Adaptation Algorithm of the Computer Text Font Size for Optimal Perception

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Abstract. The paper presents the result of the research of the influence of text font size on attention indicators. On the basis of the experimental data, the multiple linear regression of the dependence of the optimum of the font size on the criterion of maximizing the value of mental efficiency indicator from the indicators of attention and memory of the subject was constructed. An algorithm for adapting the font size of text for optimal perception is presented.

Keywords: memory, attention, font size, mental performance, psychophysiological testing, optimal font size, forecasting model, adapting algorithm.

1 Introduction

Perception is an important part of the communicative process. It affects the efficiency of receiving and assimilation of information flows. Sometimes perception is connected with examining of certain objects, which are basically combination of imaginary and text information. Increase of information volumes and appearance of new types of devices results in searching of effective items of its representation [1].

It is important to consider the influence of parameters of the provided text information, in particular a type of a font and its size, on perception of the text. However, there is no information on personification of type size in relation to the specific person.

Perception of text information and level of its assimilation depends on measure values of cognitive processes of the person working with it. That is why the current values of such indices can be selected as criterion of change of type size. There is a sense to stop on a choice only of processes of memory and attention as they generally cause perception of information and its storage, which is important in process of work with information.

The aim of the work is the research of influence of type size of the provided information on indices of attention and creation of the algorithm for adapting the font size of text for optimal perception.

To achieve this goal, the experimental research will be carried out. The stages of the research will be as follows.

1. The choice of psycho-physiological tests for the evaluation of indicators of cognitive processes. Use the test containing letters of different font sizes.
2. Carrying out an experiment and testing a group of subjects.
3. Data collection and processing.
4. Building the regression model of dependence of optimum type size on indexes of cognitive processes of the examinee.
5. Development of the adaptation algorithm of the text font size for optimal perception.

We can consider the works similar to this theme.

In [2], Peng Chengyuan et al. present an adaptive text extraction method to represent text on devices with a small display which can automatically extract key information from original text and keep semantic meanings as close as possible. The authors suggest combine both statistical methods and coarse coding algorithm from neural science to shorten long text sentences in terms of generalization. In [3], Benedicenti Luigi et al. present an expert system that can support dynamic interface adaptation. This will allow an ubiquitous applications to reformat their interface depending on the screen real estate they are granted.

Basically human examining of different objects connected with certain regularities of perception and attention and can be subjected to errors and distortions [4], [5], [6]. Some of them can lead to different negative phenomena and consequences. Adverse conditions for perception of information flows increase an operating time and reduce the volume of the acquired information. That is why researching of features of information perception including text information and creating optimum working conditions with information and its representation is an actual aim.

Perception of the examining information depends on its representation. For example, in [7], [8], Andreeva O.N. describe influence of location of information screen objects of the monitor on time and accuracy of their recognition. This and other features should be considered in case of design of new telecommunication interfaces [9]. In [10], Koumpis A. et al. offer the use of the text media type and present possible adaptations of it, with respect to the particular needs, abilities and preferences of diverse user categories, including disabled people. Moreover in case of design and using of electronic items it is important to consider specific and psychophysiological features [11], [12], attention index [13], [14].

Due to the development of electronic studding systems many labors are devoted to increasing of efficiency of submission of educational information [15]. It is one of the directions of the concept called by pedagogical design [16], [17]. It is used for creating study curse, its design and interface, creating educational materials.

The research of use of special fonts in systems of visual navigation that help to be guided in the best way in city space is described [18]. The legibility of fonts for design of texts of official papers by means of reading time dimension is research [19]. In this result the regression model of computation of a rank of a font in its geometrical parameters is described [19].

Research of features of perception of the most often used type fonts [20] based on methods of electroencephalography and oculography shows that type fonts differ not only graphic signs, but also have the psychophysiological specifics defining quality of perception of the text, his understanding and storage. There is the conclusion concerning what fonts it is the most rational to use by criteria of the largest speed of reading, readability, smaller exhaustion of the visual analyzing and the spent cognitive efforts is drawn.

On the basis of an assessment of legibility of fonts in electronic issuing by method of paired comparing and by method of speed sensing of reading in [21] revealed that grotesque fonts have advantage over serif types.

The tachistoscopic experimental research of visual sensation of meaningless text information on the display are carried out [4]. Dependence of perception of the information on type size which is characterized by certain preferable strategy of relocation of eyes is shown.

