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Micro-Refresh to Restore Intellectual Concentration Decline During Office Work: An Attempt at Quantitative Effect Evaluation

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ABSTRACT

There have been many studies on improving intellectual concentration in office. In this study, we named a short break of a few seconds to a few tens of seconds to encourage refreshment "micro-refresh (MR)" and, as a basis for this study, aimed to confirm by an experiment that the effect of micro-refresh can be measured quantitatively. In the measurement, short breaks of 20 seconds were forcibly given to the experimental participants every 7.5 minutes during the cognitive task as the cognitive task screen turned to all gray, and the difference in intellectual concentration was confirmed using objective indicator "CTR (Concentration Time Ratio)". In addition, this experiment measured participants' fatigue and workload through several questionnaires: (1) Progress questionnaire asking about subjective level of concentration and fatigue (2) NASA-TLX asking about mental workload (3) Subjective symptom screening capturing changes in fatigue status over time. As a result, the effect of MR could be quantitatively measured, and it was suggested that MR might reduce subjective fatigue and feeling of sluggishness.

Keywords: Intellectual concentration, Intellectual productivity, Office environment

INTRODUCTION

There have been many studies on improving intellectual concentration. The concentration on intellectual work such as working in office tends to decrease over time, and this needs to be prevented in order to keep intellectual work efficiency. In conventional office work, for example, a 10-minute break was taken every hour. However, in this case, their concentration is gradually getting lower by the next break. There is a possibility of suppressing the decline in intellectual concentration by interspersing short breaks of a few seconds to a few tens of seconds and give environmental stimulus to improve their refreshment in a shorter cycle. We named this break "micro-refresh" (hereafter referred to as "MR") and we have been trying to show its effect on improving intellectual concentration by experiments, and to examine the environmental

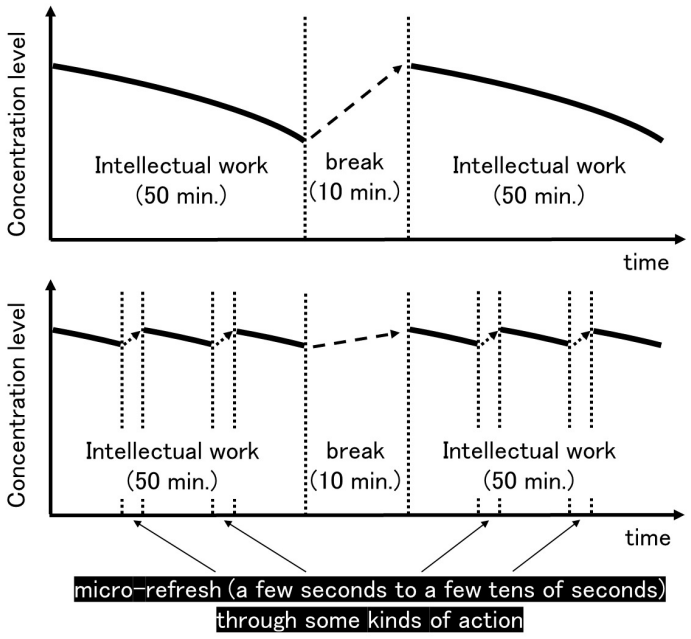

Figure 1: A concept and hypothesis of MR.

control method to introduce it appropriately in the actual working environment. This effect of MR on improving intellectual concentration is the hypothesis of the study and is shown in Figure 1.

There have been many studies that aim to improve task performance through very short breaks. For example, it is shown that taking micro-break has improve surgeons' subjective physical performance and mental focus (Hallbeck, 2017). The "micro-refresh" differs from the conventional "micro-break" in that iteffectively encourages office workers to refresh themselves in a short period of time. In other words, this research aims to actively encourage office workers to take MR by themselves through some kinds of action, such as controlling the office room environment.

METHOD

An experiment was conducted to show that the effect of MR can be measured quantitatively. Short breaks were forcibly given to the experimental participants during the cognitive task, and the difference in intellectual concentration between under the experimental condition with MR and that without MR was measured using objective indicators. In addition, participants' subjective fatigue, mental workload, and so on were measured by several questionnaires.

