Effect of Visual Scenery and Seat Vibration to the Perception of Car Interior Noise

Takeo Hashimoto, Shigeko Hatano

Department of Mechanical Engineering
Seikei University, Japan
hashimot@me.seikei.ac.jp

Abstract
This paper describes the effect of visual scenery and seat vibration to the perception of sound quality of car interior noise. According to our experience, the presence of visual scenery and seat vibration affects the perception of sound quality of car interior noise. The addition of visual scenery weakens and the addition of seat vibration strengthens our perception in general. Under the practical situation, we perceive the both effects simultaneously. We vary the levels of the sound presentation step by step to find out the trade off value of the sound level versus the practical situation for powerfulness, unpleasantness and booming sensation respectively.

Introduction
Usually, the subjective test on sound quality of car interior noise is conducted by simply presenting a sound alone to the subject to find out the effect. But according to our experience, the simultaneous exposure of visual scenery and the simultaneous exposure of seat vibration to the subject as well as car interior noise, significantly affects the perception of its sound quality. As we know, under practical situation, we have the both effects simultaneously when we drive a car for the evaluation. In order to see the simultaneous effect of the addition of visual scenery and seat vibration with the car interior noise for the evaluation of its sound quality, the sounds alone with various presentation levels are presented to the subjects as well as the simultaneous exposure of car interior noise, visual scenery and seat vibration to find out the trade off values for sound quality. From our experience, the semantic space for car interior noise is constructed in three dimensional spaces, i.e., attributes related to powerfulness, unpleasantness and booming sensation [1]. So, the evaluations of powerfulness, unpleasantness and booming sensation in a separate experiment were conducted.

1. Experiment
In order to conduct the laboratory experiment under practical condition, a car simulator consists of seat, a steering system, floor portion with the vibration exciter and front screen for projecting the moving scenery recorded simultaneously with the car interior noise is constructed. The car interior noise is presented to the subject through an equalized headphone and the low frequency content of the sound is played back through two woofers set in front of the subject. When we present car interior noise with visual scenery and seat vibration, the synchronized visual scenery is projected on the screen set in front of the subject from the digital video signal installed into the computer hard disk area though a liquid crystal projector. The seat vibration is reproduced by applying the recorded vibration signal to the large exciters set underneath the seat and to the small exciters fixed under the bottom seat and back side of the seat back. In order to know the trade off value of the car interior noise versus the effect caused by the simultaneous exposure of car interior noise with visual scenery and seat vibration, car interior noise alone with various level is presented to the subject. In this case, small variations of the sound may be added or subtracted from the original car interior noise level.

1.1. Experiment on powerfulness

1.1.1 Sound presentation
Original level, additional levels of +0.5dB step starting from +0.5dB up to 2.0dB, namely 4 conditions were used for sound alone condition. Together with the sound alone conditions, simultaneous exposure of car interior noise with visual scenery and seat vibration was also included. The order of the presentation of the sound was randomized in order to avoid the order effect.

1.1.2 Subjects
Subjects participated in this experiment were 15 males aged between 22 and 58 years old with normal hearing ability.

1.1.3 Result
The result is shown in Fig.1 and the test of variance between the sound alone conditions and the simultaneous exposure of car interior noise with visual scenery and seat vibration (hereafter this condition is abbreviated as N+S+V) is shown in Table 1 and in this
Table, RMS values are also listed. Here, RMS value means the root mean square value of the difference between the sound alone result and the N+S+V result. As is judged from Fig. 1 and Table 1, the N+S+V result is closer to the +1dB condition. In this case, the variance is 0.767 without significance and the RMS value is 0.216. These values are smallest among the other conditions. Namely, for the evaluation of powerfulness, the trade off value in SPL is +1dB with the existence of visual scenery and seat vibration. It means that, if you like to conduct the subject evaluation for powerfulness, you have to increase the sound level +1dB for sound alone condition to obtain realistic result.

1.2. Experiment on unpleasantness

1.2.1 Sound presentation

The step size of 0.5dB starting from -0.5dB from the original level up to +1.0dB including the original level were used for sound alone conditions together with the N+S+V condition. Other conditions were the same as in the powerfulness evaluation.

1.2.2 Subjects

Subjects participated in this experiment were the same as in the previous experiment, i.e., the numbers of the subject were 15 and all in males.

1.2.3 Result

The result is shown in Fig. 2 and the test of variance and RMS value are listed in Table 2. As is found from Fig. 2 and Table 2, +0.5dB condition is closer to the N+S+V condition for the evaluation of unpleasantness. Namely, the increase of 0.5dB SPL is required for sound alone experiment to obtain practical result, i.e., the result obtainable under the N+S+V condition. It means that for evaluation of unpleasantness, the trade off value is +0.5dB.

1.3. Experiment on booming sensation

1.3.1 Sound presentation

The step size of 0.5dB starting from -0.5dB from the original level up to +1.0dB including the original level were used for sound alone conditions together with the N+S+V condition as was the same for the unpleasantness evaluation. Other conditions were the same as in the previous two evaluations.

1.3.2 Subjects

Subjects participated in this experiment were the same as in the previous experiment, i.e., the numbers of the subject were 15 and all in males.

1.3.3 Result

The result is shown in Fig. 3 and the test of variance and the RMS value are shown in Table 3. As is judged from Fig. 3 and Table 3, the N+S+V condition is closer to original sound level presentation. Namely, in case of booming sensation, the evaluation is not different from the original sound presentation with the N+S+V condition. So we don’t have any trade off value with this evaluation.
Fig. 1 Result of subjective evaluation of powerfulness for trade off value with N+S+V condition

Fig. 2 Result of subjective evaluation of unpleasantness for trade off value with N+S+V condition
2. Conclusions

After conducted the experiments for the trade off values on sound quality under practical condition and sound alone conditions, the followings are obtained.

1. For the evaluation of powerfulness, the trade off value for the addition of visual scenery and seat vibration with the sound is +1.0 dB SPL compared with the sound alone condition.

2. For the evaluation of unpleasantness, the trade off value for the addition of visual scenery and seat vibration with the sound is 0.5 dB SPL compared with sound alone condition.

3. For the evaluation of booming sensation, there exists no trade off within the two conditions.

3. Reference


Fig.3 Result of subjective evaluation of booming sensation for trade off value with N+S+V condition