presentation system, the effectiveness of the optimum text blinking times and the psychological scale was confirmed.

RESUME

Une échelle de référence a été établie dans le but d'aider à déterminer le temps optimum nécessaire de clignotement d'une portion de texte d'une image vidéo étant présenté sur écrans cathodiques d'ordinateurs. Le temps optimum de clignotement est considéré ici comme étant le temps nécessaire à attirer effectivement et tenir l'attention de l'observateur de façon à augmenter la vitesse de compréhension d'un message reçue. Trois expériences, concernant la question de psychologie du temps de clignotement, ont été entreprises. La premìere expérience a examinées les notion préconçues de temps optimum de clignotement chez les observateurs i.e. ce qu'ils imaginent, à l'intérieur de leurs propres cerveaux, ce que ces temps auraient été pour des parties de textes spécifiques. La deuxìeme expérience a servi à déterminer la différence entre les notions préconçues et le changement des concepts des observateurs à propos du temps de clignotement, le tout basé sur des expériences d'essais visuels. La troisìeme expérience concerna l'application d'une échelle de temps de clignotement, basé sur les expériences acquises au cours de la deuxìeme expérience, à une nouvelle série d'observateurs dans le but de mieux raffiner notre compréhension de l'optimisation des intervals. Pour les parties de textes utilisées ici, les temps optimum de clignotement étaient centrés à environ 1.0 seconde.

De plus, à travers une adaptation de la présentation du système d'image vidéo, l'efficacité du texte et de l'échelle psychologique ont été confirmées.

KEYWORDS : Text Blinking, User Interface, Video Image Presentation, Psychological Scale.

1. INTRODUCTION

Presentation is an important way for communicating several bits of information. In the presentation, it is very important to precisely communicate the information senders' intention to the receivers (Williams,1984; Macllray and Wymann,1984; Kasahara and Miyashita,1986).

Presentation materials include texts, tables, graphs and pictures, as pertinent information passing media. When these media are precisely used, the presentation material will effectively work and accurate communication will be accomplished (Feiner,1985).

One of the most important approaches for precise communication is to find a method to attract the viewers' or information receivers' attention (DeVita,1983; Howell,1982; Kitakaze,Kasahara and Miyashita,1986). The reason is that the viewers' attention can quicken the understanding of the import.

This research is about presentation of text expressions, which attract viewers' attention, in video image presentation. A number of methods are commonly employed for attracting viewer attention, including changes in text color or font, underlining, and text blinking. Among these, text blinking -- repeated on/off sequences of a video image -- seems to be most effective. However, at the present state of the art, the text blinking time is decided by presenter's know-how. In this research, three psychological experiments were conducted to have some understanding of what blinking times in various situations might be considered optimum.

We report here on three experiments investigating the psychology of blinking time, as well as the application of the results of those experiments to a video image presentation system.

2. EXPERIMENTS

2.1. Experimental Objectives

With long interval blinking time, viewers unconsciously relax and are unlikely to have their attention held on the import of a text. On the other hand, when blinking time is too short, attention will not be held effectively because viewers tend to glance away to reduce eye strain.

Determining the optimum blinking time for a given text portion is rendered more complex by the fact that a gap may exist between a person's preconceived notion of what would be an optimum interval (hereafter referred to as the "conceptual optimum") and the perceived optimum interval (hereafter referred to as the "experimental optimum") based on their own actual visual trials. The objectives of our experiments were to confirm the existence of such a gap and to develop a scale for determining actual optimum blinking times.

Our first experiment was designed to identify our subjects' "conceptual optimum", the second was designed to determine the gap between that and a discovered "experimental optimum", and the third was designed to establish a scale to aid in the determination of optimum blinking times for visual presentations.

