



Experimental Study Based on Impacts of Time Pressure on Human-Computer Interaction Performance

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Abstract. According to studies, time pressure is a key factor impacting human-computer interaction performance. In an appointed task, the time pressure can be controlled by testing and designing a quota time length. In this paper, simulations and studies were conducted on the impact of time pressure on human-computer interaction performance through numerical calculation and input experiments. Through comparative analysis of experiment data, the impact of time pressure on numerical calculation and input performance, together with the changing pattern, was obtained. The human-computer interaction performance could be promoted if the pattern obtained from the experiment was applied to practical human-computer interactions and a reasonable time pressure was regulated and exerted by setting quota time lengths for specific interaction tasks.

Keywords: Time pressure · Quota time
Human-computer interaction performance · Numerical calculation and input
Interaction efficiency · Interaction accuracy rate

1 Study of Human-Computer Interaction Theory

With the study standard as a reference, the human-computer interaction process at the overall human-computer interaction logic level contains three links, namely information input, information processing, and information output [1]. At the level of human-computer interaction relations, there are many factors affecting human-computer interaction performance. According to analysis conducted by statistical software, time pressure has a great impact on human-computer interaction performance [2].

2 Study of Time Pressure Theory

For an assigned task in the human-computer interaction, if a quota time is set for this task, the person performing the task will feel pressure, that is, the time pressure, which can comprehensively reflect the adequacy and inadequacy of the quota time set for completing the task. With the time pressure evaluation standard as a reference, the intensity of time pressure in an assigned task can be measured according to the ratio of

the actually available time to the time perceived to be needed [2]. The calculation formula is:

$$T_p = \frac{T_R}{T_C} \quad T_R \neq 0, T_R \in (0, +\infty) \quad (1)$$

where TP represents time pressure, TR represents the actually available time for the completion of the assigned task, namely, the quota time, the length of which can be determined and set according to the assigned task. TC represents the time perceived to be needed for completing the task, which, according to the minimum output principle, is usually longer than the quota time [2]; The smaller the ratio of the two is, and thus the higher the TP (time pressure) is, and vice versa.

3 Experiment of the Impact of Time Pressure on Human-Computer Interaction Performance

3.1 Experiment Contents and Methods

The experiment design requirements include that: the experiment task should be well ordered and logic, contain input, processing and output links, and control the difficulty of the experiment task, so that the experiment can accurately reflect the information input, processing and output links in the practical human-computer interaction process and reduce the errors. Thus, this study used a numerical calculation and input experiment commonly used in human-computer ergonomical studies. So the performance of the experiment tasks included three processes, namely, numerical recognition, numerical calculation, and result output. Thus human-computer interaction process was simulated based on numerical calculation and input. In the experiment, the number and difficulty of tasks were controlled, different time pressures were reflected by the different lengths of quota time, and a study was conducted on the impacts of different time pressures on the performance of assigned experiment tasks.

In conclusion, with the standard for designing ergonomic experiments as a reference, the experiment samples were calculated and input through addition and subtraction of figures smaller than 10. The contents of the samples were 100 randomly generated calculation questions of addition and subtraction of figures smaller than 10. The test objects calculated and input the contents of the experiment samples respectively.

The experiment consisted of four stages, namely, preparatory experiment, validity experiment, formal experiment, and experiment result analysis. The preparatory experiment determined the average value and standard deviation of the time taken by the test objects to complete a numerical calculation and input task, and the corresponding quota time under no time pressure was determined based on the time pressure study standard. Then, the corresponding quota time under different time pressures was gotten one by one through calculation based on different pressure coefficients stated in the standard. Then, validation was conducted on the validity of quota time gotten from the preparatory experiment, so as to provide a basis for the setting of independent variables in the formal experiment. The contents and form of the tasks in the formal experiment took those of the

preparatory experiment as references. The independent variables were different time pressures, the dependent variables were numerical calculation and input performances, and at last, through experiment result analysis, the results delivered by the formal experiment were summarized and analyzed.

