Influence of sound environment on knowledge creative activity

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ABSTRACT

In order to investigate an influence of indoor sound environment in office on knowledge creative activity, subjective experiments were conducted in our study. In the experiments, subjective evaluations on the ease of meeting, the quietness of sound environment and the listening difficulty of speech in two different types of group meetings (discussion to think of creative ideas and decision-making meeting) were measured under five types of sound environmental conditions (no-noise $L_{Aeq,5min}$ 38 dB, ambient noise (conversation noise) $L_{Aeq,5min}$ 40 dB, 45 dB, 50 dB, 60 dB) in meeting room of the university. From these results, in regard to the quietness of sound environment, we found that the subjects start feeling noisy (not quiet) in sound environmental condition of ambient noise 50 dB, and that of 60 dB have an increased the listening difficulty of speech. Furthermore, in sound environmental condition of ambient noise 50 dB, the ease of meeting was the highest evaluation for discussion to think of creative ideas among these experimental conditions. Thus, it was suggested that recommended indoor sound environmental condition to conduct discussion to think of creative ideas was ambient noise 50 dB.

INTRODUCTION

With the advent of the knowledge creating society in recent years, construction of workplace environment to improve the productivity of intellectual activity is desired in office. In order to enhance workplace environment as knowledge creating space, active and smooth communication is required in the spaces to think up creative ideas, such as meeting rooms and common areas in office.

In previous studies related to knowledge creative productivity and indoor sound environment, it is assumed that situations of conversation of two people, simple task and memorization to perform alone, knowledge creative activity such as writing essay. Thus, these were not focused on knowledge creative activity in a group. Therefore, in our study, focusing on knowledge creative productivity and indoor sound environment in situation to carry out knowledge creative activity in a group, as a beginning, subjective experiments were conducted in order to Influence of noise level of background noise in meeting room on the ease of meeting. This paper reports relationships between the ease of meeting and noise level of background noise during each meeting.

SUBJECTIVE EXPERIMENT

In the meeting room of Tokyo Denki University, the group of subjects have each meeting during exposure to five kinds of sound environmental conditions. After each

meeting under these sound environmental conditions, the subjects were asked to evaluate the impression of sound environment and meeting space, the situation and outcome for meeting. What happened in the meeting was captured on video-tape.

Experimental Conditions

In our study, an influence of sound environment on the ease of meeting was investigated in regard to two different types of meetings such as discussion to think of creative ideas and decision-making meeting. The purpose of decision-making meeting was sharing of information and organization of knowledge. On the other hand, the purpose of discussion to think of creative ideas was creation of new ideas. These tasks in each meeting are shown in Table 1.

Table 1: Specific contents of each meeting.

Decision-making meeting	Discussion to think of creative ideas
Travel plan	Idea of new design umbrella
Plan of booths at school festival	Idea of new design chair
Plan of sightseeing tour for foreign travels	Idea of new design mask
Weekly dinner menus	Idea of new design bag
Plan of surprise party for a friend	Idea of new design camera

In this experiment, conversation noise was used as ambient noise. This noise was presented to the subjects at 40 dB, 45 dB, 50 dB, 60 dB ($L_{Aeq,\ 5min}$), pink noise was presented to them at 38 dB ($L_{Aeq,\ 5min}$). Therefore, this experiment consisted of five experimental conditions that four types of sound environmental conditions and one with pink noise as background noise condition (no-noise condition). The experimental conditions in this experiment are shown in Table 2.

Table 2: Sound environmental conditions.

Kinds of environmental noise	$L_{Aeq,\ 5min}$
No-noise (Background noise)	38 dB
Conversation noise	40 dB
	45 dB
	50 dB
	60 dB

Experimental Procedure

40 male subjects participated in this experiment. They were Japanese university students with normal hearing ability, and their age is from 18 to 24. In our study, we conducted a preliminary questionnaire survey on the degree of familiarity since it was assumed the meeting with business associates in the office. From this result, the subjects were divided into 10 groups as a group of four subjects which have the high

degree of familiarity. In these 10 groups, the subjects conducted meeting about decision-making meeting and discussion to think of creative ideas in each 5 groups. The sound environmental conditions and the contents of meeting were allocated to the experimental conditions using a Latin square design. The experimental conditions were presented in random order.

