Effect of Wall Material of a Room on Performance in Long Monotonous Work

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Abstract. A decline in concentration and physical/mental fatigue induce the occurrence of errors in monotonous work, or a decline in work efficiency. The efficiency of monotonous work is closely related to the environment of a room. Historically, Japan incorporates natural materials, such as clay, grass, bamboo charcoal in the interior construction of rooms. Natural materials used for interiors characteristically have properties which adjust to moisture levels and absorb contaminants in a house. We thus, expect the possibility of utilizing these specific effects to improve work efficiency while performing tedious work. The purpose of this study is to clarify how materials, such as wallpaper, clay wall and bamboo charcoal board, used in the construction of an interior, influence work efficiency and fatigue during long monotonous work. In this study, subjects sorted literature to represent the monotonous work used in the research. The status of work was recorded via video camera and the brain waves of the participants were measured. Fatigue levels, before and after the experiment, were also recorded.

Keywords: long monotonous work, interior environment, clay wall, bamboo charcoal, fatigue.

1 Introduction

It is generally considered that the decline in work efficiency, or the occurrence of error in monotonous work, is caused by a decline in concentration, or physical/mental fatigue [1]. However, studies show that the efficiency of monotonous work is also closely associated with the interior environment of a work room. The humidity and temperature in the room greatly influence the alertness of a worker engaged in monotonous work (for example [2]). Moreover, the smell in a room is also closely related to the alertness level of a worker (ex. [3]).

In Japan, we utilize indoor construction materials made from natural substances, such as clay wall. Some researchers report that clay wall contains properties which adjust to indoor humidity and absorb pollutants in a house (for example [4]). It is also

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considered that the smell of grass emitted from a clay wall influences the efficiency of monotonous work.

It is common in Japan to utilize charcoal made from the chamber of bamboo to assist in the elimination of bad odors from a house. Bamboo has an exceptional microstructure, and after carbonization, displays high absorption ability. Bamboo charcoal is also used to purify water, removing organic impurities and odors. Because of its ability to remove substances which have an adverse effect on the environment, such as formaldehyde, the function of bamboo charcoal has been assessed [5]. Moreover, bamboo charcoal emits far extending infrared rays. Reports have revealed that these far extending rays emitted from bamboo charcoal improve blood circulation [6]. The far reaching infrared rays from bamboo also have a deodorizing effect which could influence the outcome of monotonous work.

The purpose of this study is to clarify how materials used for interior construction, such as wallpaper, clay wall and paper board made of bamboo charcoal influence work efficiency and fatigue while performing long monotonous work. Subjects sorted literature to represent the long monotonous work used in this research. The status of the participants work was recorded via video camera and their brain waves were measured. Fatigue levels were also measured pre and post experiment. Water generated during the work was also observed and analyzed. The results were based on the findings from three types of rooms: one room with a paper wall, one with a clay wall, and one with a bamboo charcoal board wall. We compared and analyzed the percentage of efficient work time and the occurrence of error per subject, per room.

2 Method

2.1 Subject

The data of the subject is as shown in Table 1. All nine subjects were male. And the breakdown by age is as follows: 5 in their 20's, 2 in their 20's, 1 in his 40's and 1 in his 60's.

Table 1. Fig. 1. Table 2. Subjects

Subject	Gender	Age(years)	Height(cm)	Weight(kg)
A	Male	21	172	58
B	Male	23	173	74
C	Male	24	175	80
D	Male	23	172	64
E	Male	31	181	55
F	Male	23	183	75
G	Male	41	174	73
H	Male	63	172	70
I	Male	28	171	84

2.2 Measurement Environment

For our research, three rooms were created with identical layouts in the same facility. However, each room had a different wall material. As shown in Figure 1, the wall material used by room was wallpaper, clay, and bamboo charcoal board. Wallpaper is the most common interior material utilized in Japan. A clay wall is a traditional Japanese wall made from clay, sand and straw. Since the clay wall is made from only natural materials, it emits a peculiar smell, but contains properties which have a positive effect on moisture levels. Bamboo charcoal is known to emit far reaching infrared rays, and has effective properties which absorb and remove odors, prevent electromagnetic waves, purify water and improve soil. Although bamboo charcoal board has not been widely used as a wall material in Japan, its positive effects have spread in various fields such as clothing and environmental products. Recently, a charcoal board product has been developed by molding finely powdered bamboo charcoal. The charcoal board is flat so that it can be utilized as material for a wall. We expect that the application of bamboo charcoal will spread in the future.

