

Sleep Quality and Workplace Productivity Evaluation on the Wooden Interior

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Summary: Improvement of sleep quality is important because sleep deprivation reduces workplace productivity. In this study, we focus on wooden interior, which is used in previous studies as an environmental factor considered to affect sleep quality. We evaluated quantitatively by using single channel electroencephalogram (EEG) devices and polysomnography (PSG) devices, therefore, almost all of these studies used qualitative evaluation. Stress values were obtained from EEG data and KANSEI Analyzer, and sleep data were obtained from PSG. We conducted experiments of two days one night twice per subject, to obtain sleep data, workplace productivity evaluation task data, and EEG data. The result showed that wooden interior improved sleep quality, increase rates correct characters in typing task, and decreased stress values. These results show that we identified the appropriate conditions for sleep quality and workplace productivity.

Introduction: Sleep disorder and sleep deprivation is said to cause a decline in cognitive function and immune function and in workplace productivity during the day, resulting in enormous economic loss [1-5]. Workplace productivity refers to the amount and quality of intellectual work that can be performed within a certain period of time [6]. In this study, we focus on differences in bedroom interiors, which is widely dealt with in previous studies as an environmental factor having an effect upon sleep. Because the fragrance of wood has a function to suppress sympathetic nerve activity, it suggests that a bedroom with wooden interior improves the quality of sleep [7, 8]. Most of the previous studies qualitatively evaluate the influence of differences in interior on sleep quality by questionnaire or the like, therefore, we focus on electroencephalogram (EEG) measurement and polysomnography (PSG) which are biological signals as a method of quantitative evaluation. By investigating the relationship between these measurement results and the workplace productivity evaluation tasks, we evaluate quantitatively the influence of workplace interior on workplace productivity through the change of sleep quality, using EEG measurement and PSG under wooden condition and non-wooden condition.

Methods: 19 healthy subjects (12 males, 7 females; age: 22.9 ± 1.04 years) participated in this experiment. Subjects were divided into nine people who stayed in wooden interior room and ten who stayed in non-wooden interior room. Figure 1 shows the flow of the experiment conducted in this study. The rooms of model house differ depending on subjects in two kinds of wooden or non-wooden, and work place is same for all the subjects.

We used using MindWave Mobile (NeuroSky Inc.)[9], a single channel EEG device and obtained stress values from EEG data using “KANSEI Analyzer” (Dentsu Science Jam Inc.)[10]. EEG measurement point was set to Fp1 based on international 10-20 system. We measured biological signals during sleep using Alice PDx (Philips Japan, Ltd.)[11], an PSG device. Based on measured biological signals, sleep stages were divided into REM, N1, N2, and N3. These represent better quality of sleep from REM to N3. The sleep stages was determined every 30 seconds and the percentage of each sleep stage in total sleep time was calculated. In addition, the latency from turning off to N1, N2, N3, wake time after sleep onset (WASO), and sleep efficiency was also calculated.

As tasks to measure workplace productivity, typing task and mind map were performed. Tasks were conducted twice and three times respectively, in one experiment. Also, each time was 12 minutes, 20 minutes each. To eliminate individual differences, the increase rates from day 1 to day 2 were

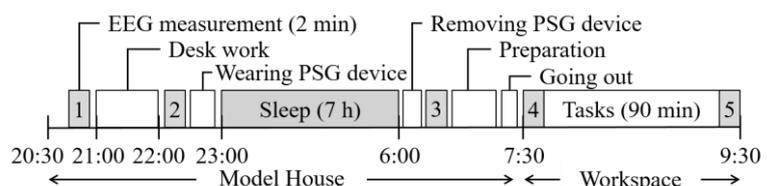


Figure 1. The experimental flow. EEG measurements were performed with trials 1 to 5.

calculated from the ratio of the number of correct and wrong characters in typing task and words written out in mind map. The total time of all tasks and rests was 90 minutes.

Results and Discussions: Firstly, we evaluated the influence of differences in bedroom interior on sleep quality. As shown in Table 1, the proportion of N3 increased significantly under the condition of wooden room. It was revealed that wooden interior significantly increased the rate of deep sleep. Secondly, we evaluated the influence of the rate of N3 on workplace productivity of the next day. The result of calculating correlation coefficients between the ratio of N3 and increase rate of task performance showed that there was a strong positive correlation between increase rate of the number of correct characters in typing task and N3 ratio in the group staying in wooden room. We confirmed the tendency that increase of N3 due to the wooden interior raised increase rate of the number of correct characters. Thirdly, we evaluated the influence of differences in bedroom interior on stress values. As shown in Table 2, the stress values in trial 4 which were before tasks decreased under the condition of wooden room. Finally, we evaluated the influence of differences in stress values between before and after trial. As shown in Table 3, between trial 2 and 3, a significant difference was confirmed under the conditions of both wooden and non-wooden room. An increase in stress values before and after sleep may be caused by an unfamiliar experimental environment. In addition, Table 3 showed that stress values before sleep and before tasks decreased under the condition of wooden room. These results suggested that wooden interior had positive influences on sleep and workplace productivity on the next day.

It is necessary to increase the number of subjects and to verify because it is small in this study. In addition, although it was confirmed that bedroom with wooden interior affects typing task through the change of sleep quality, the influence on mind map could not be confirmed. Mind map is more creative than typing task, therefore, it is necessary to evaluate the influence on creative tasks by performing other creative tasks. Furthermore, although we evaluated the influence of wooden interior on the workplace productivity of the next day through the change in the quality of sleep, we did not disclose why wooden interior have this influence. It is necessary to investigate factors that change sleep quality in wooden room.

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Table 1. The results of calculating differences in sleep data between the group that stayed in wooden room and in non-wooden room. (* $p < 0.05$)

REM [%]	N3 [%]	Latency [min]			WASO [%]	Sleep efficiency [%]
		N1	N2	N3		
-3.19	7.95*	-2.01	-2.54	-9.42	-1.88	2.40

Table 2. The results of calculating differences in stress values between the group of staying in wooden room and in non-wooden room for each trial. (* $p < 0.05$)

	Trial				
	1	2	3	4	5
Differences [%]	1.06	-2.22	-1.65	-6.94*	-3.96

Table 3. The results of calculating differences in stress values between before and after trial. (* $p < 0.05$)

	Wood			
	Trial			
	1-2	2-3	3-4	4-5
Differences [%]	5.45*	-9.00*	6.77*	-0.761
	Non-wood			
	Trial			
	1-2	2-3	3-4	4-5
Differences [%]	2.17	-8.43*	1.48	2.22