2.2. Experiment 1 -- Determining the Conceptual Optimum

METHOD: Forty-two clerical employees, not experts in the use of computers, were presented a document representing a section of a company's financial report, written in 12 lines of Japanese characters with 19 characters per line. (See Figure 1)

A written explanation of the use of text blinking and its effectiveness was read by the subjects, after which they looked over the financial report document. They were instructed to play the role of head of the company's Management Department and to think about using blinking in the presentation of the document to an audience of company managers. Subjects chose text portions which they wanted to blink and designated what they

当社の１２月期決済は、売上高３５００億円、経常利益４００億円で、対前年同期比１５％の増収、１１％の増益と好調なものであった。売上構成は、スキー用品が全体の３８％であり、次いでアスレチックウェアが２５％、アウトドア用品が１７％となっている。特に、アスレチックウェアは自社ブランド製品を開発し、スポーツ性を強調したウェアに転換し、販売の強化を図った結果である。アスレチックウェアは、５年後には、年商３０００億円、シェア５０％達成を目標としている。

Figure 1. Test material (a company finacial report)

considered, in their own minds, to be an appropriate blinking time.

RESULT: Figure 2 shows the distribution of blinking times according to the number of subjects designating such times. Conceptual optimums ranged from 1 to 30 seconds. The average of designated times was 8.1 seconds, with a standard deviation of 7.5 seconds.

DISCUSSION: The dispersion of conceptual optimums was very wide. Subjects who had given exceptionally long times were interviewed to determine whether or not they had properly understood the instructions, and it was established that they had. The great divergence suggests that a person's conceptual optimum is unlikely to be a reliable guide to establishing actual optimums.

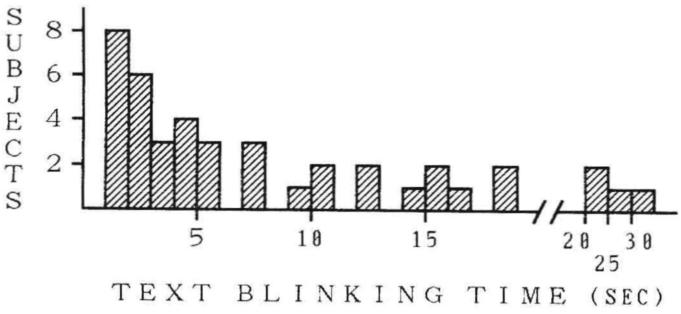

Figure 2. Blinking time destribution according to number of subjects designating such time

2.3. Experiment 2 -- Determining the Experimental Optimum

METHOD: Ten subjects from the original 42 were selected to operate a prototype visual display system. With this system, any text string of the test document, the same as that used in Experiment 1, could be made to blink on a CRT display.

Subjects were first shown a display with their chosen text portion blinking at the rate they had designated as their conceptual optimum. They were then instructed to adjust the blinking time to what they felt would be more effective by using the nine point adjustment scale ("longer/shorter") shown in Figure 3. The maximum allowable degree of change was from half to twice the current blinking time. Subjects continued their adjustments until they felt they had achieved the optimum.

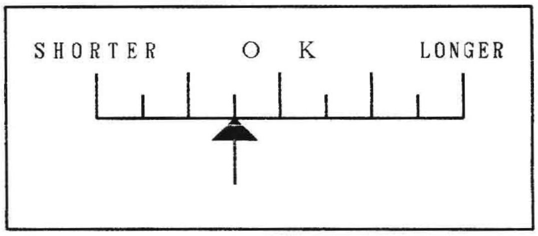

Figure 3. Subject reaction scale for changing text blinking times

RESULT: Figure 4 shows blinking time adjustments of all ten subjects. Times indicated at the zero point are those subjects conceptual optimums. It took five changes for all subjects to arrive at their experimental optimums, which were highly concentrated and ranged only from 0.4 seconds to 3.0 seconds. Figure 5 shows the average and the standard deviation of the data in Fig.4.

DISCUSSION: The widely dispersed conceptual optimums tended to be overestimates, as gauged by the experimental optimums, and the relative concentration of experimental optimums was noteworthy. Namely, the experiment clarified the gap between conceptual optimums and experimental optimums.