Fig. 1. The status of each room used for experiment

2.3 Measurement Method

The subjects were engaged in monotonous work over a long period of time in three different rooms. Measurements were conducted on 3 separate days: March 28, 2012, April 18, 2012, and May 9, 2012. Although the measurements were conducted during a three day period, the time the measurements took place remained consistent. So, the subjects were measured at the same time each day over the course of three days. Subjects were assigned to each room in a random order to obtain unbiased experiment results. We asked the subjects to sort papers which represented the long monotonous work. The material utilized for sorting were application booklets for graduate school. The booklets consisted of text, resumes and envelopes. The booklets were classified into seven sections (1) cover and back cover, (2) resume, (3) mailing labels, (4) a large sized envelope, (5) a small sized envelope, (6) recyclable paper and (7) waste paper. The subjects sorted 200 booklets in one trial. Desks and chairs were installed in each room with a layout of the room shown in Figure 2. Seven boxes, which

contained the classified documents, were placed on each desk. Prior to the experiment, instruction was given to the subjects pertaining to the booklet. Next, the subjects were told to begin work by sorting through all the booklets until they were finished. A particular method was not given as to how to remove a document from the literature.

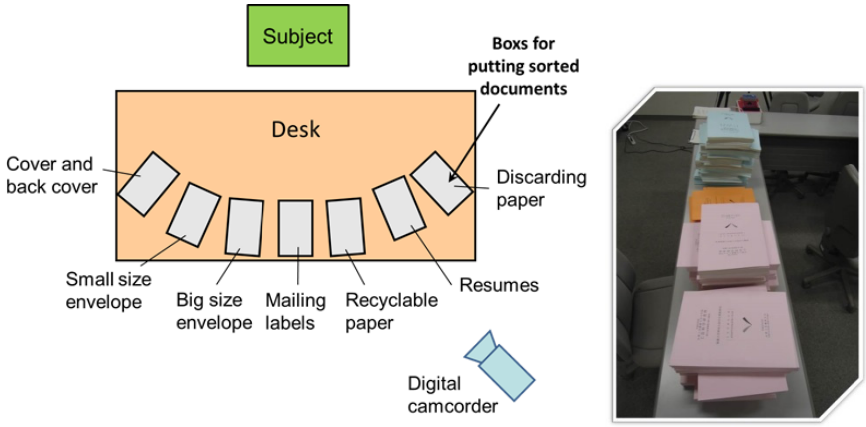


Fig. 2. Experimental Environment

2.4 Video Recording

The movement of the subjects during work was recorded by a digital camcorder. The entire time subjects engaged in work was measured and recorded via video.

2.5 EEG Measurement

Electroencephalogram (EEG) (MindSet NeuroSky) was used to measure the EEG of the subjects during work. The MindSet technology was developed for leisure. It is easy to use and low in cost. Three dry electrodes placed on the ears and chin are able to capture neural activity. By applying the algorithm, it decrypts neural activity. MindSet can detect information regarding the brain band activity of a user, and can also measure the delta, theta, alpha, beta and gamma output levels. The subjects closed their eyes for three minutes before and after work while their EEG output was measured. The EEG used for this study can calculate the the degree of attentiveness and meditation. On the assumption that the EEG of the subjects while resting was 100%, we normalized the EEG during work.

2.6 Fatigue Survey

Fatigue associated with work was surveyed before and after the course of work by using the "Survey for Awareness", published by The Industry Fatigue Committee of Japan Society for Occupational Health. This questionnaire was developed to evaluate the

tendency of fatigue from the work performed, and whether the consistency in the factorial validity was confirmed. The questionnaire consists of 25 questions to be classified into five groups and five factors. The questions include; "Feeling of sleepiness" indicating sleepiness, "sense of instability" indicating mental fatigue, “discomfort” indicating symptoms of autonomic imbalance, "sense of tiredness" indicating physical dissatisfaction and "feeling blurry" indicating complaints of eye strain. The answers for each question were prepared in advance to include, "Not at all true", "slightly true" "a little true" "quite true" and "applies very well." Then, we assigned a 5 point system, with 5 being the highest and most intense, and summed up each factor.

