

Psychoacoustics and Jury Testing for Automotive Applications – Today and Tomorrow

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1. Meaning of Product Sound Quality

Specific product sounds help manufacturers to stand out against their competitors in times of a highly competitive market. Although sound quality of technical products has already been studied for decades, up to now no universal approach or standard for the “measurement” of sound quality is established. Product sound quality is a descriptor of the adequacy of the sound attached to the product and thus does not exist as a concept independent of the product and context. It is not even an inherent property of the product; it develops when listeners are exposed to the product and judge it with respect to their expectations in specific contexts. Thus, the investigation of product sound quality requires, besides the analysis of sound, a discussion of the typical product context, the interactive product handling, expectations and wishes regarding the product. It requires a detailed understanding of sound quality. However the distinction between the dimensions sound character and sound quality is frequently neglected. Sound character represents the basic attributes of the auditory event and aims at the sensory properties of acoustic events, which can be assessed in the laboratory in an “unbiased” way. In contrast, sound quality describes the complex perception affected by aspects such as product meaning, context, cognition, interaction. This criterion cannot be judged without reference to a concept of desired product features. The awareness of these dimensions is very important with respect to the adequate interpretation of test results.

2. Consideration of Product Context

Industrial applications are strongly oriented towards the sound character dimension of a technical product. Tests and measurements are performed out of product context, because of their good reproducibility. It is important to be aware about the necessary consideration of context and interactive product use, which have significant influences on the perceived sound quality; which finally is the most relevant criterion with respect to customer acceptance. It is always a challenge to find the best compromise between standardized procedures allowing for generalizing test results with limited external validity, and the realistic tests in actual product use and context (making the analysis more difficult).

3. SQ Investigation in Automotive Applications

The increasing electrification of the powertrain after 125 years of continuous development of the internal combustion engine leads to reduced levels of vehicle interior and exterior noises. New engine concepts come or will come into the market in the near future, such as micro-hybrids, mild hybrids, full hybrids, plug-in hybrids, extended-range electric vehicles and battery-electric vehicles. These concepts will be applied to all kinds of vehicles, such as passenger cars, motorcycles, buses, small transporters and heavy vehicles. The German government estimates the number of electric-driven cars to reach 1 million in 2020 in Germany. With this development, people affected by traffic noise hope for quiet cities in general. However, surveys have shown the increased risk of accidents for pedestrians and cyclists with respect to collisions with quiet vehicles, a topic already causing lively discussion about acoustical warning systems for the prevention of crashes. It is inevitable develop intelligent and comprehensive solutions to warn drivers as well as pedestrians about a potential collision danger, far beyond concepts of simply continuously emitting a warning signal and hoping that the vulnerable pedestrian hears, early enough, the approaching vehicle. The use of car-to-car communication as well as additional devices for persons at risk is conceivable. It is expected that due to the intended differentiation between brands, the development of company-related warning signals is preferred by the manufacturers. This means that a standard alerting signal for all electric vehicles is presumably not in the interest of manufacturers and maybe of customers. Since an alerting vehicle sound should be unmistakable and

should not confuse identification, the creation of warning signals appears very limited. All in all, different sound concepts are thinkable fulfilling these requirements.

For interior sound aspects the lower levels inside the passenger cabin due to electric drive offer great sound design options. It is important to accept that new constraints and new drive concepts are emerging in the automotive field, which requires a general rethinking. Since sound engineering must always reflect the vehicle's class and performance, the brand image of the company, the preferences of the potential customers and the wishes of the intended customer target group, adequate sound design must be applied. To identify relevant noise aspects and to determine effective modification, psychoacoustic analyses are required to provide important information about perceived intensity, spectral distribution, time structure and spatial distribution of the sources. But only when reasons are known for noise aspects which must be optimized, can concrete optimization proposals be made. Here, methods like transfer path analysis have to be used, enabling reliable identification of the reasons for acoustical problems by separation of sources and transfer paths, permitting via simulated modifications an estimation of the optimization potential. It is possible to listen to modifications by using the binaural transfer path analysis and synthesis, so that proposed measures can be evaluated regarding the costs/benefit relationship. By means of driving simulators, different measures can then be evaluated interactively within the authentic context. With respect to interior sound design, on the one hand the character of the electric motor should be preserved to bring to mind acoustically to the customer the novelty of the electric drive. On the other hand, there are ideas for the complete individualization of vehicle interior noise, selectable on pushing a button. Surely, the simple electric motor sound - "tram on wheels" - will not be the final solution. Due to the favored differentiation of brands in the automotive industry, a certain acoustic image and emotional bonding is needed. Manufacturers want to transfer their brand core concepts via sound, design, haptics, driving dynamics, etc. Thus, an emotionless, "faceless" sound is not an option for representing comfort, modern lifestyle and image. So far, everything seems possible, from emphasis and optimization of the existing electric motor, to sound masking, to introducing certain sound elements generating along with the present noise a harmonious sound climate, to a complete artificial generation of a virtual engine noise.

All in all, vehicle acoustics, sound design and NVH will become more important, whether for vehicles with a combustion engine or for electric vehicles.

4. Summary of Presentation

- Introduction to SQ,
- Newest test procedures and metric developments,
- New requirements and solutions in vehicle acoustics,
- Conceptual developments in product design,
- Applications examples