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## AN ANALYSIS OF NOISE EFFECTS IN LISTENING TO MUSIC (II)<sup>1</sup>

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By using a method of paired comparison, this study investigated what noise parameters disturbed the listening condition when music mixed with noise. Twenty-seven subjects listened the paired stimuli and compared which stimulus was annoying. The stimuli presented in two ways, the music mixed with noise (Experiment 1) and the noise only (Experiment 2). In each of the experiments, the data were analyzed by dual scaling method and quantification theory type 1, and the results were associated with that from prior study using a rating method (Matsunaga, Maruyama, & Kudoh, 1992).

Essential outcomes are as follows:

- 1) A parameter of noise playing a dominant role for annoyance is loudness throughout both studies.
- 2) Total duration of noise pulse had fairly large disturbance comparable to it from loudness at both conditions of music + noise and noise only in the prior study using a rating method. But it faded away under the both conditions of this study employed a paired comparison. The verbal rating method might caused these discrepancy.
- 3) Noise with high frequency band affected Ss' music listening fairly large at music + noise condition in both studies, but it diminished at noise only condition in the prior as well as this study. This effect might be brought about by a interaction of music and noise.
- 4) Therefore, it cannot infer the noise effect on listening to music from an experiment on noise only condition. The music + noise condition is without missing for it.

**Key words:** music and noise, noise effect, dual scaling method.

### INTRODUCTION

When the listening condition is interrupted by noise, it is necessary to investigate how the noise influences the listener and it causes a loss to the timbre of music. Nevertheless, the studies for the direct effect of noise upon music has been found scarcely. The studies for evaluating noise or timbre have been done respectively.

There are some studies of examining the noise effect for music (Namba, Kuwano, & Nikaïdo, 1982 ; Suzuki et al., 1982 ; Suzuki, Sone, & Soma, 1985). The main purpose of them was to investigate how music receives a bad influence from noise, that is, the extent of

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loss on tone quality. In other words, they investigated the evaluation of tone quality when noise disturbs music.

The main purpose of this study is to consider the noise effect upon the listener and to investigate how characters have bad influence on listening condition of music. As the experiments of a prior study (Matsunaga, Maruyama, & Kudoh, 1992) was rough, it needs to reconsider them according to more elaborated method. So the results of a prior study are reexamined by a method of paired comparison about evaluating word "annoyance". The word is selected as that it is usually used to express the state of annoying in everyday life and in many studies of evaluation of noise.

#### EXPERIMENT 1 (MUSIC + NOISE CONDITION)

##### METHOD

*Subjects:* Twenty-seven office workers of ALPINE ELECTRONICS INC., 23 males and 4 females (aged from 20s to 30s), were cooperated with this experiment. All of them were fond of listening to music. The experiment was done to three or four people all together.

*Stimuli:* As for the musical stimulus, "Memories" (composed by Drdla) was employed (first 20 sec). It was found that the presentation of first 20 sec was sufficient to investigate the effect of noise upon music from a prior study. It is played on the violin with the piano.

FFT analysis of this music on the replay level of CD is presented in Fig. 1.

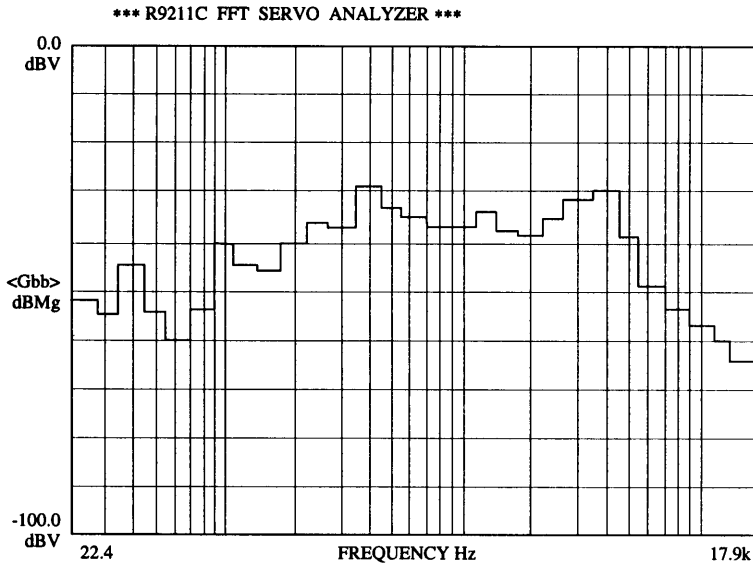


Fig. 1. FFT Analysis of the music used in Experiment 1.