The experiment was conducted following the schedule as shown in Figure 2. To familiarize the participants with the cognitive task and to make them somewhat fatigued so that the effects of the MR can be observed. QB (questionnaire before the task) included progress questionnaire and subjective symptom screening, and QA (questionnaire after the task)

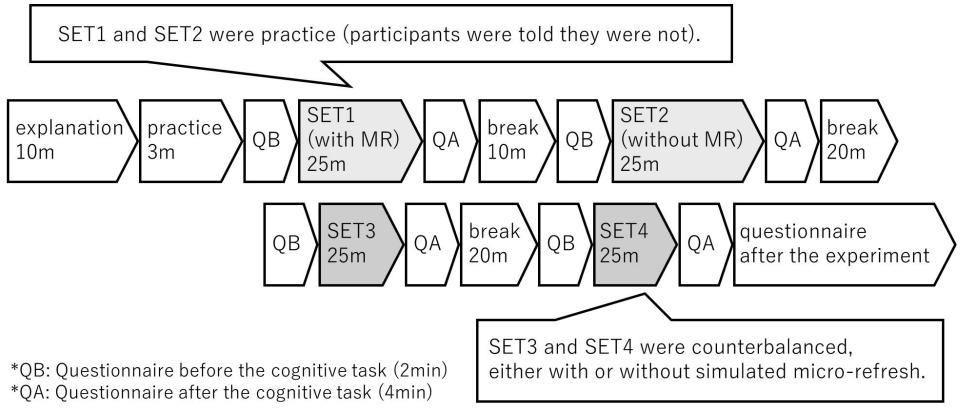

Figure 2: An experimental procedure.

included these two and NASA-TLX. After the experiment, a questionnaire was conducted asking for feedback on how participants felt about the MR prompted by the screen change during the cognitive task.

The experiment took place in an experimental room of Kyoto University on July 23 and 28, 2022, from 3:00 to 6:30 p.m., respectively. The participants were eight students from Kyoto University recruited through co-op part time job Web sites. This experiment was conducted with the approval of the Ethics Review Committee of the Graduate School of Energy Sciences, Kyoto University.

- **CTR (Concentration Time Ratio)**

CTR (Concentration Time Ratio) was used as an index to quantitatively evaluate intellectual concentration using the response time data of a cognitive task. CTR is an indicator devised by Uchiyama et al. (Uchiyama, 2013). It expresses the ratio of time spent concentrating on a task to the total work time.

- **Questionnaires**

  In the experiment, the following questionnaires were conducted.

  i. Progress questionnaire: asking about subjective level of concentration and fatigue.
  ii. NASA-TLX: asking about mental workload.
  iii. Subjective symptom screening: capturing changes in fatigue status over time.

- **Cognitive task**

In order to evaluate intellectual concentration using CTR, response time data from a cognitive task consisting of multiple questions of constant difficulty is needed. Therefore, a comparison task (Ueda, 2013), which satisfies these conditions, was used as the cognitive task to evaluate intellectual concentration in this experiment. Figure 3 shows the problem screen and the solution method of the comparison task. The questions are displayed on the iPad screen, and the participants answer the questions by selecting and

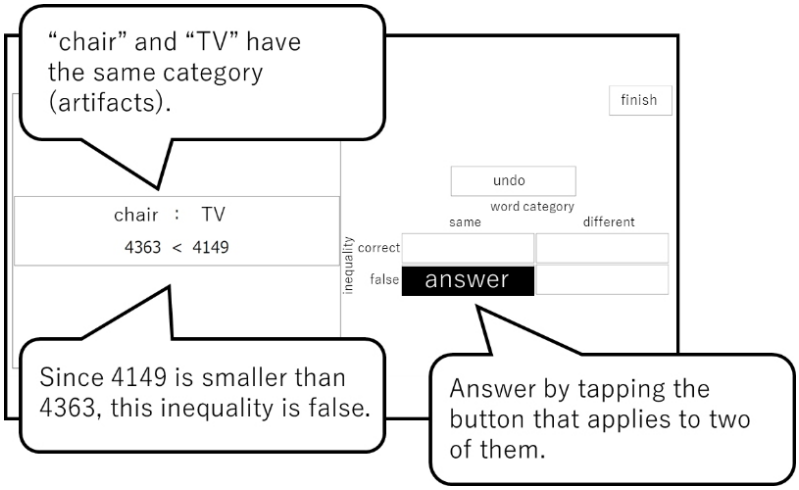

Figure 3: A screen of comparison task.