In the meeting room of Tokyo Denki University, the subjects were conducted the meeting for 20 minutes under five experimental conditions. The state of subjective experiment is shown in Figure 1. The subjects were instructed to come to a conclusion about its theme in either meeting. The environmental conditions in the meeting room are shown in Table 3.

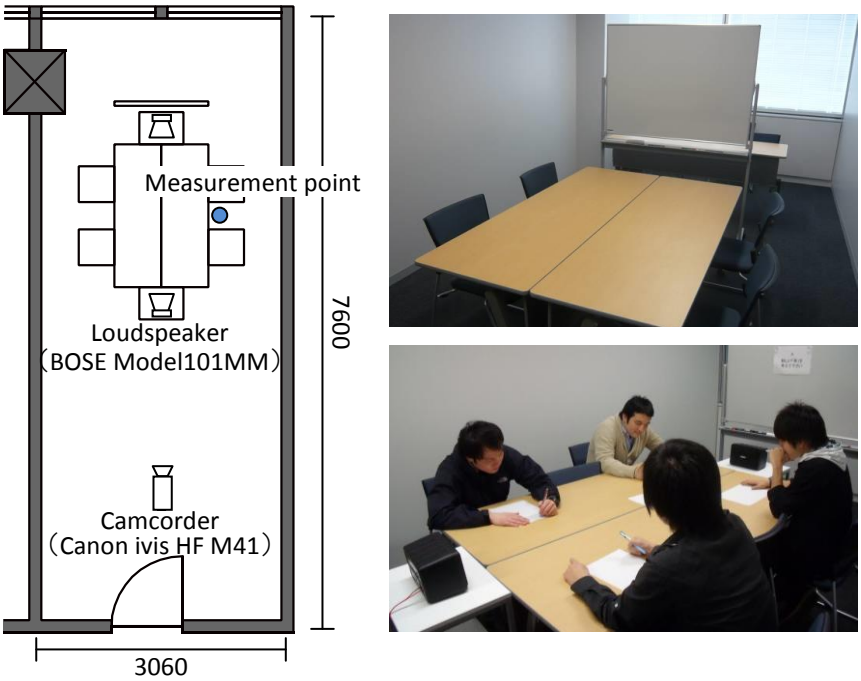

Figure 1: The state of subjective experiment

Table 3: Environmental conditions in the meeting room.

Environmental factor	Result of measurement
Temperature	From 19 to 20 degrees
Humidity	30 %
Illuminance on the desk	From 700 to 750 lx

After each meeting, the subjects were asked to evaluate 32 items for evaluation in which consisted of the impression of sound environment and meeting space, the situation and outcome for meeting by rating scale method using 5-step category. These evaluation items and 5-step category scale used in this experiment are shown in Table 4 and Figure 2.

Table 4: 32 items for evaluation used in this study.

Evaluation item for sound environment	Evaluation item for meeting space	Evaluation item for situation of meeting	Evaluation item for outcome of meeting
Comfort	Comfort	Ease of meeting	Accomplishment of meeting
Quietness	Hospitable	Ease of conversation	Meaningful discussion
Familiarity	Relax	Ease of speaking	Satisfaction of outcome
Lively	Brightness	Ease of transmission ofvoice	Difficulty of meeting
Composure	Sense of openness	Listening difficulty of speech	Unique idea
Disturbance	Large	Enjoy meeting	Attractive idea
	Close-set	Good conversation	Remark in meeting
		Relax	Effort
		Tired	Summarize idea
			Interisting

