

SUBJECTIVE EXPERIMENT ON CAUSAL RELATIONSHIP BETWEEN INDOOR TEMPERATURE AND OCCUPANTS' PERFORMANCE MEDIATED BY AROUSAL STATE



Tomonobu Goto*, Department of Architecture and Building Science, Tohoku University, Japan
 Makoto Koganei, Department of Architectural Design and Engineering, Yamaguchi University, Japan
 Miki Hiramatsu, Department of Architecture and Building Science, Tohoku University, Japan

Background Many studies have shown the impacts of indoor environment on occupants' performance. However, degrees of the impacts are different among the studies, and some studies have shown little impacts. In order to explain such differences, we must reveal the mechanism of the causal relationship between Indoor environment and occupants' performance.

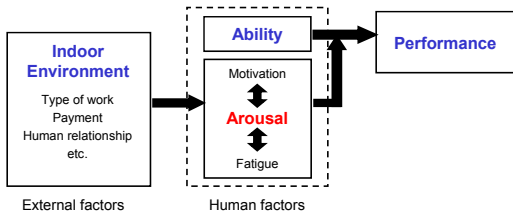


Figure 1. Schematic of causal relationship between indoor environment and performance

Arousal We assumed this relationship can be expressed as Figure 1. We focused on arousal as one of the human responses mediating the causal relationship. Based on some studies in psychology, we consider that the arousal consists of two components, i.e. **Energetic Arousal (EA)** and **Tense Arousal (TA)**. Our previous study (HB2015, ID 575) had verified the relationships between indoor environment and arousal state (Figure 2), and between arousal state and work performance (Figure 3), respectively.

Objectives 1) To validate that arousal state intermediates between indoor environment and work performance, 2) To validate that some types of tasks calm down arousal level regardless of indoor environment. Consequently, little impacts are observed on the performance

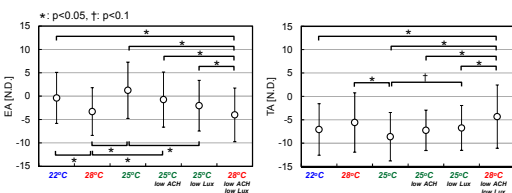


Figure 2. Impacts of indoor environment on arousal state

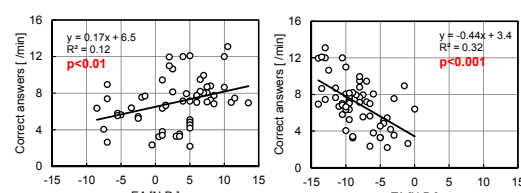


Figure 3. Impacts of arousal state on performance (Sudoku)

Method We conducted a subjective experiment. Indoor temperature was selected as the environmental parameter (Table 1). Subjects' performance was evaluated with three types of tasks (Figure 4). Subjects participated in three experimental sessions (Figure 5) with different cases but an identical task. Arousal state, i.e. EA and TA were evaluated with Japanese UIST Mood Adjective Checklist (JUMACL, Table 2). Skin conductance (SC) was measured as an additional indicator of arousal state (Figure 6).

Table 1. Experimental cases

	Indoor temp.	OA supply rate	Illumination Intensity	Humidity	Clothing
Case 1	22°C	30 m³/h/p	300 lx	Not controlled	0.7 clo
Case 2	25°C				
Case 3	28°C				

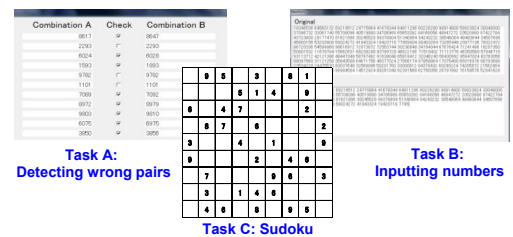


Figure 4. Types of tasks

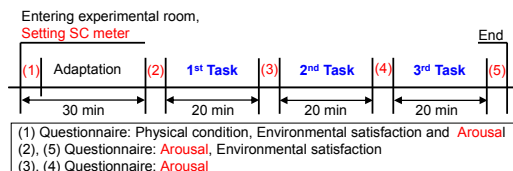


Figure 5. Schedule of experimental session

Table 2. JUMACL

Does the adjective define your present mood?	(1: Definitely, 2: Slightly, 3: Slightly not, 4: Definitely not)
Restful	1 2 3 4
Bright	1 2 3 4
Energetic	1 2 3 4
Relaxed	1 2 3 4
Nervous	1 2 3 4
Sleepy	1 2 3 4
Industrious	1 2 3 4
Composed	1 2 3 4
Tense	1 2 3 4
Passive	1 2 3 4