2 Choosing of psychophysiological tests

Indices of attention and short-term memory can be determined by results of psychophysiological testing with use, for example, of proof test [22] and the test for storage of numbers [23]. The main reason of a choice of proof test is that the training practically does not exert the considerable impact on test results. Besides, the possibility of further implementation and automation of conducting testing in an information display system was considered.

In case of a choice of option of proof test stopped on Burdona-Anfimov's test as it can be easily automated (in comparison with Landolt's rings and tests with Ivanov-Smolensk modification) and its execution is a little more difficult for the adult user, than at Burdon's test [22]. It is important for an assessment of abilities of examinees of different level for a short period of time.

Correction test of Burdon-Anfimovs [22] is the technique intended for a research of stability and productivity of attention, calculation of an index of fatigue, determination of mental working capacity. This technique consists in presentation to the examinee of lines from a random series of letters of the Russian alphabet which it shall view and eliminate two given letters sequentially. Results of test are estimated by quantity of the passed signs, on runtime or by quantity of the viewed signs [22].

The results of Burdon-Anfimov's test define main indexes of attention: index of mental working capacity A_{mp}, attention performance index A_p, level of concentration of attention A_{ca}, quality of working A_{qw} [22]:

$$A_{mp} = \frac{N}{t} \cdot \frac{M - (O + P)}{n}, \tag{1}$$

$$A_p = \frac{N}{t}, \tag{2}$$

$$A_{ca} = \frac{S - P - O}{n}, \tag{3}$$

$$A_{qw} = 1 - \frac{O + P}{N}, \tag{4}$$

where N is number of characters in the part of proof test worked by the examinee; t is runtime of the test in seconds; M is total number of the crossed-out characters; O is number of incorrect crossed out characters; S is number of correctly crossed out characters; P is number of the passed characters; n is number of characters which needed to be eliminated in the viewed part of proof test.

These indexes characterize operation with text information. So the performance measure of attention corresponds to number of the letters viewed in unit of time, an index of mental working capacity is to number of the letters viewed in unit of time taking into account existence of errors. The figure of merit of operation is equal 1 in the absence of errors and decreases in case of their appearance of subjects more, than the number of the passed and incorrect eliminated characters are more. Level of concentration of attention shows a share of truly crossed out letters from total number of characters which needed to be eliminated.

For testing of abilities of a short-term memory is selected the test for storage of numbers. This test consists in presentation to the examinee of 10 different double-valued numbers which it shall reproduce on memory after their viewing within 30 seconds [23]. Coefficient of a short-term memory K_{sm} it is calculated by a formula:

$$K_{sm} = \frac{K}{L}, \tag{5}$$

where K is the quantity of correctly reproduced double-valued numbers, L is number of the initial numbers.

3 Procedure of the research

For the research of influence of type size of the text on indices of attention and creation of a mathematical model of dependence of optimum type size on indices of attention and memory of the examinee the following series of experiments was conducted:

1. Carrying out method
   (a) Participants. Participants of an experiment were 30 students of 3-5 courses of the Ryazan State Radio Engineering University. Number of males is 15, women's is 15. Average age of participants is about 21 ± 0.8 year.
   (b) Materials. For carrying out an experiment 4 types of forms of Burdona-Anfimovs differing only in type size of letters were used 10 pt., 12 pt., 14 pt., 16 pt. Also was used the record of 10 double-valued numbers (L=10).
   (c) Procedure of the research. Experiments were made in the first half of day in 3 days at groups till 8-12 of people. External conditions at all groups were created identical. After briefing and explanations of a sense of an experiment examinees passed trial test for memory and attention. At the same time examinees were told two letters which they shall look

for and eliminate in attention tests. Further record of 10 double-valued numbers was shown and the memory test was executed. Then forms of the test of Burdona-Anfimov which type size 10 pt. were distributed and examinees were doing it within 5 minutes. Tests with type size 14 pt. and 16pt. were similarly executed.

2. The results
   For each examinee by results of execution of proof test and the test for memory the set of the following values used in formulas (1)-(5) was created: N, M, O, S, P, n, K. The results are in the Table 1.

