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Human physiological responses to wooden indoor environment

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HIGHLIGHTS

- The study explores human physiological responses in a wooden indoor environment
- The experiment measured physiological parameters at work and rest
- Subjects have less tension in wooden indoor environments than in non-wooden environments

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ABSTRACT

Previous studies are mainly focused on non-wooden environments, whereas few are concerned with wooden ones. How wooden indoor environments impact the physiology of the occupants is still unclear. The purpose of this study was to explore the distinct physiological responses to wooden and non-wooden indoor environments, assessed by physiological parameters tests including blood pressure, electrocardiogram measurements, electro-dermal activity, oxyhemoglobin saturation, skin temperature, and near distance vision. Twenty healthy adults participated in this experiment, and their physiological responses were evaluated in a 90 minute investigation. The results illustrated that; less tension and fatigue were generated in the wooden rooms than in the non-wooden rooms when the participants did their work. In addition, the study also found that the wooden environments benefit the autonomic nervous system, respiratory system, and visual system. Moreover, wooden rooms play a valuable role in physiological regulation and ease function especially after a consecutive period of work. These results provide an experimental basis to support that wooden environment is beneficial to indoor occupants than the non-wooden indoor environment.

1. Introduction

Given the amount of time we spend inside a room, the indoor environments play a critical role in our health, with physical surroundings contributing in both positive and negative ways. Studies have measured physiological responses to explore the impact of indoor environments on human health [1–3]. However, these findings have been mainly derived from non-wooden indoor environments; there is a lack of research related to wooden indoor environments.

Burnard and Kutnar [4] hypothesized that bringing nature into the built environment may improve the well-being of occupants. The wooden environment is a particularly good example for this purpose. Other researchers have explored this concept. As summarized in literature surveys performed by Tsunetsugu et al. [5,6], a difference in a wood ratio in the interior wall resulted in different physiological responses, especially in terms of autonomic nervous system activity. The studies showed that pulse rate increased significantly in the 45% wood ratio room, systolic blood pressure decreased in the 90% wood ratio room and that these two indices were unchanged in the 0% wood ratio room. In addition, Sakuragawa et al. [7] performed a similar study that used full-sized hinoki wall panels and a white steel wall panel to explore the effect of visual stimulation from wood panels. Continuous blood pressure measurements were used as the physiological indicator. Results showed that the systolic blood pressure decreased significantly in the subject group who saw the hinoki wall panels, while it increased in the subject group who saw the white wall panels. In addition to research on visual stimulation, Sakuragawa and Kaneko [8] attempted to explore the physiological reactions of the human body after contact with wood. They found that contact with wood produced a safe or comfortable sensation and did not create a physiological state of stress since no associated increases in systolic blood pressure measurements were observed. Indeed, Fell [9] clarified that using wood for

Abbreviations: ECG, electrocardiogram; HR, heart rate; HRV, heart rate variability; SCL, skin conductance level; SpO_2, oxyhemoglobin saturation.

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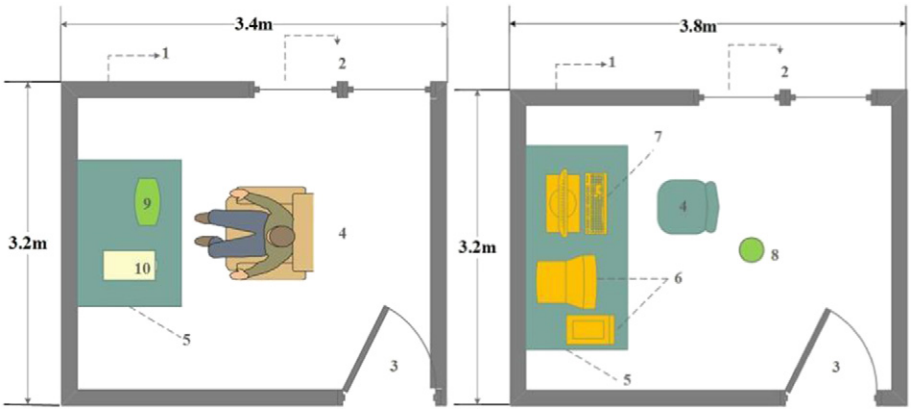

Fig. 1. Arrangements of experimental rooms. (1) maintenance wall; (2) shutters; experiments were conducted with the shutters closed; (3) entrance door; (4) working chair; (5) working desk; (6) physiological measuring instrument and monitor; (7) personal computer for performing the work task; (8) thermal environment monitoring point; (9) eye patch; (10) instruments to measure blood pressure and pulse rate.

interior treatments in indoor environments has a positive impact on well-being, especially related to indicators of stress. In his study, skin conductivity and inter-beat interval were tested as two branches of the autonomic nervous system: Results showed that both skin conductance level (SCL) and the frequency of non-specific skin responses were lower in the wooden room in the baseline period. During the stressful test period, skin conductance level did not differ between wooden and non-wooden rooms. Generally, these studies focused on wood productions (panels or furniture) as well as the effects of the visual impact.

The above studies re-centered the focus of environmental effects on people, especially as they relate to positive outcomes. Kaplan and Kaplan [10] refer to these positive environments as "restorative environments." Ulrich [11,12] conducted related research in healthcare facilities and found that patients recovering from stress due to similar surgeries differed in their recovery and demands for pain medication based on the view from their recovery room window. In a study that involved built, indoor school environments, Grote proposed that a wooden environment plays a positive role in improving concentration and reducing stress [13]. However, there is currently not enough data to prove that wooden indoor environments lead to recovery from stress. Thus, relevant restorative research of wooden indoor environments is still lacking. At the same time, research regarding the use of restorative environments in an office setting is also insufficient to draw conclusions. The limited results in the current literature indicate that this field is in a nascent stage. Therefore, it is important to conduct further investigation to examine the effects of physiological responses to wooden indoor environments. Former studies usually selected blood pressure and pulse rate as physiological indices and results showed that these two indicators were sensitive to environmental change. In this study, other parameters of the autonomic nervous system, vision system, and respiratory system were also used to reflect the physiological differences in wooden and non-wooden environments.

2. Methods

2.1. Experimental conditions

In order to simulate the office environment, five identically sized rooms (L × W × H = 3.8 m × 3.2 m × 2.8 m) were established: one preparation room, a basic room (non-wooden), and three contrast wooden structure rooms. All rooms were free from decoration, except for a worktable, a chair, and a laptop (Fig. 1). The envelope of three wooden rooms were wooden frame and interior wood walls were completely exposed (Fig. 2). More details can be found in Table 1. Windows were opened for thorough ventilation during

Fig. 2. The pattern of the interior wood wall.

Table 1
Information of five experimental rooms.

Rooms	Code	Maintenance structure	Interior wall	Physical environment
Preparation room		Non-wooden (steel concrete)	100% painted white	T: 22–24 °C
Basic room	TR	Non-wooden (steel concrete)	100% painted white	RH: 30–40%
Comparison rooms	YR	Wooden	100% dark brown wood	500 lx
	RR	Wooden	50% light brown wood and 50% painted white	
	PR	Wooden	100% light brown wood	

T, temperature; RH, relative humidity.