PRESENTATION OF TEXT ON VIDEOTEX

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ABSTRACT

Videotex services are expected to provide easy access by the general public to data bases containing large amounts of textual and graphical data. In order to reach that goal, designers of such services must maximize ease of use of the system by both naive and experienced users, while at the same time, keeping the cost to the user at a minimum. Human factors research at the federal Department of Communications attempts to provide input to videotex system design to help reach these objectives.

Information is currently displayed on a home television display modified to accept RGB video input. A major concern has been the design of character sets for the display of text on television, as well as the most desirable spacing between letters and between lines. Character sets were designed by professional graphic artists, and the best spacings were determined from the results of letter search experiments.

Although the ability to scroll text is available on most video display terminals reading experiments indicate that scrolled text is difficult to read. For this reason, and because the scrolling hardware adds significantly to the cost of a terminal, alternatives to scrolling for videotex terminals were examined.

RÉSUMÉ

Les services vidéotex visent à permettre au grand public d'avoir accès à des bases de données comprenant une grande quantité de textes et de graphiques. Pour atteindre cet objectif, les responsables de la conception de ces services doivent faciliter le plus possible l'utilisation du système tant pour les utilisateurs débutants que pour ceux qui possèdent de l'expérience en la matière, tout en maintenant les frais le plus bas possible. Le ministère fédéral des Communications mène à cet égard une recherche sur les facteurs humains qui devraient intervenir dans la conception du système vidéotex.

Actuellement, l'information est affichée sur un écran de télévision ordinaire, qui a été modifié de façon à recevoir les signaux vidéo "RVB" (rouges, verts, bleus). On a accordé beaucoup d'importance à la conception des ensembles de caractères qui seront utilisés pour l'affichage des textes sur les écrans de télévision, ainsi qu'au choix de l'espacement le plus approprié entre les lettres et entre les lignes. En effet, les ensembles de caractères ont été conçus par des spécialistes des arts graphiques, et les espacements ont été déterminés d'après les résultats de recherches en discernement des lettres.

Bien que le défilement des textes est possible sur la plupart des écrans vidéo, des expériences ont montré qu'il est difficile de lire les textes présentés de cette façon. De plus, le matériel utilisé pour le défilement fait augmenter considérablement le coût d'un terminal. On a donc examiné d'autres techniques de présentation susceptibles d'être utilisées à l'égard des terminaux vidéotex.

Introduction

The research performed by the Behavioural Research and Evaluation group at the Dept. of Communications is intended to support the development of positions on standards of interest to the department, as well as to facilitate the development of Canadian industries involved in the manufacture of communications hardware and software.

The spacing of characters displayed on videotex terminals became a standards issue of international importance because of the need to maintain the spatial relationship between graphics and any accompanying alphanumeric annotations. Developers of the British and French videotex systems wish to display 24 rows of text which can be supported by their 625 line television system. If 24 rows is appropriate for the 625 line system, it is likely that 24 rows cannot be supported by the North American 525 line system. Research investigating the minimum desirable row spacing for North American videotex systems is discussed in this paper.

Some other issues were related not to the making of standards but were also concerned with how to make television text more readable. Terminal manufacturers would benefit from information about the best spacing of words, the use of proportional spacing, and the utility of alternatives to scrolling. This paper discusses research addressing these issues.

Experiments

Character Spacing

The first experiment on character spacing used a letter search procedure to investigate legibility of letters as a function of letter and row spacing. The experiment is described in detail in Treurniet (1980). In that experiment, a number of rows of random, lower-case letters designed in a 5X7 matrix were displayed on a colour television monitor under normal office lighting conditions. A cue was placed in the left margin adjacent to the middle row of letters. Subjects identified the first letter in the cued row (either a g, j, p, q or y), scanned the row and located the next occurrence of that letter. Their response was the name of the next letter in the row. If the target letter was not found, subjects were instructed not to retrace but to say the name of the last letter in the row. Subjects were also requested to regulate their scanning rates so that they missed targets on about 10 percent of the trials. The task was considered relevant to the issue of readability because the horizontal motor movements involved are also present during reading. Three variables were manipulated factorially. The space between characters and between rows was one, two, or three pixels, and the descender components of the target letters extended below the line by zero, one, or two pixels (a pixel is the smallest addressable area on the screen). The 27 possible combinations of the three variables were presented in random order in each of ten blocks of trials. The dependent measures were the time from onset of the display to when the response was detected with the aid of a voice switch, and the frequency with which the target letter was missed.

