

Influence of Vehicle Interior Design and Sound on Comfortability in Cabin using VR System

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KEY WORDS: Vibration, noise, and ride comfort, Sound quality evaluation, Interior design, Virtual reality system, Interior sound (B3)

In this study, we focused on comfortability in cabin and investigated an influence of vehicle interior sound and design on total comfortability using VR system. In the test, various interior sound and design were presented in a VR system. In the evaluation, the participants wore VR headset as shown in Fig. 1 and heard vehicle interior sound binaurally recorded at vehicle running condition at constant speed. The participants could move their head freely to see the entire interior design. About the presented auditory stimuli, 10 sound samples recorded binaurally when a vehicle was running at constant speed were used. The SPL range was from 59 to 67 dB. About the interior design, four design patterns were prepared as shown in Fig. 2.



Fig. 1 Employed VR system.

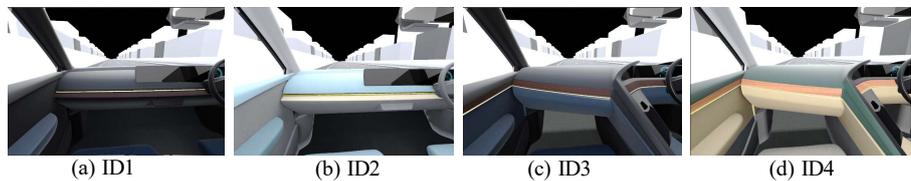


Fig. 2 Presented interior design images in VR system.

There were three color patters and two shapes in the presented interior design. ID1 and ID3 were dark color and ID2 was pastel color design and ID 4 was beige color design. About the shape, center console was separated from instrumental panel in ID1 and ID2 design. They were connected in ID 3 and ID4. In the subjective evaluation test, we carried out three test patterns. In the first test, only sound stimulus was presented. In this test, not any visual information was presented from VR system. In the second test, only visual stimulus was presented from VR system and auditory stimulus was not presented. In the third test, both auditory and visual stimulus were presented. In all test patterns, the participants were asked about comfort of the presented stimulus from “1: Very uncomfortable” to “5: Very comfortable”. In addition, loudness, pitch, rough of the presented sound was assessed in the first test (interior sound evaluation). And brightness, spaciousness and hardness were asked in the second test (interior design evaluation). Figure 3, 4 and 5 shows the average score of the comfort of the presented stimulus in each test pattern.

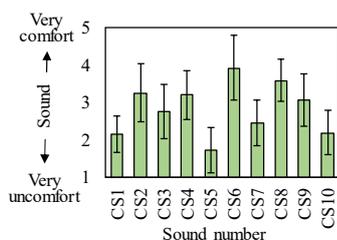


Fig. 3 Sound comfort score

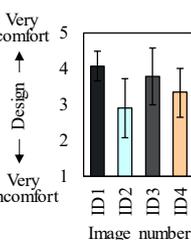


Fig. 4 Design comfort score

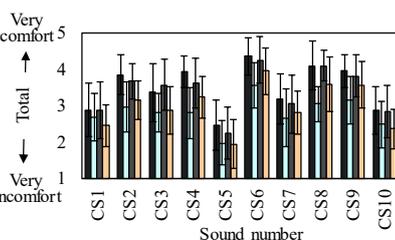


Fig. 5 Total comfort score

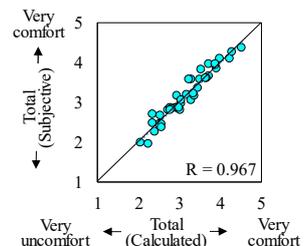


Fig. 6 Relationship between subjective and calculated comfort score.

As shown in Fig. 5, the total comfort to the presented interior sound and design is observed to be affected by both sound and design comfort score (Fig. 3 and Fig. 4). Subsequently, the quantification model was considered to express the evaluation tendency of the total comfort score. Equation (1) shows the total comfort evaluation equation.

$$Total\ comfort = 0.87 \times Interior\ sound\ comfort\ score \times Interior\ design\ comfort\ score \quad (1).$$

Figure 6 shows the relationship between the total comfort score obtained from the subjective evaluation and the calculated total comfort score from Eq. (1). As shown in Fig. 6, the correlation was very high and the equation was found to be able to express the subjective total comfort score very well. In addition, the sound comfort was found to be increased by soft and smooth sound through further analysis, and the solid and dark interior design was also found to increase the design comfort. Furthermore, the total comfort was observed to be affective by multiplying interior sound comfort score with the interior design comfort score. This means that the influence of sound comfort on total comfort changes according to the interior design. For example, in case the design comfort is not high, the total comfort is not expected to increase significantly even though we improved the sound comfort. From these results, it was found that both improvement of the interior sound and comfortable interior design is necessary to realize comfortable cabin.