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The Effect of Different Interrupting Tasks on Sequential Task in Human-computer Interaction

Zongmin Yang

School of Economics and Management, Jiangsu University of Science and Technology, ZhenJiang, 212003, China

MengXi road, JingKou district, Zhenjiang in Jiangsu province, China

yangzongmin2011@163.com

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Abstract. With the development of information technology, interruption phenomenon becomes more and more common to the mental workers. On the previous study of interrupts are microscopic, rather than as a whole. This experiment was used to explore the influence of the position and cognitive load of interruption on the primary task. [Methods] There are 75 college students in 9-step sequential human-computer task test experiment. Character recognition and judging work is used in the primary task. In 8 positions between 9 steps, interruption tasks appeared equal probability. There is only one interruption in each cycle. Participants were divided into three groups, one group's interruption tasks are entering the characters, the second group's interruption tasks are the simple numerical calculation, the third group's interruption tasks are complex numerical calculation. Computer program records the subjects' overall operation process. [Results] Results show that: (1) in the experiment, the error rates and response latencies caused by different interruption-positions had significant difference. (2) There were no significant differences on error rates and response latencies in different cognitive loadof interrupting tasks. [Conclusion] In sequential human-computer tasks, destructive arising out of the interruption phenomenon occurred in the middle position is significantly higher than the start and end positions.

Introduction

Nowadays, the widespread popularity of computer, network, communication equipment, bring convenience to people's life and work at the same time, also led to a more complicated work environment. On the one hand, instant messaging, E-mail, news, advertisements, weather and other message window pops up, frequently interrupt the normal workflow, which makes the interruption phenomenon are becoming more common in the process of human-computer interaction. Another aspect, a team of highly efficient collaboration and enterprise division of refinement need people to maintain communication with other colleagues to update information in real time communication, which has increased the possibility of employee performing the task of the current is interrupted. Gonzalez and Mark found that information workers' task switching is very frequent, about once every 3 minutes an interruption or conversion [1]. As a result, people often need to focus on multiple tasks at a time, this cause of the current task frequent interruptions.

Information technology research firm Basex has published a report that interruption brings to the enterprise loss of about 588 billion dollars a year [2]. In some environments, the minor errors caused by interruption are acceptable. But in some environments, such as medical care and surgery, military, aerospace, locomotive driving monitoring and testing system of heavy industry complex work environment, slight mistake can lead to losses, even casualties. So how to solve the negative effects of the task interruption in a complex environment becomes a wide public concern problem.

Study of task interruption in various fields, including business [3-5], medical [6], military [7], driving [8], human-computer interaction [9], nuclear energy and so on. For the research of sequential task in human-computer interaction, past research mainly focus on the error rate in the process of primary task recovery [10-12].

David programming to simulate the VCR task to study the impact of simple interruption and

complex interruption on the primary task, it is found that compared to simple interruption, complex interruption after more time to restore the primary task[13]. Cades in the programming of the VCR interface while the participants were inserted into three different kinds of interruption tasks, it was found that the more difficult interrupting task will bring more damage to the primary task[14]. Different from the above studies, in this study, the primary tasks similar to Altmann, Hambrick et al.[15-17]This paper explores the influence of different interrupting tasks and positions on the primary tasks in the process of human-computer interaction.

Experiment

Participants. 75 university students between 18 and 40 years of age from Jiangsu University of Science and Technology participated in this study. All of the participants (normal vision or visual acuity), no color feebleness, no color blindness, did not participate in similar experiments. After the end of the experiment to give a certain reward.

Materials. This experiment performed on the PC, the screen resolution of 1440 x 900, refresh rate of 60Hz. All task stimuli and instructions are given by the computer, the participants input through the keyboard and mouse.