Figure 6. Skin conductance

Results Thermal satisfaction was almost identical among the tasks, i.e. Case 3 was significantly lower than the other cases (Figure 7). However, EA and TA regarding Task A and B were not different among the cases (Figures 8 & 9). Both EA and TA were considered to be subsided by simplicity and monotony of the tasks. Thus, the EA and TA became lower regardless of the indoor temperature. On the other hand, there were some significant differences in both EA and TA regarding Task C. The EA in Case 1 was significantly higher than that in Case 3, and the TA in Case 1 was significantly lower than that in Case 3. Results of SC were not contradictory to the results of EA and TA (Figures 10).

Performance regarding Tasks A and B were not different among the cases (Figures 11). It was reasonable because the subjects' arousal state was not different among the cases. On the other hand, a difference in the performance was found in Task C at the 3rd period.

Conclusions

Arousal state intermediates between indoor environment and task performance. At least partially, differences in impacts of indoor environment on task performance can be explained by the arousal state.

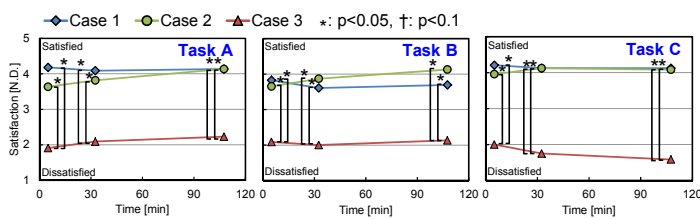


Figure 7. Satisfaction with thermal environment

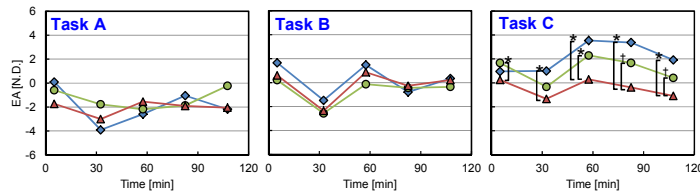


Figure 8. Energetic arousal (EA)

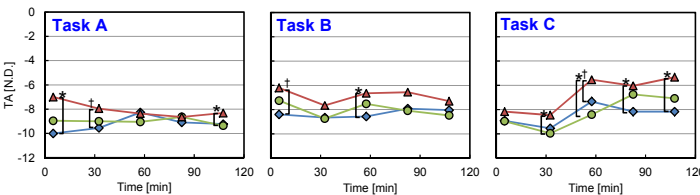


Figure 9. Tense arousal (TA)

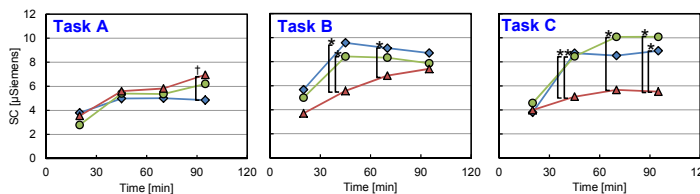


Figure 10. Skin conductance (SC)

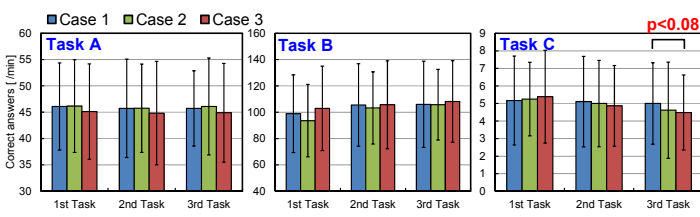


Figure 11. Task performance

*Contact information