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The Promoting Effect of Mint Odor on Recovery from the Mental Stress Evoked by Simple Summation Task[1]

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This study aimed to examine whether the odor of minty flavors (menthol, peppermint, and spearmint) have easing effect on mental stresses or not. Participants in this study were asked to solve the Uchida-Kraepelin mental test. After completing this test, participants showed high arousal level, high anxiety and elevated activation of sympathetic nervous system. These indices of mental stresses showed tendency to be lowered by receiving minty odors, but not by rose or skatol odors. These results show minty odors have some easing effects on mental stresses, but it is only marginal.

Key words: mental stress, odor, mint, heart rate, STA-I

Introduction

There are many stressors in our everyday lives. These stressors cause mental stresses, and consequently mental illness, such as depression, bipolar mood disorders, and so on. Mental stresses cause deficits of attention that can cause fatal accidents, and also cause suicidal behavior. The latter is one of the social problems in Japan, because it is a major cause of death.

Many researches aimed to develop methods for coping with mental stresses (Atsumi and Tonosaki, 2007, Lehrner, Marwinski, Lehrm Johren and Deecke, 2005, Macht and Mueller, 2007, Watanabe, Kokubo, Takazawa, and Kawano, 2008, Koike, Kaneki, Yamada, and Kamimura, 2011). In a study done by one of the authors (Sakai, 2009), smelling coffee aroma or orange aroma was suggested to be useful coping behavior that ease mental stresses caused by solving puzzles. Also Sadachi et al. reported that tooth-brushing behavior has an effect of easing mental stresses (Sadachi, Murakami, Tonomura, Yada and Simoyama, 2010). This effect was enhanced when the toothpaste was added the flavor of citrus and the taste of caffeine

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(Sadachi, Murakami, Hosoya and Yada, 2010).

This study aimed to reveal the factor of easing effect of tooth brushing on mental stresses. Because tooth brushing behavior involves activities of muscles, somatosensory and tactile stimulations of oral cavity, and olfactory stimulations, the most effective factor in easing mental stresses remains unclear. If the somatosensory stimulations of oral cavity by mint flavors are the most effective factor (Labbe, Almiron-Roig, Hudry, Leathwood, Schifferstein, and Martin, 2009), one would ease one's mental stresses only by tasting a menthol tablet or a menthol pipe during work. If other factor, such as activities of muscles, is most effective, one should walk around or brush one's teeth during work.

This study adopted the hypothesis that the most effective factor for easing mental stresses by tooth brushing is somatosensory and olfactory stimulations with mint odors, and examined this hypothesis by an experiment where the mint odors were presented during recovery from mental stresses caused by solving Uchida-Kraeperin mental test.

Method

Participants

Seventy female university students participated in this study. They were received information about the aim and the procedure of this study, and the rights of participants. They gave written consent by themselves. After this informed-consent procedure, the participants were randomly grouped into seven groups.

Odor stimuli

Five kinds of natural oil (extracts from peppermint, menthol, spearmint, rose, orange), and one odorant (skatol) were used as odor stimuli. The odor stimuli were dissolved in a solvent (a mixture of propylene glycol and tri ethyl citrate). Concentration for each odor was determined by a perfumer to be moderate, but detectable by all participants. As a control stimulus, liquid hydroxybenzoate dissolved in the same solvent was used. All these stimuli were presented to participants with mouillette (7mm x 150mm).

Mental workload

To induce mental stress, participants were asked to solve the Uchida-Kraepelin mental test. The Uchida-Kraepelin mental test consists of 30 lines of one-digit numbers. The participants of the test must sum the adjacent numbers and write one-figure of the answer on the test sheet. The participants were asked to calculate as fast as they can. The average participant calculates 30~50 numbers in a minute, and is asked to repeat this procedure for 30 times. A break is imposed after 15 times of calculation. After completion of the test, almost all participants report exhaustion.

Measurement of mental stress

As subjective measurements of mental stresses, State-Trait Anxiety Inventory (form JYZ; STAI) and the Japanese UWIST mood adjective checklist (JUMACL; Matsumoto, Takushima and Hakoda, 2008) were used. The former consists 40 items; half of them are checklist for trait of anxiety, and the others are state of anxiety. Because this study was aimed to observe mental stress evoked by the Uchida-Kraepelin mental test, only 20 items for measuring state of anxiety were used.

