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High school paper textbooks usability: leading and satisfaction

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Abstract

The work shows the research results of dependence of generated dissociated texts spatial structure satisfaction degree from a text spatial characteristic. The randomized sample was composed of 50 student age people from Institute of Professional Education and Information Technologies of the Bashkir State Pedagogical University, Ufa city, Russian Federation. As the only independent variable which characterizes spatial organization of the text the leading was used - total 13 grades from 0.8 to 2.2. The text printed on white paper substrates was reviewed by respondents with constant light conditions. The dependence of the page spatial structure positive assessment frequency from the leading has a maximum in range of 1.35–1.85. The ranking method offered allow to reveal the internal structure of assessments. In the field of low leadings a consensus assessment was observed in the range of 0.8–1.6. In the field of high leadings assessments were polar, therefore a bimodality was observed.

Keywords: Education, Leading, Qualimetrics, Text, Usability

Introduction

The problem of creating human-oriented products exist in almost all spheres of human activity. It is especially sharp in education. This is related to the fact that the effectiveness of the learning depends on the usability of its carriers. Currently, electronic and paper media are competing with each other. Despite the rapid development of information technology the paper media, however, is still very important in the learning process. According to ISO 9241 (1998), the usability is the effectiveness,

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efficiency and satisfaction with which specified users achieve specified goals in particular environments. In this work the question of high school textbook texts quality assessment is considered in terms of usability. The usability of texts is closely related to their readability. Readability is a property of the text material which characterizes the ease of perception of it by a man. The readability of text is related to it spatial organization. The analysis of researches in the field of readability of texts shows insufficient scrutiny of issues related to finding the best representation of the spatial characteristics of textual information. In this work text leading is selected as the only one independent variable of spatial structure of texts. Thus, the research of perception of the spatial characteristics of the type page area on the example of leading seems to be actual. The aim of the research was to investigate the student age people perception of the text-based information from the leading. The research was conducted by direct interview and questionnaire. It involved 50 respondents, which are mainly made by the students of the Institute of Professional Education and Information Technologies of the Bashkir State Pedagogical University and Ufa State Aviation Technical University.

1. Readability overview

1.1. Readability and main features of text and font

The main readability criteria of specific typographic sample is reading speed of this sample. The measure of readability is the time in which one can read the text, or the amount of text that can be read over a period of time. Also readability is one of the major advantages of a good (“readable”) font. The readability of the font is determined by speed, i.e. quickness of perception, and the readability of individual characters, and the text as a whole, as well as the accuracy of comprehension without undue stress and fatigue. When reading due to a readable font the eye pressure doesn’t increase (Glushkova, 1987), the attention concentrates mainly on the information itself, rather than the means of transmission. So it is advisable to choose a set of quality and legible fonts to text typing on the prepress stage, as well as the correct choice of other text typing parameters and layout.

Readability of font is influenced by: form of font characters, typographic composition, font definition, font clarity. Necessity of obeying the readability requirements caused by psychophysiological characteristics of man, manifested in the process of reading and understanding the text (Smirnov, 2007). Question of the font size influence on legibility in a coherent text is well studied and confirmed by practice. Most readable font size for the text connected to adult skilled readers is the size of 10 points (Dubina, 2004). Smaller font sizes are read with a lot of stress when placing signs. If the font is too small, the reader is often "lost line": having read to the end of the line, hardly finds the beginning of the next. With too large font sizes line, by contrast, are shortened, resulting in some of the transitions to the next line.

Line length also affects readability. James Felichi (2004) gives several ways to determine the optimal length of the line: it is equal to 1.5-2 lengths of all lowercase alphabetic characters line length; optimal length line should contain 9–10 words on average consist of 5 letters each; the minimum length of the line is 27 characters, the optimum length is 40 characters, the maximum length is 70 characters.

This work is focused on another spatial characteristics of page, the leading. Leading factor is calculated by dividing the line spacing to the font size (in points). Line spacing - the distance between the baselines of the text. Baseline – an imaginary line along the bottom edge of the main element of character. In Fig. 1 shows the basic lines of text, and the distance between them.

