An Analysis of Noise Effects in Listening to Music (1)

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AN ANALYSIS OF NOISE EFFECTS IN LISTENING TO MUSIC(Ⅰ)[1]

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By using a rating method, this study investigated what noise parameters disturbed the listening condition when music mixed with noise. Twenty-three subjects listened the stimuli and rated questionnaires. The stimuli contained two presenting ways, the music mixing with noise and the noise only, which were compared with each other. In the way of mixing the music with noise, the 17 words expressing interrupted state in questionnaire were classified by cluster analysis and 3 dimensions were extructed by the classification. In each dimension, how each noise parameter showing noise character affected the listening condition was analyzed by dual scaling method and quantification theory type Ⅰ.

The results showed that the sizes of noise parameters were different according to the methods of presentation and the extructed dimensions. In music + noise condition, the effects of loudness and frequency band were fairly large. In noise condition, the items of total duration of noise pulse and loudness had large effects.

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. The studies for the direct effect of noise upon music has 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, & Nikaido, 1982; Suzuki, Sone, & Soma, 1985). The main purpose of them is to investigate how music receives a bad influence from noise, that is, the extent of loss on tone quality. In other words, they investigate 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.

Experiment 1 (Music + noise condition)

Method

Subjects: Twenty three office workers of ALPINE ELECTRONICS INC., 19 males and 4 females (ages from 20s to 30s), were cooperated with this exeperiment. All of them were fond

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of listening to music.

Stimuli: As the musical stimulus, "Memories" (composed by Drdla, F.) was employed. It is played on the violin with the piano. FFT analysis of this music on the replay level of CD are presented in Fig. 1.

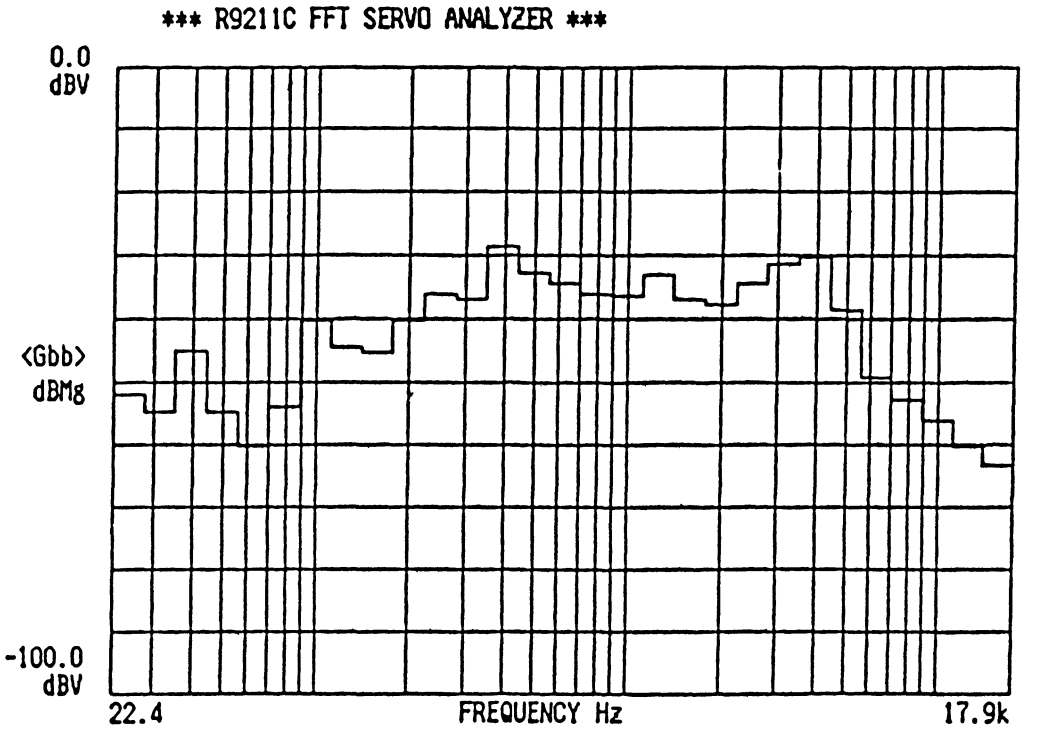


Fig. 1. .FFT Analysis of the music used in Experiment 1.

White noise from the noise generator was passed through a filter to make noise stimuli. Since white noise was selected for this experiment according to it's sound pressure level, frequency and phase rapidly and randomly change, so the noise is listened subjectively to the steady noise.

In this experiment, 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, and 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). It was confined to use 15 samples not to impose a burden on subjects. 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. This experiment was run for 40 minutes.

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

1. Total duration of noise pulse

Long	···	20sec
Middle	···	12sec
Short	···	3sec

2. Fixation of the duration of noise pulse

Fixed
Not fixed

3. Number of noise pulse per 60sec

High	···	100
Middle	···	50
Low	···	20

4. Cycle of burst onset

Fixed
Not fixed

5. Loudness (dBA)

Frequency band:		High	Middle	Low
High	···	40.0	48.5	50.0
Middle	···	44.0	46.0	49.0
Low	···	40.0	44.0	44.0

6. Frequency band

High	···	2000Hz ~
Middle	···	50 ~ 2000Hz
Low	···	~ 500Hz

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 60sec	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

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 without noise was presented to the subjects for one minute to grasp the impression of it wholly.

