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Effect of the Intermittent Aroma Stimuli on Work Performance: Analysis Using the Drop Point of Time-series Intellectual Concentration

Kimi Ueda[1], Kohei Yumura[1], Hirotake Ishii[1], Hiroshi Shimoda[1], and Fumiaki Obayashi[2]

[1]Department School of Energy Science, Kyoto University, Kyoto, 6068501, Japan
[2]Panasonic Corporation, Tokyo, 1058301, Japan

ABSTRACT

Aroma fragrance is one possible method to improve workplace environment and the authors have continued research on its effect on workers' performance. In this study, new analysis method that using time-series intellectual concentration data and finding its drop points: the timing of losing concentration was applied to previous experimental data. The average concentration rate was marginally significantly higher under with- than without-aroma condition, and small effect was found that aroma stimuli decreased drop-points among the group whose average concentration was improved by aroma. The intermittent aroma stimuli might have been improved the performance by suppressing the decline of intellectual concentration.

Keywords: Cognitive task, Answering time analysis, Intellectual concentration, Workplace environment

INTRODUCTION

With the rapid development of information society, the importance of knowledge work is increasing. Various methods have been applied to discuss workers' performance and it is known to be affected by workplace environment (Al Horr et al. 2016). The authors have been focused on workers' intellectual concentration to evaluate workers' performance and developed CTR (Concentration Time Ratio) (Ishii et al. 2018). CTR is a performance evaluation index based on the ratio of time spent concentrating on a cognitive task for a total task conducted time. Although concentration on work changes from moment to moment due to fatigue accumulation, distraction, and other factors, CTR ignored the time-series changes in performance while conducting the task. Thus, the authors have been trying to analyze the effect of workplace environment on workers' concentration by analyzing time-series changes of concentration (Ueda et al. 2022).

In this study, a new analysis that focusing on the drop-point of time-series concentration was applied to evaluate the effect of intermittent aroma stimuli on work performance, which was evaluated previously by CTR

(Ueda et al. 2020). The objective of this study is to discuss about how the intermittent aroma stimuli affect on the workers' concentration based on the analysis of drop-point of time-series concentration.

METHOD

Experimental Conditions: With- and Without-aroma Conditions

In the experiment (Ueda et al. 2020), two experimental conditions: with- and without-aroma conditions were provided to participants and their performance and subjective expression were evaluated and compared by CTR and questionnaires.

In the with-aroma condition, aroma stimuli were presented for 10 seconds every 5 minutes. Lemon fragrance was provided as aroma stimuli since it is known to have positive effect in aromatic usage and other studies supports its possibility of cognitive performance improvement (Igarashi et al. 2014, Kawakami et al. 1999, Narae et al. 2022, Du et al. 2022). AROMASTIC (Sony, OE-AS01): a small spot aroma diffuser using dry air blower to provide scented airflow was used to expose the lemon aroma directly to each participant. In the without-aroma condition, AROMASTIC was driven but with no fragrance oil, so that scentless airflow was provided in the same time interval as with-aroma condition.

Data Analysis

In the experiment (Ueda et al. 2020), 22 participants performed 2 sets each in 2 conditions, with-aroma and without-aroma, so that totally 88 answering time data of the 30-minutes comparison task were analyzed.

Participants joined the experiment continuous 3 days: the first day was conducted as a practice day to make them accustomed to the experimental schedules and the second day and third day were conducted to get the cognitive task answering time data. Half of the participants conducted two sets of the task under with-aroma condition on the second day and without-aroma condition on the third day, and the other participants experienced in opposite sequence to make counter balance. Comparison task (Ueda et al. 2016) is a cognitive task developed to evaluate the workers' intellectual concentration during conducting the task, which requires numerical and language processing, comparison and judgement.

Time-series data of concentration were generated using the method used in our previous study (Ueda et al. 2022). Since aromatic environment was fluctuated during conducting task in with-aroma condition, the time window of concentration rate calculation was changed shorter to be 60 seconds to capture short-term temporal variation in concentration on task. Figure 1 shows the brief explanation about the time-series concentration.