Scanning rate in characters/sec and the frequency of misses were used to ascertain the spacings at which the maximum rate of input occurred with minimal error. The best spacing between the characters of a row was two pixels, the best spacing between rows of characters was at least three pixels, and the best descender length was at least one pixel. These results have implications for the maximum number of rows of text that can be displayed on television. The space of three pixels between rows and the extra row for descender characters increases the height of the character matrix from seven to eleven pixels. In one field of the North American television frame, there are 262 raster lines of which 241 carry video information. According to the SMPTE Recommended Practice 27.3 (1972), only 80 percent, or 192 lines, are in the "safe title image area within which the more important information must be confined to ensure visibility of the information". This is so because manufacturers deliberately introduce overscan in television sets to prevent the appearance of blank borders around the image. Thus, 192 lines will accommodate 17 rows of text when each row requires 11 lines of pixels.

A space of three pixels between rows is less than that recommended by Roufs and Bouma (1980) on the basis of accuracy in locating new lines during reading. They propose that the space between lines should be three times the space between adjacent letters. Therefore, increasing the number of rows to 20 by decreasing the space between rows to two pixels and by relaxing the overscan constraint from 80 to 83 percent is possible but is probably sub-optimal. It is still less desirable to increase the number of rows to 24 in order to match the European videotex displays.

The previous results derive entirely from single, 5X7 character set. To consider the generality of the results, the experiment was repeated with a character set designed in a 7X9 matrix. All the lower case letters in this set except "m" and "w" used only six of the seven available columns of the character matrix. Thus, the horizontal spacings between successive matrices of one, two, and three pixels most often resulted in two, three, and four pixels, respectively, between the displayed lower-case letters. The experiment showed no effect of the space between rows of letters on either scanning rate or miss frequency. However, scanning rate decreased significantly, $F(2,20)=30.208$, $p<.01$, as did miss frequency, $F(2,20)=3.595$, $p<.05$, as horizontal spacing increased. Scanning rate also increased, $F(2,20)=16.514$, $p<.01$, and miss frequency decreased, $F(2,20)=29.378$, $p<.01$, as descender length increased. No interactions

Table 1

Percentage of Total Variance Explained

	Miss Frequency	Characters/ Second
Horizontal Spacing	2.5	4.5
Descender Length	16.1	3.2

were significant. Table 1 shows the proportion of the total variance explained by each of the significant effects, and Figures and 2 show the corresponding means.

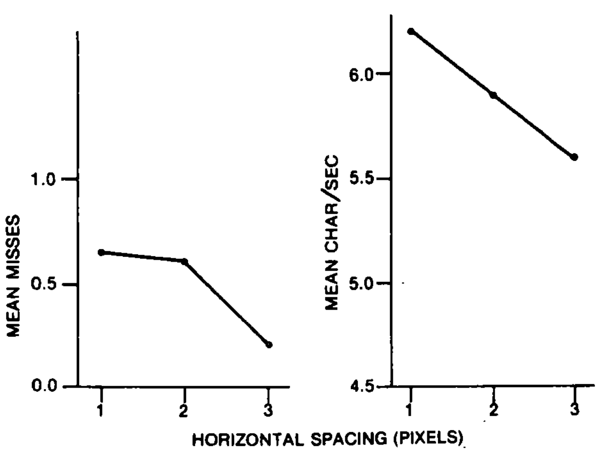

Figure 1: Effect of spacing between adjacent letters on scanning rate and miss frequency.

