

# COMBINED EFFECTS OF VISUAL AND OLFACTORY STIMULATION BY INTRODUCING WOOD WHILE WORKING OR RESTING

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**ABSTRACT:** This study aimed to investigate the impact of visual and olfactory stimulation related to wood on subjective evaluation indices by incorporating wooden interiors and wood scents in simulations of real-life work and rest scenarios. We conducted subjective evaluations while participants performed tasks on a computer or rested to assess the combined effects of visual and olfactory stimulation. The working and resting rooms were either covered with wooden material or concrete-looking wallpaper, and the scent of Hinoki cypress (*Chamaecyparis obtusa*) was introduced into some of the rooms. The results of the experiment suggest that the introduction of both the Hinoki scent and wooden panels may enhance the olfactory impression during work and weaken it during rest, but the visual impression remains unchanged. Additionally, the results of the mood states suggest that the combined introduction of visual and olfactory stimulation from wood may improve mood state during work and rest. The results of the subjective fatigue also suggest that individual stimuli can affect subjective feelings of fatigue, and the Hinoki cypress scent may have potential in reducing various forms of fatigue. Overall, the results indicate that the combined visual and olfactory stimulation from wood may affect individuals differently depending on their activities.

**KEYWORDS:** Hinoki cypress, wooden interior, combined effect, subjective evaluation

## 1 INTRODUCTION

An increasing number of companies have been prioritizing environmentally friendly practices, including the development of eco-friendly materials and space design. The demand for low-carbon, CO<sub>2</sub>-emitting wooden structures has increased as companies aim to become more carbon neutral, which has enhanced the value of wooden spaces. Furthermore, wooden spaces may potentially have a stress-relieving effect on people. Lowering stress is of great significance in contemporary society. In Japan, a significant portion of employees are reported to endure high stress levels in their jobs and daily life. A space that fosters a strong connection to nature can serve as an effective setting for individuals to recuperate from stress [1].

The suitability of wood as a material for stress relief is being explored in various studies [2]. These studies focus on examining the comfort provided by spaces that utilize wood and the stress-reducing effects of the material.

While many studies have explored the visual and olfactory effects of wood [3-4], most have centered around a single stimulus, and few have investigated the combined effect of both the visual and olfactory elements. To effectively utilize wooden stimuli in the workplace, the psychophysiological effects of incorporating wood

and utilizing wooden spaces (e.g., for work and rest) need to be understood more comprehensively.

In this study, we aim to examine the impact of both visual and olfactory stimulation related to wood by incorporating wooden interiors and wood scents into simulations of real-life work and rest scenarios. The findings of this study are focused on the effects of the combined stimulation on subjective evaluation indices.

## 2 MATERIALS AND METHODS

### 2.1 PARTICIPANTS

Twelve adults (three men and three women in their 30s, and three men and three women in their 40s) were recruited for this study. All participants were confirmed to not have a habit of smoking. In addition, they did not have any symptoms of nasal inflammation or consume alcohol the day prior. This study was performed in accordance with the regulations of the Ethics Committee of Kajima Technical Research Institute.

### 2.2 STUDY PROTOCOL

In this experiment, the ambient conditions in the rooms were maintained at 23–26 °C and 40–60% relative humidity. The illuminance near the participant's head was

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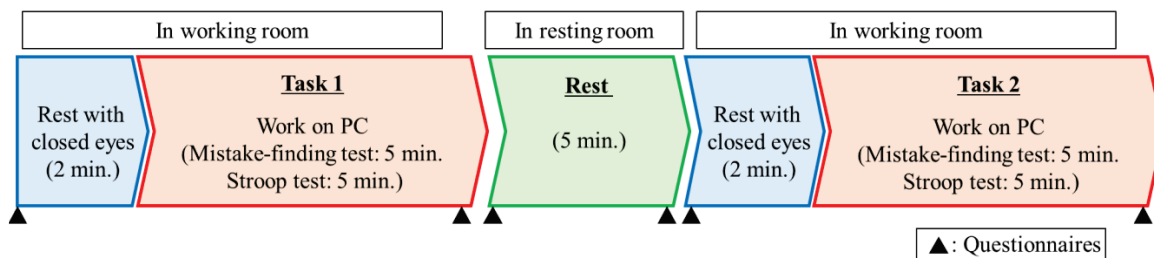