As physiological measurements of the mental stress, heart rate variability (HRV) and salivary amylase were adopted. To monitor the HRV, pulse analyzer plus (TAS9; YKC Corporation, Tokyo) was used in this study. TAS9 could report fourteen indices such as heart rate (HR), percentage of numbers where the interval of N to N is over 50ms (pNN50), heart rate variability index, mental stress index (rate of normalized number of low frequency of HRV by normalized number of high frequency of HRV; MSI) and so on. However, because there are no significant changes in almost all indices, but in HR, pNN50 and MSI, results of these three indices were reported here.

To monitor the salivary amylase, salivary amylase monitor (CoCoRo meter; Nipro Corporation, Osaka) was used in this study. CoCoRo meter can non-inventively detect α-amylase in saliva with colorimetry (Higashi, Mizuno, and Yamaguchi, 2005).

Procedure

A simple figure of the procedure is shown in figure 1. After participants entered in the laboratory, they received a paper of informed consent. After listening to the information about the experiment, they made written consent voluntarily. Then, they were shown a sheet of Uchida-Kraepelin mental test, and were told how to complete the test. After these explanations, the participants did some trials of summation.

The first measurements of the mental stress were done after the training. The second measurements of the mental stress were done after completion of the test. Then, the participants were presented one of the odors or control stimulus with mouillette. After this stimulation, the third measurements were done.

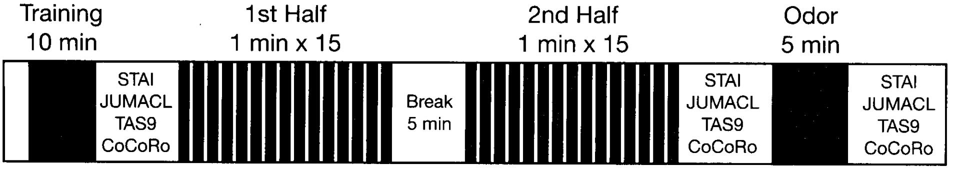

Figure 1. A schema of the experimental procedure of this study.

Results

Mental stress after Uchida-Kraeperin mental test

Participants felt mental stresses after completing the Uchida-Kraeperin mental test. Repeated ANOVA found that the tense arousal and the total arousal scores of JUMACLE after tests were significant higher than those before tests ($F(1,69) = 17.4$, $p<0.001$ for tense arousal, $F(1,69) = 5.8$, $p<0.05$ for total arousal), but a significant difference was not found in the energetic arousal score ($F(1,69) = 0.1$, $p>0.80$). There were no significant differences in a main effects of the groups (Fs(6,69)<1.0, ps>0.44) and an interaction of the groups and the periods (Fs(6,69)<0.79, ps>0.58). Results of the tense arousal score were shown in Figure 2.

The same tendency was found in the results of STAI. The state anxiety scores (P, A and total scores) were significantly heightened after the Uchida-Kraeperin tests ($F(1,69) = 21.5$

