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EFFECTS OF BACKGROUND NOISE ON THE 'WANTED LISTENING LEVEL' OF 'SOUND MEDIA' IN DWELLING ROOMS

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1. INTRODUCTION

Recent progress in digital technology and revolutions in mass media have resulted in big changes in the dwelling environment. Thus new ways of organizing living spaces must be considered to reflect these changes. For example, one room might be set aside for appreciating large screen video, and digitally reproduced live sound. Some design goals for such a room would be to reduce indoor noise, to ensure a reasonable reverberation time, to enhance the quality of media and to ensure minimal sound disruption. Among these conditions, ensuring minimal sound disruption is the most essential. But in real environments, noises from outdoors often interfere with indoor sound quality. When target sounds and unwanted sounds with different frequencies and level fluctuations interact simultaneously, what is the effect on sound quality? This experiment investigated the effect of background noise – mainly traffic noise(the most common) – on television viewers, to determine the degrees of dissatisfaction associated with various levels of background noise. The results of this study should help us determine how much background noise has to be suppressed to produce a comfortable auditory environment.

2. EXPERIMENTAL METHOD

Research plan

Two types of laboratory experiments were carried out. Experiment 1 required each subject to adjust the volume of a TV using a remote control against various levels of background noise. Experiment 2 asked subjects to evaluate the severity of background noise and to indicate their degree of satisfaction or dissatisfaction with the listening conditions. The noise sources used in the experiments were compact disks of traffic noises ; i. e. aircraft noise, railway noise, and road traffic noises (free

flowing and nonfree flowing). White noise was also included in order to compare its effects with those of the traffic noises. The noise level varied from 40 dB L_{Aeq} to 60 dB L_{Aeq} in 5 dB steps according to the expected levels in normal dwelling rooms. The wanted sound source used in the experiments was a television news soundtrack at suggested levels of 50, 55, 60, 65, 70 dB L_{Aeq}. Fig.1 shows the level fluctuations for each traffic noise and Table 1 shows the combinations of TV sound and background noises used in the experiments.

Fig.1 Level fluctuations of background noises

Table 1. Experimental plan showing the combinations of TV sound levels and background noise levels chosen for the experiments

No. of Stimuli	Experiment 1		Experiment 2				Type of Background Noises
	Method of Adjustment		Method of Rating Scale				
	Target sound level	Background Noise Level L_{Aeq} dB	Noisiness of the background noise	Dissatisfaction of listening TV	Background Noise Level L_{Aeq} dB	TV Sound Level L_{Aeq} dB	
1	By Remote Control	40 dB(A)	7 scale categories	7 scale categories	40 dB(A)	50	
2~6		45			45	55	aircraft
						60	railway
						65	road traffic (free flow)
							white noise
							road traffic (nonfree)
7~11		50			50	70 dB(A)	//
12~16		55			55		//
17~21		60			60		//

Test Subjects

Twenty-three male and 8 female subjects, aged 21 to 35, participated in experiment 1. Sixty-one male and 28 female subjects, aged 16 to 35, participated in experiment 2. The number of subjects who had fixed TV listening habits was checked because listening habits were found to be major factors affecting responses in previous

surveys.[1] In the case, six subjects were found to have a habit of listening to TV quietly and nine were found to prefer high-volume television. Each subject had normal auditory ability.

Test Facilities

The test space was composed of two rooms separated by furniture. One room contained a TV, table and seats, and the other contained speakers and noise-controlling equipment. This separation was intended to simulate the transmission path by which noise intrudes into the indoors from outdoor structures. For the experiments the background noises were recorded and edited on a digital audio tape recorder, while the television soundtracks were recorded on a video recorder. Measuring and analysing equipment for the experiments were as follows;