Figure 1: Experimental procedure

maintained at about 500 lx. The overall experimental procedure is illustrated in Figure 1. The experiments were conducted every other day for seven days. On the day of the experiment, each participant entered the room to work on a PC. The participants were instructed to close their eyes for 2 min and then start working on the PC (Task 1). After working for 10 min, each participant left the room and entered the resting room, where they rested for 5 min (Rest) before returning to the working room. The participants were again instructed to close their eyes for 2 min and work on the PC for 10 min (Task 2).

The experimental conditions are listed in Table 1. Except for Condition I, either or both the visual stimulation by the wooden room and/or the scent of Hinoki cypress were introduced in the experiment.

Table 1: Experimental conditions (words in red indicate introduction of wooden stimulation)

Conditions	Working room stimulation		Rest room stimulation	
	visual	olfactory	visual	olfactory
I : N-N	Concrete	None	Concrete	None
II : W-N_Work	Wooden	None	Concrete	None
III : N-H_Work	Concrete	Hinoki	Concrete	None
IV : W-H_Work	Wooden	Hinoki	Concrete	None
V : W-N_Rest	Concrete	None	Wooden	None
VI : N-H_Rest	Concrete	None	Concrete	Hinoki
VII : W-H_Rest	Concrete	None	Wooden	Hinoki

### 2.3 VISUAL STIMULATION

Two rooms of 10 square meters each were set up and furnished with wooden (walnut) paneling and concrete-style wallpapers on the ceilings and walls, as illustrated in Figure 2. To enhance the illusion of open space behind the walls, photos of the company's training center were affixed to the front and right sides of the rooms. The training center was designed with a wood-like texture, and in the room with concrete wallpaper, a grayscale version of the same photo was used.

### 2.4 OLFACTORY STIMULATION

The scent of Hinoki cypress (*Chamaecyparis obtusa*) was introduced into either one or none of the rooms using an aroma diffuser (Tree of Life Co., LTD; Figure 2). For the wood condition, 1 ml of Hinoki essential oil was mixed

with 10 ml of water, and water (without essential oil) was used in the control conditions. The concentration of the mixture was determined through a preliminary experiment conducted on 12 individuals in their 20s, separate from the main experiment. The participants performed 10 deep breaths in the room where the scent of Hinoki cypress was generated, then responded to a subsequent survey on the odor intensity. The concentration that fell between the average range of "weak odor" to "easily noticeable odor" was used. The composition of the odor was analyzed by collecting air at nose level and conducting gas chromatography. When introducing the scent of Hinoki cypress, we confirmed that the concentration of the main aromatic component,  $\alpha$ -pinene, did not exceed the concentration described in previous papers as "slightly unpleasant".



Figure 2: Experiment rooms covered with sliced walnut veneer (wooden room) (top) and concrete-patterned wallpaper (concrete-looking room) (bottom)

## 2.5 PC TASKS

The study required the participants to perform two PC tasks. In the first 5 minutes, the participants were asked to compare two slips on a PC and identify a character that was different, which they entered using a keyboard. For the latter 5 minutes, a Stroop test was administered. Participants are presented with color names written in a color and it evaluates the phenomenon where naming the color takes longer when the color and the written word do not match compared to when they do match. The Stroop test is originally designed to assess selective attention [5], but in this study, it is introduced as a stress task. In this experiment, characters written in red, blue, yellow, and green were displayed every second. There were 16 possible combinations of colors and characters. Participants were required to read the characters as they were displayed and respond by pressing the corresponding key on a keyboard to match the character's color.

## 2.6 MEASUREMENT

Three questionnaires for subjective evaluation were administered before and after the participants entered the rooms. Subjective ratings were given on a 7-point scale to describe the effects of visual or olfactory impressions. The visual impression was evaluated using six items, which were "like-dislike," "familiar-unfamiliar," "settling-unsettling," "luxurious-simple," "spacious-small," and "natural-artificial." The olfactory impression was evaluated using six items, which are "good-bad," "like-dislike," "familiar-unfamiliar," "settling-unsettling," "luxurious-simple," and "mild-pungent."