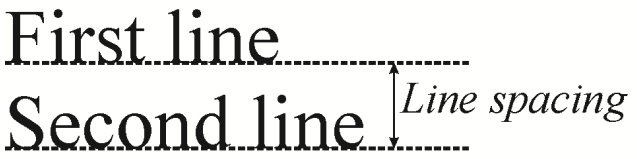

Fig. 1. Line spacing

1.2. Readability researches

History of readability research dates back more than 100 years. In 1885, Cattell (Cattell,1885) attempted to assess the readability by tachystoscopic measuring of the recognizability threshold. Tachystoscopia is allow to determine the minimum time required for recognition of characters, words, groups of words. Based on these studies, Cattell placed lowercase letters of the alphabet in their degree of recognizability in sequence. Sanford (1987) had repeated studies, but using a different font, he received another letter order. This suggests that the fonts do differ in their recognizability. Pyke (1926) summarized the results of studies of readability. Report noted the fragmentation of research and the lack of a systematic approach to the research of text recognition and readability. Pyke himself singled out 15 readability criteria and the first was reading speed. Based on the analysis, Pyke concluded that readability is not to be confused with the letters and words discernibility, it should be studied separately from the discernibility. He proposed to assess the readability by comparing the text read with that is understood when read. Thus, it was concluded that the readability should be judged not by the disparate characters, but on the examples that contain meaningful text. Then there was the question of the speed of reading. The reading speed means the amount of time which takes to read a particular text. First reading speed as a readability criteria was proposed by Weber in 1881, but actually became considered after the Pyke's report. Tinker and Paterson (1929) got the following results: text of capital letters read by 11.8% slower than typed with upper and lower letters; italics not slow reading speed, if used short; bold no less readable than light,

and sans-serif fonts are not inferior to the readability of serif fonts; fonts from a size 8 to 13 are equally readable with a size optimal for a given length of the string.

In the USSR the research of a comparative readability of fonts was conducted in 30-40's. of XX century in OGIZ research institute, in 50-60s. of XX century in the department of movable types of Polygraphmash institute. Artemov V.A. (Artemov, 1933) proposed to distinguish the concept of visibility and readability of font, as readability significantly affected by the certain physiological reading characteristics of the reader, while the visibility of the font depends on the quality of type faces and features of the person's vision. In 1973, in the Moscow Polygraphic Institute Geshev (Geshev, 1973) and Kolosov where investigated the effect of font size, string format, inter-word spacing and leading on the text readability. It was concluded that the optimal value of inter-word space is constant and independent of other factors. The optimal value of the font size and format of the string is the smaller, when the font is more readable. (Tokar, Zilbergleit, Petrova, 2004) Also since the late 19th century, there have been many studies on the optimal line length for printed publications made, but the ideal solution has not appeared. Wide paragraph gives the best results in reading speed, but eyes get tired faster. In a long line, the eye has to overcome a greater distance, making it harder to find the following line (Vakorin, 2005). Readability is also associated with the color. The human eye is much easier to perceive colored letters on a colored background (Teksheva, 2008). If we collect the results of research, it is possible to draw some conclusions (see Table 1).

1.3. Description of some known methods

Noted to the facts listed above objective methods of readability surveys have been formed. They can be divided into two groups:

1. Methods which aimed primarily at researching legibility of words, individual characters and their combinations:

a) tachystoscopia;

b) determination of the threshold distance;

c) determination of the illumination threshold;

d) optical measurement of visibility.

2. Methods that are relevant to the research of reading:

a) measurement of the reading speed;

b) registration of eye movements during reading;

c) registration of blink frequency;

d) counting the number of errors when reading aloud.

Table 1. Researches to determine the optimal length of a line of text

Inverstigator	Optimal length of text line, cm	Notes
Weber (1881)	10.0	Maximum line length 15 cm
Tinker, Paterson (1929)	7.5–9.0	Used black text on white paper, size 10 pts, Paragrphs with length 18,5 cm read slower than the others
Cohn (1883)	9.0	Maximum line length 10 см
Duchnicky and Kolers (1983)	18.7	Line 18.7 cm read faster by 28% than 1/3 of the screen - 6.2 cm
Dyson and Keeping (1998)	18.2	Used text 12 points. Tests have shown that reading speed increased along with the number of characters per line. The slowest readable text length 10 cm
Youngman and Scharff (1998)	20.0	Used text 12 points. 20 cm have been optimized for speed reading, but users preferred length 10-12.5 cm
Bernard, Fernandes and Hull (2002)	24.5	Used text 12 points. This test did not reveal any difference in reading speed between the three sizes - 24.5 cm, 14.5 cm and 8.5 cm. But adult users choosen 2 shorter lengths.