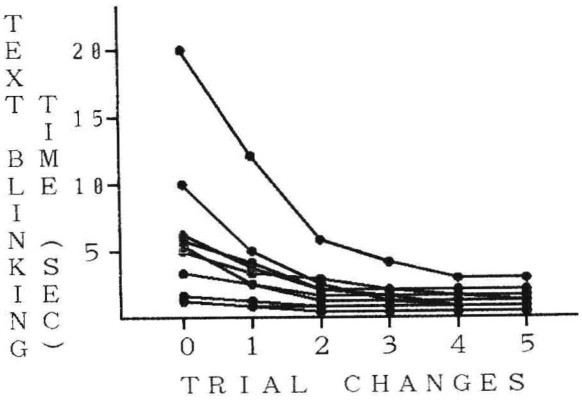

Figure 4. Text blinking time adjustments

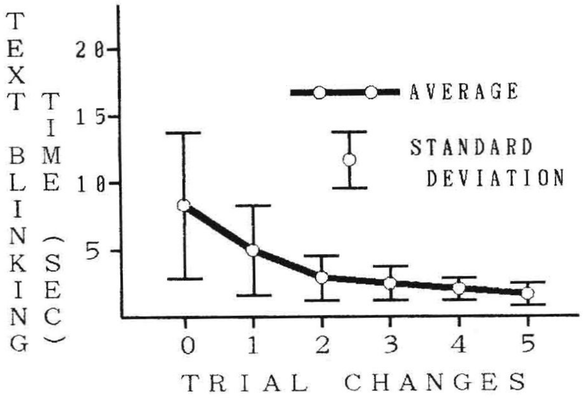

Figure 5. Average and standard deviations of text blinking times

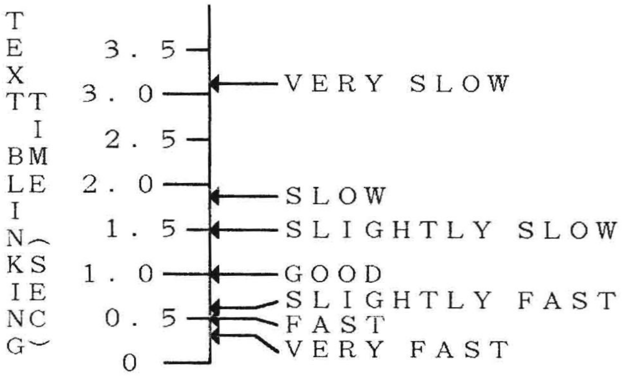

Figure 6. Resultant reference scale

2.4. Experiment 3 -- Establishing an Optimum Text Blinking Time Scale

METHOD: Fresh subjects, 17 clerical and technical employees who were not experts in using computers and who had no special knowledge about text blinking were presented the display material of Experiment 2. The experimenter had free control of text blinking times.

Each subject was given a 7-step evaluation scale: "very fast", "fast", "slightly fast", "good", "slightly slow", "slow", and "very slow", and they indicated their reactions to seven different blinking times. Each subject was tested with 50 presentations.

RESULT: The method of successive categories† was applied to the data gathered, producing a psychological scale for use in determining optimum blinking times. The optimum blinking time was 1.0 second, which was indicated as "good" in the psychological scale. This scale is shown in Figure 6, wherein 0.3 seconds is designated "very fast", 0.5 seconds, "fast"; 0.6 seconds, "slightly fast"; 1.5 seconds, "slightly slow"; 1.9 seconds, "slow"; 3.1 seconds, "very slow".

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† The method of successive categories is a scaling method which give arithmetical values to each rating level and estimate their intervals. Psychological level **M** is given by $\mathbf{M}=\Sigma Pi Ci$, in which Pi is the rate of the category i and Ci is the interval scaling value of the category i. Guilford discusses this method in detail.