tapping the correct button on the right side of the screen as the combination of the answer to the word category judgment question and the inequality correct/false judgment question displayed on the left side of the screen. In the word category judgment, meaning categories of two words are compared. The two words belong to one of the following meaning categories: place names, artifacts, animals, and plants, and the participants answer whether they belong to the same category or not. After answering one question, the next question is displayed, and the undo button allows the user to correct the previous answer.

- **An experimental System**

An overview of an experimental system is shown in Figure 4. As a simulated MR, the experimental system has been developed in which the screen changes to all gray after an arbitrary time has passed and the answer to the problem being solved at that time is completed. While the screen is gray, the participants are not able to answer the cognitive task, so they take a break while the screen is turned gray. The interval between the screen changing was set to 7 minutes and 30 seconds, and the time until the changed screen returned to the task was set to 20 seconds. These conditions were determined based on the previous study on improving intellectual concentration by controlling room airflow (Obayashi, 2019). This previous study showed that applying airflow for 20 seconds once every 10 minutes improved intellectual concentration. Since the comparison task was considered to have a higher cognitive load than the cognitive task used in the previous study, it was decided to give breaks at shorter intervals.

RESULTS

Six participants were included in the analysis, excluding participants No.1 who was clearly not focused on the cognitive task (CTR<40%) and

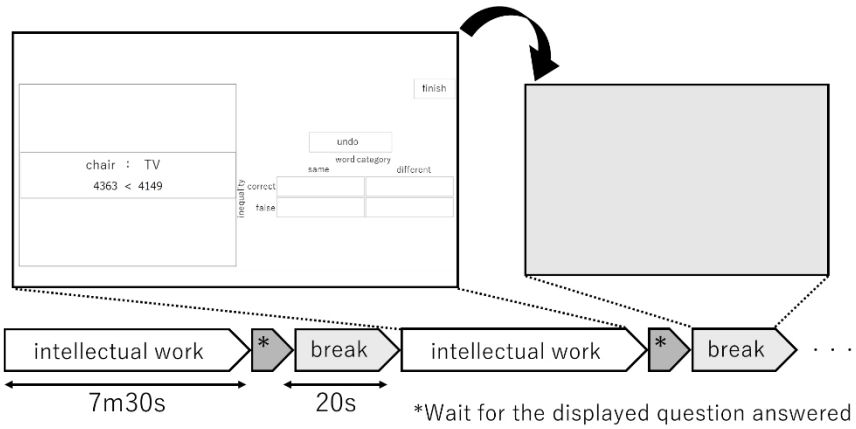

Figure 4: An overview of the experimental system.

Table 1. CTR for each condition for each participant.

Participants No.	CTR with simulated MR (%)	CTR without simulated MR (%)
2	73.1	80.8
3	59.4	45.8
4	71.5	66.6
5	51.1	54.9
6	50.9	59.6
7	60.6	64.1
Average	61.1±9.6	62.0±11.8

Table 2. The average difference in self-reported concentration and fatigue before and after the cognitive task.

Question item	with simulated MR	without simulated MR
Concentration	0.0±18.7	−10.8±16.6
Fatigue	22.5±20.9	21.7±12.1

participants No.8 who did not take the MR at the same time as the other participants due to system trouble. Note that SET3 and SET4 are the subject of the analysis that follows.

Table 1 shows the CTR for each condition. The average differences in self-reported concentration and fatigue before and after the cognitive task for each condition that are the results of the progress questionnaire, are shown in Table 2. Also, the average differences in feeling of sleepiness, that of blurriness, and that of sluggishness before and after the cognitive task for each condition that are the results of the subjective symptom screening, are shown in Table 3. In addition, the average of participants' workload for each condition that is the results of NASA-TLX is shown in Table 4.