2.7 Survey of Work Error

Photographs of the documents were taken after subjects finished their work with the documents. Then, it was classified into three categories; “torn pieces of paper”, “ripped paper” and “miss-sorted paper”. The examples for “torn pieces of paper” and “ripped paper” are shown in Figure 3.

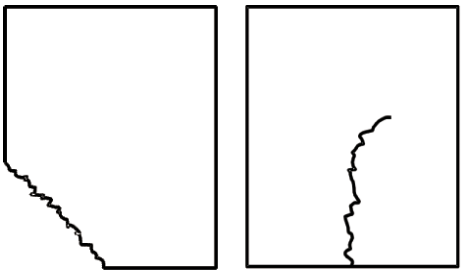


Fig. 3. Working Error Examples

3 Results

3.1 EEG Measurement for Fatigue Survey

Although previous findings regarding EEG measurements, fatigue survey and work time have been covered, a summary of the results are listed [7]. The EEG results measured the degree of attentiveness and meditation. We observed the levels of attentiveness in each room. The results revealed that attentiveness was greatest in the bamboo room. The clay room was the second highest, followed by the wallpaper room. The level of attentiveness declined during work when compared to the “resting” level of all subjects. The attentiveness observed in the bamboo charcoal board room was significantly higher than the clay wall and wallpaper rooms. The meditation degree was highest in the wallpaper room, followed by the clay wall room and lastly, the bamboo charcoal board room.

The meditation degree in the clay wall-room indicated a significantly higher rate than the wallpaper and bamboo charcoal rooms. And the degree of meditation in the bamboo charcoal room was significantly higher than wallpaper room.

The average time worked in all rooms was 2 hours, 6 minutes and 43 seconds. The average time worked in the bamboo charcoal room was 2 hours and 43 seconds. The wallpaper room was 2 hours, 3 minutes and 24 seconds and the clay wall room averaged 2 hours, 16 minutes and 2 seconds. The least amount of hours worked were observed in the bamboo charcoal board room. The fatigue level tendency was shown to increase in all rooms, especially the wallpaper room. A significant degree of complaints of "local pain or dullness" were expressed in the wall paper room.

3.2 Work Time, Total Number of Sorted Papers, Number of Ripped Papers and Torn Papers

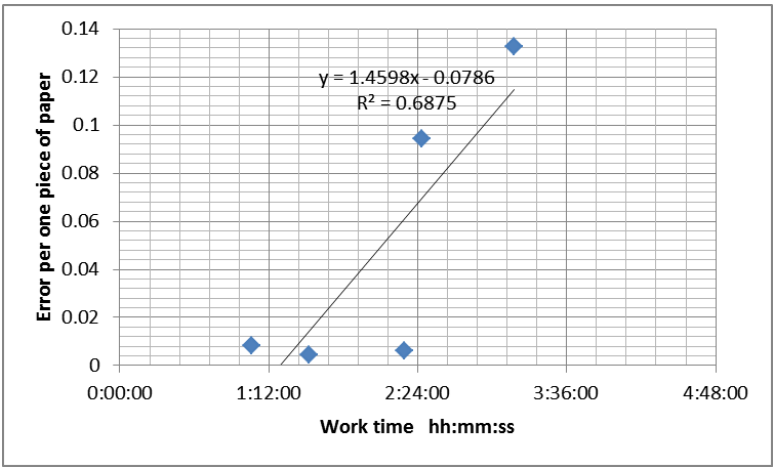
Table 2 shows the aggregated results from hours worked per subject, the number of sorted papers, and the number of torn pieces of paper and ripped paper. Based on this data, we found a correlation among error occurrence, working time and working efficiency by each subject.