DISCUSSION: It may be noticed that as blinking time decreases, viewers seem to become more sensitive to smaller changes in interval. This results in the non-linear nature of the scale, which may be applied effectively to the determination of the optimum blinking time for a given text by working about a standard of 1.0 second and adjusting as necessary in jumps of the magnitude indicated by the various grades the scale indicates.

2.5. Summary

It has become apparent here that there is a wide range in peoples' preconceived notions of what optimum blinking times might be imagined to be and that there was a large gap between this preconceived notion and peoples' experimentally perceived optimum blinking time. Furthermore, the optimum blinking times determined by actual trial tended to be dispersed over a far smaller range than were the preconceived notions. Application of the method of successive categories produced a non-linear psychological scale, with a standard optimum blinking time of 1.0 seconds, from the use of which the optimum blinking time for a given text might be effectively determined.

3. ADAPTING EXPERIMENT RESULTS TO VIDEO IMAGE PRESENTATION SYSTEM

The optimum text blinking time and the psychological scale were adapted in a system for making information presentation materials.

First adaptation is to use the experimental optimum, 1.0 second, which was "good" in the viewer's acceptance scale, as a default value. The reason is that, in many case, a presenter can get his own optimum blinking time easily and quickly, when 1.0 second was adapted as a default value, in comparison with he must input data as his likes.

Second adaptation is to use the psychological scale as a changing scale for setting text blinking time. A function to change the text blinking time is required, because the time effect varies by factors such as the contents of a document and number of letters. According to the result of the experiments, we developed a interface which involves user's time sense like "longer" or "shorter", and the changing magnitude along the psychological scale.

After this adaptation, information sender could set up a text blinking display, which could communicate the operator's intentions to his audience, very easily.

4. CONCLUSION

The optimum text blinking time, 1.0 second, and the psychological scale have been obtained as a result of three psychological experiments. Existence of a large dispersion of established text blinking time which use only time concept and a gap between the conceptual optimum and the experimental optimum become clear. It is also found that a users' retention becomes greater when the text blinking time is short. Moreover, an adaptation to the video image presentation system, using the optimum text blinking time and the psychological scale, was proposed.

Further research is planned to establish a design method and an user interface reference scale, considering the information sender's intention and receiver's understanding. Moreover, research to support these establishments will also be carried out.

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WHY READING WAS SLOWER FROM CRT DISPLAYS THAN FROM PAPER

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Abstract

Experiments, including our own (Gould et al., 1982; 1984; 1986), have shown that people read more slowly from CRT displays than from paper. Here we summarize results from a few of our fifteen experiments that have led us to conclude that the explanation centers on the image quality of the CRT characters. Reading speeds equivalent to those on paper were found when the CRT displays contained character fonts that resembled those on paper (rather than dot matrix fonts, for example), had a polarity of dark characters on a light background, were anti-aliased (e.g., contained grey level), and were shown on displays with relatively high resolution (e.g., 1000 x 800). Each of these variables probably contributes something to the improvement, but the trade-offs have not been determined. Other general explanations for the reading speed difference that can be excluded include some inherent defect in CRT technology itself or personal variables such as age, experience, or familiarity at reading from CRT displays.

Key Words: Reading, displays, productivity

Introduction

The main reason for on-line computer displays is for people to read from them. Unfortunately, several recent experiments have shown that people read more slowly from CRT displays than from paper (Gould & Grischkowsky, 1982; 1984; 1986; Gould, 1986; Heppner, Anderson, Farstrup, & Weiderman, 1985; Kak, 1981; Kruk & Muter, 1984; Mills and Weldon, 1984; Muter, Latremouile, Treuniet, & Beam, 1982; Stevens, personal communication, 1983; Wright & Lickorish, 1983). While some of these experiments are open to various explanations, and there has even been experiments that have reported no reading speed difference (Cushman, 1986; Switchenko, 1984), the reading speed deficit is nevertheless real.

