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Dimensions of vehicle sounds perception

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ABSTRACT

Vehicle sounds play an important role concerning customer satisfaction and can show another differentiating factor of brands. With an online survey of 1762 German and American customers, the requirement characteristics of high-quality vehicle sounds were determined. On the basis of these characteristics, a requirement profile was generated for every analyzed sound. These profiles were investigated in a second study with 78 customers using real vehicles.

The assessment results of the vehicle sounds can be represented using the dimensions “timbre”, “loudness”, and “roughness/sharpness”. The comparison of the requirement profiles and the assessment results show that the sounds which are perceived as pleasant and high–quality, more often correspond to the requirement profile. High-quality sounds are characterized by the fact that they are rather gentle, soft and reserved, rich, a bit dark and not too rough. For those sounds which are assessed worse by the customers, recommendations for improvements can be derived.

1. Introduction

From the customer's point of view, many products become more and more similar. Therefore, it is very important that a product is able to fascinate the customers and raise their emotions (Shaw, 2007; Lee et al., 2009). Today, technological quality of a product is not enough to achieve success. Thus, many organizations are looking for new ways to achieve a competitive advantage (Montignies et al., 2010; Gale and Wood, 1994; Woodruff, 1997).

The vehicle sound can be one of the most significant distinguishing features in the automotive sector – besides other quality aspects such as design or material (Fastl, 2005; Nor et al., 2008; Otto and Wakefield, 1993; Schifferstein, 2006). Vehicle sounds play an important role in relation to customer satisfaction. Customers instinctively believe that a high–quality product also sounds high–quality (Miśkiewicz and Letoweski, 1999; Schulte-Fortkamp et al., 2007).

Customer satisfaction represents a complex psychological phenomenon. The expectation confirmation theory of customer satisfaction regards satisfaction or dissatisfaction as the result of a cognitive comparison of product performance and expectation standards (Oliver, 1980; Oliver and Bearden, 1985). This comparison can lead to three possible results: the expectations of customers are excelled, reached or disappointed. If the expectations concerning a product are not matched, this results in a lack of satisfaction among customers (Oliver, 1993; Trommsdorff, 2008).

Due to the high importance of aspects of customer perception on product quality, customer evaluations can be an important factor of success (Gale and Wood, 1994; Montignies et al., 2010; Zeithaml, 1988). It is therefore the task of customer research to identify the properties characterizing high-quality and manufacturer-typical sounds. Customers are confronted with a lot of different sounds inside the vehicle. These range from door closing sounds and the sound of indicators or switches through to wind, rolling and engine noises (Wagner, 2014). In their investigations regarding door closing sounds, the research groups centered around Kuwano et al. (2006) and Parizet et al. (2008) revealed that different factors play a role in the subjective evaluation of these sounds. In this way, Kuwano et al. (2006) could identify the three factors (“pleasant”, “metallic” and “powerful/hard”) which play an important role for the perceived quality of door closing sounds. Pleasant sound perception is also closely linked to the sound qualities gentle, dark and heavy. Investigations

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with further, not only vehicle-specific sounds also revealed the importance of the factors for the impression of a sound's quality as mentioned above (Kuwano et al., 1993; Namba, 1996).

Studies with respect to nationality or culture, age and gender differences, established that the factor "comfort" is used in the same way in all European countries (Sottek et al., 2005). This could not be proved for any other factor. Kuwano et al. (2006) found accordance in sound preferences of German and Japanese participants. A further study revealed that Americans sometimes tend to evaluate the stimulus (vehicle interior sound during driving) as "louder" than Western – Europeans. Women tend to evaluate the stimulus louder than men, as well as older people more than younger participants (Kuwano et al., 1993).

1.1. Aim of the study

In this article, two different studies will be explained in more detail. They will be named as Survey Study (study 1) and Experimental Study (study 2). The Experimental Study (study 2) is based on study 1. The primary question is which characteristics customers assign to high-quality vehicle sounds. Furthermore, the investigation of dimensions which can represent these characteristics, is an additional field of interest. Based on the findings of Kuwano et al. (1993, 2006) we were also interested in certain differences due to nationality, age or vehicle class. The aim of both studies was to focus not only on a single sound category, but to investigate most of the sounds a customer could be confronted with when driving a vehicle.

