

Objective Evaluation Method for Interior Sound Quality in Electric Vehicles (Third Report)

- Verification of the Generalizability of Interior Sound-Quality Metrics for Electric Vehicles by NVH Experts -

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KEY WORDS: Vibration, noise, and ride comfort, Idling vibration/idling noise/acceleration noise, Sound quality evaluation/ride comfort evaluation, Electric vehicle, Vehicle interior noise, Sound quality, Subjective evaluation, Psychoacoustic metric [B3]

This study investigated whether objective sound-quality metrics previously proposed for electric-vehicle (EV) interior sound can be generalized to new EV interior sound samples and a partly different evaluator group. Earlier studies proposed the Electric Powertrain Noise Index (EPNI) as an indicator of the prominence of tonal components in in-cabin electric powertrain (e-PT) noise and showed that the combined use of EPNI and Loudness is effective for evaluating overall EV interior sound quality. However, because those findings were obtained using the same sound samples and the same evaluator group, their applicability under different experimental conditions had not been sufficiently verified.

Subjective evaluation experiments were conducted using newly prepared sound samples and 14 NVH development experts, six of whom had not participated in the previous studies. The experiments used Scheffé's paired comparison method and comprised two parts: Experiment I focused on in-cabin e-PT noise, whereas Experiment II focused on overall EV interior sound. Four representative driving conditions, including acceleration, deceleration, and cruising, were evaluated. The resulting subjective scores were analyzed using multiple regression models with Loudness, EPNI, and Sharpness, the three psychoacoustic metrics shown in Fig. 1, as explanatory variables.

The results reconfirmed that subjective evaluations of e-PT noise can be accurately explained by EPNI, as shown in Fig. 2. For overall EV interior sound, the evaluators were divided into two clusters according to their evaluation tendencies; however, this difference reflected whether greater emphasis was placed on Loudness or EPNI. The subjective scores for both clusters were accurately predicted using the two metrics of Loudness and EPNI, as shown in Fig. 3.

These results were consistent with those reported in the previous studies. This consistency indicates that EPNI is effective as an objective metric for evaluating in-cabin e-PT noise and that the combined use of EPNI and Loudness enables objective evaluation of EV interior sound quality. The findings also show that the proposed metrics remain valid even when different sound samples and a partly different evaluator group are used, suggesting that they possess a certain degree of generalizability. Moreover, reducing both Loudness and EPNI is considered important for enhancing the interior sound quality of EVs.

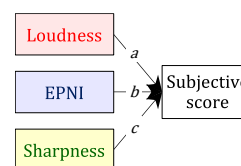


Fig. 1 Multiple regression model for predicting NVH experts' subjective evaluation scores of EV interior sound quality

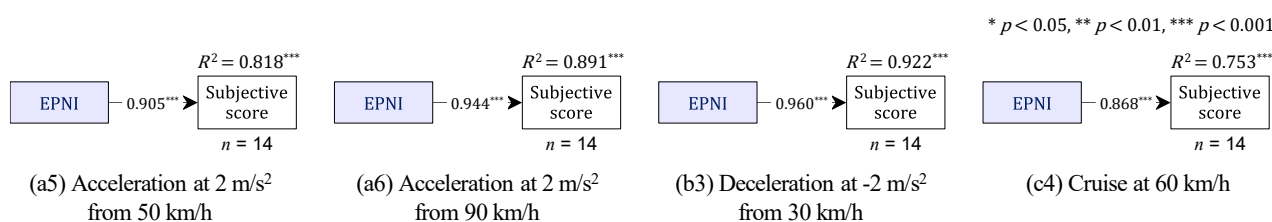


Fig. 2 Results of multiple regression analysis for subjective score of unpleasant EV interior sound by psychoacoustic metrics

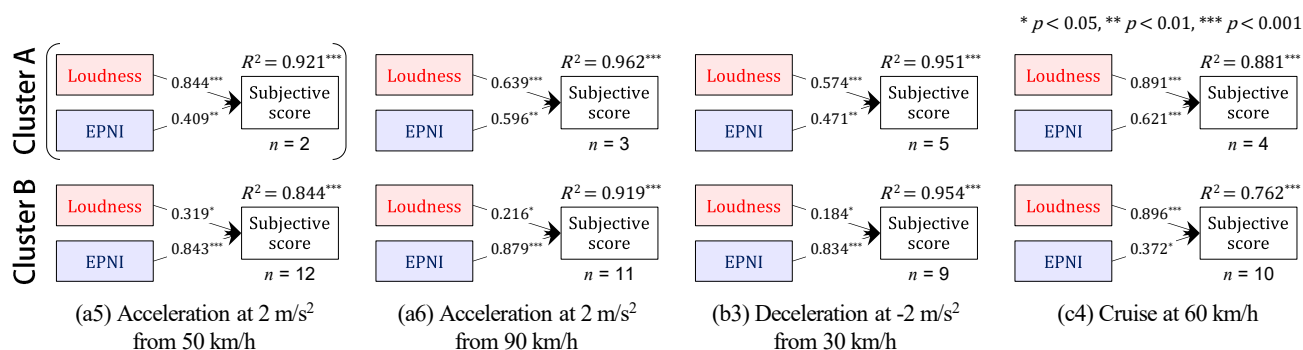


Fig. 3 Results of multiple regression analysis for subjective score of unpleasant EV interior sound by psychoacoustic metrics