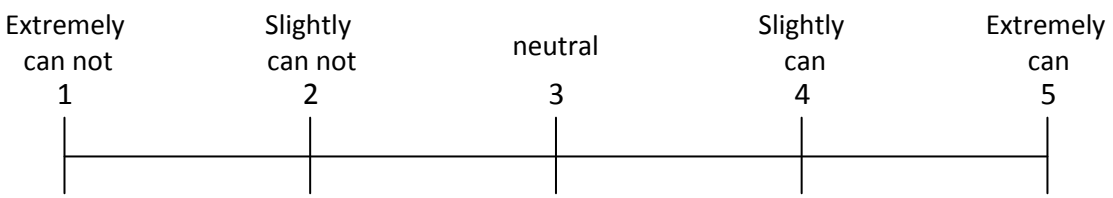

Figure 2: 5-step category scale

RESULTS AND DISCUSSION

Subjective Evaluation of Sound Environment

Relationships between sound environmental conditions and the evaluation of quietness of sound environment, listening difficulty of speech for each meeting are shown in Figure 3 and 4. In these figures, the averaged evaluation and the standard deviation for 40 subjects are presented.

In regard to the evaluation of quietness of sound environment, two-way ANOVA in which sound environmental conditions and the types of meeting were used as factors was calculated. From the results, a main effect of sound environmental conditions was significantly different only (p<0.01). Therefore, multiple comparison (Tukey-Kramer's test) was calculated. The result of this test is presented in Figure 3. This result shows that there is a tendency for noise level to rise as the evaluation of quietness of sound environment decreases, and the subjects begin to feel loud at noise level higher than 50 dB.

In regard to the evaluation of listening difficulty of speech, one-way ANOVA in which sound environmental condition was used as factor was calculated in each meeting. From the result, a main effect of sound environmental condition was significantly different in both meeting (p<0.01). The multiple comparison (Tukey-Kramer's test) is shown in Figure 4. As will be noted from Figure 4, it was suggested that the evaluation of listening difficulty has been beginning to go up at noise level 60 dB.

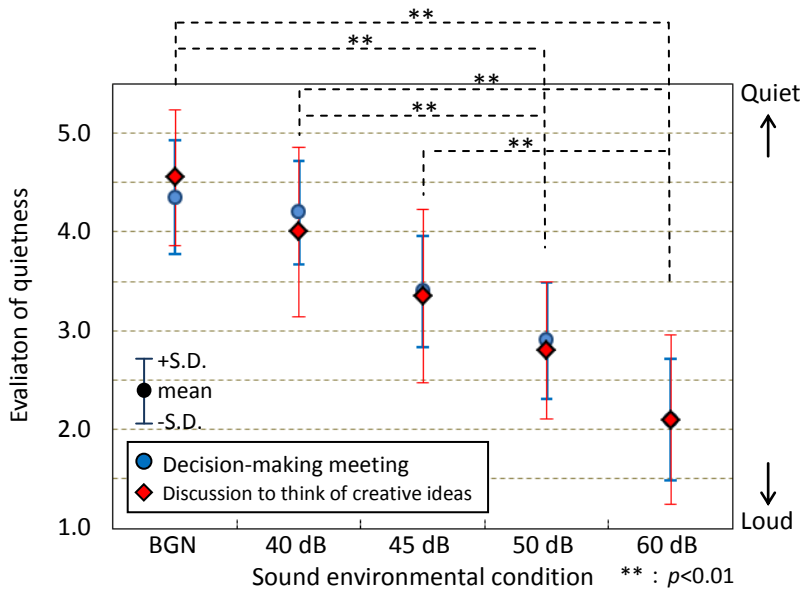

Figure 3: Evaluation of quietness of sound environment for each noise level.