On the basis of the Survey Study (study 1), ideal requirement profiles of 19 different sounds will be derived. In the next step, these profiles are compared with the help of sound evaluations (study 2), the so-called actual profiles. Whereas study 1 investigates the expectation component of the expectation confirmation theory, study 2 focuses on assessing the perception of real sounds. The comparison between the customers' expectations and requirements for high-quality sounds (study 1) and the sound evaluations of real vehicle sounds (study 2) could show possible weak spots, which could be eliminated or at least improved in future acoustic engineering.

2. Survey study (study 1)

2.1. Method

An online survey was chosen as testing method in order to reach the highest possible number of customers and enable a cultural comparison as well as a comparison between customers of different vehicle segments. The data for study 1 was collected using an online panel with a total of 2913 drivers (vehicles of luxury, upper-range and mid-range segment) from Germany and the United States of America who are invited for several online surveys per year.

2.1.1. Sample

The response rate was 61.93%. Questionnaires from 42 participants (2.33%) were not included in the study because they had not finished the questionnaire. In total, data from 1762 German and US drivers of vehicles in the luxury, upper-range and mid-range segment were incorporated in the study. 1288 men and 474 women with an average age of 53.79 years (SD = 12.72) took part in the online study. The exact distribution among the countries is shown in Table 1.

2.1.2. Materials

The online survey used in study 1 was programmed using the EFS Survey of Questback GmbH. The study participants needed around 15–20 min to complete the questionnaire. The questionnaire comprised a broad range of items addressing different aspects of customers' opinions about car acoustics. Customer requirements towards the 19 evaluated sounds were operationalized using an evaluation profile (requirement profile) based on 5-point semantic differentials describing different sound attributes (c.f. Wagner, 2014). The semantic differentials are presented in Table 2 (see 2.2 Results: factor analysis study 1). The construction and selection of the semantic differentials used for the evaluation profile is based on preliminary studies (interviews, focus groups, item evaluations). In order to cover a broad range, customers as well as acoustic and/or vehicle experts were involved in these preliminary studies. The goal of these studies was to develop a pool of items to subjectively describe and evaluate vehicle sounds. So, the semantic differentials used in study 1 are the result of these preliminary studies.

The sound sources of the 19 different sounds were: acoustic signals (e.g. seatbelt reminder), turn indicator, power window, parking brake, glove compartment, tailgate, air conditioning, rotary light switch, engine (from inside of the vehicle), engine (from outside of the vehicle), sunroof, seat adjustment, door opening (from inside of the vehicle), door opening (from outside of the vehicle), door closing (from inside of the vehicle), door closing (from outside of the vehicle), central operating element in the center console, central locking (from inside of the vehicle), and central locking (from outside of the vehicle). Based on their sound source the 19 different sounds are classified into a total of six superordinate groups of sounds/categories of sounds – shifting systems, acoustic indicators, engine noises, fan, switches and operating elements as well as doors, flaps and filings. Most of the sounds are related to the car interior, while only four sounds differed in interior and exterior perception (door opening, door closing, engine noise, central locking). Therefore, evaluation profiles (requirement profiles) of these four sound sources were used to combine requirements for sounds of one and the same component heard "from outside" (exterior sound) and "from inside" (interior sound) the vehicle (see 2.2.1). These comparisons are interesting for vehicle development resp. the acoustic engineering department due to the fact that customers normally hear the sound of one and the same component under two different hearing conditions. Each participant had to compile a requirement profile for only one of the 19 sounds. The sounds were randomly assigned to the participants using the randomization function of the EFS tool. Example: "Imagine, you could determine how the sound of the *door closing (from inside)* should sound in the vehicle. What qualities would this sound have for you to be a high-quality vehicle sound?" Independent random samples of 68–109 study participants per sound result from this.

2.1.3. Statistical analyses

The statistical analyses of the data were conducted using the software SPSS for Windows. Factor analyses, analyses of variance and *t*-tests were performed for calculating the results. The evaluations were based on a significance level of 5%.

2.2. Results

The results of the factor analysis of the evaluation profile (requirement profile) based on semantic differentials used for evaluating the sounds can be seen in Table 2.

The requirements of customers for high-quality sounds can therefore be represented (67% explained variance) on the basis of the four factors "roughness/sharpness" (factor 1), "loudness" (factor 2), "timbre/richness" (factor 3) and "pitch/tonality" (factor 4).

As previously mentioned (see 2.1.2 Materials), the 19 sounds