The experiment consists of two parts: primary task and interrupting task. The primary task consists of 9 steps — after each picture was presented on the screen, participants were asked to answer 9 questions in sequence (U, N, R, A, E, G, P, D, L). There are two characters in each picture: a letter (A, B, U, X), a number (1,2,8,9) and a rectangular box. The participants were asked to answer questions based on the location, size and format of the two characters in the picture. Each step is named as the first letter of the step problem option. The primary task of the experiment is shown in figure 1. In this case, the letter "U" in the form of the underline, the color is yellow, located in the top of the rectangular box; the number "8" color is white, the number is even, in the rectangular box. After completing the last step "L", start from the "U" step to the next cycle.

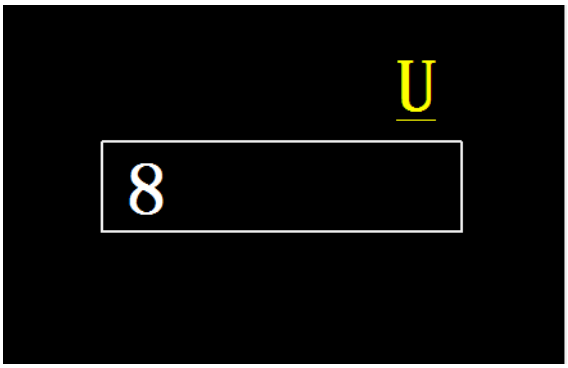

Figure 1. Sample stimulus for the primary task

Participants performed in 9 steps with equal probability of random interruptions between the 8 positions. The program will immediately switch to the interrupting task interface when the primary task is completed. The "OK" button in the primary task interface is the trigger button for the interrupting task. The interrupting task is included 3 types—the entry of the 6 characters, simple numerical calculation and the complex numerical operation task. After correct entry, participants should click the “ok”. The program will automatically return to the primary task interface. The interrupting task interface is shown in fig. 2.

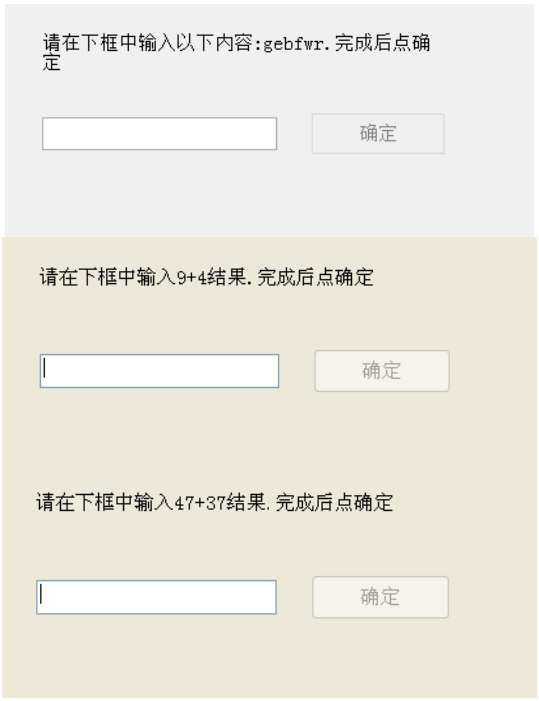

Figure 2. Sample stimulus for the interrupting task

Design. Two factors between-subject mix design was used in the experiment. The independent variables are the interrupting tasks (character input, simple numerical computation and complex numerical computation) and eight different interruption positions. The dependent variables are the error rate and response latency after task interruption. The participants were tested in a quiet laboratory condition.

Procedure. The participants were divided into three groups: the input group, the simple operation group and the complex operation group. The number of each group was 25. All the experimental conditions were the same except for the interruption task. In order to ensure the effect of the experiment, the participants were asked to carry out two cycles (18 steps) before the experiment was carried out.

After the start of the experiment, the participants click "U" step with the mouse into the answer. After completing one step, click the "OK" button on the primary task interface to enter the next step. The "OK" button for each step in the primary task interface may be the trigger button for an interrupting task. When the interrupting task, participants need to press the correct answer requires entry of 6 characters or the input of numerical calculation, click "OK" button interrupting task interface, then will return to the main interface to the primary task of the task. After the completion of the final step of the "L", and then from the "U" step, enter the second cycle. The experiment consists of 32 cycles, each of which has a total of 9 steps, with a total of 288 steps. Each cycle has an interrupt and a total of 32 interruptions. Each experiment takes about 30~40min. The program automatically records the content, time and response of each step of the test, and the data during the exercise period is not included in the statistical analysis of the results.