3.2 Test Objects

To reduce experiment errors and raise the reliability of results, the conditions of screening people to be test objects were that: 50 people were randomly selected from 100 NUST students volunteering to participate in this experiment, including 25 male students and 25 female students at 20–25 years old, 22.8 years old on average, with a standard deviation of 0.91, and they were healthy undergraduate or graduate students with normal thoughts and logic and usually handling things with right hand.

3.3 Experiment Equipment and Software

The hardware equipment in this experiment was a laptop of Asus G60VW6700, with an operating hardware environment of Intel Core i7 CPU 3.6 Ghz. Its display part was 15.6" LED display screen of the laptop, with a resolution ratio of 1920*1080 and a refresh rate of 60 Hz. The experiment program was designed and programmed with Quiz Creator software. As a powerful test question producing tool, Quiz Creator can create and evaluate test questions as well as output and analyze test results accurately [3].

3.4 Preparatory Experiment

The fifty test objects conducted the experiment tasks as per the procedures of the preparatory experiment in turn. After every test object completed the task of the preparatory experiment correctly, the total time taken to perform the task was output. Through SPSS 23.0 was used to conduct descriptive statistics on the values of time taken by the fifty test objects to complete the task of the preparatory experiment, which is shown in Table 1:

Table 1. Descriptive statistics of values of time taken by the fifty test objects to complete the preparatory experiment task

Time taken to complete the experiment task (S)	Maximum	Minimum	Average value	Standard deviation	Number of valid test objects
	83.86	51.26	69.37	6.398	50

The standard for judging the intensity of time pressure was obtained from the study of Ordonez and Lehman and the study of Weening and Maarleveld, and this standard was widely accepted in studies [1]. In this study, with this standard as a reference, the average value of time taken to complete the experiment task was taken as the quota time under no time pressure. The value of time 50% lower than the average value was

taken as the quota time under a high time pressure [1]. Then, the corresponding quota time under low, relatively low, medium, and relatively high time pressures was calculated according to different time pressure coefficients specified in the standard. The lower the time pressure coefficient was, the shorter the quota time was, and vice versa. Time pressure state, coefficient, and quota time are shown in the following Table 2 respectively:

Table 2. Setting of corresponding quota time under different time pressures

Time pressure state	No pressure	Low pressure	Relatively low pressure	Medium pressure	Relatively high pressure	High pressure
Time pressure coefficient	1	0.88	0.79	0.68	0.59	0.49
Quota time (S)	69.37	61.05	54.80	47.17	40.93	33.99

3.5 Validity Test

Validation was conducted on the validity of the quota time determined and set in the preparatory experiment. To conduct the validation, Likert scale was used in the form of questionnaire inquiries to quantitatively evaluate the pressure subjectively felt by the test objects conducting the experiment tasks under different time pressures, with the evaluated data being processed and analyzed. First, SPSS 23.0 was used to conduct descriptive statistics on quantitative data of the test objects' subjective feelings about pressure, and the statistical results showed that such feelings increased with the increase of time pressure. Then, the data of descriptive statistics was tested by testing F values in SPSS 23.0. The test results were that: $F(\text{no and low time pressure}) = 55.69$, $P = 0.000$; $F(\text{low and relatively low time pressure}) = 69.36$, $P = 0.000$; $F(\text{relatively low and medium time pressure}) = 71.68$, $P = 0.000$; $F(\text{medium and relatively high time pressure}) = 78.87$, $P = 0.000$; and $F(\text{relatively high and high time pressure}) = 85.59$, $P = 0.000$. It showed that there were significant differences in the pressure felt by the test objects conducting the experiment tasks under different time pressures. The quota time obtained from the preparatory test could be used for the setting of variables in the formal experiment.

3.6 Formal Experiment

In the formal experiment, fifty test objects performed the assigned experiment task under different time pressures respectively. During the experiment, when they completed the task in the quota time or the experiment time exceeded the quota time, the experiment would end, with experiment data being output. The procedures of the formal experiment are as shown in the following Fig. 1.