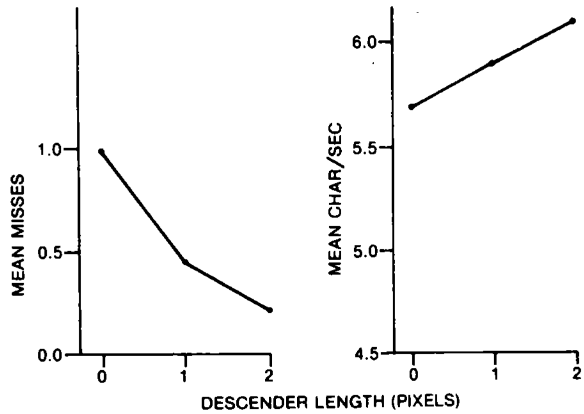

Figure 2: Effect of descender length on scanning rate and miss frequency.

The statistical significance of differences among the means was tested using the Newman-Keuls procedure (Winer, 1962). Frequency of misses decreased significantly with each increase in length of descender. Further, scanning rate increased significantly with each increase in descender length. Thus, for good legibility with this character set, the descender should extend below the row by at least two pixels.

Scanning rate also decreased significantly with each increase in horizontal spacing with no indication of an asymptote within the range employed. Alone, the rate measure suggests that the fastest rate of information input occurs at the smallest horizontal spacing. However, a space of three pixels resulted in significantly fewer misses than the two smaller spacings, while the latter two did not differ. Thus, the slower input rate at a spacing of three pixels is preferred because of the associated lower miss frequency.

Differences in the results of the two experiments suggest that the best spacings to use depend on the characteristics of the character set employed. Table 2 contrasts the conclusions of the earlier experiment (5X7 character set) with the conclusions of the present experiment.

The difference in the size of the character matrices in the two experiments can be expressed as a difference in the ratio of the stroke width to matrix size (SW/MS). Strokes are the line elements composing the characters. When this ratio is small, the

Table 2

Comparison of the Recommendations of the Two Experiments

Character Set Size	Descender Length	Vertical Spacing	Horizontal Spacing
5X7	1	3	2
6X9	2	1	4

interiors of letters appear more empty than when the ratio is large. The impression of emptiness within the letter structure may decrease discriminability of letter boundaries when letters are very close together. Thus, horizontal spacing should be increased as the SW/MS ratio decreases.

The differences in optimal vertical spacing may arise from the influence of information in the visual periphery upon perceptual processes at the fovea (i.e., where fixated information is projected on the retina). Consistent with this, Breitmeyer and Valberg (1979) have shown that stimulation at the periphery of the visual field can inhibit perception of foveally projected material. Therefore, the high density of information throughout the visual field reflected in a relatively large SW/MS ratio may reduce legibility of letters in foveal vision. Increasing the space between adjacent rows of text might improve legibility by reducing the amount of noise in peripheral vision. The character set with the smaller SW/MS ratio might not need the extra space between the rows if the peripheral noise were already sufficiently small.

To test the hypotheses, part of the above experiment was repeated using a character set with the same matrix size but with a thicker vertical stroke width (two pixels rather than one). Length of descender was fixed at two pixels. According to the hypotheses, such a character set should require more space between rows than the previous set and less space between the characters than the previous set for best legibility. Analyses of scanning rate and miss frequency confirmed the predictions. The effect of vertical spacing on scanning rate was significant, $F(2,22)=7.221, p<.01$, as was the effect of horizontal spacing, $F(2,22)=22.094, p<.01$. The interaction was not significant. Figure 3 shows the effect of varying horizontal and vertical spacing on scanning rate. Newman-Keuls tests showed that a vertical space of two or three pixels resulted in significantly faster scanning than a vertical space of one pixel. There was no difference between the

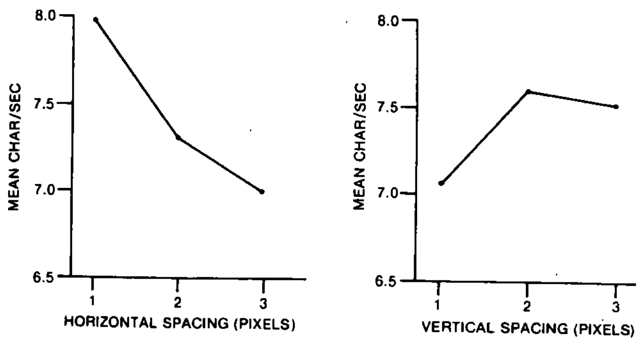

Figure 3: Effect of varying horizontal and vertical spacing on scanning rate.

two and three pixel spacings. Also, each decrease in horizontal spacing resulted in a significant increase in scanning rate. However, there were no significant effects of horizontal or vertical spacing on miss frequency. Therefore, the results indicate that, for this character set, the space between adjacent characters should be one pixel, and the space between rows should be at least two pixels. As predicted, the horizontal spacing is smaller and the vertical spacing is larger than the spacings recommended for the character set of the preceding experiment. It appears, therefore, that the best space around a character matrix is dependent on the relative sizes of the stroke and the matrix.