We conducted one series of ten experiments in which individual variables were isolated and experimentally studied to learn how much of the reading speed difference each variable accounted for (Gould, 1986). Variables studied included experience in using CRT displays; display orientation; character size; font; polarity; aspect ratio; contrast; different displays. The basic result was that no one variable--by itself--accounted for most of the difference.

In a second series of experiments we attempted to make CRT displays look similar to good print on paper (Gould, Alfaro, Finn, Haupt, and Minuto; 1986). With this approach, we have been able to identify conditions under which people read as fast from CRT displays as from good quality print on paper. This note, similar to another recent one (Gould, Alfaro, Finn, Haupt, Minuto, and Salaun, 1986), contains the tentative conclusions we have reached, and summarizes a few of our recent experiments.

Method

In each of the four experiments mentioned here, participants proofread for misspelled words (about one every 150 words). They were told their performance would be evaluated upon their accuracy and speed of proofreading. Participants indicated misspelled words by saying them aloud to the experimenter. Appropriate experimental designs, generally greco-latin squares, were used to counterbalance display conditions, reading materials, and order of presentation.

The reading material on paper and the CRT displays studied had the same character fonts, polarity (dark characters on a light background), size, color (almost), and layout. If a transparency was made of a page of print on paper and placed on the CRT screen, there was a very good match. The CRT characters were anti-aliased versions of paper-like fonts (Sholtz, 1984) produced by the YODA system (Gupta, Bantz, Sholtz, Evangelisti, and DeOrazio, 1986). Anti-aliased characters contain picture elements (so-called pixels or pels) with grey level, or intermediate luminance values, rather than bi-level picture elements that are either completely on or completely off. The purpose of anti-aliasing is to enhance the perceptual goodness of the CRT characters, presumably by enhancing their perceived resolution. The CRT displays used here had somewhat better addressability (resolution) than did those we studied previously (Gould, 1986).

Results

Experiment 1. Table 1 shows the results from our first experiment in this series in which 18 volunteers proofread six 5-page articles. Participants proofread significantly faster from Paper than from the CRT (Means= 220 and 209 words per minute (wpm), $F(1,17)=6.72$; $p<.05$). The 95% confidence interval for this mean difference was 11+-9 wpm. This means that, at the 95% confidence level, the true difference between these two means is between 2 and 20 wpm in favor of Paper. This 5% difference was the smallest we had so far found between Paper and CRT displays. There was no difference in accuracy of proofreading (Means=69% and 70% hits; $F(1,17)<1.0$). There was less than one false-positive per article (mean=0.67).

Experiment 2. In the above experiment a color Mitsubishi display (640 x 480 addressability on a 6.5 x 8.75 in. active screen area; 73 pel addressability) was used. This display gave poor contrast when the characters were shown in monochrome. Table 2 shows results from a second experiment in which 16 participants proofread four 1000-word articles, two from Paper and two from an IBM monochrome 5080 display (1024 x 1024 addressability on an 11.2 x 11.2 in active screen area; 91 pel/in). Participants proofread at about the same rate from Paper and from the CRT (Means= 201 and 196 words per minute (wpm), $F(1,15)=1.31$; $p>.10$). The 95% confidence interval for this mean difference was 5 +- 11 wpm. This means that, at the 95% confidence level, the true difference between these two means is between 16 wpm in favor of Paper and 6 wpm in favor of CRT. There was no difference in accuracy of proofreading (Means=78% and 73% hits; $F(1,15)<1.0$).

Experiment 3. The 5080 display regeneration rate was 50 hertz, and some participants reported it flickered. We obtained an experimental 5080 monochrome display which regenerated at 60 hertz and had the same resolution as in the previous experiment. Twelve participants proofread four 1000-word articles, two from Paper and two from the CRT display. Participants proofread at about the same rate from Paper and from the CRT (Table 3; Means= 206 and 204 words per minute (wpm), $F(1,15)<1.0$. The 95% confidence interval for this mean difference was 2 +- 14 wpm. This means that, at the 95% confidence level, the true difference between these two means is between 16 wpm in favor of Paper and 12 wpm in favor of CRT. There was no difference in accuracy of proofreading (Means=81% and 79% hits on Paper and CRT, respectively; $F(1,11)<1.0$). There were few false-positives (0.67 per article).