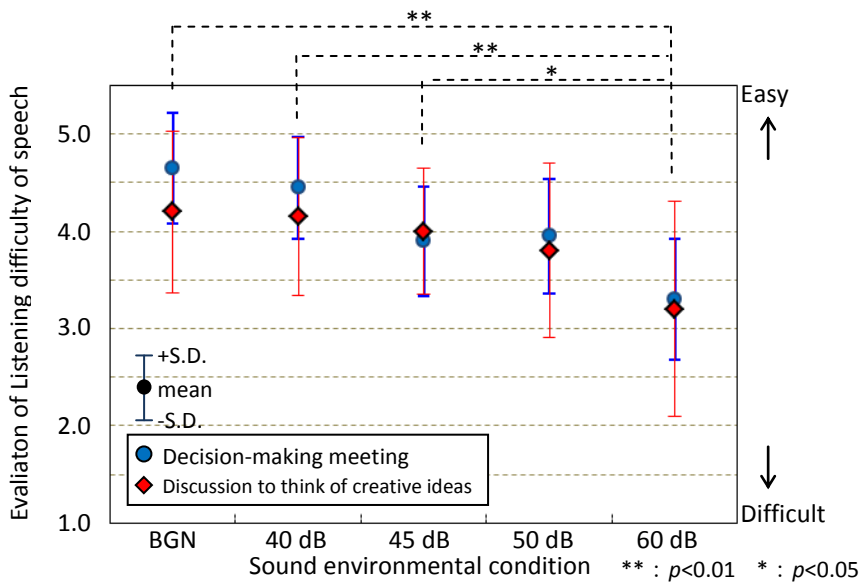

Figure 4: Evaluation of listening difficulty of speech for each noise level.

Relationship between the Ease of Meeting and Noise Level

In order to investigate an influence of sound environmental conditions on the ease of meeting, in both meetings (discussion to think of creative ideas and decision-making meeting), one-way ANOVA in which sound environmental condition was used as factor was calculated. From the results, in discussion to think of creative ideas, a main effect of sound environmental condition showed significant differences (p<0.01). However, in decision-making meeting, the main effect was not significantly different.

Tukey-Kramer's test as multiple comparison was calculated, this result is shown in Figure 5. In discussion to think of creative ideas, the ease of meeting showed significant differences between each noise level shown in Figure 5, the evaluation of ease of meeting in noise level 50 dB is the highest among these sound environmental conditions in this experiment.

These results demonstrate that sound environment has no influence on the ease of meeting in decision-making meeting. However, it has effect on that in discussion to think of creative ideas. It was suggested that sound environment that is easy to conduct a meeting is ambient noise at 50 dB.

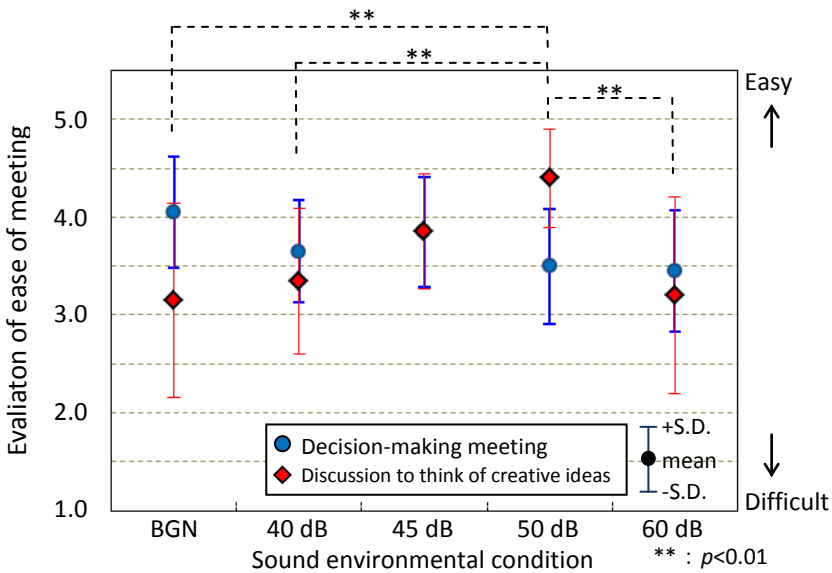

Figure 5: The evaluation of listening difficulty of speech for each noise level.