- CD player : Potable Digital Compact Player ; Singer, Korea
- DAT1 : Digital Audio Tape-Corder TCD-D10 ; Sony, Japan
- DAT2 : Digital Audio Tape-Corder TCD-D7 ; Sony, Japan
- AMP : Digital Stereo Amplifier LA-8800 ; Lotte, Korea
- Speaker System : Lotte Speaker LS-909V ; Lotte, Korea
- Dual Channel Real-Time Frequency Analyzer ; Type 2133, B&K, Denmark
- TV : DTQ-2975FWS(29inch colour) ; Daewoo, Korea
- Video Tape Recorder : DVR-1080, Daewoo, Korea

After being exposed for 50 seconds to the stimuli, the subject adjusted the TV sound level or filled in a questionnaire during 10 second periods. Before the experiments the subjects were given instructions about test procedure and questionnaires. In Experiment 1, each subject was asked to adjust the TV volume using a remote control under variously combined conditions of background noise level and TV sound levels. In Experiment 2, six subjects participated at the same time, and filled in a questionnaire. Two questions were asked after subjects were exposed to background noises for 50 seconds: Q1. How noisy did the background noise seem to you when you were listening to the TV? Q2. How dissatisfied do you feel listening to TV under these conditions?

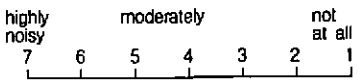


Fig. 2 Response categories for Q1.

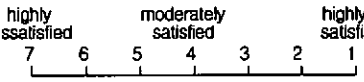
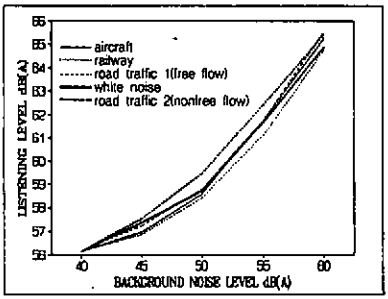


Fig. 3 Response categories for Q2.

3. RESULTS AND DISCUSSION

Experiment 1

This experiment was performed to identify the most obtrusive types of noise, and to derive the preferred volumes for listening to target sounds under various conditions



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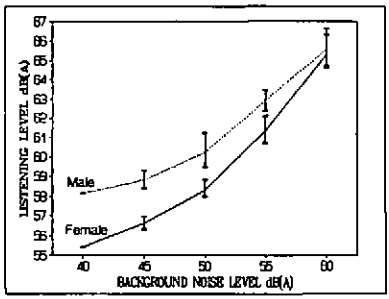


Fig. 5

of background noise. Fig.4 shows the relationship between background noises and subject-controlled TV volume. From the figure it can be seen that TV volumes chosen under background noise conditions of 40, 45, 50, 55, 60 L_{Aeq} dB are 56.1, 57.2, 58.8, 61.7, 65.2 L_{Aeq} dB respectively. As the background noise level increases, the chosen TV volume also increases. But the difference between target sound volume and noise level declines as background noise increases. It can also be seen that railway noise is perceived as less obtrusive than other traffic noises, and that stop-and-start traffic is perceived as the most obtrusive of all. This result is either in accordance with previous research or not.[2][3] It is interesting that white noise, which has no fluctuations, is perceived similarly to free flowing traffic noise. Fig.5 represents differences in TV volume chosen between males and females. From this figure it can be seen that females selected TV volumes which were higher than the male choices by 0.3-2.7 L_{Aeq} dB. This tendency is most evident when low levels of background noise were involved. But in the range of 60 L_{Aeq} dB above, the difference is negligible. This would be an interesting subject for future study. Listening habits also affected the volume choices as shown in Fig.6. The figure shows that the group who habitually listened to moderately higher volumes of sound had a tendency to listen to TV sound about 2 L_{Aeq} dB higher than other groups.