The Japanese version of the Profile of Mood States 2<sup>nd</sup> Edition Short Form (POMS2; Kaneko Shobo Co., Tokyo, Japan [6]) was administered to assess negative mood states. The POMS2 evaluates the state of mood and emotion using seven scales: "anger-hostility," "confusion-bewilderment," "depression-dejection," "fatigue-inertia," "tension-anxiety," "vigor-activity," and "friendliness". There are five questions for each scale, and each question is evaluated on a scale of 0 to 4, representing the individual's mood. The Total Mood Disturbance (TMD) score, indicating a comprehensive negative mood, is calculated by the scores of all scales except "friendliness."

The Jikaku-sho Shirabe (Industrial Fatigue Research Committee of Japan [7]) was utilized to measure subjective fatigue. This tool provides a subjective evaluation of fatigue on five scales, i.e., drowsiness, unsteadiness, discomfort, sluggishness, and haziness. Each dimension comprises five questions, to which the participant answered on a five-point scale from 1 to 5. By observing changes in scores over time, the extent of the participants' fatigue complaints can be assessed.

## 2.7 STATISTICAL ANALYSIS

We conducted statistical tests between the conditions to determine the differences in impression scores after Task

1, after rest, and after Task 2. To verify the effects of visual stimulation alone and the combination of visual and olfactory stimulation, statistical tests were performed between conditions I, II, and IV after the tasks and between conditions I, V, and VII after rest for the visual impression items. To determine the individual effects of olfactory stimulation and the combined effects of visual and olfactory stimulation, statistical tests were conducted between conditions I, III, and IV after Task 1 and between conditions I, VI, and VII after rest for the olfactory impression items.

Statistical tests were performed between each condition regarding the changes in scores of the Jikaku-sho Shirabe and POMS2 before and after Task 1, before and after rest, and before and after Task 2. To compare the effects of individual and combined stimulation, the changes in scores before and after tasks were compared between conditions I, II, III, and IV, and those before and after rest were compared between conditions I, V, VI, and VII.

The differences between the conditions were tested using the Wilcoxon signed-rank sum test (Bonferroni correction) (SPSS 28.0.1.1, IBM). The significance in difference was set at 5%.

## 3 RESULTS AND DISCUSSION

### 3.1 IMPRESSION EVALUATION

The visual impression scores after the tasks and rest are shown in *Figure 3*. After Task 1, the impression scores of settling-unsettling were significantly higher in both conditions II (introduced only wooden panels) and IV (introduced both wooden panels and the scent of Hinoki cypress) than in condition I (nothing introduced). The scores of luxurious-simple were significantly higher in condition II ( $p < 0.05$ ) than in condition I. After rest, the scores of like-dislike significantly increased in condition VII (introduced both wooden panels and the scent of Hinoki cypress) compared to condition I ( $p < 0.05$ ). After Task 2, the scores for the impression of luxurious-modest significantly increased compared to condition I in both conditions II and IV ( $p < 0.05$ ).

The olfactory impression scores after tasks and rest are shown in *Figure 4*. After Task 1, the scores of like-dislike and luxurious-simple were significantly higher compared to condition I in both conditions III (introduced only the scent of Hinoki cypress) and IV, and the scores of good-bad were significantly higher compared to condition I in condition IV ( $p < 0.05$ ). After rest, the impression score of luxurious-simple was significantly higher compared to condition I in both conditions III and IV, and the scores of good-bad, like-dislike and familiar-unfamiliar were significantly higher compared to condition I in condition III ( $p < 0.05$ ). After Task 2, the scores of good-bad, like-dislike, settling-unsettling, and luxurious-simple were significantly higher in both conditions VI (introduced only the scent of Hinoki cypress) and VII than in condition I ( $p < 0.05$ ).