2. The music with noise was presented to them for one minute. Next, they rated the list of 17 evaluating words listening to it from the beginning. For each words they were asked to evaluate on 0～6 scale (0= not feeling, 6= much feeling).

In 15 samples, the sample No.6 was thought that subjects did not rate extremely. The sample No.6 was presented first and last, therefore, subjects listened 16 stimuli. The first 4 samples (No.1, 6, 8, and 13) and the last sample (No.6) were fixed, and other samples were presented randomly. Subjects were asked to rate the first sample (No.6) moderately to

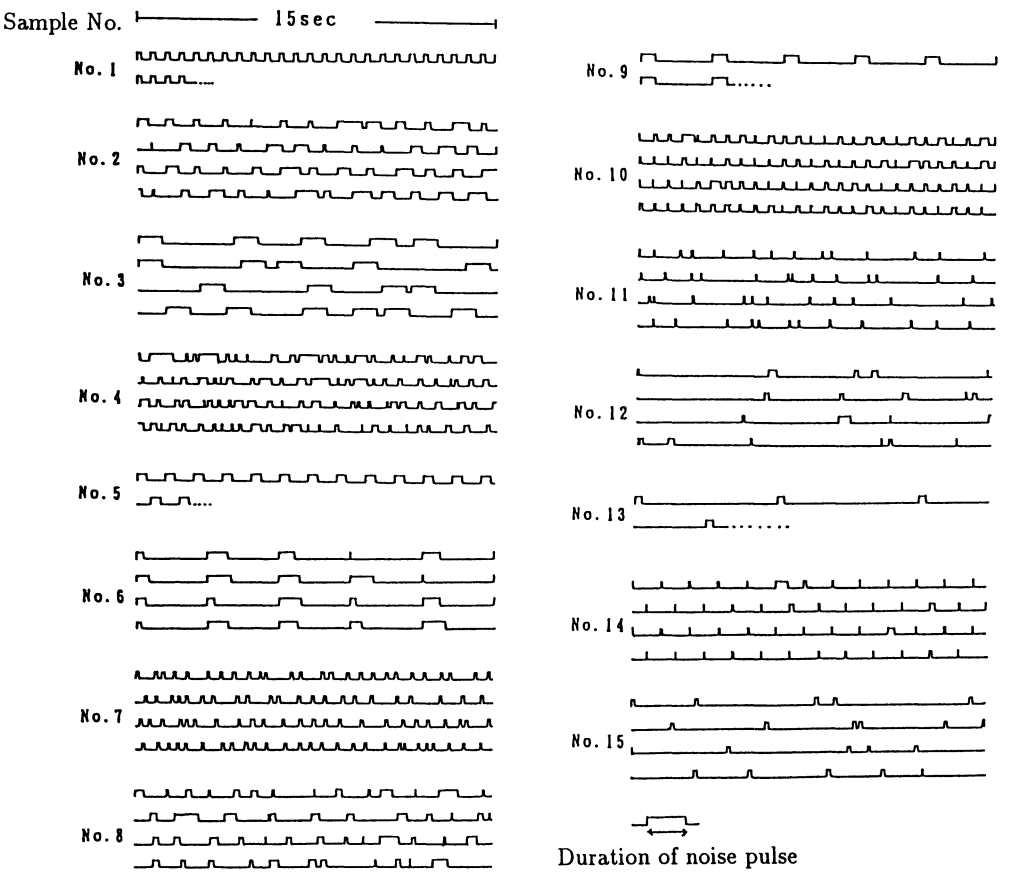


Fig. 2. Time pattern of 15 noise samples.

prevent them rating on both sides of scale. So the last sample (No.6) was used for the analysis of result.

List of evaluating words: The following four dimensions of evaluating words are assumed beforehand.

1. interference of attention: the words indicating the state of attracting one's attention to noise or distracting one's attention from noise, *for instance*, disagreeable, distractible, *etc.*

2. interference of feeling: the state of showing the feeling reaction. The degree of interruption of feeling is larger than the interference of attention, *for instance*, annoying, noisy, *etc.*

3. opinion against noise: the words expressing advice on noise, *for instance*, undesirable. It is better without noise, *etc.*

4. deterioration of music: the words not expressing the degree of noise disturbance directly but showing the state of music influenced by noise, *for instance*, indistinct, muddy, *etc.*

Along the above four dimensions, the evaluating words were collected. And 3 to 6 words frequently used in each dimension were selected for making list. In Table 3, the words employed for the list are presented.

Table 3. 17 evaluation words employed for the list.

Interference of attending :	1. Disturbing
	4. Disagreeable
	5. Offensive
	6. I can't concentrate on the music
Interference of feeling :	3. Noisy
	8. Too loud for listening to music
	9. Irritated by noise
	11. Annoying
	12. Uncomfortable
	14. Unendurable
Opinion against noise :	2. Dislike
	7. Undesirable
	13. It is better without noise
Deterioration of music :	10. Difficult to listen to music
	15. Muddy
	16. Not extensive
	17. Not smooth

RESULTS

1. The dimension analysis of evaluating words

a. Classification using the cluster analysis

As shown in Fig 3, cluster analysis is used for the mean of subjects' evaluating value of 17 words to each sample. In the assumed dimensions, the dimensions of interference of attention and opinion against noise are put together. Since three dimensions of evaluating words, the dimension of interference of attention / opinion against noise, the dimension of interference of