In this experiment, as a prior study, six noise parameters (items) (1. total duration of noise pulse 2. fixation of the duration of noise pulse 3. number of noise pulse per 60 sec. 4. cycle of burst onset 5. loudness 6. frequency band) were used. It was thought that these parameters influenced upon music largely. They were combined with among them to make samples. As shown in Table 1, each item was divided into two or three categories. 15 samples were formed by combination of these item-categories for applying dual scaling method (Nishisato, 1980). Not to impose a burden on subjects, 10 samples were selected among 15 samples. The score of weight of the dimension of interference of feeling from dual scaling method (prior study) was referred to select samples.

The combination of item category for each sample is presented in Table 2. In Fig. 2, it is shown the time pattern of 15 noise samples. In them, No. 1, 2, 4, 5, 6, 10, 12, 13, 14, and 15 were used in this study.

Table 1. The item-categories included in 15 samples.

1. Total duration of noise pulse	4. Cycle of burst onset			
	Fixed			
Long ... 20000 msec	Not fixed			
Middle ... 12000 msec				
Short ... 3000 msec	5. Loudness (dBA)			
	Frequency band:	High	Middle	Low
2. Fixation of the duration of noise pulse	High ...	40.0	48.5	50.0
Fixed	Middle ...	44.0	46.0	49.0
Not fixed	Low ...	40.0	44.0	44.0
	6. Frequency band			
3. Number of noise pulse per 60 sec	High ...	2000 Hz ~		
High ... 100	Middle ...	500~2000 Hz		
Middle ... 50	Low ...	~ 500 Hz		
Low ... 20				

This experiment was run for 45 minutes.

*Apparatus:* The music replayed by CD player (SONY CDP-333ESA) was combined with the noise samples to be recorded on DAT tape as stimuli. These were presented to the subjects over two speakers at an A-weighted sound pressure level of 58 dB in the listening room.

*Procedure:*

1. The music with noise (1) was presented to the subjects for 20 sec.
2. The music with noise (2) was presented to them for 20 sec.
3. They compared (1) with (2), and decided which music was disturbed by noise. The interval of (1) and (2) was about 10 sec. The inter trial interval was about 8 sec. The 45 trials making from above 1-3 were repeated at random. The trial order from (2) to (1) was also done.

Table 2. The combination of item-categories for each sample.

Item	Category	Sample															Total
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
Total duration of noise pulse	Long	○	○	○	○	○											5
	Middle						○	○	○	○	○						5
	Short											○	○	○	○	○	5
Fixation of the duration of noise pulse	Fixed	○		○		○		○		○		○		○		○	8
	Not fixed		○		○		○		○		○		○		○		7
Number of noise pulse per 60 sec	High	○			○			○			○			○			5
	Middle		○			○			○			○			○		5
	Low			○			○			○			○			○	5
Cycle of burst onset	Fixed	○	○			○	○			○	○			○	○		8
	Not fixed			○	○			○	○			○	○			○	7
Loudness	High	○				○			○		○				○		5
	Middle			○	○		○					○	○				5
	Low		○					○		○				○		○	5
Frequency band	High		○			○		○				○	○				5
	Middle	○		○			○		○					○			5
	Low				○					○	○				○	○	5

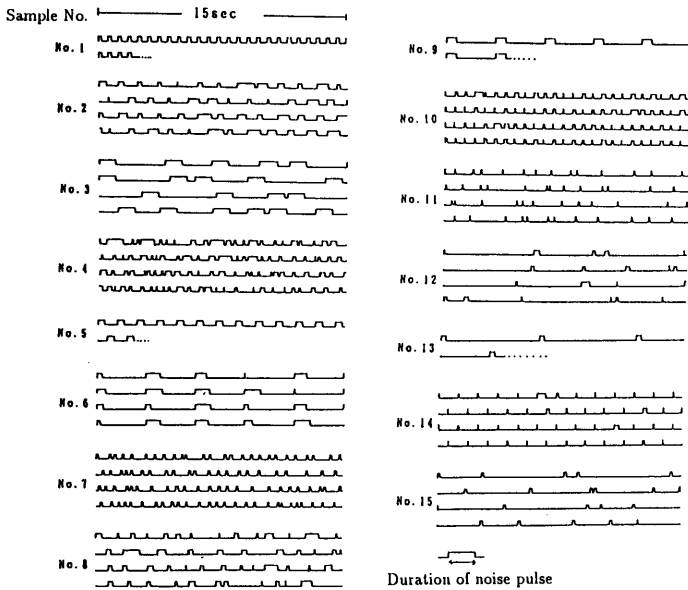


Fig. 2. Time pattern of 15 noise samples.