The results of this experiment showed that the visual impression after the tasks and after rest did not differ. On the other hand, the assessment of olfactory impression

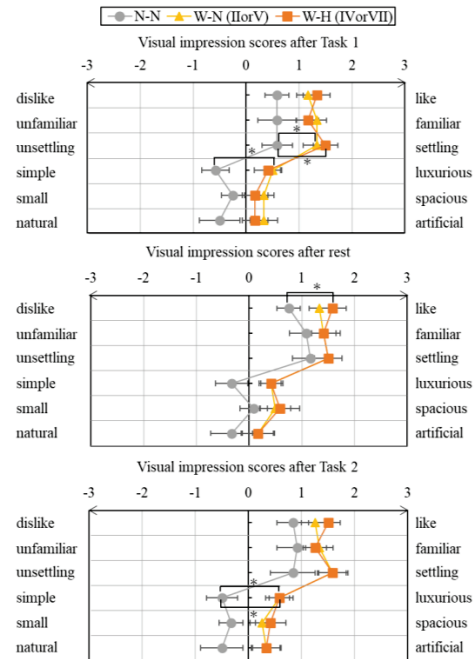
showed that during tasks, most items tended to be higher when both stimulations were introduced compared to when only olfactory stimulation was introduced, whereas during rest, the condition in which only olfactory stimulation was introduced showed a significant improvement over the control condition.

The results of this study suggest that the introduction of both the scent of Hinoki cypress and wooden interior did not alter the visual impression but led to an improvement in the olfactory impression during work, while the olfactory impression may have weakened during rest. This implies that the combined stimulation of the wooden material and scent may have an impact on the perception of the space.

### 3.2 MOOD STATES

The changes in the mood state scores before and after the tasks and rest are shown in *Figure 5*. The changes in scores on the anger-hostility, confusion-bewilderment, fatigue-inertia, and TMD scales depicted in *Figures 3-5* showed significant differences between the conditions. The change in scores of anger-hostility was larger in condition I (nothing introduced) than in condition IV and VII (introduced both wooden panels and the scent of Hinoki cypress) during both Task 1 and rest, with a significant increase during Task 1 and a significant decrease during rest ( $p < 0.05$ ). The change in confusion-bewilderment scores was significantly smaller for condition II (introduced only wooden panels) compared to condition I during Task 1 ( $p < 0.05$ ), while during rest, condition VII showed a larger decrease than condition V (introduced only wooden panels) ( $p < 0.05$ ). During Task 2, condition IV as found to have a smaller increase compared to condition I ( $p < 0.05$ ). The change in scores of fatigue-inertia was significantly smaller for condition II compared to condition I during Task 2 ( $p < 0.05$ ). The change in TMD scores was significantly smaller for condition IV compared to condition I during Task 2 ( $p < 0.05$ ). No significant differences were observed in the changes in the depression-dejection, tension-anxiety, and vigor-activity scores between conditions.

In many evaluation scales of POMS2, introducing visual or olfactory stimulation, or both, has been observed to improve mood states during both work and rest. Additionally, the improvement in mood states was significantly higher only in the confusion-bewilderment scale when both visual and olfactory stimulation were introduced compared to when only visual stimulation was introduced. No significant differences were observed between the conditions of introducing only olfactory stimulation and introducing both stimulation in all scales. However, significant differences were observed between the conditions where both visual and olfactory stimulation