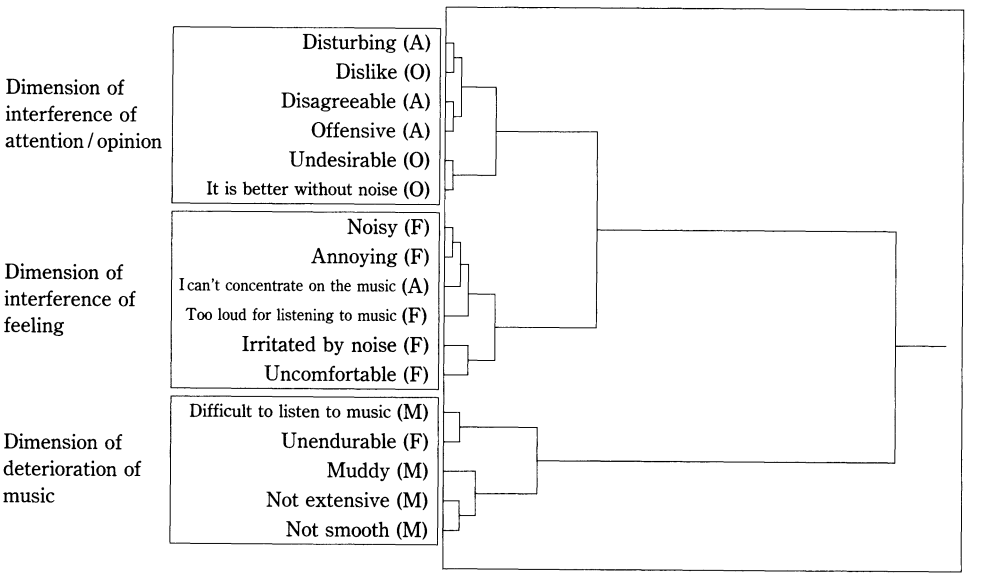


Fig. 3. Classification of evaluating words
by using principal component analysis.
In parentheses the four dimensions assumed beforehand are shown,
A : Dimension of interference of attention,
F : Dimension of interference of feeling,
O : Dimension of opinion against noise, and
M : Dimension of deterioration of music.

feeling and the dimension of deterioration of music are classified.

b. Classification using the principal component analysis

Principal component analysis is applied for the mean of subjects' evaluating value 17 words to each sample. The first component (as X axis) and the second component (as Y axis) are presented in Fig. 4. In Y axis the lower the score is, the higher the degree of disturbance against noise is. Three dimensions categorized by cluster analysis are in the order of interference of attention / opinion, interference of feeling and deterioration of music along to X axis, but it is not clear the interpretation of the first component.

2. The analysis of each dimension

Dual scaling method (categorical principal component aralysis) is used for evaluating words in each dimension classified by cluster analysis as succesive categories data. The scores of weights on each sample marked on the line are presented in Fig. 5. The scores of weights on each sample were analyzed by quantification theory type Ⅰ. The scores of item-categories are shown in Fig. 6.

1) In the dimension of interference of attention / opinion against noise, the effect of loudness is most, in the order of middle, high and low. The effect of total duration of noise pulse is also large, but the effect of fixation of the duration of noise pulse is little.

2) In the dimension of interference of feeling, the effect of frequency band is larger than any other effects of item-categories, in the order of high, low and middle. The effects of loudness

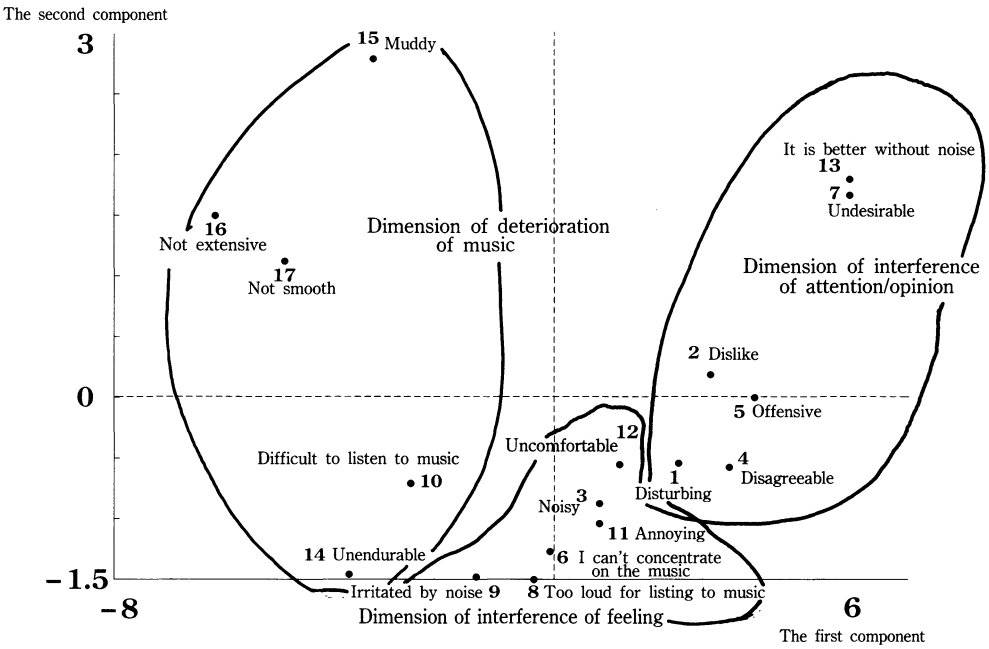


Fig. 4. Classification of evaluating words by using principal component analysis.