RESULTS

Dual scaling method (Nishisato, 1980) was applied to this paired comparison data. The scores of weights on each sample marked on a line of solution I are presented in Fig. 3. The scores of weights on each sample were analyzed by quantification theory type I. As 6 items are too much for 10 samples, the partial correlation coefficients for 6 items come to 1. So explanatory variable was selected using backward elimination method. From the result, four items, that is, total duration of noise pulse, number of noise pulse per 60 sec, loudness, and frequency band, were analyzed by quantification theory type I. The scores of item-categories of the solution I are shown in Fig. 4. The interpretations for the solution II and III analyzed by quantification theory type I were impossible, so the analysis for these was omitted.

The following features may be pointed out:

- 1) The effect of frequency band and also that of loudness are dominant. As to the effect of loudness, the result is different from the prior study, where the middle loudness was more dominant than high one, but the effect of this high level is most in this study.

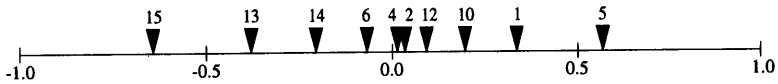


Fig. 3. The scores of weights on each sample.

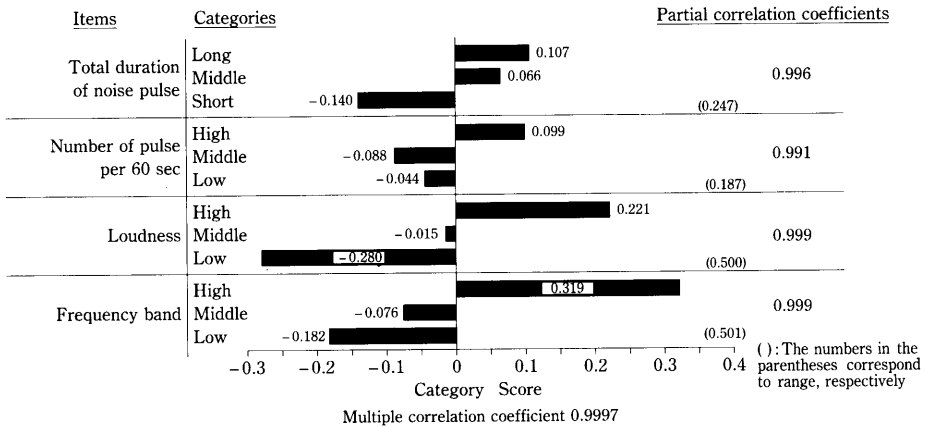


Fig. 4. Analysis of the item-categories by using quantification theory (type I).

2) The disturbing force of total duration of noise pulse converted rather weaker than that of prior study, so that its effect came to rank with that of number of noise pulse per 60 sec.

#### EXPERIMENT 2 (NOISE CONDITION)

A purpose of this experiment was to reexamine the outcome from noise only condition at the prior study by using a method of paired comparison on "annoyance".

Using noise samples only in Experiment 1 as stimuli, it was inquired whether noise condition is different from music + noise condition.

#### METHOD

*Subjects:* The same subjects to Experiment 1 were participated in this experiment.

*Stimuli:* The same only 10 noise samples on Experiment 1 were used.

*Apparatus:* The noise samples recorded on DAT tapes were presented as Experiment 1. Their three loudness levels are shown in Table 1.

*Procedure :* 1. The noise (1) was presented to the subjects for 20 sec.

2. The noise (2) different from (1) was presented to them for 20 sec.

3. They compared (1) with (2), and decided which noise was annoying.

The interval of (1) and (2) was about 10 sec. The inter trial interval was about 8 sec.

Total 45 trials making from above 1-3 were repeated at random. The trial order from (2) to (1) was put together.

After Experiment 1, Experiment 2 was run for about 45 minutes.

#### RESULTS

Dual scaling method was administered for each evaluating word as paired comparison data. The scores of weights on each sample marked on a line of solution I are presented in Fig. 5. And the same item-categories of Experiment 1 were analyzed by quantification theory type I.