Table 1. Results of the experiment (Average value)

Index	Average value	For font size 10	For font size 12	For font size 14	For font size 16
N	459.7 ± 35.6	449.5 ± 34.6	444.9 ± 48.3	465.9 ± 23.0	478.4 ± 20.4
M	26.4 ± 6.7	29.0 ± 9.1	24.3 ± 5.6	28.1 ± 4.2	24.1 ± 5.8
O	0.03 ± 0.2	0.03 ± 0.2	0.03 ± 0.2	0.03 ± 0.2	0.0 ± 0.0
S	26.7 ± 6.5	30.1 ± 7.8	24.3 ± 5.6	28.2 ± 4.2	24.1 ± 5.8
P	3.0 ± 2.6	3.3 ± 3.0	2.7 ± 1.9	3.3 ± 3.2	2.7 ± 2.0
n	29.7 ± 6.0	33.5 ± 6.8	27.0 ± 5.2	31.5 ± 2.8	26.7 ± 5.8
K	6.7 ± 0.24				

3. Processing of results of the experiment
   Processing of results of the experiment was carried out in a statistical packet of R. By results of the experiment on the basis of values N, M, O, S, P, n, K for each examinee, is created the set of 30 observations with the following variables calculated by formulas (1)-(5): A_{ca1}, A_{mp1}, A_{p1}, A_{qw1} where $x = 10$;
   A_{ca2}, A_{mp2}, A_{p2}, A_{qw2} where $x = 12$;
   A_{ca3}, A_{mp3}, A_{p3}, A_{qw3} where $x = 14$;
   A_{ca4}, A_{mp4}, A_{p4}, A_{qw4} where $x = 16$;
   K_{sm};
   where x is type size in Burdona-Anfimov's test.

In the received results the dispersion of values was watched. We will mark that the task is directed to creation of model for prediction of optimum type size on indices of memory and attention. Therefore the measure values received, for example, after classes or in the evening when in most cases measure values of cognitive processes are lowered, can be also used for prediction of optimum type size. We visualize the received attention measure values with the boxplot (Fig. 1). This figure shows the median (bold line in rectangles), quantiles and the values located between them (rectangles) and range (line with the mustache) of the corresponding indicators and illustrate the results obtained as a result of the experiment.

Histograms of attention indexes based on proof test results with the type 10 pt. are represented on the Fig. 2. Due to the Shapiro-Wilk test value distributions

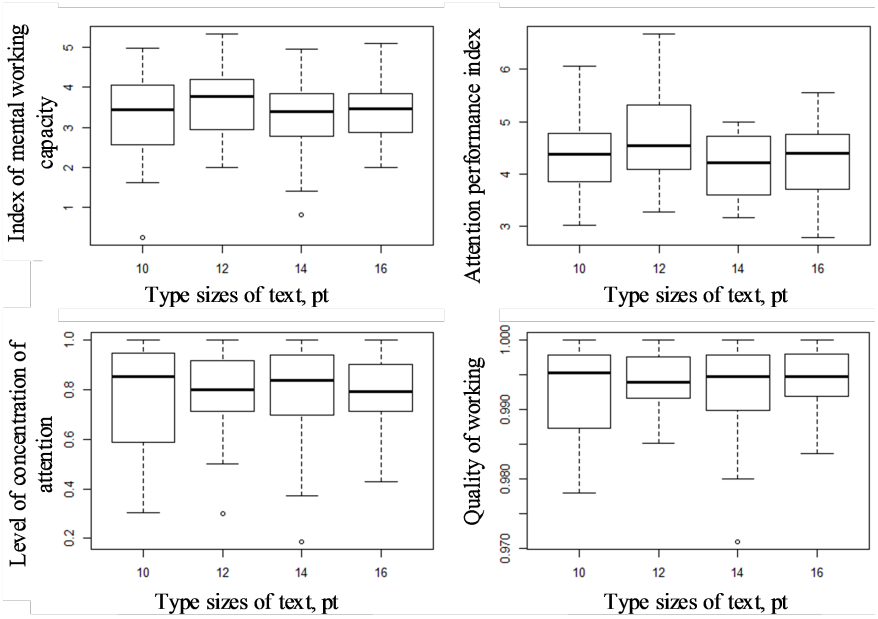

Fig. 1. The boxplot of the received attention index in case of different type sizes

of indexes of mental working capacity and productivity of attention are normal ($p > 0.05$). Value distributions of indexes of attention concentration level and accuracy of operation aren't normal and are offset to the right. It is connected to the fact that the greatest possible value of these indexes is equal to unit and corresponds to faultless execution of proof test, and the most part of examinees executed this test correct or almost correct. It isn't excluded that if time of carrying out an experiment was big, then it would lead to increase in number of errors owing to rise of exhaustion and as result, to offset of value distribution of these indices to the left and its approaches to normal.