Proportional Spacing

When letter matrices are placed next to one another to form a row of text, the effect is uneven spacing between letters. This occurs because some characters occupy fewer columns of the matrix than do other characters. For example, the letter "m" may occupy five columns of the matrix, while the letter "i" occupies only one column. The inequality of letter spacing can be eliminated on computer displays by removing matrix columns that are not used to describe the character. This is defined as proportional spacing.

Proportional spacing is commonly used in the print media. It may reduce uncertainty about word boundaries by removing confusing spaces within words and, by freeing letter positions from columnar alignments on the page, it reduces or eliminates vertical rivers of background colour. However, empirical evidence for the utility of proportional spacing is sparse and equivocal. Campbell, Marchetti and Mewhort (in press) showed that reading efficiency is affected by variations in the spacing of text elements. They found that right-justified text is read more quickly and accurately when the space between letters within words is adjusted to be proportional to the space between words, than when the space between letters within words is fixed.

Some recent work by Muter in our laboratory showed no difference in the amount of proportionally and non-proportionally spaced text that people read in two hours. However, since the spacing between lines of text was the same for both conditions, the presence or absence of proportional spacing was confounded with density of information on the page. Previous legibility experiments demonstrated that high character densities reduce the rate of scanning a row of letters. Therefore, the higher character density of the proportionally spaced text may have countered the benefit of proportional spacing. Thus, although proportionally spaced text appears more pleasing that non-proportionally spaced text, more research is needed to determine if it facilitates reading performance.

Space Between Words

When proportional spacing is employed, the space between words appears excessive when it is the full width of the character matrix plus the space between adjacent characters. Therefore, an experiment was performed to determine the best spacing between words. Photographs were made of a television screen displaying proportionally spaced text with various spacings between words. The space was varied from four to seven pixels for the 5X8 (5X7 with an additional line of pixels for descenders) character set, and from four to nine pixels for the 7X11 (7X9 with two additional lines of pixels for descenders) character set with vertical strokes two pixels wide. The space between adjacent letters within a word was always two pixels.

Ten people were asked to choose the most preferred spacing from those displayed by each set of photographs. For each character set, space of six pixels was most often preferred. In both cases, six pixels is less than the matrix width plus the space between adjacent characters. Since a six-pixel space appears inappropriate for much larger character sets, further research is necessary to determine the relationship between character size and preferred space between words.

Alternatives to Scrolling

When the screen of a visual-display terminal (VDT) has been filled with text and additional text is pending, the text already presented typically is displaced (scrolled) upwards by one row-position as each new row of text is displayed. Unfortunately, text scrolled in this manner is poorly read (Kolers, 1980), and informal reports indicate that the motion resulting from the scroll is distracting.

Given the limitations of the scrolling procedure, erasure of the full screen prior to display of the additional text may appear a viable alternative; it eliminates expensive scrolling hardware and avoids a procedure of questionable benefit to the user. However, scrolling does permit the later lines of the preceding text to be present on the screen simultaneously with the earlier lines of the new text. Thus, although scrolling itself may be undesirable, one aspect of the procedure may be worth preserving. The simultaneous presence of both old and new material may promote greater continuity in reading and, thus, enhance ease of reading.

The experiment assessed the utility of the simultaneous presence of both old and new text on the screen. Specifically, once the request for a new page of text was issued, either the whole screen was erased or all but the lowest one, two, or four lines of text were erased and display of the new page begun. Once the new text reached the beginning of the retained text, the latter was erased and the new page completed. In this way, the distracting motion of scrolling was avoided and the effect of retaining "old" material could be assessed.