Experiment 4. The purpose of a this experiment was to determine whether display polarity, i.e., the use of dark characters on a light background, rather than vice versa, contributed to the proofreading rate from the 5080 CRT display. Previous evidence suggests that, to the extent there is a difference, faster reading occurs with dark characters on a light background (Bauer & Cavonius, 1980; Cushman, 1986). Fifteen participants proofread 1000-word articles from paper, from the 5080 display with dark characters on a light background, and from the 5080 display with light characters on a dark background. Optimal contrast might be different for each polarity. Therefore, of the four articles read from the CRT display, participants read one in each polarity with a 10:1 contrast ratio. On the other two articles, they themselves set the contrast ratio for each polarity.

There was no significant difference in the five reading speed means, $F(4,48)=2.27;p>.10$. Participants proofread at 252 wpm from paper and 241 wpm from the four display conditions (Table 4, $F(1,14)=2.86;p>.10$). Nine of the 15 participants proofread faster on Paper than on CRT ($p>.10$). The 95% confidence interval for this mean difference was 11+-15 wpm. This means that, at the 95% confidence level, the true difference between these two means is between 26 wpm in favor of Paper and 4 wpm in favor of CRT. Proofreading accuracy was about 75% in all conditions (Table 4). Dark CRT characters were read somewhat faster than light characters, but this difference was not significant (Table 4; means=247 wpm on dark characters and 235 wpm on light characters; $F(1,14)=2.55;p>.10$). Twelve of the fifteen participants were faster on the polarity with dark characters, and the other three participants were faster on the polarity with the light characters (chi-square=4.26;$p<.05$). In the adjustable contrast conditions, the mean contrast setting of participants for the dark character/light background condition was 8, and it was 11 for the other polarity.

Discussion and Conclusions

The exciting result here is that we have identified conditions under which people can read as efficiently from CRT displays as from good paper. The reading rates demonstrate that this equivalence was not achieved by using degraded or less than high quality print on paper, as have some unpublished reports that have been brought to our attention recently. The results were obtained using the same methods that in the past had shown reading speed to be faster on good paper (Gould & Grischkowsky, 1984; Gould, 1986). The present direct, within-subject comparison experiments of several displays and paper indicate a true improvement in reading from CRT displays (see the longer report, Gould et al., 1986). The evidence, as discussed in the longer report, suggests that variables associated with the image quality of the displayed characters themselves account for the reading speed difference. The evidence from these and our earlier work (Gould, 1986), rules out an explanation associated with people themselves (e.g., people lack familiarity or experience with CRTs), or an explanation based upon something inherently wrong with CRT technology.

What display image quality variables account for the difference? Our analyses (Gould, et al., 1986) show that no one variable compellingly explains most of the improved reading from CRT displays. Rather, the displays studied here seem to be improved in several ways over those studied earlier, and, given this, each variable contributing to this improvement does so in a small, cumulative way. Polarity is a good example of this. As can be seen in Table 4, the evidence is marginal about its contribution. It contributes something (e.g., 12 of 15 participants were faster on dark characters on a light background than on light characters on a dark background), but not a whole lot. Based upon the dramatic interactions of image quality variables on reading speed from paper (Tinker, 1963), these display variables probably interact, but in unknown ways. Our tentative conclusion is that display polarity (dark characters on a light, whitish background), improved display resolution, and anti-aliasing itself each contribute to the elimination of the Paper/CRT display reading rate difference. Associated with these three variables was a difference in fonts, but we are unable to make an argument independent of the above three variables that font contributed to this reduction.

Publication Note

This is a summary of a portion of a longer paper. It is not intended to preempt publication of the longer report, nor is it considered to be prior publication of it.

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