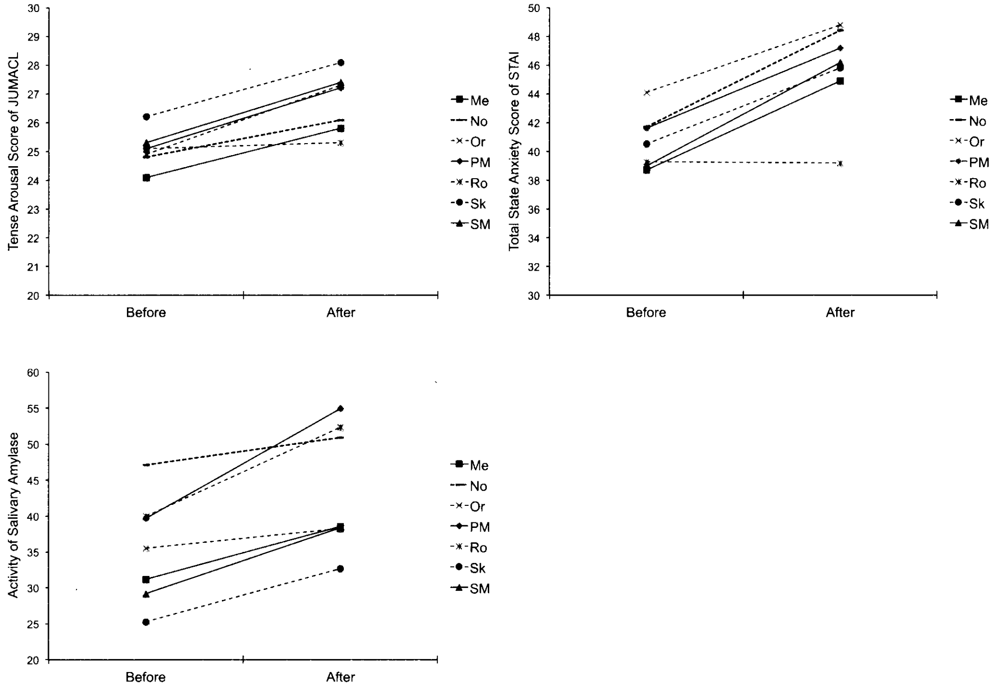

Figure 2. Changes of subjective evaluations about participants' mental states and of salivary amylase activities before and after the Uchida-Kraeperin mental test. Abbreviations are Me: menthol, No: no odor (control), Or: orange odor, PM: peppermint odor, Ro: rose odor, Sk: skatol odor, SM: spearmint odor.

for P, $F(1,69) = 15.2$ for A, $F(1,69) = 25.4$ for total, $ps<0.001$). There were no significant main effects of groups ($Fs(6,69) <2.0$, $ps>0.08$) and interactions of groups and periods ($Fs(6,69) < 1.1$, $ps>0.34$). Results of the total state anxiety scores were shown in Figure 2.

Also salivary amylase of the participants significantly increased after the test ($F(1,69) = 8.6$, $p<0.01$). This result was shown in Figure 2.

Indices of TAS9 showed that the Uchida-Kraeperin mental test heightened participants' activities of the sympathetic nervous system (e.g. increasing HR) and lowered those of the parasympathetic nervous system (e.g. decreasing pNN50). Results of TAS9 also revealed that the participants felt mental stresses by the test (e.g. increasing MSI). There were significant main effects of the periods in three indices of TAS9 ($F(1,69) = 16.4$, $p<0.001$ for HR, $F(1,63) = 4.46$, $p<0.05$ for pNN50, and $F(1,69) = 6.39$, $p<0.05$ for MSI). On the other hands, there were no significant interactions and main effects of groups in these indices ($Fs(6,69) < 2.00$, $ps>0.05$). These results were shown in Figure 3.

Recovery of mental state after Uchida-Kraeperin mental test

To indicate the recoveries from mental stresses, the recovery indices were calculated for each data. The recovery indices of the data about negative mental states and activities of