The scores of item-categories of solution I are shown in Fig. 6. As the result of Experiment 1, the interpretations of solution II and III analyzed by quantification theory type I were impossible, and the analysis for these were omitted.

The following features may be pointed out:

1) Similar to the result of prior study (noise condition), loudness puts the most effective annoyance as seen in the magnitude of range. High loud noise was evaluated as annoying and low was the reverse.

2) Total duration of noise pulse did not bring the annoyance effect similar amount to the prior study. It remained rather weaker as much as that from frequency band.

3) In summary, therefore, a comparable effect resulted in the noise only condition of the prior study as well as this study, exclusive of the effect of total duration of noise pulse as the above.

4) The effect of frequency band was ascertainable in music + noise condition of the prior

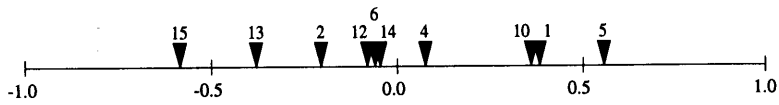


Fig. 5. The scores of weights on each sample.

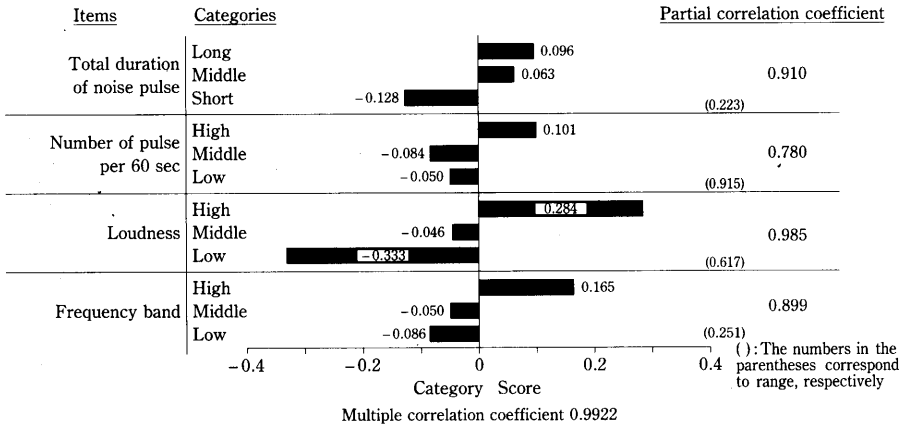


Fig. 6. Analysis of the item-categories by using quantification theory (type I).

study as well as this study. However in noise only condition, the effect diminished in both studies.

5) It is concluded that Ss did not evaluate the noise disturbance in the mixing condition of music + noise in the same way as noise only condition, because some dissimilar effects came forth here.

### CONCLUSION AND DISCUSSION

Putting together the results from this study by paired comparison and the prior study of disturbance rating, the effects of noise are summed up as follows.

1) Each of all four parameters on noise has annoying agency more or less. These four parameters are total duration of noise pulse, number of noise pulse per 60 sec, loudness, and frequency band.

2) Among these, loudness has upper hand over the other at both of the studies.

3) Total duration of noise pulse acted as marked factor for annoyance at the prior study employed a rating method, but it diminished at this study of paired comparison to the amount comparable to that of number of noise pulse per 60 sec. This might be caused by the



difference of experimental method, *i.e.*, verbal rating versus paired comparison.

4) The effect of frequency band was large amount equivalent to that of loudness in the prior as well as this study under merely the music + noise condition. Noise with high frequency brings both annoyance for listening to music. Under the noise only condition, this annoyance character of noise casted down its force to weak level equivalent to that of number of noise pulse per 60 sec at both studies.

Since the music of drdla used in both studies was composed for the most part of high frequency, high frequency noise might have significant agency. This interpretation of frequency bands between music and noise must be examined in next investigation, therefore.

5) The above data point out that the differential effect is affected between two conditions. Accordingly, it is said that Ss did not attend merely to the noise's character at music + noise condition but they took care of an ensemble of music with noise. So, to explore the disturbance effect of noise on music listening, it is insufficient to estimate it from noise only condition.

6) Summerizing the results of this study, it may be concluded that a comparable disturbance effect was introduced at both conditions of music + noise and noise only, excluding it from frequency band. This effect from frequency band of noise turns into powerful in response to putting together of music and noise. This point is similar to the results of prior study.

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