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Effect of Active Breaks during e-Learning and Mental Arithmetic Tasks

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Abstract: In this study, we analyzed the effects of taking active breaks during mental arithmetic and e-Learning tasks. Active breaks are defined as breaks that involve light exercise. An experiment was conducted to analyze the effects of active breaks on recovery from fatigue and the effects on the task results. Here, each subject's fatigue was analyzed using the leg movement measurement method. As a result, in the e-Learning task experiment, recovery from fatigue was observed after active breaks. However, improvement in learning effectiveness was not observed. In the mental arithmetic task experiment, recovery from fatigue was also observed after active breaks. In addition, it is possible that the recovery from fatigue enabled the subjects to maintain a high rate of correct responses to the mental arithmetic task. It was suggested that active breaks may be more effective in improving work efficiency when the cognitive load of the task is greater.

Keywords: Active breaks, leg movement measurement, educational support system, fatigue estimation

1. Introduction

In recent years, due to the influence of COVID-19, an increasing number of students are learning at home. In this context, students are expected to take appropriate breaks on their own, rather than at set times as in school. However, it is difficult to assess fatigue objectively to determine weather it is appropriate to take a break. A previous study suggested appropriate break timing based on students' learning performance (Ramachandran, Huang, & Scassellati, 2017). and the results of that study demonstrated that individually determined break times improved test scores compared to students who took breaks at predetermined times. The study included various breaks, such as tic-tac-toe, stretch, and breathing, however, the effects of the content of these breaks were unclear. Thus, we considered that task performance may differ depending on the student's behavior during a break. In this study, we focused on active breaks, which involves performing light exercise, as a break behavior.

Fatigue is a common cause of poor learner performance. And it is important to consider the degree to which fatigue is recovered by breaks. Most fatigue estimation methods utilize facial expressions and eye blinking. These methods employ video cameras and may give pressure to be monitored to the learner. In contrast, leg movement measurements can estimate fatigue without giving pressure to be monitored to the learner because leg movements are measured using a pyroelectric infrared sensor (Hamada, Terui, & Egi, 2022). When using wearable devices, the discomfort caused by the device may affect concentration and fatigue. However, leg movement measurement devices can be used to estimate fatigue without contact; thus, the influence of the device is negligible.

In this study, we analyzed the effects of active breaks on task performance and fatigue recovery. The target tasks included e-Learning and a mental arithmetic task, because such tasks incur sufficient cognitive loads.

2. Methods

In this study, active breaks were performed by walking on a treadmill. Note that the load incurred by active breaks is considered to vary for individuals. Thus, the Karvonen method was used to set the exercise intensity, and active breaks were performed at a treadmill speed that was appropriate for each learner. The Karvonen method can calculate the heart rate to achieve the target exercise intensity based on the learner's resting heart rate and age (Karvonen, 1957).

Here, the learner's fatigue was estimated by measuring leg movements, and this information can be used to estimate the learner's mental condition without burdening on the learner because it can realize contactless acquisition of biometric information. It has been shown that there is a correlation between the learner's leg movements and mental fatigue (Aikawa, Asai, & Egi, 2019).

3. Experiment and Results

Experiment I involved the e-Learning task, and Experiment II involved the mental arithmetic task.

To analyze the effect of active breaks on the learning effectiveness of e-Learning, we focused on the rate of increase in scores on the pretest and post-test. Here, the rate of increase in scores was calculated by dividing the percentage of correct answers in the post-test by the percentage of correct answers in the pretest. The rate of increase in scores was defined as the rate of correct responses on the post-test divided by the rate of correct responses on the pretest. Results-AB (score) represents the results of the test in the range studied after taking active breaks, and Results-PB (score) represents the results of the test after taking passive breaks.

A paired-sample t-test between the active and passive breaks showed no significant difference in the percentage increase in scores ($p = 0.45$, $t = -0.77$, degrees of freedom = 15). However, the mean score of the test corresponding to learning after passive-breaks was greater than that for the test corresponding to learning after taking active breaks. Thus, it is possible that the passive-breaks were more effective in terms of improving the learning effect.

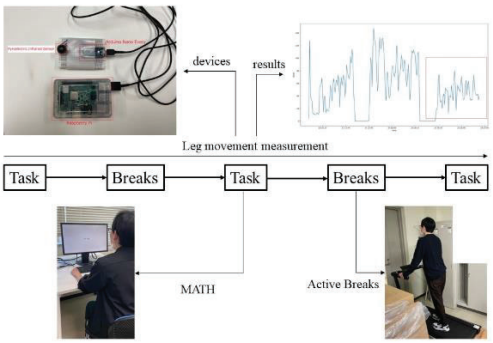

Figure 1. Experiment flow

In this study, the amount of leg movement was considered to analyze the effect of active breaks on recovery from fatigue on learners during e-Learning. However, leg movements involve many individual differences; thus, our analysis used the value obtained by dividing the amount of leg movements by the average of the individuals. A Wilcoxon signed-rank sum test revealed that the amount of leg movements after active breaks was significantly lower ($p < 0.05$). An example of low leg motion after active breaks is shown in Figure 1(upper right, leg movements after active-breaks are in red box). Note that this example was taken from a subject in the PB-AB group.

The results of question indicate that many respondents were positive about the fatigue-relieving effects of the active breaks. There were several comments that could be read as "active breaks helped me feel better."

The score trends for each of the 100 MATH questions for the 10 subjects did not change significantly for any of the subjects. By comparing the results of the mental arithmetic task after breaks and active breaks, we found that all but three subjects showed a slight increase in scores after taking active breaks. These three subjects did not exhibit a significant decrease of greater than 10 points of scores.

It is thought that as the experiment progresses, fatigue accumulated, concentration declined, and the scores decreased. However, most subjects were able to maintain their scores, which suggests that the active breaks had a positive effect on the MATH task.

Similar to the results of experiment I, here, we found that the amount of leg movement after active breaks was low. A Wilcoxon signed-rank sum test revealed that the amount of leg movements after taking active breaks was significantly lower than the amount of leg movements after taking passive breaks ($p < 0.05$). The results of question indicate that many respondents were positive about the fatigue-relieving effects of the active breaks. However, some subjects were negative about taking active breaks and one subject said “I lost my concentration.”

4. Conclusion

In this paper, we analyzed the effects of taking active breaks while performing two types of tasks, i.e., e-Learning and mental arithmetic tasks. The experimental results demonstrated that the active breaks helped recovery from fatigue in both tasks, but active breaks helped improvement task performance in the only mental arithmetic task. Therefore, the difference in the degree of cognitive load between the e-Learning and mental arithmetic tasks suggests that active breaks have a greater improve task performance effect on tasks with greater cognitive load. However, there were several subjects who did not feel the effects of active breaks; thus, it is necessary to determine which type of breaks is most appropriate for each individual learner.

In the future, we would like to develop a system that suggests appropriate break content and timing based on the given task content and level of fatigue.

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