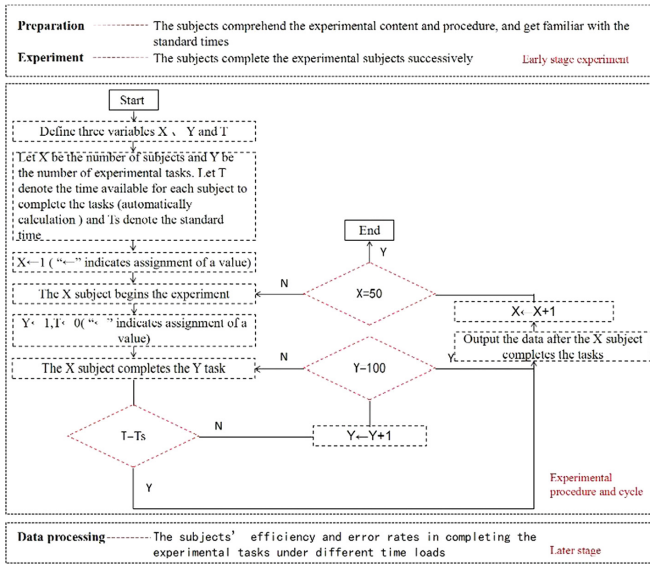


Fig. 1. Formal experiment procedures

3.7 Experiment Evaluation Index

With human-machine interaction performance evaluation standard as the reference, this experiment evaluated the task completion results based on numerical calculation and input performance. The performance consisted of two parts, namely, the efficiency and accuracy rate of numerical calculation and input [5].

The formula for calculating the numerical calculation and input efficiency is as follows:

$$C = \frac{N_X - F_X}{N_X} \times 100\% \quad X \in [1, 50], N \in [1, 100], N^* = 100 \quad (2)$$

where E represents numerical calculation and input efficiency; NX represents the number N of tasks actually completed by the test object X within the quota time in the formal experiment; N*x represents the number N* of tasks required to be completed by the test object X within the quota time in the formal experiment [5].

The formula for calculating the numerical calculation and input accuracy rate is as follows:

$$E = \frac{N_X}{N_X^*} \times 100\% \quad X \in [1, 50], F \in [1, 100], N \in 100 \quad (3)$$

where C represents numerical calculation and input accuracy rate; FX represents the number F of mistakes among tasks actually completed by the test object X within the

quota time in the formal experiment; N_X represents the number N of tasks actually completed by the test object X within the quota time in the formal experiment [5].

The formula for calculating the numerical calculation and input performance is as follows:

$$Q = \frac{N_X}{N_X^*} \times \frac{N_X - F_X}{N_X} \times 100\% \tag{4}$$

where Q represents numerical calculation and input performance and it is the product of efficiency and accuracy rate [5]; the higher the efficiency and accuracy rate of numerical calculation and input are, the higher the performance is, and vice versa.

3.8 Discussion and Analysis of Experimental Results

According to deep comparative analysis of the performance of the test objects conducting assigned experiment tasks under different time pressures, a summary was made with respect to the pattern of how the time pressure impacted the performance of numerical calculation and input. Analysis was conducted on the impact of time pressure on numerical calculation and input performance. SPSS 23.0 was used to conduct descriptive statistics on the experiment results, which is shown in Fig. 2.

Time pressure state	Maximum(%)	Minimum (%)	Average(%)	Standard deviation	Number of valid test objects
No time pressure (pressure coefficient: 1)	98.00	76.00	88.16	5.571	50
Low time pressure (pressure coefficient: 0.88)	99.00	80.00	90.72	4.131	50
Relatively low time pressure (pressure coefficient: 0.79)	88.00	69.00	76.58	4.603	50
Medium time pressure (pressure coefficient: 0.68)	75.00	55.00	66.22	4.196	50
Relatively high time pressure (pressure coefficient: 0.59)	65.00	51.00	57.54	3.829	50
High time pressure (pressure coefficient: 0.49)	55.00	39.00	46.22	4.344	50

Fig. 2. Descriptive statistics of numerical calculation and input performance under different time pressures

According to the statistical indexes of the average value in the descriptive statistics, the performance of numerical calculation and input under low time pressure is the highest (90.72%); it is slightly higher than that under no time pressure (88.16%); and that under high time pressure is the lowest (46.22%).