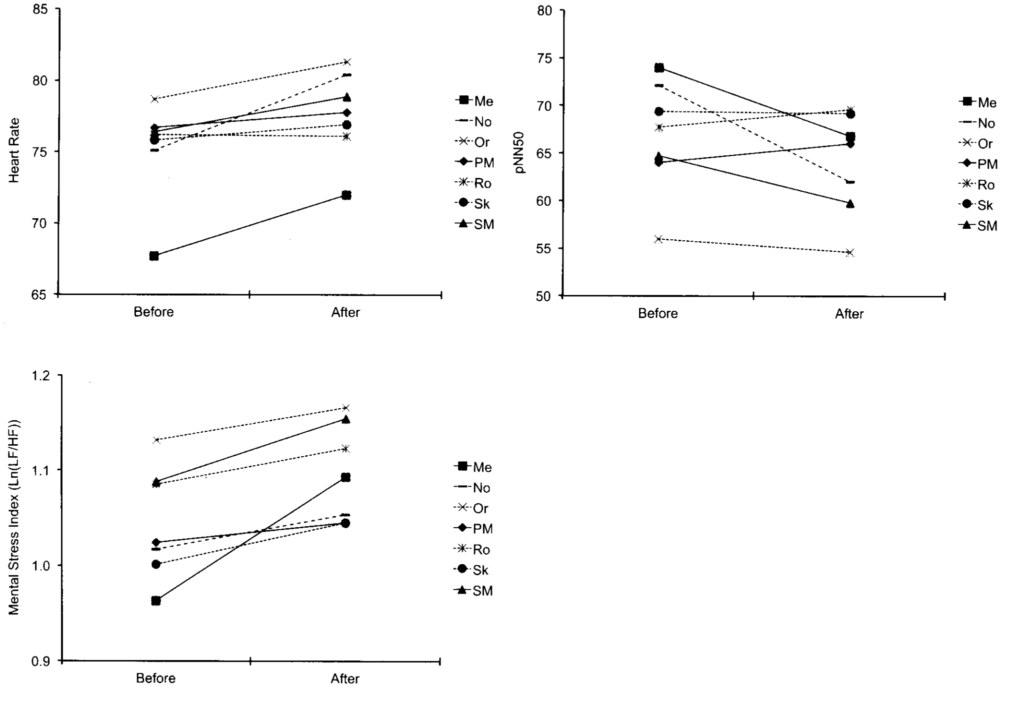

Figure 3. Changes of participants' physiological parameters before and after the Uchida-Kraeperin mental test. Abbreviations in the figure are same as those in Figure 2.

sympathetic nerve systems, such as tense arousal scores of JUMACL, all scores of STAI, activities of salivary amylase, heart rates and mental stress indices of TAS9, were earned by subtracting the data after stimulation from the data before stimulation. The recovery indices of the data about positive mental states and activities of parasympathetic nervous systems, such as energetic arousal scores of JUMACL and pNN50 of TAS9, were earned by subtracting the data before stimulation from the data after stimulation. Positive numbers of these recovery indices showed recoveries of the participants' mental states from mental stresses.

Averaged recovery indices of JUMACL were shown in Figure 4. These results suggested that the highest energetic arousal recovery was found in the control group (No), and that in all groups, but not in the orange odor stimulation group (Or), positive changes of participants' mental states after odor stimulations were found. On the other hand, the highest tense arousal recovery was found in the peppermint odor group (PM), and in all groups, but not in the control group (No), positive changes of participants' mental states after odor stimulations were found. However, these tendencies were not statistically significant ($F(6,69) = 0,72$, $p>0.63$ for energy and $F(6,69) = 0.28$, $p>0.94$ for tense).

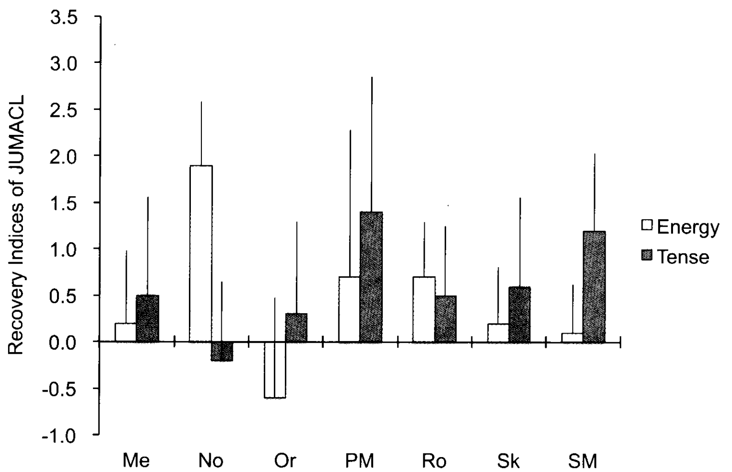

Figure 4. Effect of odor stimulations on recovery from mental stresses measured with JUMACL. Abbreviations in the figure are same as those in Figure 2.

The results of STAI (total, P and A scores) were shown in Figure 5. Recovery indices of STAI were positive in all groups, but not in the rose and the skatol groups (Sk). There were significant main effects of odor stimulation in the total anxiety and the absence of anxiety (A) scores of STAI ($F(6,69) = 3.04$, $p<0.05$ for total and $F(6,69) = 2.96$, $p<0.05$ for A). However, a significant main effect was not found in the presence of anxiety (P) score ($F(6,63) = 1.37$, $p>0.24$).

