Influence of Visual Information on Subjective Evaluation of Road Traffic Noise

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ABSTRACT

It is well known that human auditory and visual senses interact with each other, and that visual information has an influence on human subjective impression of sound. The purpose of this study is to clarify an influence of visual information on a subjective evaluation of sound as to road traffic noise. We carried out a subjective evaluation experiment using video of a driving motor vehicle as a visual stimulus taken with a video camera in the vicinity of a road, and sound data of the driving motor vehicle as an auditory stimulus. Subjects performed subjective evaluations for a case with the auditory stimulus only and a case with both the auditory and visual stimuli. After an analysis of variance, the result showed that presence or absence of the visual stimulus has a statistically significant influence on a subjective evaluation value of the noise.

Keywords: Road traffic noise, Subjective evaluation, Visual information

I-INCE Classification of Subjects Number(s): 63.2

1. INTRODUCTION

A human subjective evaluation of sound is affected not only by sound stimuli obtained by an auditory sense but also by visual stimuli obtained by a visual sense. Miyagawa et al.[1)] have conducted an experiment concerning an influence of video of a sound source on an impression of the sound using the semantic differential (SD) method. The study has confirmed that an evaluation about the impression of the sound varies due to the video added to the sound.

As to an influence of visual information on noise, there are studies by J. Song et al.[2)] and Kim et al.[3)]. J. Song et al. have conducted an experiment concerning an influence of a difference in color or brightness as a visual stimulus on annoyance with road traffic noise. The study shows an effect of interaction between color and noise level on the annoyance. Kim et al. have conducted an experiment concerning an influence of a difference in hue and chroma as visual stimuli on loudness and annoyance perception caused by noise. The study shows a significant influence of the difference in color on the loudness and annoyance, as well as a relationship between the loudness and chroma.

In the past, the authors of this study have confirmed that visual information in an interior space of an architectural structure influences on an impression of sound.[4)] Based on the results, it can be expected that visual information has an influence on the human impression of sound also in an outdoor sound environment such as an outdoor space involving a traffic sound. This study reports on an experiment for clarifying an influence of video of an actual driving motor vehicle on an evaluation of road traffic noise.

2. EXPERIMENT

2.1 Method of experiment

A subjective evaluation experiment was performed involving subjects to confirm how visual information influences on the subjective evaluation of a driving sound of a motor vehicle. In the experiment, a case where the subject was presented with the driving sound of the motor vehicle as a

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sound stimulus was compared with a case where the subject was presented with the sound stimulus synthesized with video of an actual driving motor vehicle, in order to examine an influence of the visual stimulus on the sound stimulus. Since the noise level varies depending on the driving speed of the motor vehicle, there were set three steps of driving speed of the motor vehicle to perform the experiment.

Eight students of 19 to 22 years old participated in the experiment.

2.2 Method of presentation

The driving sound of the motor vehicle as the sound stimulus was presented to the subject using headphones (MDR-CD900ST, SONY). For presenting both the sound and visual stimuli to the subject, the sound stimulus was presented through the headphones in the same way as in the case of the sound stimulus only, whereas the visual stimulus was presented using video of a driving motor vehicle reproduced by a computer on a personal computer display screen (FLATRON W2486L, LG) of 24 inches. The distance between the display and the subject was about 50 cm at the presentation of the visual stimulus to the subject. The display screen for presenting the visual stimulus was surrounded with a black practitioner for preventing information other than the visual stimulus from entering in the view of the subject.

2.3 Preparation of stimuli for presentation

In order to prepare the sound and visual stimuli, a motor vehicle driving in a public road was taken in video and the driving sound at the roadside was recorded. At the same time, the sound environment was recorded using a noise meter.

A motor vehicle driving at a constant speed of 40 km/h, 50 km/h, and 60 km/h was taken using a video camera (HC-V600M, Panasonic) at the roadside. The noise meter (LA-5210, ONO-SOKKI) and a recording device (PCM-D50, SONY) were set in the vicinity of the video camera setting position in order to record and measure the sound environment at the time of driving. Table 1 shows $L_{A,Fmax}$ values measured at each driving speed of the motor vehicle.

Table 1 – Driving speed of motor vehicle and measurement value

	40km/h	50km/h	60km/h
$L_{A,Fmax}$ [dB]	73.7	75.1	79.5

At presenting the sound stimulus to the subject using the headphones, the output of the headphones was controlled in the following manner. First, the recorded driving sound was reproduced using a loudspeaker while controlling the volume so as to correspond to the $L_{A,Fmax}$ value obtained by the actual measurement. Then, the output of the headphones was controlled so that the sound from the headphones is equal to the reproduced sound from the loudspeaker. The stimuli were presented to the subject at random order. Figure 1 shows parts of the video presented to the subject. The video was shot not to include any motor vehicle other than that shown in the pictures.