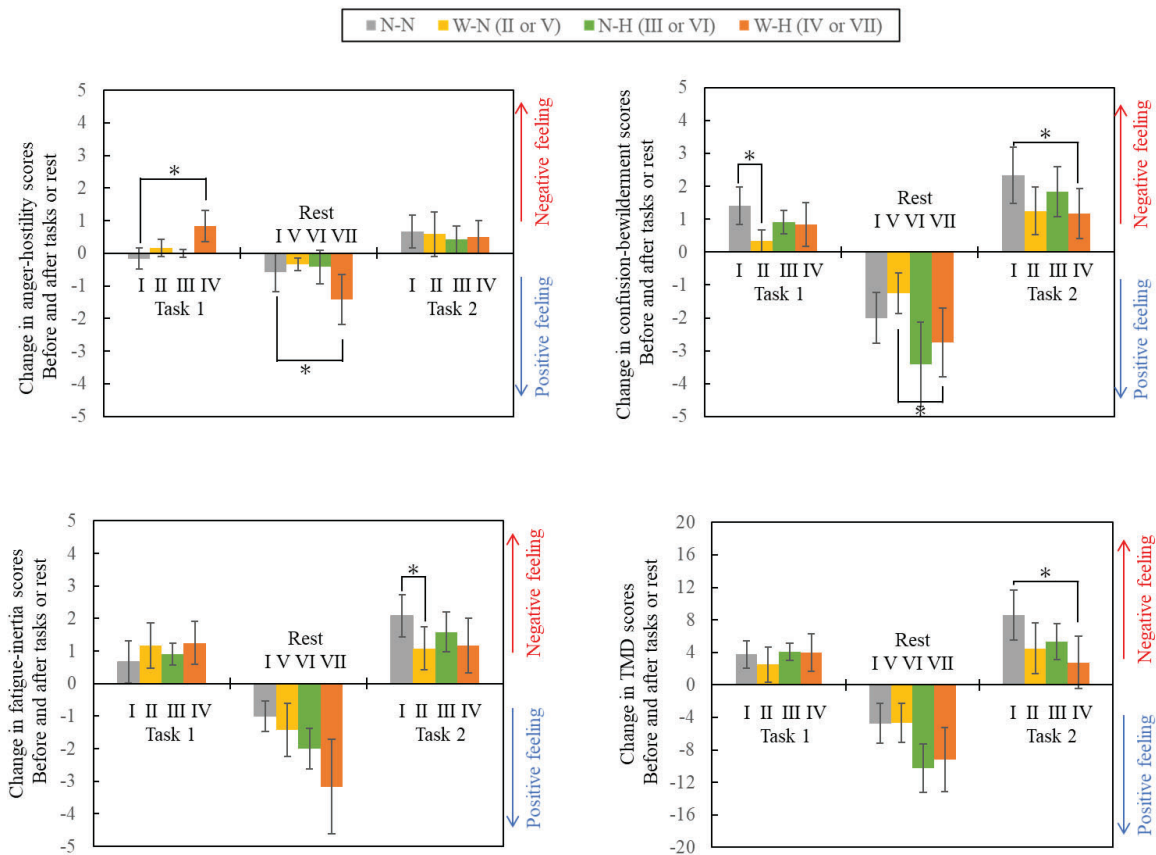
**Figure 3:** Visual impression scores after tasks and rest with different visual conditions as mean  $\pm$  S.E. ( $n=12$ ).

\*  $p < 0.05$ , Wilcoxon signed-rank sum test (Bonferroni correction)



**Figure 4:** Olfactory impression scores after tasks and rest with different olfactory conditions as mean  $\pm$  S.E. ( $n=12$ ).

\*  $p < 0.05$ , Wilcoxon signed-rank sum test (Bonferroni correction)



**Figure 5:** Changes in mood state scores (“anger-hostility,” “confusion-bewilderment,” “fatigue-inertia,” and TMD) before and after tasks and rest with different olfactory conditions as mean ± S.E. (n=12). \*p<0.05, Wilcoxon signed-rank sum test (Bonferroni correction)

were introduced and the control conditions on many scales, indicating the potential to enhance stress relief during work and rest by incorporating both visual and olfactory stimulation of wood in the office space.

### 3.3 SUBJECTIVE FATIGUE

The changes in the subjective fatigue scores (from the Jikaku-sho Shirabe) before and after tasks and rest are shown in Figure 6. The changes in drowsiness, discomfort, and haziness scores depicted in Figures 3-5 showed significant differences between conditions. The change in drowsiness scores was found to be significantly larger for condition III (introduced only the scent of Hinoki cypress) compared to condition II (introduced only wooden panels) during Task 1 (p<0.05). The discomfort scores significantly decreased more in condition III than in condition I (introduced nothing) during rest (p<0.05). Condition VI (introduced both wooden panels and the scent of Hinoki cypress) showed a larger decrease than condition V (introduced only wooden panels) (p<0.05). The haziness scores showed significantly less change

compared to condition I during Task 2 in conditions II and III. No significant differences were observed in the score changes of unsteadiness and sluggishness between the conditions.