Tachystoscopia allows to determine the minimum exposure time required to recognition of characters, words and groups of words. The disadvantage of this method is the fact that sometimes parts of images are detected before the end of the exposure, thus suggesting the correct answer. This method is more suitable for assessing the distinctiveness of individual characters, than to measure the readability of solid text. The method of determining the threshold distance. The set of some signs placing at a certain distance from the observer, so that he could not recognize them. Then they are getting closer to that range until the observer begins to identify them correctly However, this procedure is suitable for the selection of fonts for posters, signs, ads, urban orientation system, where a few words have to be read from a distance. Method of optical measurement of visibility is used with an optical device, which measures the visibility of images from a common to read distance. Changing the lens focusing, the observer determines the point at which the image is recognizable. The result is

approximately corresponds to the threshold distance. In the method of the research of the reading process to count the number of errors the subject must read the text aloud, and the experimentally found that the rate of such reading would be about three times slower than reading silently. Therefore, in this method, as the readability criteria it should choose not text read time, but the number of errors recorded in the reading process. But at the same time reading aloud is not typical and is not familiar to most skilled readers. Errors when reading may be due to the forced text pronunciation. The value of eye movements registration method in reading is that as a result of its use some features of the process of reading have been set. As a result of experiments conducted by S.E. Taylor (Taylor, 1966), (Taylor, 1965), it was found that the speed of reading is characterized by a large individual variation even among subjects with the same reader's qualifications.

The most objective and functional method of readability researching is considered to be method for reading speed measuring. It is to determine the time of reading a connected or disconnected text of a given size. Another embodiment of the method is to determine the number of characters read by the subjects over time (Tokar, 2011). And this method is used in this work. In this research, the text reading speed was adopted as a main criterion of specific printing solution in the hard copy version readability. When considering the various leading readability some contradictions that have led to finding the optimal ratio spacing for printed and electronic texts have been found. It’s attempted to identify the laws relating the perception of the text and its spatial characteristics.

2. Sampling and procedure

2.1. Sampling

As respondents 50 students (age 20-22) were selected. The experiment was conducted in daylight once a week in the classroom of the Bashkir State Pedagogical University, Ufa city, Russia. As a stimulus material 13 dissociated (meaningless) texts of 1000 characters were specially generated. It was made to eliminate the cognitive aspect from the perception which could affect the reading speed. Texts where placed to individual pages with different leading values and under identical set of other (knowingly readable) parameters: font Times New Roman, font size 14 points, margins 2 cm, indentation 1.25 cm, justification for the width of the page, text color is black, paper color is white. Selected leadings (according to MS Word) shown in Table 2. Stimulus material was printed on writing paper A4, 80 g/m^2 by laser printer KMbizhub C220. The average line length was 164.84 mm and 73 characters (include spaces). In addition line spacings and leadings on all pages were measured by microscope with a metric ruler, and metric leading factors were calculated (see Table 2).

Table 2. Values of line spacings and leadings on the samples

Leading (by MS Word)	**0.8**	**1.0**	**1.1**	**1.2**	**1.3**	**1.4**	**1.5**	**1.6**	**1.7**	**1.8**	**1.9**	**2.0**	**2.2**
Line spacing, mm	4.56	5.66	6.21	6.80	7.35	7.95	8.54	9.04	9.64	10.18	10.78	11.33	12.50
Font size, mm	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.50	4.50
Calculated leading factor	1.01	1.26	1.38	1.51	1.63	1.77	1.90	2.01	2.14	2.26	2.40	2.52	2.78

In the experiment the perception of the paper printed text patterns has been evaluated. Respondents were asked to read the series of 13 variants of stimulus material with a comfortable for themselves speed, without gaps or repetitions. Reading time of each page was controlled with stopwatch. Once reading of each 13 texts is completed, respondents made notes on the reverse side of the sheet: pleasant or unpleasant there was to read the text. After reading all of the material respondents, freely looking through, without paying attention to the content, laid out sheets left to right on a table in ascending order of perception comfort of the spatial structure only. Then every

sheet was numerated by number from 1 to 13 according to the order in which the sheets were laid out. Thus, the number “13” was assigned to the most satisfied text (text with most perception comfortability).

2.2. Data preparation and processing

For the preparation for processing of data obtained during the experiment Microsoft Access 2007 was used. The file structuring the data obtained was created in the program. Values of time spent on reading the text of 1 000 characters were transferred to the values of reading speed in characters per second. For data processing a parametric and non-parametric statistical tests were used (Serpik, Yagudina, 2010). When processing results Z-test and non-parametric Mann-Whitney U-test was used and calculated in Statistica 10.