Table 3. The average differences in feeling of sleepiness, that of blurriness, and that of sluggishness before and after the cognitive task.

Factor	with simulated MR	without simulated MR
Feeling of sleepiness	0.75±3.77	0.25±1.91
Feeling of blurriness	2.00±2.71	1.00±0.92
Feeling of sluggishness	2.50±2.60	3.50±3.60

Table 4. The average mental workload after the cognitive task.

	with simulated MR	without simulated MR
NASA-TLX	67.6±10.9	69.9±19.4

DISCUSSION

As shown in Table 1, average CTR is 0.9% lower with simulated MR than without simulated MR. However, this result cannot be said to suggest that MR may reduce concentration. CTR is calculated by the ratio of time spent concentrating on a task to the total work time, and in this study, the time when the screen is grayed out, i.e., when participants are taking a break, is included in the total task time. Since MR is prompted three times per SET, the total task time includes 60 seconds of extra time in the with simulated MR condition. Considering the above, the total task time, or the denominator of the formula to determine CTR in the with simulated MR condition is 1440 seconds instead of 1500 seconds, so the value of CTR could be 1500/1440 = 1.04 times higher. Applying this consideration to the results, the average CTR in the with MR condition is 63.5%. Therefore, it can be inferred that MR is unlikely to reduce concentration.

The results of the three questionnaires presented in Tables 1 through 3 show no consistent trend by MR status. The first possible reason for these results is the small number of participants. In this experiment, only six people were included in the analysis, so the results may have been greatly influenced by those who responded with extreme values in the questionnaires. Therefore, it is required to conduct the experiment with a larger number of participants. The second possible reason is experimental control. When the participants solve a cognitive task, whether the screen changes or not, they may voluntarily take a break due to fatigue or loss of concentration like Figure 5. Such voluntary breaks may not allow us to measure the effect of MR. In other words, it is not clear whether changes in concentration, fatigue, etc. are due to simulated MR or spontaneous breaks. Therefore, it may be necessary to instruct the participants not to voluntarily take a break except when the screen changes to gray in the with MR condition.

CONCLUSION

The purpose of this study was to try to measure the effect of MR quantitatively by an experiment. In the experiment, the screen of the cognitive task was changed to gray to simulate a MR. As a result of the experiment,

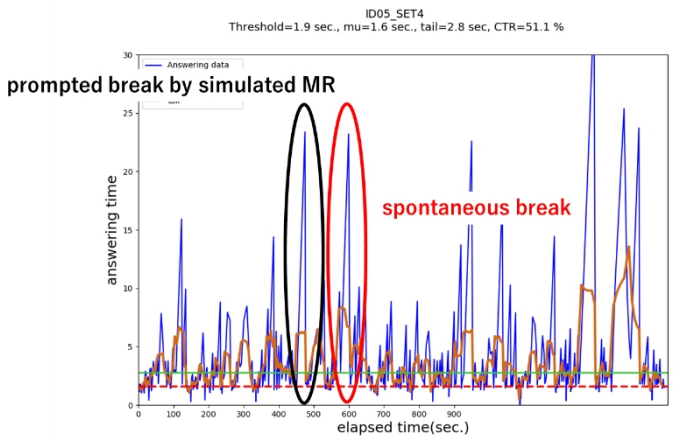

Figure 5: An overview of the experimental system.

CTR, which indicates the degree of intellectual concentration, was almost the same with and without simulated MR. However, there was a possibility that MR may reduce subjective fatigue and feeling of sluggishness. In terms of quantitatively measuring the effects of MR, this experiment achieved its objective.

As a future prospect, a similar experiment, with instructing not to take a break during the task except when the screen changes to gray in the with simulated MR condition, should be conducted with a larger number of participants to statistically investigate the effects of MR itself. In addition, since it is expected that the timing at which micro-refresh should be encouraged depends on individuals, it is necessary to investigate the effect of improving intellectual concentration when micro-refresh is encouraged at the most appropriate timing for that person. If the effects of taking micro-refresh on intellectual concentration are objectively demonstrated through these experiments, environmental control methods that can appropriately induce micro-refresh in actual work environments should be studied.

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