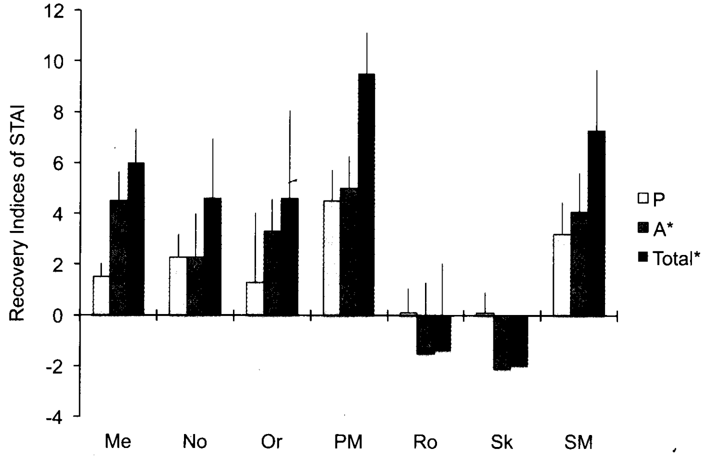

Figure 5. Effect of odor stimulations on recovery from mental stresses measured with STAI. Abbreviations in the figure are same as those in Figure 2.

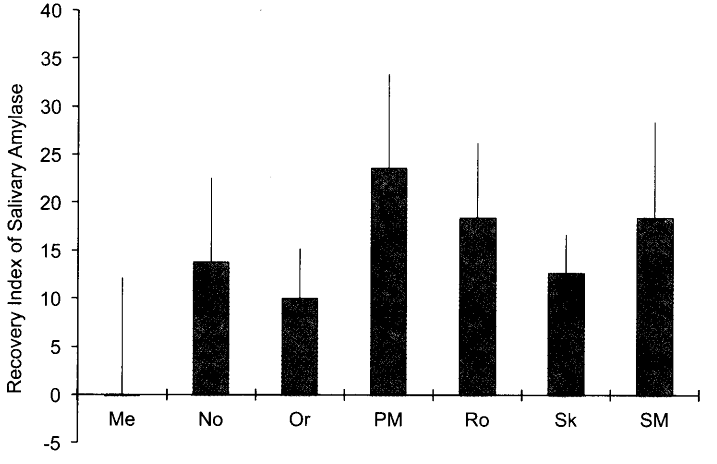

Figure 6. Effect of odor stimulations on recovery from mental stresses measured with CoCoRo meter (activity of salivary amylase). Abbreviations in the figure are same as those in Figure 2.

Recovery index of the salivary amylase was shown in Figure 6. All groups without the menthol group (Me) showed recovery from mental stresses after odor stimulations. There was no significant main effect of odors ($F(6,63) = 0.77, p>0.60$).

Recovery indices of the heart rate, the pNN50 and the MSI were shown in Figure 7. The peppermint group (PM) failed to show the recovery from the mental stresses after odor

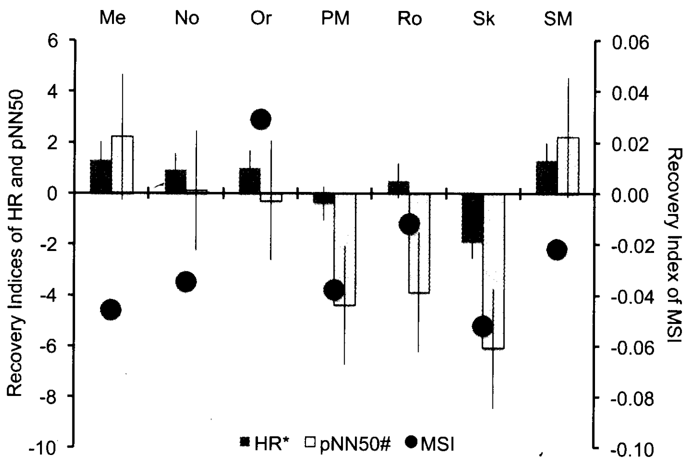

Figure 7. Effect of odor stimulations on recovery from mental stresses measured with heart rate variability. Abbreviations in the figure are same as those in Figure 2.

