# TEMPORAL VARIATION OF SOUND QUALITY UNDER LONG-TERM EXPOSURE OF CAR INTERIOR NOISE AND SEAT-FLOOR VIBRATION

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#### ABSTRACT

Temporal variation of sound quality is observed under long-term exposure of car interior noise even in a case where the level of the sound remained constant. The effect is stronger for in the first one third of the total exposure time, i.e., one hour. The evaluation of sound quality is also affected by the simultaneous exposure of seat-floor vibrations. In order to examine these effects quantitatively, subjective evaluation of sound quality by the continuous SD method utilizing a personal computer as an input device has been conducted under long-term exposure of car interior noise and seat-floor vibrations.

#### INTRODUCTION

When we think of the practical situation for long drive between cities, the expecting travel time will be more than one hour. During the travel hour, the passengers inside the compartment are exposed of interior noise together with the seat-floor vibrations. And for a travel between cities, we usually use motorway instead of using urban traffic road. Under this condition, the vehicle speed on a motorway is rather constant, for example, 100 km/h for the vehicle to cruise. So, the passengers inside the car compartment are exposed of car interior noise at a constant level

provided that the road surface is the same and smooth. Even under this condition, the subjective impression on sound quality varies with time. In order to examine this effect, subjective evaluations on sound quality of car interior noise at an constant vehicle speed with the simultaneous exposure of seat-floor vibrations are conducted.

In order to see the effect of vibration level to the perception of sound quality under long term exposure, the vibration levels are varied in four steps, i.e., high, medium, low and without vibrations.

### EXPERIMENT

Experimental Apparatus In order to realize the practical running condition under laboratory condition, vibration exciters are fixed to the seat where a subject is asked to sit for the evaluation. For the reproduction of vibration signal, transducers are also fixed under the floor panel and below the sitting seat.



Fig.1 Experimental setup for subjective evaluation

During one-hour exposure of car interior noise and seat-floor vibrations, subjects are asked to respond their instantaneous impression on unpleasantness, powerfulness, desirability and booming sensation in every four minutes by utilizing computer keyboard as the input device. The time required for evaluations for subjects is less than 20 seconds for four polar adjective scales. So during the rest of time until the next evaluations, subjects are asked to hit the computer mouse at the timing when three continuous odd numbers appear on the screen by watching the monitor display where random integer numbers are continuously displayed to simulate the car-driving task.

<u>Sound and Vibration Presentation</u> The pairs of speakers set in front of the subjects reproduce car interior noise. The noise level at the ear position of the subject is set 73 dBA. Concerning the vibration levels, high vibration is equivalent to one and half times more to the existing level. For medium and low vibration levels, these are equivalent to existing level and one half of the existing level respectively.

<u>Subjects</u> Subjects joined in this experiment are 10 males aged between 22 and 24 years with normal hearing ability.

### **EXPERIMENTAL RESULTS**

<u>Evaluation on Unpleasantness</u> The result of evaluation on unpleasantness is shown in Figure 2. As is shown in Figure 2, temporal variation in unpleasantness is observed from the onset of the sound exposure until the 20 minutes after the onset of the stimulus. Namely, car interior noise became more unpleasant in the first one third of the total exposure time and then the evaluations took rather stable values. From the more precise observation, evaluation became less unpleasant in the last 12 minutes under Noise alone condition. From the overall results, the evaluation obtained under high vibration condition was most unpleasant compared with other three vibration conditions.



Fig 2 Evaluation on unpleasantness

Evaluation on Powerfulness The evaluation on powerfulness is shown in Figure 3. As is not like the result obtained for unpleasantness, strong dependence on vibration levels is observed in case of powerfulness evaluation. The evaluations were more powerful for high and medium vibration conditions from the onset of the stimulus until 36 minutes, and then the evaluation were in order with the vibration levels, i.e., under high vibration condition, sound was most powerful then it was more powerful compared with other two under medium vibration condition and it was less powerful under noise alone condition. Concerning the temporal variation on powerfulness, it was observed within the 16 minutes and 24 minutes from the onset of the stimulus although there were differences with the different vibration conditions.



Fig 3 Evaluation on powerfulness

Evaluation on Booming Sensation The result of evaluation on booming sensation of car interior noise is shown in Figure 4. As is shown in Figure 4, temporal variations on booming sensation were observed from the onset of the stimulus until 20minutes from the beginning with an exception of medium vibration condition. For this condition, we could not find clear tendency for temporal variation. Beyond the 20 minutes from the onset, the evaluations became stable and we could not find significant differences between the four vibration conditions.

Evaluation on Desirability of Sound The temporal variation on desirability of car interior noise is shown in Figure 5. From this figure, we can observe monotonous decreasing of the desirability of

sound from the onset of the stimulus until 12 or 16 minutes from the beginning. Concerning the difference in evaluation due to the difference of vibration exposure level, there existed no clear tendency.







Fig 5 Evaluation on desirability

## CONCLUSIONS

Under long-term exposure of car interior noise with simultaneous exposure of seat-floor vibrations, we observed the following facts.

- Temporal variations on unpleasantness, powerfulness, booming sensation and desirability of sound were observed from the onset of the stimulus until the 24 minutes at most. The most frequently observed temporal variations were within 20 minutes from the beginning.
- 2. Significant difference on evaluation of powerfulness observed for different vibration levels.

## REFFERENCE

[1] T. Hashimoto, S. Hatano et al.: Relation between Sound Quality and Interior Noise of Small Diesel Truck and Physiological Data during Long-term Exposure, Proc. of JSME VS Tech'97, No.97-37, pp.176-180, (1997)(in Japanese with English summary)