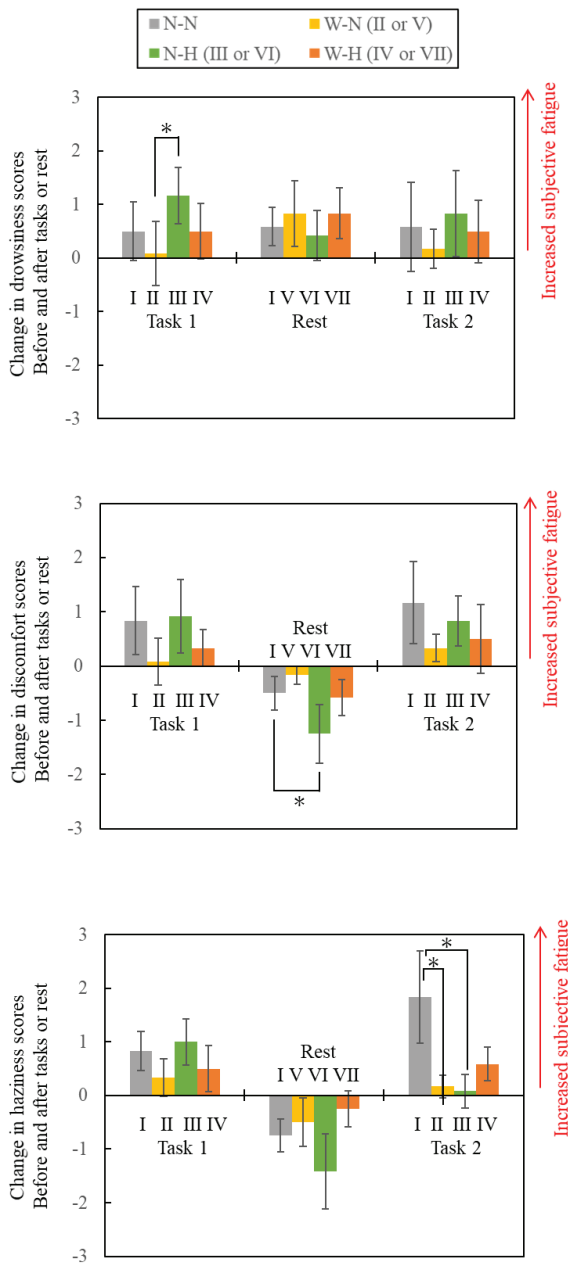
In the Jikaku-sho Shirabe, the scale of discomfort showed a reduction in fatigue during rest in the condition where the scent of Hinoki cypress was introduced compared to when nothing was introduced. The scale of haziness indicated that fatigue from the task was relieved in the condition where visual or olfactory stimulation was introduced. On the other hand, during Task 1, the increase in drowsiness after Task 1 was greater in the condition where the scent of Hinoki cypress was introduced than when the wooden panels was introduced. While the results might seem conflicting when considering subjective fatigue as a whole, drowsiness can occur as a feeling state even during relaxation. Therefore, this result aligns with previous research [4] and demonstrates the relaxing effects of the scent of Hinoki cypress.

The combined effects of both olfactory and visual stimulation were not observed in this measurement. The subjective fatigue was affected by the individual stimulus,

and the potential for reducing various types of fatigue was particularly evident when the scent of Hinoki cypress was introduced.

## 4 CONCLUSION

The aim of this study was to examine the combined effects of olfactory and visual stimulation derived from wood materials. We conducted a subjective experiment where participants performed tasks and rested in a space containing wood panels and the scent of Hinoki cypress. The results of the experiment suggest that when both the Hinoki scent and wooden panels were introduced, the visual impression did not change, but the olfactory impression may improve during work and weaken during rest. The results of the POMS2 also suggested that the combined introduction of visual and olfactory stimulation from wood into the space may further improve mood state during work and rest. The results of the Jikaku-sho Shirabe suggest that individual stimuli can impact subjective feelings of fatigue, and the introduction of Hinoki cypress scent shows potential in reducing various forms of fatigue. The results suggest that the combined visual and olfactory stimulation from wood may affect individuals in different ways, depending on the activities in which they are engaged.



**Figure 6:** Changes in subjective fatigue score (drowsiness, discomfort, and haziness) before and after tasks and rest with different olfactory conditions as mean  $\pm$  S.E. ( $n=12$ ).

\*  $p < 0.05$ , Wilcoxon signed-rank sum test (Bonferroni correction)

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