3. Results and discussion

3.1. The satisfaction of texts

For drawing the plot of dependence of printed text satisfaction from leading (Fig. 2) the proportions of responses "nice" were calculated. According with the curve on the plot it can be concluded that the maximum located in the interval form 1.35 to 1.85. It is assumed that the maximum expressed implicitly due to insufficient data. To check the statistical significance of the observed differences a z-test was conducted 6 times. Proportions corresponding to the leadings of 1.5 and 1.7, 1.4 and 1.8, 1.3 and 1.9 with maximum proportion of leading 1.6 where compared.

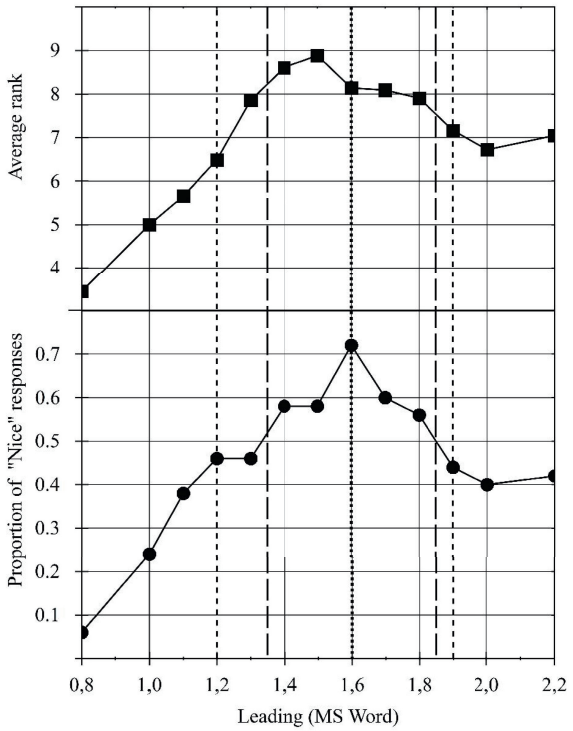

Fig. 2. Dependences of satisfaction from leading

That calculations were made to find the proportion of "*nice*" responses, in which achieved p-value would have been less than the given significance level $\alpha = 0.05$. Thus desired proportions corresponding with borders of interval of leadings from 1.35 to 1.85 have been found. This result confirms the assumption that the probability of a positive assessment of the spatial structure of the page on leading has a maximum. In particular, the observed maximum located in the interval (1.35-1.85).

3.2. Ranking procedure

In the last stage of the experiment respondents assign ranks from 1 to 13 to texts in ascending order of perception satisfaction of the text spatial structure. Table 3 shows the matrix of rank frequencies. Ranking procedure has revealed the internal structure of rates: the table shows that in the "high" leadings the bimodality is observed. The presence of bimodality talks about the differences by some sign within the sample.

Normally, the average rank calculation is incorrect, but in this case it was used to evaluate the best leading, because distribution appeared bimodal. For further calculations the values of average ranks, standard deviation (SD) and coefficient of variation were determined. Table 3 shows that the lowest coefficient of variation and standard deviation match the leading 1.5. The dependence of average rank from leading shown in the plot in Fig. 2. The plot shows that the maximum is reached at the point corresponding to the leading of 1.5. Such it's concluded that the most satisfaction of text perception found with leading of 1.5. Fig. 3 shows a 3D bar chart constructed on the basis of the matrix of rank frequencies (Table 3). The diagram shows that the best unimodality achieved with leading of 1.5. This shows the least variation in estimates, i.e. most consensus of opinions among the respondents.