Figure 1 – Parts of video of driving motor vehicle as visual stimulus

The length for presenting the video was 10 seconds for 40 km/h, and 7 seconds for 50 km/h and 60 km/h.

2.4 Answer items

After the presentation of stimulus, the subject gave answers as to the evaluation on the sound. Table 2 shows answer items concerning the sound. A scaling method was used in the evaluation. The obtained results were converted to scores of 0 to 100 to be shown by numerals.

Table 2 – Answer items for evaluation of sound

Evaluation of sound
Loudness of whole driving sound
Loudness of maximum driving sound
Noisiness of whole driving sound
Noisiness of maximum driving sound
Annoyance of driving sound

3. EXPERIMENTAL RESULT

3.1 Result of analysis of variance

Using analysis of variance (ANOVA), there was examined whether presence or absence of visual stimulus influences on the evaluation by the subject on impression of the sound stimulus. As a result, significant influence concerning presence or absence of the video was found in items including "loudness of maximum driving sound", "noisiness of whole driving sound", and "noisiness of maximum driving sound", out of the five items for evaluation on the sound. Tables 3, 4, 5 show results of ANOVA for each answer item.

Table 3 – Result of ANOVA for loudness of maximum driving sound

Variance source	df	SS	MS	F ratio	p value
Total	47	15363.128			
With/without video	1	1368.613	1368.613	4.628	0.037
Driving speed	2	1524.305	762.152	2.577	0.088
Interaction	2	49.886	24.943	0.084	0.919
Error	42	12420.324	295.722		

Table 4 – Result of ANOVA for noisiness (whole)

Variance source	df	SS	MS	F ratio	p value
Total	47	11565.910			
With/without video	1	1350.736	1350.736	7.134	0.011
Driving speed	2	2148.427	1074.214	5.673	0.007
Interaction	2	114.317	57.159	0.302	0.741
Error	42	7952.430	189.344		

Table 5 – Result of ANOVA for noisiness (maximum)

Variance source	df	SS	MS	F ratio	p value
Total	47	13942.675			
With/without video	1	1900.152	1900.152	8.267	0.006
Driving speed	2	2177.096	1088.548	4.736	0.014
Interaction	2	212.150	106.075	0.462	0.633
Error	42	9653.276	229.840		

3.2 Comparison between cases with and without visual stimulus

Figure 2 shows a relationship between the driving speed and loudness of maximum driving sound. In Figure 2, white circles show average values of answers of the subjects in the case of the sound stimulus presentation only, whereas black circles show average values of answers of the subjects in the case of presentation of both the sound and visual stimuli. In Figure 2, ranges of standard deviation of the answers of the subjects are also shown for each condition. It will be understood that the subject tends to provide a lower evaluation in the case of presentation of both the sound stimulus and video, that is, the case where the subject is presented with the sound stimulus while watching the video of the driving motor vehicle as compared to the case of the sound stimulus presentation only. The evaluation value tends to become higher as the driving speed increases. This is possibly attributed that the $L_{A,Fmax}$ value measured at the roadside becomes greater as the driving speed of the actual motor vehicle increases as shown in Table 1.

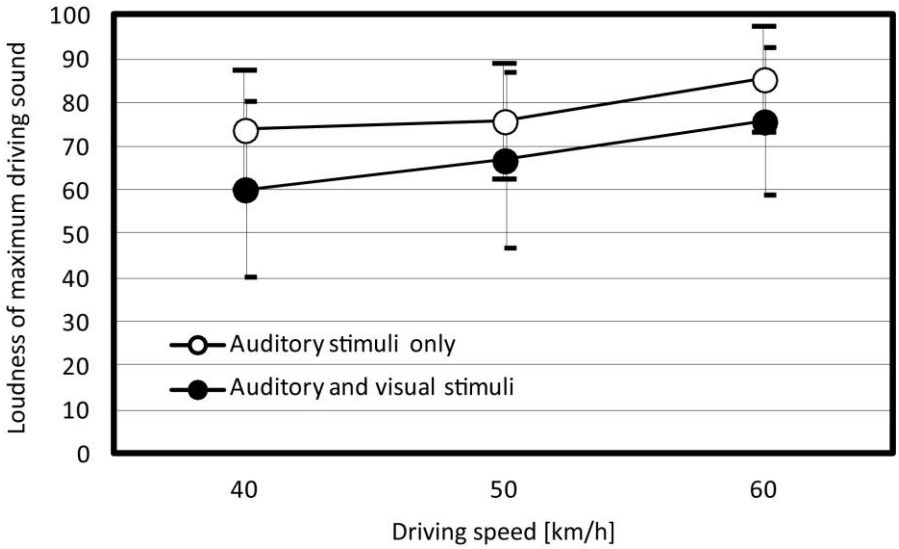

Figure 2 – Relationship between driving speed and loudness of maximum driving sound

Figure 3 shows a relationship between the driving speed and noisiness of whole driving sound, and Figure 4 shows a relationship between the driving speed and noisiness of maximum driving sound. From the figures as well, it will be understood that the noisiness evaluation tends to be lowered in the case of presentation of both the sound stimulus and video as compared to the case of the sound stimulus presentation only.