Psychological Factor in Relation to the Ease of Meeting

To investigate psychological factors related to the ease of meeting, in each meeting, one-way ANOVA in which sound environmental condition was used as factor in regard to the evaluation items shown in Table 4 was calculated. From these results, a main effects of sound environmental condition showed significant differences (p<0.01) in 12 evaluation items of discussion to think of creative ideas and in 13 evaluation items of decision-making meeting. Multiple regression analysis in which the ease of meeting was used as objective variable and the evaluation items which a main effect of sound environmental condition showed significant differences was used as explanatory variable was performed. These results are shown in Table 5, 6.

Standardized partial regression coefficient of listening difficulty of speech is 0.38 in decision-making meeting, the value is the highest among 13 evaluation items (Table 5). On the other hand, standardized partial regression coefficient of the ease of conversation is 0.58 in discussion to think of creative ideas. The value is the highest among 12 evaluation items (Table 6). From these results, it was suggested that the ease of conversation lead to better meeting in discussion to think of creative ideas, and the ease of listening of speech lead to better meeting in decision-making meeting. Standardized partial regression coefficient of listening difficulty of speech in discussion to think of creative ideas is lower than that of decision-making meeting. Furthermore, in both meetings, standardized partial regression coefficient of summarize idea (the extent to reach a consensus) has a relatively high value compared to the other items. This means that the evaluation related to the extent of

summarize of meeting have an effect on the ease of meeting in both of decision-making process and knowledge creating process.

Table 5: Result of multiple regression analysis in decision-making meeting.

	Adjusted R-square	Explanatory variable	Standardized partial regression coefficient
Ease of meeting	0.39	Listening difficulty of speech	0.38
		Summarize idea	0.20
		Good conversation	0.19
		Comfort of sound environment	0.19
		Satisfaction of outcome	0.15
		Meaningful discussion	0.10
		Difficulty of meeting	0.07
		Disturbance	0.04
		Quietness	-0.03
		Lively	-0.03
		Attractive idea	-0.12
		Composure	-0.13
		Accomplishment of meeting	-0.22

Table 6: Result of multiple regression analysis in discussion to think of creative ideas.

	Adjusted R-square	Explanatory variable	Standardized partial regression coefficient
Ease of meeting	0.66	Ease of conversation	0.58
		Summarize idea	0.15
		Composure	0.13
		Good conversation	0.13
		Listening difficulty of speech	0.10
		Relax	0.08
		Accomplishment of meeting	0.03
		Lively	0.02
		Satisfaction of outcome	-0.02
		Disturbance	-0.02
		Meaningful discussion	-0.05
		Quietness	-0.07

CONCLUSIONS

In this study, in order to find a relationship between the ease of meeting and noise level under different types of group meetings, subjective experiments were conducted. Furthermore, to investigate psychological factors related to the ease of meeting, multiple regression analysis was performed.

From their results, in regard to the quietness of sound environment, we found that the subjects start feeling noisy (not quiet) in sound environmental condition of ambient noise 50 dB, and that noise 60 dB have an increased the listening difficulty of speech.

Furthermore, in the condition of ambient noise 50 dB, the ease of meeting was the highest evaluation for discussion to think of creative ideas among experimental conditions. Also, sound environment of ambient noise 50 dB produce lively discussion in group meeting such as discussion to think of creative ideas. It was suggested that recommended indoor sound environmental condition to conduct discussion to think of creative ideas was ambient noise 50 dB.

From the results of multiple regression analysis, we found that the ease of conversation become the most important component of the ease of meeting in discussion to think of creative ideas. Additionally, the listening difficulty of speech is emphasized in decision-making meeting. In discussion to think of creative ideas, standardized partial regression coefficient of the listening difficulty of speech is lower than that of decision-making meeting. Furthermore, in both meetings, standardized partial regression coefficient of summarize idea has a relatively high value compared to other items.

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