Table 3. Matrix of rank frequencies

		Leading												
		0.8	**1.0**	**1.1**	**1.2**	**1.3**	**1.4**	**1.5**	**1.6**	**1.7**	**1.8**	**1.9**	**2.0**	**2.2**
Ranks	**1**	**0.63**	0.02	0.02	0.00	0.02	0.00	0.00	0.02	0.00	0.05	0.02	0.05	**0.16**
	2	0.07	**0.35**	0.05	**0.14**	0.05	0.02	0.00	0.02	0.02	0.00	0.02	**0.12**	**0.14**
	3	0.02	0.09	**0.33**	0.02	0.02	0.02	0.00	0.07	0.07	0.07	0.05	**0.16**	0.07
	4	0.02	0.09	**0.12**	**0.19**	0.05	0.09	0.02	0.00	**0.12**	0.05	**0.16**	0.05	0.05
	5	0.00	**0.12**	0.09	0.09	**0.21**	0.09	0.02	0.05	0.02	0.09	0.09	0.09	0.02
	6	0.05	0.02	0.07	0.09	0.07	**0.14**	0.09	0.09	0.07	0.05	**0.16**	0.05	0.05
	7	0.02	0.07	0.05	0.05	**0.12**	0.02	**0.26**	**0.12**	0.05	**0.12**	0.05	0.05	0.05
	8	0.05	0.02	0.07	**0.16**	0.02	0.00	**0.14**	**0.19**	0.05	**0.12**	0.07	0.09	0.02
	9	0.00	0.07	0.02	0.09	0.07	**0.19**	0.09	0.09	**0.21**	0.09	0.02	0.02	0.02
	10	0.02	0.02	0.07	0.00	0.07	0.05	0.02	**0.12**	**0.23**	**0.16**	**0.14**	0.02	0.07
	11	0.00	0.02	0.05	0.07	0.07	**0.12**	**0.14**	0.07	0.07	0.07	**0.14**	**0.16**	0.02
	12	0.05	0.09	0.00	0.07	0.09	0.09	**0.12**	**0.12**	0.05	0.07	0.07	0.09	0.09
	13	0.07	0.00	0.07	0.02	**0.14**	**0.16**	0.09	0.05	0.05	0.07	0.00	0.05	**0.23**

Average rank	3.40	5.00	5.70	6.50	7.90	8.60	8.90	8.10	8.10	7.90	7.20	6.70	7.00
Standard deviation	4.03	3.4	3.31	3.16	3.51	3.31	2.46	2.97	2.94	3.18	3.09	3.87	4.78
Coefficient of variation	1.17	0.68	0.58	0.49	0.45	0.38	0.28	0.36	0.36	0.40	0.43	0.58	0.68

To determine the interval of leading which contains maximum average rank the Mann-Whitney U-test with significance level $\alpha = 0.05$ was used. The sample corresponding to the leading of 1.5 was compared in turn with the samples, relevant to nearby leadings (1.2, 1.3, 1.4, 1.6, 1.7, 1.8, 1.9). This procedure was similar to the procedure of proportion comparison. Thus, it can concluded that the maximum average rank lies in the range of leading from1.2 to 1.9.

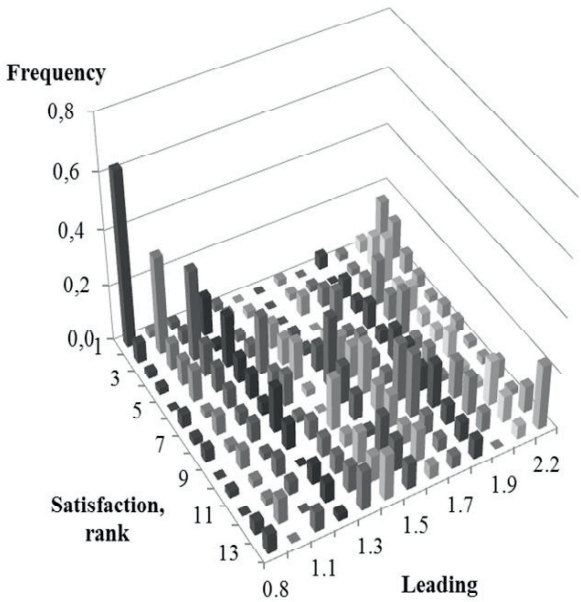

Fig. 3. 3D bar chart constructed on the basis of the frequency table

4. Conclusion

When considering the question of usability with various leadings some contradictions have been found. It has led to the need to find the optimal leading for textbooks. We attempted to identify the

features relating the satisfaction with perception of the text depending from its spatial characteristics.

The analysis of the literature led us to the formulation of hypotheses: the probability of a positive assessment of the spatial structure of the page varies with a leading variation. To test the hypotheses experiments with 50 student age respondents were designed and conducted. Then developed a method of processing the data, allowing to obtain the valid conclusions in terms of research objectives.

Analysis of the text perception data and using Z-test showed that the page spatial structure positive assessment probability on the leading has a maximum in the interval from 1.35 to 1.85. To verify this conclusion the Mann-Whitney test has been used. With this criterion the interval of leadings 1.2-1.9, which contain maximum average rank relevant to the leading 1.5 was defined.

The text spatial structure perception data ranking method also helped to identify the sample heterogeneity caused by differences on the unknown attribute inside the sample.

Results of the research can be used to optimize the texts makeup in education in order to facilitate its perception, which will improve the quality of information assimilation. Because the text perception is culturally conditioned it’s very important to conduct the same research in different culture media and for different languages.

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