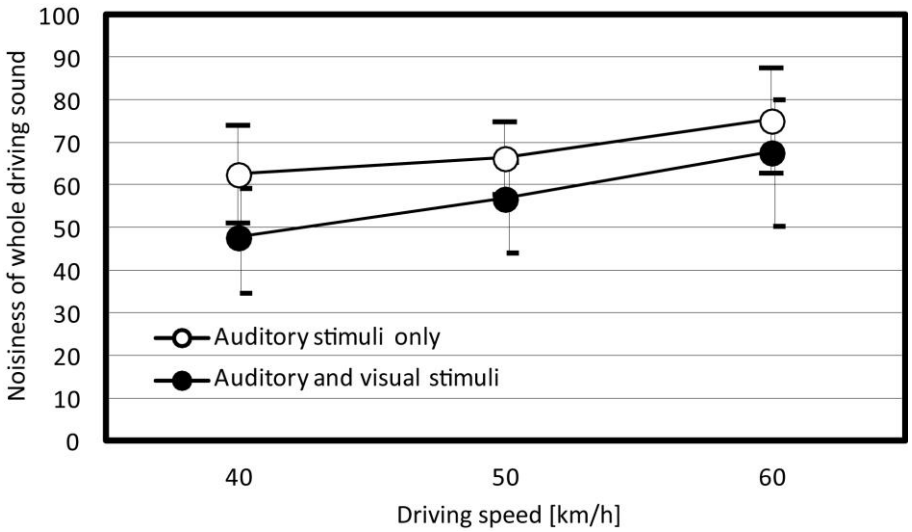

Figure 3 – Relationship between driving speed and noisiness of whole driving sound

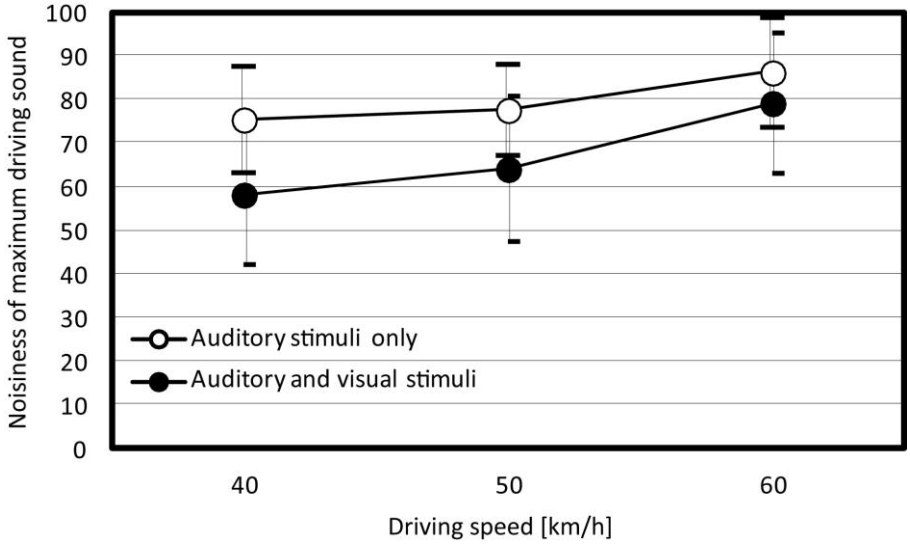

Figure 4 – Relationship between driving speed and noisiness of maximum driving sound

Reasons why the evaluation value tends to lower in the case of presentation of both the sound and visual stimuli may include the followings. First, by the presentation of the visual information, the awareness of the subject is possibly divided into the sound stimulus and visual stimulus to lower the awareness about sound stimulus. Second, the presentation of the visual information facilitates the understanding of the subject about the situation of the noise source, so that the subject possibly evaluates the driving sound presented as the sound stimuli as being within an allowable range.

4. CONCLUSIONS

The experiment was carried out in order to confirm the influence of the visual information on the subjective evaluation of a driving sound of a motor vehicle. In the experiment, there were used driving sound of a motor vehicle as the sound stimulus and video of the driving motor vehicle as the visual stimulus to compare the case of the sound stimulus presentation only to the case of presentation of both the sound and visual stimuli. As a result, there was found a significant influence of the visual stimulus on loudness and noisiness. It was shown that, in the case of the presentation of both the sound and visual stimuli, the evaluation by the subject about the loudness and noisiness tends to lower compared to the case of the sound stimulus presentation only.

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