If the simultaneous presence of both old and new information enhances continuity in reading, one might expect shorter reading times with partial-page erasure than with full-page erasure. In the experiment, observers read three short stories under one of the four erasure conditions and the time to read all three stories was recorded. The results of the experiment are presented in Figure 4.

The figure shows that mean reading times were longer when one or two lines of old text were retained than when four lines were retained or the full page was erased, $F(1,44)=6.91$, $p<.025$. There was, however, no difference between the one-line and two-line conditions, $F(1,44)=0.77$, $p>.05$, or between the full-page erasure and four-line retention conditions, F(1,44)=0.001, p>.05. At this point, it is important to note that scores on comprehension questions administered following each story were equivalent across the four conditions (0.67, 0.67, 0.66, 0.65). It appears unlikely, then, that observers in the full-page and four-line conditions sacrificed comprehension for speed to a greater extent than those in the one-line and two-line conditions.

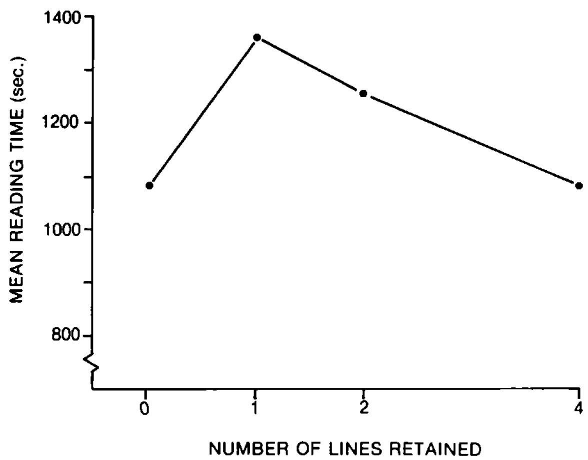

Figure 4: Mean reading times for the four erasure conditions.

Clearly, the results do not show the anticipated advantage of partial-page erasure reading times for partial-page conditions were not shorter than those for full-page erasure. To interpret the results, one might assume that speed and ease of reading improve, at least to a point, with the amount of older text retained. However, the distracting influence of the removal and replacement of text at one part of the screen while the observer reads from another may reduce speed and ease of reading in the partial-page erasure conditions. Such competing tendencies could yield the function shown in Figure 4; the distraction would not arise with full-page erasure, and that produced by partial-page erasure would be offset less by retention of only one or two lines of text than by retention of four lines.

When only reading times and comprehension scores are considered, the full-page erasure and four-line retention conditions appear equivalent. However, when instructed to ignore story quality and to indicate their opinion of their reading condition, observers in the four-line condition tended to respond more favourably than those in the full-page condition [Modes: pleasant vs. neutral; Dispersions (Kirk, p. 73): 0.46 and 0.50]. Thus, the balance of evidence appears to favour the four-line condition.

In conclusion, the limitations of scrolling previously mentioned make it important to explore other methods of presenting passages that require more than one full screen. Of the alternatives explored in the experiment, retention of four lines of text appears more appropriate than full-page erasure.

Character Set Design

Thus far, the paper has concentrated on the spatial organization of text. The design of the character sets themselves will also affect the user's satisfaction with videotex displays. Consequently, a professional graphic artist (H-P Bronsard) was contracted to design character sets on a 5X8 matrix and on a 7X11 matrix. Figures 5, 6, 7, and 8 show the results of his work. The character set in Figure 5 is named Bronsard 3, and the character set in Figure 6 is named Bronsard 2. Figure 7 and 8 show two sizes of the international G2 character set which are also required for videotex terminals. The character set in Figure 7 is named Bronsard 3-G2, and the character set in Figure 8 is named Bronsard 2-G2.

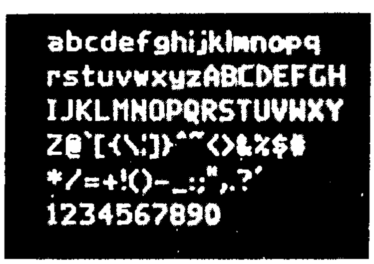

Figure 5: Character set professionally designed on 5X8 matrix (Bronsard 3).