Based on the generated time-series data of concentration, drop points were found and counted by the method shown in Figure 2. The drop points represent the timing at which the participants restarted concentrating and solving the cognitive task after slowing down due to fatigue accumulation or other factors while conducting the task. In other words, it is expected that there

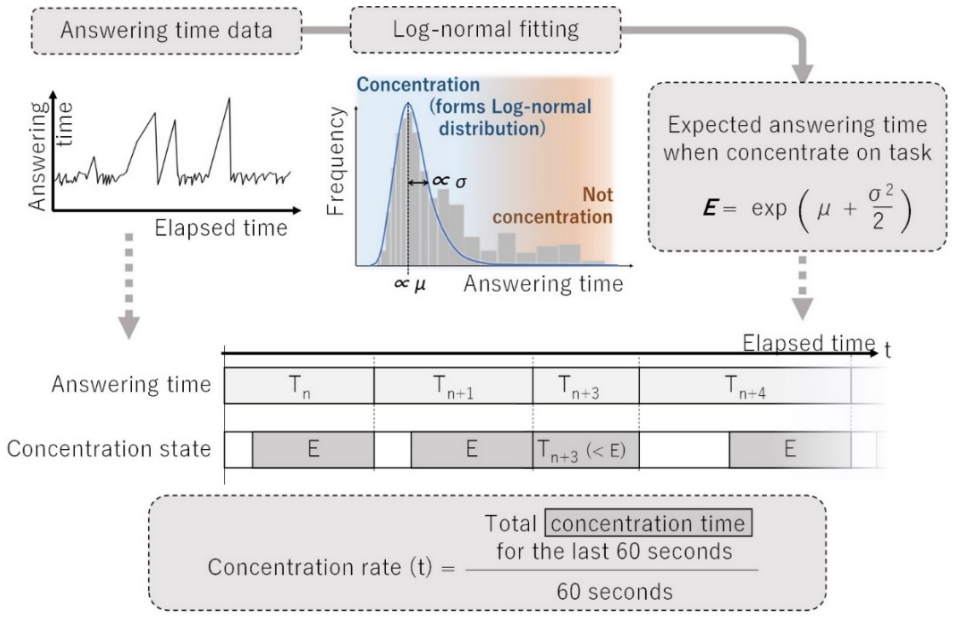

Figure 1: Time-series concentration data generation method (Ueda et al. 2022).

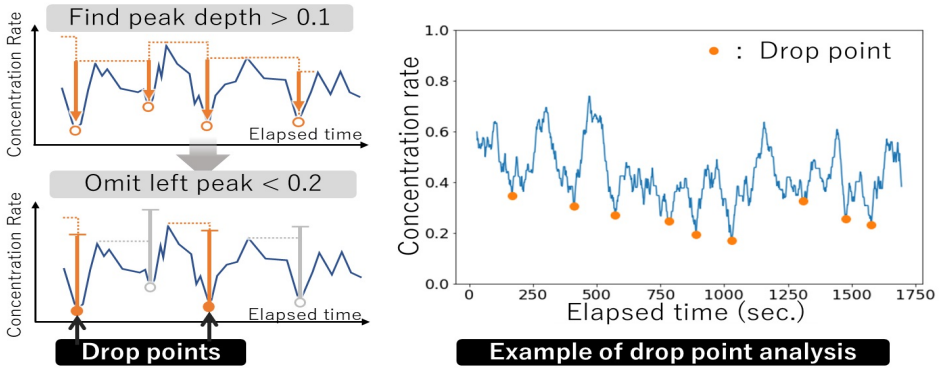

Figure 2: Finding method of drop points of the time-series concentration and example results of drop point analysis.

are more drop points when they were unable to maintain their concentration during the task time. In addition, the average value of time-series concentration in each set were also calculated to check the effect of intermittent aroma-stimuli over entire time of each set. It would be similar value of CTR which previously used to show the effect of aroma (Ueda et al. 2020), so that it would be expected that the average value under with-aroma condition is higher than without-aroma condition similar with previous analysis results.

RESULTS AND DISCUSSIONS

The Average values of the number of drop-points and the average concentration rate under with- and without-aroma conditions are shown in Figure 3.