Measure. If the participants does not perform the "N" step after completing the "U" step, instead of repeating the "U" step or skipping the "N", the task is executed directly". In the course of the 9 step of the primary task, if the participant has a wrong answer to a question, it is called a "response error". The time interval from completing the interrupting task to the beginning of the primary task is called "response latency".

Results and Discussion

The average response time delay and error rate of Character input task, simple numerical

calculation tasks and complex numerical computation task in the 8 interruption positions of primary task are shown in table 1.

Table 1 Average response latencies and error rates of 3 kinds of interruption tasks in 8 interrupt positions（SD）[ms]

Interruption position		Character input	Simple calculation	Complex calculation
After U	response latency	1072.37（367.50）	1283.77（1108.29）	1050.54（298.82）
	error rate	5%（10.2%）	3%（8.29%）	11%（25.08%）
After N	response latency	1142.58（348.37）	1285.16（720.92）	1197.50（465.56）
	error rate	17%（20.05%）	14%（20.51%）	20.33%（24.06%）
After R	response latency	1215.64（321.69）	1274.43（573.24）	1242.06（547.91）
	error rate	26%（27.46%）	8.67%（17.75%）	19%（26.30%）
After A	response latency	1373.48（498.84）	1458.94（826.39）	1447.84（568.97）
	error rate	26%（23.36%）	11.67%（20.83%）	16.33%（26.07%）
After E	response latency	1530.50（804.63）	1738.24（800.62）	1569.51（485.64）
	error rate	28%（25.33%）	19%（25.29%）	25%（31.45%）
After G	response latency	1369.65（476.28）	1472.11（955.58）	1379.94（453.14）
	error rate	31%（25.29%）	20.67%（27.96%）	41%（38.78%）
After P	response latency	1413.84（723.73）	1321.20（574.57）	1245.34（383.24）
	error rate	17%（21.31%）	16.67%（23.93%）	31.33%（33.27%）
After D	response latency	996.73（283.96）	1003.33（390.29）	1008.79（310.07）
	error rate	8%（15.67%）	4%（9.35%）	14%（26.1%）

3 (interrupting task)×8 (interrupt position) of the repeated measures ANOVA showed that the main effect of the interruption position significantly, F (7,592) =14.764, p=0.00<0.05, the middle position caused by interruption response latency is greater than the start and end position. The main effect of the interrupting task was not significant, F (2,72) =0.338, p=0.714, although with the increase of the task load, the latency was also increased, but the difference was not significant. The interaction between interrupting task and interrupt position was not significant, F (2,72) =0.513, p=0.871, which showed that the response latency did not change significantly with the increase of cognitive load.

Analysis of variance of repeated measurement of error rate showed that the main effect of the interruption position was significant, F (7,592) =11.596, p=0.00, intermediate position error caused by the error rate is higher than the start and end position. The main effect of interrupting task was not significant, F (2,72) =3.013, p=0.055, although with the increase of the load, the error rate was also increased, but the difference was not significant. The interaction between interrupting task and interrupt position was not significant, F (2,72) =1.390, p=0.178, which showed that the error rate did not change significantly with the increase ofcognitive load.

Conclusion

In the experiment, the primary tasks are in the order of the task, and in the 9 steps between the 8

locations of the same probability random interrupt. It was found that the response latency at different locations showed significant differences in the three experiments. The delay caused by the interruption at the start and end positions is significantly less than that in the intermediate position.

Through the comparative analysis of the experimental results, it showed that the cognitive load of the task, the order error rate and the response latency were increased to some extent, but the difference was not significant. No interaction was observed between interrupt position and interrupting task.

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