stimulation. On the other hands, the recovery indices of the HR and the pNN50 revealed that the menthol (Me) and the spearmint groups (SM) showed recoveries from mental stresses. On the other hand, the recovery index of the MSI suggested that the only orange group (Or) showed recovery from the mental stresses. One way ANOVA revealed that there were a significant main effect of odors in the HR ($F(6,69) = 2.95$, $p<0.05$) and a marginal main effect of odors in the pNN50 ($F(6,69) = 1.90$, $p<0.09$). Post hoc comparison revealed that the HR of the skatol group (Sk) showed significantly lower recovery than the other groups ($p<0.05$). There were no significant main effects in MSI.

Discussion

This study aimed to examine whether and how the mint odors promote the recovery from mental stresses evoked by solving the Uchida-Kraeperin mental test. The results suggested that the peppermint odor and the spearmint odor could promote recoveries from the mental stresses, but the effect is only marginal. On the other hand, the skatol odor prolonged the mental stresses. Many studies reported that there are individual differences in odor perception (e.g. Sakai, Takahashi, Kobayakawa, Yamauchi, Imada and Saito, 2007). This individual differences cause differences in autonomic and emotional responses to odors (Prescott and Wilkie, 2007). Participants' perceptions for the odors except for skatol could vary from participant to participant, and those individual differences of odor perception caused individual differences of autonomic response for the odors. On the other hand, perception for the skatol odor could be similar within the participants, as an odor of feces, and thus all of the participants evaluate the skatol as unpleasant odor. A research reported that the odor of isovaleric acid, which was used as the mimetic sweat odor, activated the sympathetic nervous systems (Kanai, Ishizawa, Nishimatsu, and Miyasaka, 2007). The odor of isovaleric acid is also evaluated as an unpleasant odor as the odor of skatol is. This is the reason why the skatol odor prolonged the mental stresses.

This study also aimed to ascertain whether the mint odor is the most effective factor of refreshment effect of tooth brushing on easing mental stresses. This study could not clearly prove that the mint odor of the toothpaste is the most effective factor of easing mental stresses. The reason of this failure is considered as following: 1. The number of participants for each group is too small to show a significant main effect of odors. In this experiment, the numbers of participants for each group were ten, but the differences in degrees of mental stresses evoked by the Uchida-Kraeperin mental test and in hedonics for the odors among participants might be too large. 2. In this experiment, the mint odors were presented orthonasally. On the other hand, in the preceding studies by Sadachi et al. (Sadachi, Murakami, Hosoya and Yada, 2010; Sadachi, Murakami, Tonomura, Yada and Simoyama, 2010), participants brushed their teeth with toothpaste and smelled the mint odors from retronasal route. The brain responses for the odors presented orthonasally were reported to be different from those presented retronasally (Small, Gerber, Mak, and Hummel, 2005). The authors also reported that the differences in brain responses for the mint odors was varied by the way that the odor was delivered (Yoshimatsu, Sakai, Ikenishi, Niikura, Kondo, and Sako, 2011). Thus, the method for delivery of odorant used in this study is not appropriate for easing mental stresses. 3. Recently a study (Sasaki-Otomaru, Sakuma, Mochizuki, Ishida, Kanoya, and Sato, 2011) reported that regularly chewing a mint flavored gum lowered negative moods of students in nursing colleges (many of them were female), and that tasting a mint tablet did not show the lowering effect. Thus, it is suggested that the main factor of tooth brushing effects on easing stress is the activities of muscles or/and the tactile stimulations of oral cavity, and not the mint flavors.

This study also suggests that the absence score (A) of the state anxiety (STAI) is the most sensitive measurement of mental stresses. This is the same for the suggestion by Sakai (2009), in which A score of STAI showed rapid rising after solving a confusing number puzzles and showed moderate, but significant, correlations with the subjective evaluations of mental stresses and the changes of salivary amylase. Because A score of STAI is earned by summing the scores of only 10 items, it is very simple and useful tool which can detect the mental stresses of the participants.

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