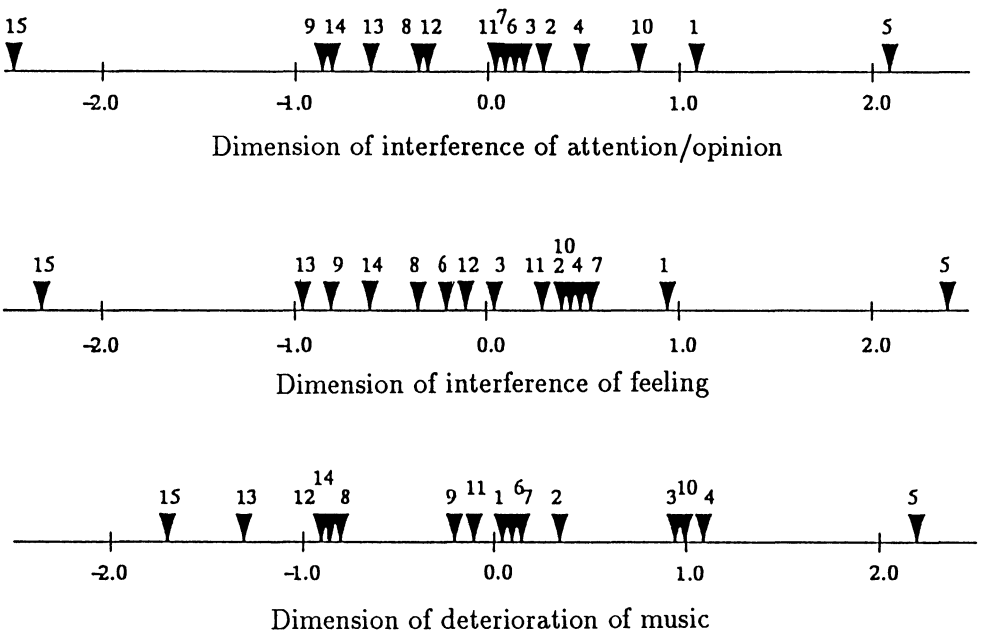
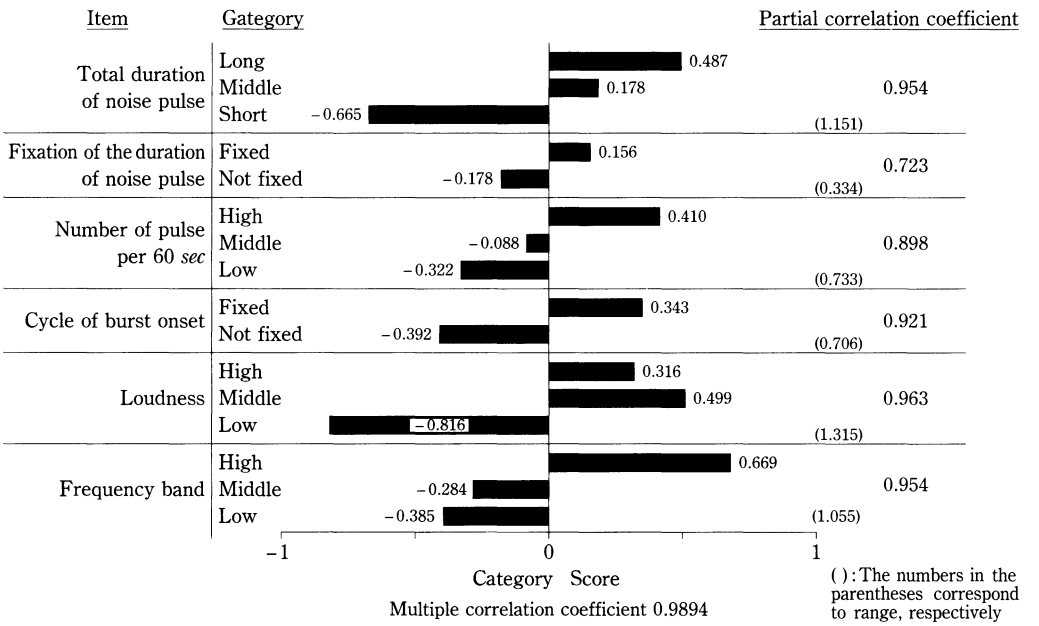
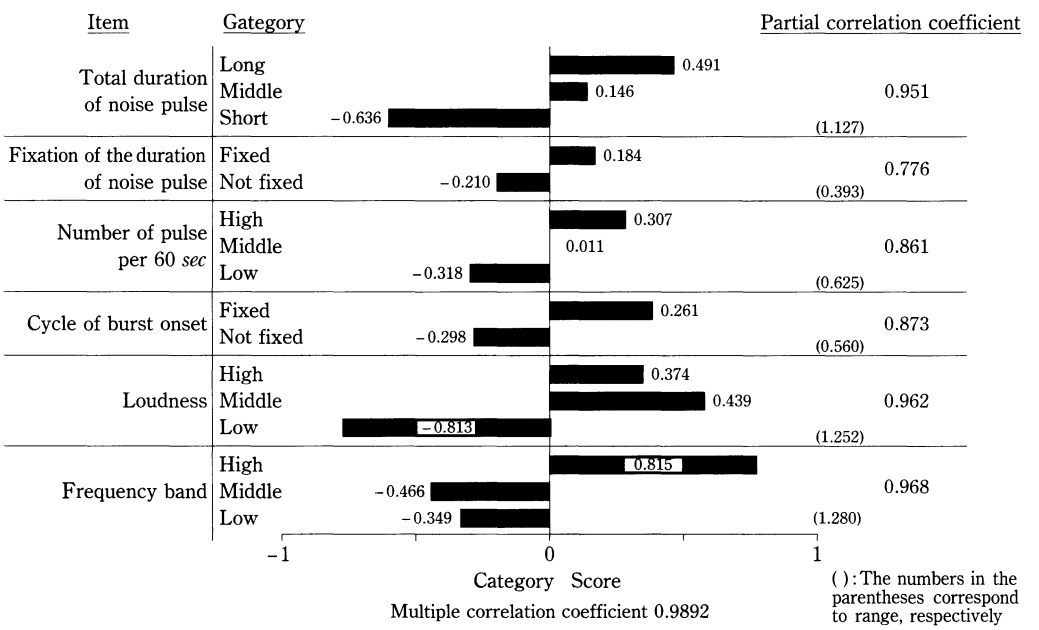