Table 2. Result of Worke Time, Total Number of Sorted Paper, Number of Ripped Papers, and Torn Paper of each Subject

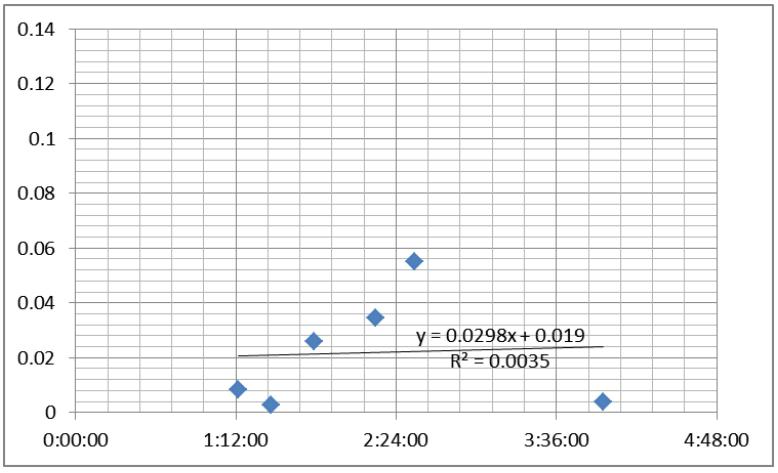
Wall material	Subjects	Work time hh:mm:ss	Total number of sorted paper	Total number of ripped paper	Total number of torn paper
Wall paper	B	1:31:41	467	0	2
	C	2:26:12	339	23	9
	F	1:03:53	603	2	3
	G	3:10:29	1522	197	5
	H	2:17:46	811	5	0
Clay wall	B	2:14:53	437	15	0
	D	1:47:12	501	8	5
	E	1:27:41	382	0	1
	F	1:13:05	828	6	1
	G	3:57:17	1804	2	5
	H	2:32:24	943	50	2
Bamboo charcoal board	A	2:05:49	416	3	0
	B	1:27:11	478	11	0
	C	2:18:43	491	6	1
	D	1:29:48	439	9	0
	F	1:12:37	905	29	1
	G	3:16:28	536	49	0
	I	2:04:15	1268	42	8

3.3 Correlation between Work Time and Error

We normalized the number of errors according to the total number of sorted paper per each subject. In the wallpaper room, the subject who worked a long period of time showed a high tendency to make errors. However, in the bamboo charcoal room and the clay wall room, the tendency to make errors declined. All the samples were in the range of three sigma.

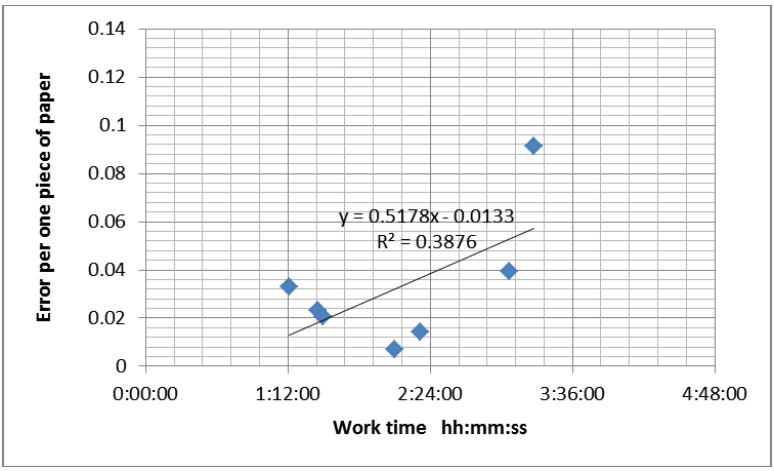


(a) Wall paper



(b) Cray wall

Fig. 4. Correlation between Work Time and Error per One Piece of Paper

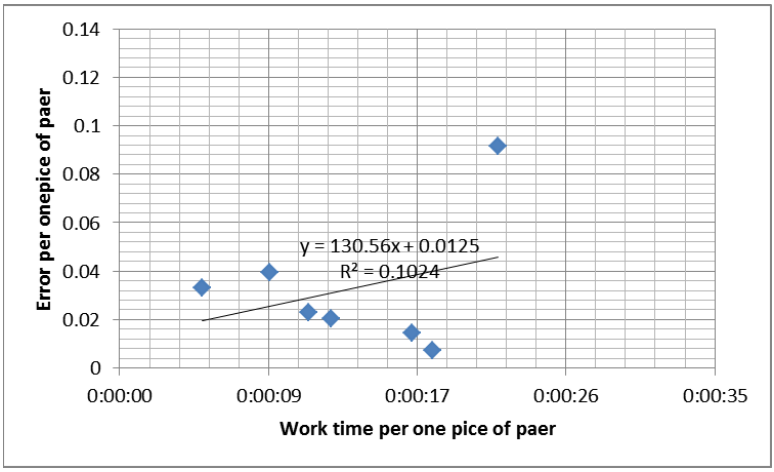


(c) Bamboo charcoal board

Fig. 4. (*Continued.*)