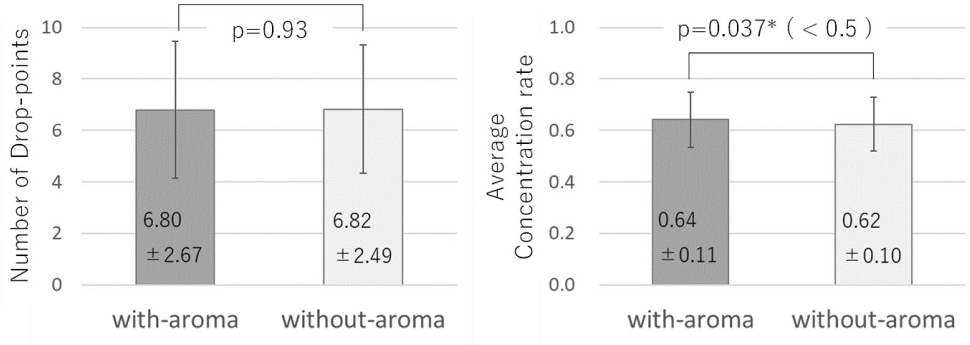

Figure 3: Average values of the number of drop-points (left) and the average concentration rate (right) under with- and without-aroma conditions. The p-value were calculated by paired *t*-test.

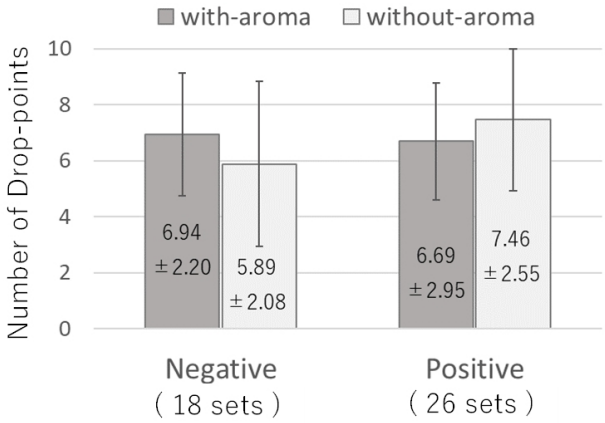

Figure 4: Average values of the number of drop-points in each group under with and without-aroma conditions.

As a result of paired *t*-test, the average concentration rate was marginally significantly higher under the with-aroma condition, which was expected from our previous result (Ueda et al. 2020). It would also support that intermittent aroma stimuli improved workers' concentration over entire time of working time.

When comparing the average concentration rate between the task sets conducted at the same time period under with- and without-aroma conditions, average concentration rate of with-aroma condition was higher in 26 sets than that of without-aroma condition, and lower in 18 sets. Thus, the former group (n = 26 sets) was named the positive set group as the set that the aroma stimuli improved workers' entire concentration. The latter group (n = 18 sets) was named the negative set group.

Average values of the number of drop-points in positive and negative set groups under with- and without-aroma conditions are shown in Figure 4. The results of two-way ANOVA are shown in Table 1, which was calculated with type-III sum of squares because of its unbalance numbers of data.

Table 1. Results of two-way ANOVA.

	Sum of squares (type III)	df	F	p	Effect size† (η^2)
Effect (Negative and Positive)	9.27	1	1.394	0.241	0.016
Conditions (With- and Without-aroma)	0.44	1	0.066	0.799	0.001
Effect * Conditions	17.71	1	2.66	0.106	0.030
Residual	558.72	84			

† Sum of squares (total) = 585.72, $0.01 \leqq \eta^2 < 0.06$: Small effect

There was no significant effect based on the p-value of ANOVA, but small effects were shown in the single factor between the negative and positive set groups and the interaction effect. The figure shows that the negative group had fewer drop-points in the without-aroma condition and the positive group had fewer drop-points in the with-aroma condition. This suggests that participants might be likely to lose their concentration when they didn't concentrate on task so much, and they might be more likely to lose their concentration when they got negative effect from the intermittent aroma stimuli.

SUMMARY

In this study, the effects of the intermittent aroma stimuli to improve workers' performance was newly examined based on an analysis focusing on drop-points, which are the timing of breaks in concentration, using time-series data of participants' concentration on a task. The results suggest that intermittent aroma stimuli might have reduced the number of drop-points which means the break in concentration was suppressed, especially in tasks in which concentration was promoted by intermittent aroma stimuli. Results provided the possibility of intermittent aroma stimuli could improve workers' performance by suppressing the concentration decline, which contributes to a discussion of previous results (Ueda et al. 2020) from a new aspect of time-series change of intellectual concentration. On the other hand, since it could be interpreted from the results that the aroma stimuli break concentration more frequently when workers got adverse effect in entire working time, it is important to adjust aroma stimulation for each individual to prevent adverse effects in order to improve overall workers' performance.

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