4 Regression model of dependence of optimum type size on indexes of cognitive processes of the examinee

In general it is possible to set different optimization tasks on operation with text information, for example, minimum time of viewing, the minimum number of errors, the maximum volume of viewing.

The minimum values of such parameters of operation will lead to maximizing values of certain indices of attention.

Therefore in case of creation of regression model it is necessary for each examinee to define type sizes y_1, y_2, y_3, y_4 in case of which the maximum values of the appropriate indices of attention are watched:

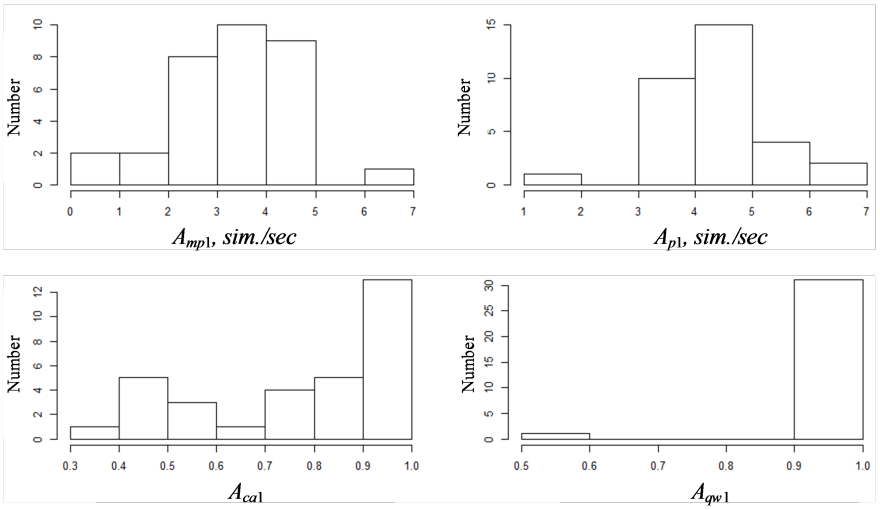

Fig. 2. Histogram of distribution of indices of attention A_{ca1}, A_{mp1}, A_{p1}, A_{qw1}

$$\begin{aligned}
&\text{at } y_1 \text{ obtained} \max(A_{mp1}; A_{mp2}; A_mp3; A_{mp4});\\
&\text{at } y_2 \text{ obtained } \max(A_{p1}; A_{p2}; A_{p3}; A_{p4});\\
&\text{at } y_3 \text{ obtained } \max(A_{ca1}; A_{ca2}; A_{ca3}; A_{ca4});\\
&\text{at } y_4 \text{ obtained } \max(A_{qw1}; A_{qw2}; A_{qw3}; A_{qw4}).
\end{aligned} \tag{6}$$

Let us set the task of a prediction of optimum type size y in case of which minimum time of viewing of the text with the minimum number of errors is watched, that corresponds to the maximum index of mental working capacity, on measure values of proof test of a certain type size, for example 10 pt.

$$y_{\text{opt}} = f(A_{mp1}, A_{p1}, A_{ca1}, A_{qw1}, K_{sm}). \tag{7}$$

So, the set of values of the predicted variable will consist of sets of y_1 values of each examinee. Set y_1 was chosen with the figure that it based on the A_{mp1} value that calculates both the operating time, and number of the made mistakes.

Values A_{ca1}, A_{mp1}, A_{p1}, A_{qw1} are defined from values N, M, O, S, P, n, K, which were received in tests. From the point of view of formulas (1) and (2) the value A_{p1} is a part of A_{mp1}. To estimate a possibility of switching on of these, as well as others, indices at model, we will realize verification of presence of multicollinearity in the coefficients of inflation of dispersions this by determination between couples of values. We have the maximum value of such coefficient between A_{ca1} and A_{mp1} equal 1.31. Therefore, the problem of multicollinearity is absent and it is possible to include all considered attention indices in model

Except checking out on multicollinearity, there was the check of premises of the linear model.

As a result of regression analysis multiple linear regression of a look was received

$$y_{\text{opt}} = a_0 + a_1 \cdot A_{\text{ca1}} + a_2 \cdot A_{\text{mp1}} + a_3 \cdot A_{\text{p1}} + a_4 \cdot A_{qw_1} + a_5 \cdot A_{\text{sm}} \quad (8)$$

with $R^2 = 0.4329$ ($F(5, 24) = 3.664, p < 0.05$).