Fig. 5. The scores of weights on each sample.



Dimension of interference of attention / opinion



Dimension of interference of feeling

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

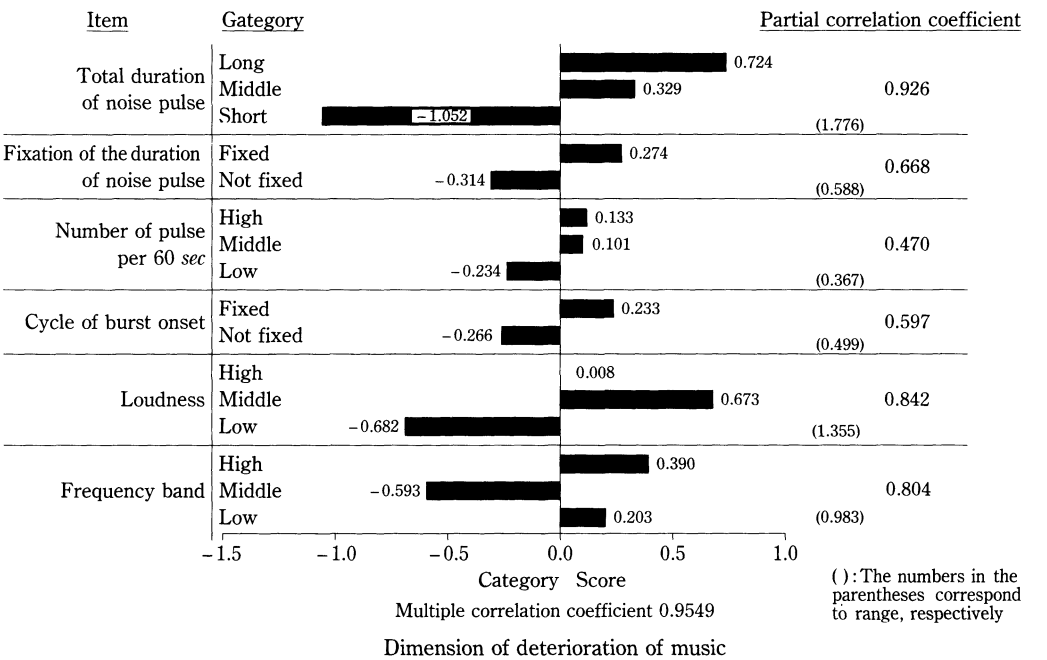


Fig. 7. (*continued*)

and total duration of noise pulse are also large. In this dimension the effect of fixation of the duration of noise pulse is also little.

3) In the dimension of deterioration of music, the effect of total duration of noise pulse is extremely large, in the order of long, middle and short. The effects of number of noise pulse per 60 sec and cycle of burst onset are rather little. In this dimension the large effect of item-categories (especially the effect of total duration of noise pulse) is different from two other dimensions.

4) It is common to all dimensions that the effects of total duration of noise pulse, loudness and frequency band are fairly large, but the effects of fixation of the duration of noise pulse, number of noise pulse per 60 sec are rather small. In all dimensions the effect of loudness is large, in the order of middle, high and low.

Discussion

1. The dimension analysis of evaluating words

1) In the assumed dimensions, the dimension of interference of attention and the dimension of opinion are united. So 3 dimensions are categorized by cluster analysis. It is thought that evaluating words in the dimension of opinion express the demand for the listening condition without noise and do not show such a large degree of disturbance of noise. So this dimension is similarly categorized with the dimension of interference of attention, which the degree of disturbance is thought smaller than that of the dimension of interference of feeling.

2) In the result of the principal component analysis, the second component is interrupted

as the axis expressing the degree of noise disturbance. The scores of evaluating words in dimension of opinion assumed are marked at the lower point of *Y* axis, those in dimension of interference of feeling are marked at higher points of *Y* axis than those in two other dimensions, and are categorized rather convergently.

3) In the dimension deterioration of music, the scores of evaluating words are marked at fairly low points. Since it is thought that the disturbance against tone quality of music is rather little directly.