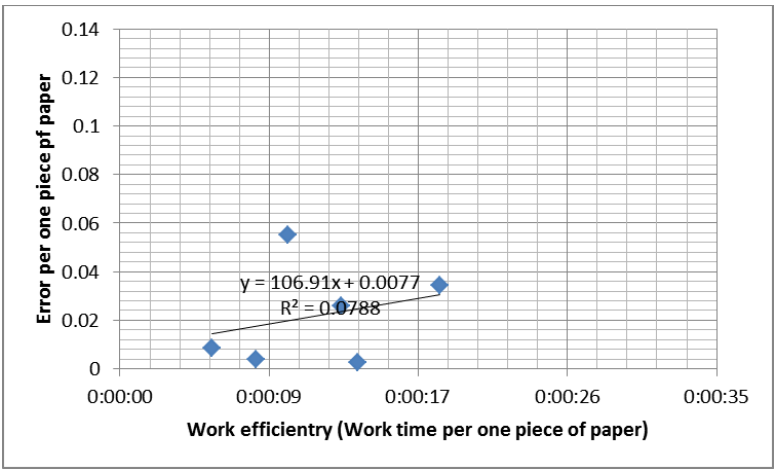
3.4 Correlation between Work Efficiency and Error Per One Piece of Paper

The work efficiency was calculated by dividing the total number of sorted paper, which is the time required for sorting one piece of paper. In either room, the subjects with low working efficiency, which means a long working time, showed a high tendency towards error occurrence. However, all subjects showed only a weak correlation, and a significant difference was not observed. All the samples were in the range of three sigma.

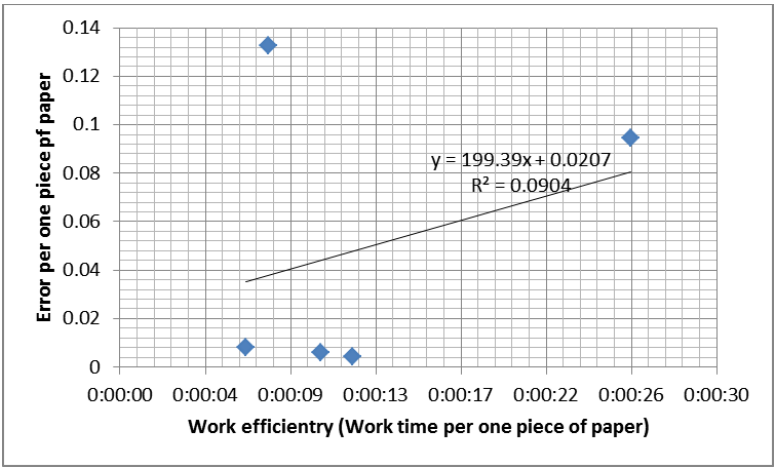


(a) Wall paper

Fig. 5. Correlation between Work Efficiency and Error per each Paper



(b) Cray wall



(c) Bamboo charcoal board

Fig. 5. (*Continued.*)

4 Conclusion

In this study, we verified the correlation among error occurrence, hours worked and working efficiency when exposed to long monotonous work in a bamboo charcoal room, a clay wall room and a wallpaper room. We observed that subjects who experienced a long duration of work in the wallpaper room had a higher tendency to make errors. The tendency to commit an error declined when in the bamboo charcoal room, followed by the clay wall room. The correlation between error occurrence and work efficiency was weak in all rooms. And no significant differences per each wall

material were observed. Our research suggests a room with bamboo charcoal walls could possibly reduce the amount of error when exposed to long monotonous work. We believe we need to further our study to reveal more findings.

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