More successful model from the point of view of R^2 value, which is differ from value in model (8) is multiple linear regression with interactions:

$$y_o pt = a_0 + a_1 \cdot A_{ca1} + a_2 \cdot A_{mp1} + a_3 \cdot A_{p1} + a_4 \cdot A_{qw1} + a_5 \cdot K_{sm} + \\ + a_6 \cdot A_{ca1} \cdot A_{mp1} + a_7 \cdot A_{mp1} \cdot A_{qw1} + a_8 \cdot A_{p1} \cdot A_{qw1} \quad (9)$$

with $R^2 = 0.6418$ ($F(8, 21) = 4.703, p < 0.01$).

In that model coefficients have values:

$a_0 = -460.86, a_1 = -7.65, a_2 = 117.34, a_3 = 177.89, a_4 = 479.5, a_5 = -0.58, a_6 = 7.39, a_7 = -112.19, a_8 = -179.66$.

So, the model which allows to predict optimum type size of the text for obtaining the maximum level of mental working capacity on indices of memory and attention, defined in case of type size 10pt. is received. In case of obtaining the fractional values of type size received on model it is necessary to carry out its rounding to the next value to within 0.5.

5 Adaptation algorithm of the text font size for optimal perception

The received model of dependence of optimum type size on indices of cognitive processes of the examinee can be used in perspective display systems of information which have potential of personification and can change automatically parameters of the displayed information depending on personal properties and the user's indices. In this case such systems shall possess modules for an assessment of measure values of memory and attention.

The following algorithm of operation of a perspective display system of information with the built-in software module exercising control of type size of the provided text information is offered:

1. After user login it is offered to pass Burdona-Anfimov's test with type size 10pt., and then the test for storage.
2. By results of passing of these tests on formulas (1)-(5) there is a calculation of measure values A_{ca1}, A_{mp1}, A_{p1}, A_{qw1}, K_{sm}.
3. Proceeding from the received measure values of attention and memory, on a formula (9) is performed the calculation of best value of type size y_{pt}.
4. The output of text information is carried out with type size y_{pt}.

5. If works is carried out with the text for a long time and probably rise of exhaustion, then the user is offered to pass repeatedly these tests for the purpose of obtaining new value y_{pt}. The duration of a period of the continuous working with information, on which termination is necessary to multiple definition of values A_{ca1}, A_{mp1}, A_{p1}, A_{qw1}, K_{sm} y_{pt} depends on individual users features. The assessment of its value is a subject of future research.

In the offered algorithm the model is used (9). It was received with test of Burdona-Anfimov on paper forms. According to researches reading the text from the screen is carried out for 25% more slowly, than at paper form. It will be visible in attention indexes A_{mp1} and A_{p1}. The model will predict best value of type size in case of such values. And if the monitor reproduces information 1:1, then the received best value can be used without any changes. In general it is planned to conduct the research specifying this moment and need of adjustment of the predicted value of type size depending on monitor type.

6 Conclusion

Efficiency of perception of computer information is influenced by a set of factors, including its representation and users psychophysiological status.

The research conducted in labor on the example of use of proof test showed change of measure values of attention in case of change of type size of the shown text. On the basis of the data obtained as a result of an experiment the model of dependence of an index of mental operability of type size, optimum from the point of view of maximizing, on indexes of attention and memory is constructed. For increase in coefficient of determination it is necessary to include in model bigger quantity of factors, including measure values of other cognitive processes and parameters of text information. Also the forecasting accuracy of optimum type size can be raised due to specification of coefficients of model when carrying out bigger number of experiments, including using bigger number of the sizes of fonts.

The received model allows predicting optimum type size for the specific user and can be used in perspective display systems of information for personification of parameters of the output text information. As an example of such systems where the problem of optimization of layout of information and application of the offered algorithm of adaptation of type size is urgent, it is possible to give systems of e-learning and interactive electronic technical manuals with which different experts work at post-production stages of life cycle of difficult knowledge-intensive products.

Further working in this direction assumes carrying out experiments taking into account bigger number of factors. For example colors, line spacing, the size of area of the screen on which the text is provided etc. Also there will be research of influence of exhaustion on value of optimum type size. Some of such researches are planned to be conducted with use i-tracker, realizing the analysis of movement of a look of the examinee. The statement of criterion of optimization

of information representation not only on the basis of maximizing one index of attention, and on the basis of integral criterion is of interest.

Moreover, more difficult process can be considered. Such as understanding, including not only the perception of information, but also its comprehension and the analysis.

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