Experiment 2

This experiment was carried out to provide designers with useful guidelines for noise regulation and standards. Such guidelines could be based on percentages of response on our rating scale ; i. e. percentages of "highly noisy" ratings, percentages of "highly dissatisfied" ratings etc.[4] Fig.7 represents the relation between percentages of "highly noisy" ratings and actual levels of background noise, regardless of TV volume. Fig.8 represents the relation between percentages of

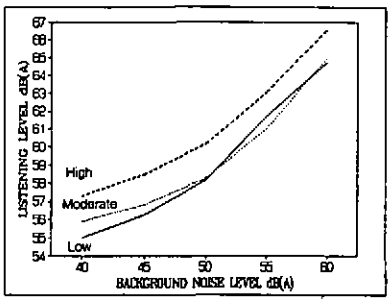
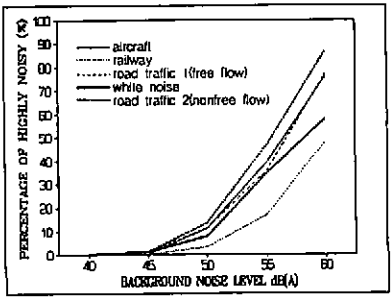


Fig. 6



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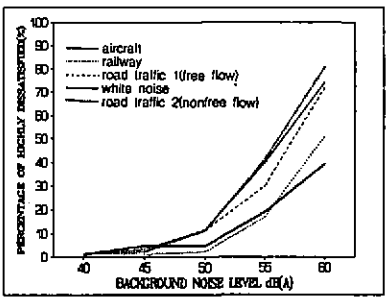

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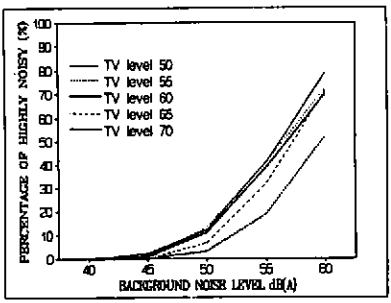

Fig. 9

"highly dissatisfied" ratings and the volume of background noise level regardless of TV volume. These two figures display similar results to Experiment 1. Stop and start traffic noise was perceived as the most noisy and disruptive among all background noises at the same sound level, while railway noise was perceived as less noisy and disruptive than other traffic noises. It may be assumed that since railway noise has few frequencies and little fluctuation, it interferes less with the intelligibility of speech.[5] The effect of background noise on listening to TV sound can be represented as the percentage of subjects feeling dissatisfied or judging the environment as noisy. Figures 9 and 10 illustrate the percentages of judgement of high noisiness and dissatisfaction regardless of the types of background noises. The percentage of negative responses increases steeply upwards with the background noise levels of 50 L_{Aeq} dB and over. Thus it may be supposed that the combination of background noise levels in the range of 50~55 L_{Aeq} dB and TV volumes of 60 L_{Aeq} dB in Experiment 1 would be considered unacceptable by twenty percent of

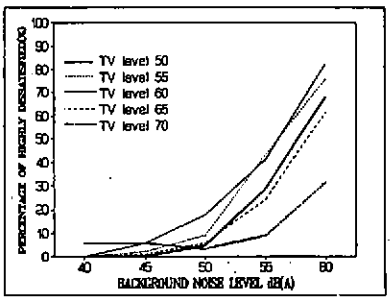

Fig. 10

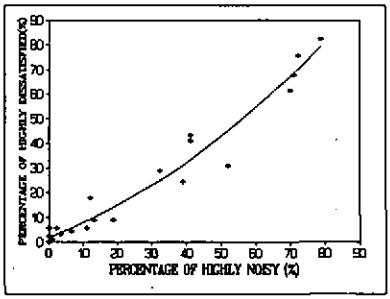

Fig. 11

listeners (very noisy or dissatisfying). Considering the present noise environment, it may be desirable to restrict background noise levels within the range of 50 L_{Aeq} dB and below. Fig. 11 shows the relation between percentage of "highly noisy" and "highly dissatisfied" responses with each of the various background noises. The relation between the two responses is nearly linear, but perhaps this is because the language of satisfaction- dissatisfaction is too narrow to elicit varying responses.

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