2. The analysis of each dimension

1) In the dimension of interference of attention / opinion the effect of loudness is large. When the loudness of noise is large to some degree, attention to the noise is attracted. When the item of loudness was settled, there was not so difference among categories. So it may seem the effect of disturbance is produced around middle level.

2) In the dimension of interference of feeling the effect of frequency band is largest. It is thought that high frequency band noise causes emotional response. As the dimension of interference of attetion / opinion, the effect of loudness and total duration of noise pulse is also large. So it seems that items related to the amount of noise energy bring large effect of disturbance.

3) The dimension of deterioration of music produces different result from above two dimensions. In the above two dimensions partial correlation coefficients of all 6 items have rather large values, but the partial correlation coefficient is different from items in the dimension of deterioration of music. In this dimension the partial correlation coefficient of total duration of noise pulse is maximum. It is thought the tone quality of music is apt to be effected by the longer duration of noise pulse per unit time.

4) The effect of item is different from each dimension. It seems that the evaluating words in two dimensions (interference of attention/opinion and interference of feeling) express the noise effect directly but the evaluating words in dimension of deterioration of music is indirectly.

Experiment 2 (Noise condition)

In Experiment 1, it is also thought that subjects did not consider the noise effects against music, but pay attention to noise only. So if subjects are not asked to evaluate noise in the presentation of music with noise but in the presentation of noise only, it seems sufficient to evaluate noise effects. It is thought that the result of music with noise condition is similar to that of noise condition.

Using noise samples only in Experiment 1 as stimuli, it is examined whether noise condition is different from music with noise condition.

Method

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

Stimuli: The same 15 noise samples on Experiment 1 were only used.

Apparatus: The noise samples recording by DAT tapes were only presented as Experiment 1.

The presented level is shown in Table 1.

Procedure: Subjects rated the list of four evaluating words (1. too loud 2. annoying 3. uncomfortable 4. disagreeable) listening to noise presented to them for one minute as to 16 noise samples. For each evaluating word they were asked to rate on 0～6 scale (0 = not feeling, 6 = much feeling).

The method of presentation was same as Experiment 1. After Experiment 1, Experiment 2 was run for about 20 minutes.

Results

Dual scaling method is used for each evaluating word as succesive data. The scores of weights on each evaluating word marked on the line is presented in Fig. 7. The scores of weights on each word are analyzed by quantification theory type I. The scores of item-categories are shown in Fig. 8.

1) In the all four words the effect of loudness is most. In the evaluating word "too loud" the effect of loudness is in the order of high, middle and low but in other words in the order of middle, high and low.

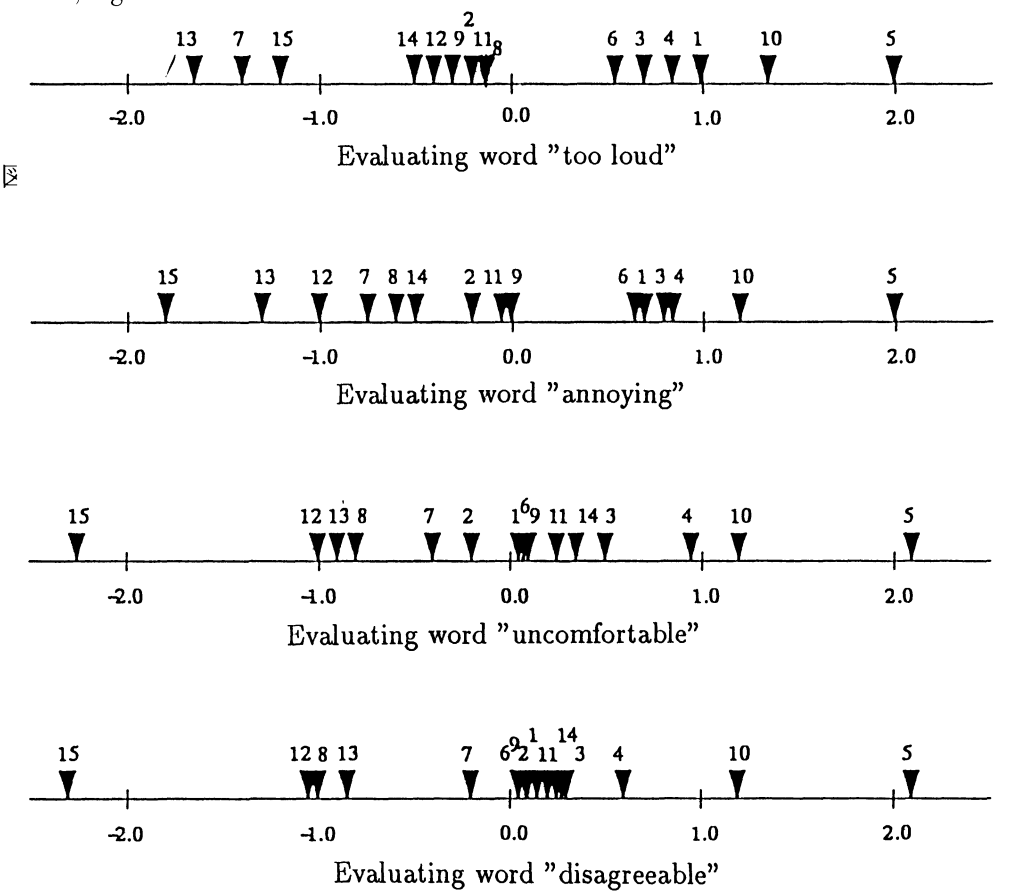
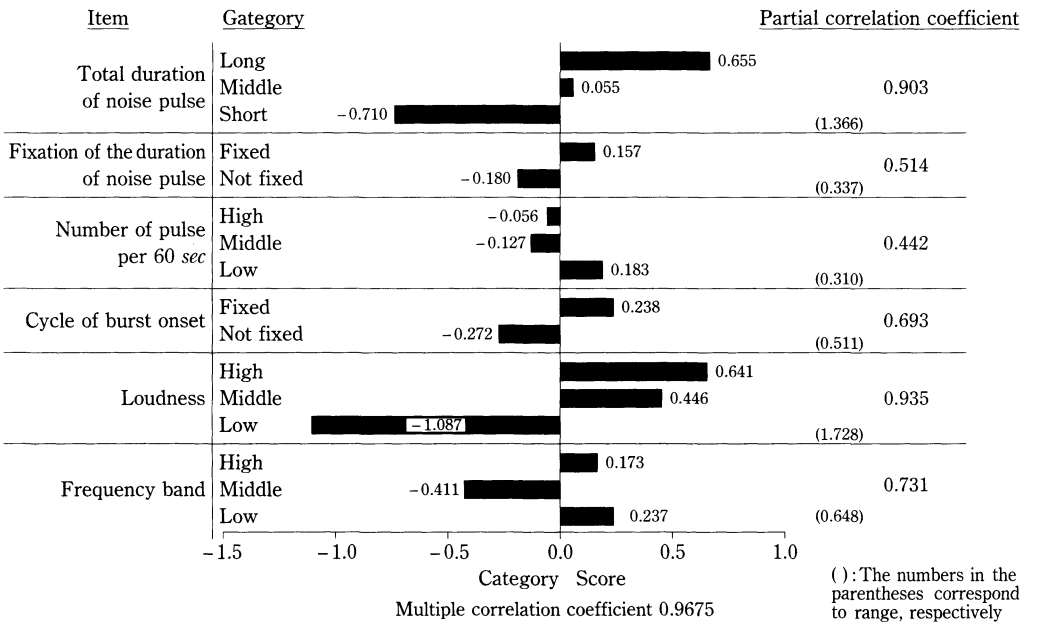