The designs were made available to Canadian videotex terminal manufacturers. The Bronsard 2 set and the Bronsard 2-G2 set, with vertical strokes two pixels wide, are recommended for televisions using composite video input. The thicker strokes compensate for the bandwidth restriction imposed by existing television standards. All of the above sets may be used with RGB systems (where the red, green, and blue colour signals are input separately). The character set designs were optimized for display on an Electrohome Model C40 19 inch

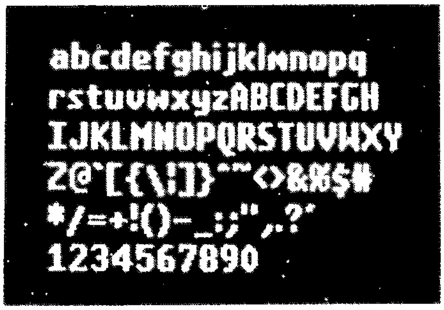

Figure 6: Character set professionally designed on a 7X11 matrix (Bronsard 2).

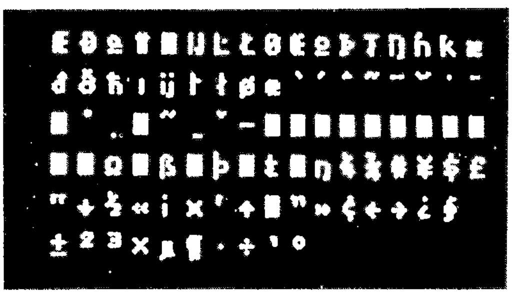

Figure 7: The G2 character set professionally designed on a 5X8 matrix (Bronsard 3-G2).

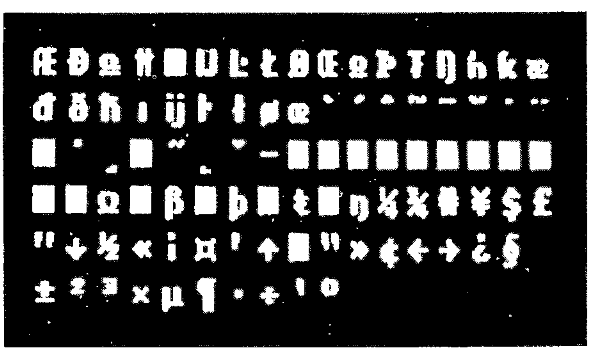

Figure 8: The G2 character set professionally designed on a 7X11 matrix (Bronsard 2-G2).

colour television set with a shadow mask consisting of relatively small rectangular colour elements. Thus, these character sets should be used with caution on other televisions with larger colour elements since undesirable effects may occur.

Larger character sets for videotex terminals have also been designed by Mr. M. Cartier, another graphic artist, in collaboration with Mr. Bronsard. These are shown in Figures 9 and 10. The character set in Figure 9 is named Bronsard-Cartier 1, and the set in Figure 10 is named Bronsard-Cartier 0. The use of these character sets is not yet practical economically because of the relatively large amount of memory required to store the character definitions. Availability of these character sets awaits a further reduction in memory costs, or the development of the ability to load character sets into the terminal when they are required.

Figure 9: Character set professionally designed on a 10X16 matrix (Bronsard-Cartier 1).

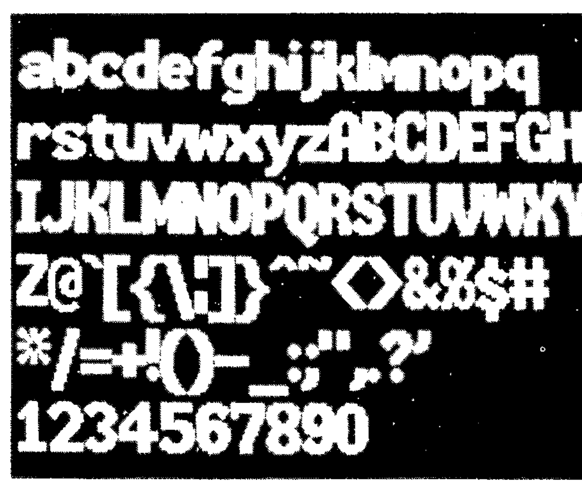

Figure 10: Character set professionally designed on a 14X22 matrix (Bronsard-Cartier 0).

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