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Psychoacoustic Bias in Vehicle Interior Noise – Preliminary Study

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Abstract

This paper presents a preliminary study of psychoacoustic response bias in vehicle interior noise. The subjective response in psychoacoustics require human subject with relevant background and tendency for the best data analysis. In the vehicle interior sound quality subjective investigation, different vehicle owner have different expectation in vehicle comfort based on their preference. The perception and hearing sensitivity will be based on their day-to-day exposure. The objective of this paper is to study the bias response in vehicle sound quality judgement for different categories of car user (such as compact, sedan and luxury car). In this study, a survey has been conducted in an automotive service workshop. The questionnaire was designed to obtain the perception towards overall vehicle interior noise. The questionnaire are divided into three section; Part I: demographic information, Part II: Customer comfort level on level in vehicle cabin, Part III: Customer comfort level of sound loudness. The part III questions is created based on Loudness Fastl's Thermometer. The respondents were given brief demonstration of loudness and sharpness. Two examples of each type were given to assist respondent in grasping the concept and come out with their judgement toward the related sound mentioned in the survey. In this study, 30 male and 12 female respondents participated in the survey. The results showed 80% of the respondents feel comfort with their respective vehicle regardless of what type of car there are driving. This indicates clear bias response based on the user's experience in driving different type of car. In a nutshell, different car owner define comfort level differently. Even if the sound level is different in comfort, sedan and luxury car, the driver still feel comfort which lead to different perception in defining vehicle cabin interior noise comfort.

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Keywords: Psychoacoustics; Bias; Vehicle interior noise.

1. Introduction

Psychoacoustic is a field where objective and subjective evaluation are integrated to simulate sound quality of a product. In automotive noise, vibration and harshness (NVH), vehicle cabin noise has been an important factor in determining the sound quality of a car. Nowadays the sound quality research of vehicle is heading towards defining suitable sound for specific purpose and expectation. In general, vehicle cabin noise consist of structural borne and air borne noise which dominate the perception of sound to vehicle driver or passenger. In general, the structure-borne noise transmission path dominates at low frequency (<200 Hz), the air-borne noise transmission path dominates above 500 Hz and in the mid-frequency range, both transmission paths have usually the same level of importance [1]. Psychoacoustics investigation of sound quality in automotive industry concern practically all sounds present in the vehicle's acoustics environment, such as door-closing sound, starter sound, engine noise, tire noise, wind noise, power window sound, air condition system noise and sound produced by car audio system [2]. In practical application, two main interest related to sound quality investigation are sound evaluation and sound quality engineering. The different between both investigations is that sound evaluation deals with improvement of existing sound and sound quality

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engineering will be focusing on tailoring a suitable sound for a specific product or application [3]. It is a great challenge of sound quality engineer to match the expectation of customer with the vehicle cabin noise produced which bridging the differences of physical and subjective evaluation. The other concern on the sound quality is that different car type have different level of comfort and expectation from customers. From luxury car to compact car, different sound quality will be expected and require further investigation in term of sound classification based on car segment. In this case, bias in perception will occur since different customer have their preference based on their interest and daily exposure. The characteristics of vehicle interior sound can be described as informative, implies a certain image and may identify similar optical impression [4].

In sound quality measurement, different type of car have different interior sound level. This will lead to tendency of car driver or passenger to get use to certain level of sound which turned into expectation or perception. Therefore it will expected that biasness will happen if perception of human subject is used for subjective evaluation. In compact car, vehicle interior noise level will increase with time. At speed of 60 km/h, the noise level can reach 60 dBA whereby at the speed of 120 km/h, the sound level will reach 70 dBA [5]. This will create a norm to the driver when they get used to the sound environment and created perception in noise comfort. Therefore if they are presented with the same level of noise, it will reach their expectation of comfort. In B segment car, the interior sound could reach 61.2 dBA at the speed of 60 km/h and as the speed increased to 100 km/h, the sound level can reach 62.2 dBA [6]. Instead of having sound pressure level, it is not good enough to give a definitive result of sound experience. Psychoacoustic metrics such as loudness, sharpness, fluctuation strength and roughness are the most suitable parameter to objectively quantify the sound experience. In current practice of sound quality engineering, psychoacoustic metrics are considered to be the most suitable indicator to quantify sound perception by human. The parameter of Loudness, sharpness, fluctuation strength and roughness will describe the sound spectrum for all audible frequency level in quantifying sound annoyance to human. Other than that, one of the method to investigate noise comfort is through subjective investigation such as jury test session. Basically the idea of this session is to get the real response of human towards sounds. The sound of vehicle cabin will be recorded with binaural technique and later will be reproduced over headphones to the listeners. The live real-time sound is not used to prevent inconsistent sound production during the session. It is important to reproduce the sound which resemble the real sound which encountered by vehicle user. Binaural recording will take into consideration the effect of human head, outer ear shape and torso to sound received by ears. In this study three main questions will require special attention; How bias happen in subjective response experiment? Will different car user have different perception? How can we verify they have different perception? Our hypothesis is that bias will likely to happen during subjective investigation based on several factors related to human subject background. Therefore the objective of the study is to understand the bias condition of different car user and analyze how the bias condition happen under different types of car owner with different drive condition. This is the factor which believed to be the root cause of bias to happen in performing jury test or other subjective method test.

2. Methods

In this study, a set of questionnaires was prepared to get human respond towards sound based on their life experience, not based on sound reproduction. This initiative had been taken because due to one important issue where the respondent are not trained to evaluate sound accordingly. This will create stress among subject which could lead to incorrect data. By doing survey, subject or respondent will have sufficient time to respond accordingly based on their life experience towards the sound of interest. In addition, it will be a good findings to get respond from real customers from automotive workshop or service center who are critical in giving feedback and complain. The survey activity centralized in D'Alpha Auto Service Center in Shah Alam region, Selangor, Malaysia. It is an automotive service and diagnose center which specialized in computerized diagnosis and troubleshooting. The target respondents are the waiting customers. However technical staff and workshop management also take part in this survey to support the activity.

Table 1. Customer Driving experience (Mean: 5, Standard deviation: 4.8, Range: 18, Interquartile range: 21.5)

Driving experience	Frequency	Percent	Cumulative percent
Less than 5 years	13	31	31
6 – 10 years	16	38.1	69
11 – 15 years	8	19	88.1
16 – 20 years	5	11.9	100
Others	0	0	100