Fig. 7. The scores of weights on each sample.



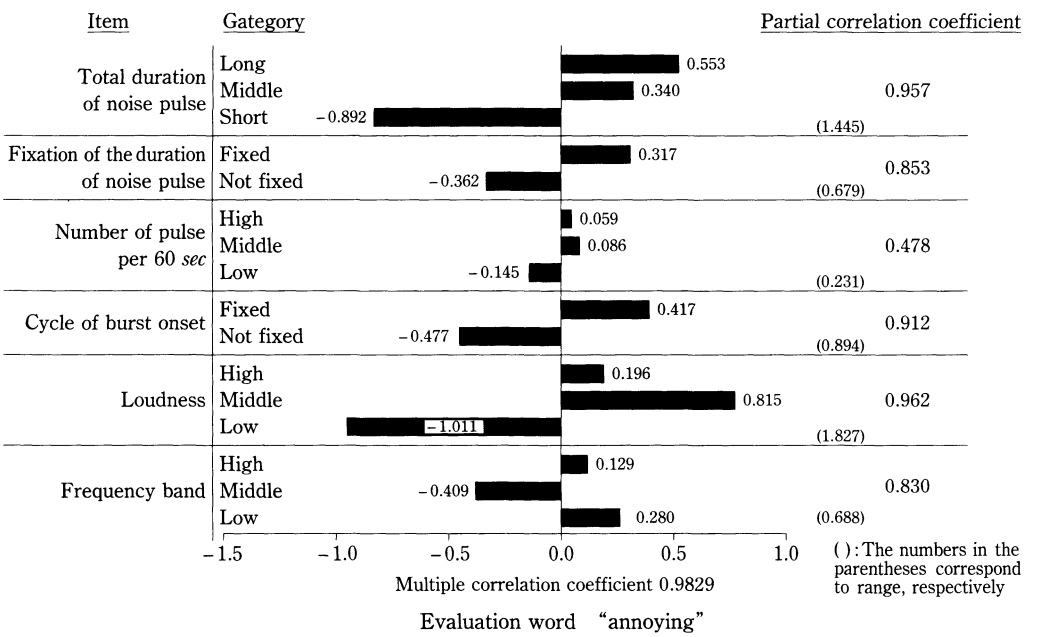
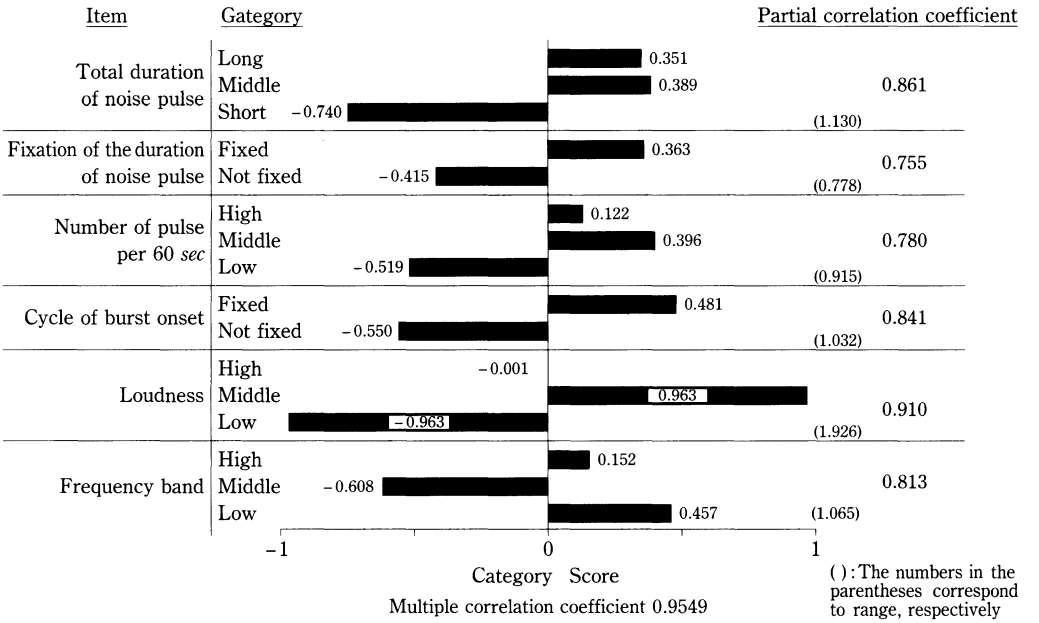
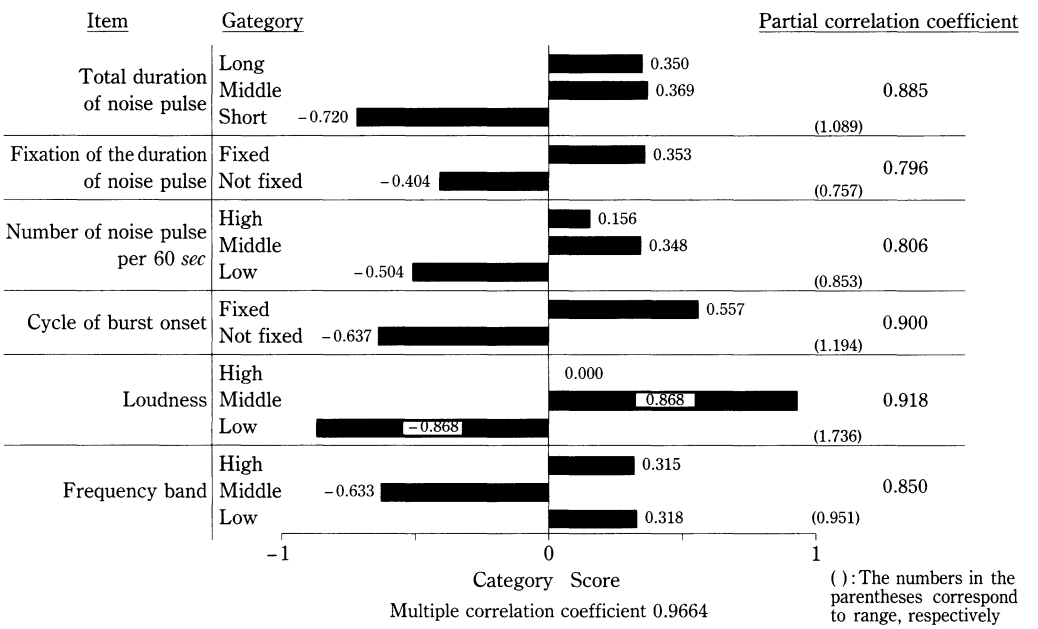


Fig. 8. Analysis of the item-categories by using quantification theory type I.



Evaluation word "uncomfortable"



Evaluation word "disagreeable"

Fig. 8. (*continued*)

2) The effect of total duration of noise pulse is also large. The order of category score is different from evaluating words, in the long and middle conditions the effect of disturbance is large, but in the short it is little.

3) In comparison with the result of Experiment 1 that the effect of frequency band is rather large, it is not so large in Experiment 2. And the order of category score is different from Experiment 1 and the effect of low frequency band is maximum.

4) In all evaluating words the partial correlation coefficients of loudness and total duration of noise pulse are large, and effect of cycle of burst onset is rather large. The effects of fixation of the duration of noise pulse and number of noise pulse per 60sec is not so large.

Discussion

The following features may be pointed out:

1) In Experiment 2, as comparison with Experiment 1, it is thought the effects of loudness and total duration of noise pulse are large, the items related with amount of energy of noise are effective in the presentation noise only.

2) In the fixed condition of both items, fixation of duration of noise pulse and cycle of burst onset, that is, in the cyclic noise condition it was seemed large effect of disturbance in the results of both experiments. It is thought subjects is easy to pay attention to the noise because they can predict noise appearance on time or they can perceive readily another current of noise itself separated from melody of music.

3) The different condition of presentation (music + noise condition or noise condition) and different evaluating words cause another effects of disturbance even if the same noise samples use. In music + noise condition subjects do not pay attetion noise only. So if only noise is evaluated, the effect of noise against music does not become clear.

4) As for the effect of loudness, the effect of middle level is large in both experiments. it is not clear whether the effect of disturbance is large around settled "middle" level or the difference of level is vague according that settled three level is close.

5) The music used in Experiment 1 includes the part of high frequency band. So it is predicted that the effect of disturbance varies according to different kinds of music.

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