Based on this, a further study was conducted on the pattern of how the numerical calculation and input performance changed with the time pressure, which was to conduct deep analysis on the average value, maximum, and minimum of the descriptive statistics about the performance by using the statistical diagram, which is shown in Fig. 3.

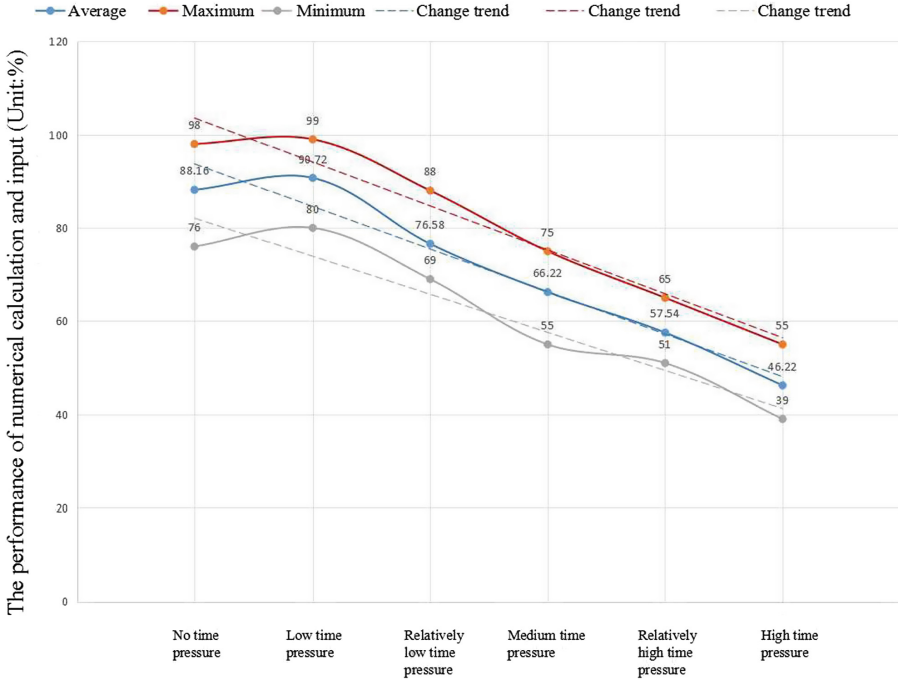


Fig. 3. Pattern of how the numerical calculation and input performance changed with the time pressure

As shown in the figure, the maximum, minimum, and average value of the numerical calculation and input performance of the test objects all show a trend of slightly increasing and then significantly decreasing under six different time pressures, namely, no time pressure, low time pressure, relatively low time pressure, medium time pressure, relatively high time pressure, and high time pressure. This means that, as the time pressure increases gradually, the performance of numerical calculation and input increases slightly first and then drops significantly. Among these pressures, the difference in performance under no time pressure and low time pressure is minor.

The judgment standard for the intensity of the time pressure was applied [5]. In the case of an assigned task, the coefficient of no time pressure, that is 1, was taken as a reference, and the length of the quota time was set as per a low time pressure coefficient of 0.88. The performance of numerical calculation and input were raised accordingly by selecting proper time pressure. With the time pressure coefficient being decreased further, that is, the shortening of the quota time, the time pressure increased gradually and exceeded the reasonable scope. The performance dropping correspondingly.

4 Conclusion

The following study conclusions were drawn by extending the study results and pattern of numerical calculation and input to the practical human-computer interaction occasions:

In the human-computer interaction process, its performance showed a changing pattern of increasing first and dropping then with the increase of time pressure. Compared with the occasions without any time pressure, a reasonable time pressure could make people in the interaction more focused and concentrated and thus deliver better human-computer interaction performance.

In practical human-computer interaction occasions, with the experiment study method being a reference, the time pressure was controlled by setting the quota time length of the assigned task. First, a preparatory experiment was conducted to obtain the time taken under no time pressure. Then, the corresponding quota time under a low time pressure was set by referring to the standard of time pressure coefficient. After that, a reasonable time pressure was given to improve the efficiency and accuracy rate of human-computer interaction so as to maximize the performance and reduce human errors effectively.

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