

# **METHODS FOR A TARGET-ORIENTATED DESCRIPTION OF SOUND QUALITY**

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## **1. INTRODUCTION**

The classification of sound quality is based in general on subjective judgement. The resulting target descriptions normally are not useful for the engineering work. They imply questions such as: “What does the improvement in sound quality really mean?” or “Which modification of the acoustical situation is required?” In consequence, an objectivation of the subjective judgement is necessary. It simply means the transfer from an ambiguous phonetic description of sound to applicable measures whatever they look like.

This approach requires comprehensive research work to understand the language of sound. A main step is the “correlation analysis“ between subjective evaluation on one hand, and physical and psychoacoustical descriptors on the other hand. The proceeding must be focused on a particular product group (i.e. electric motors or interior noise of vehicles); a general approach will not lead to sufficient results due to the underlying multiple dimensions and aspects.

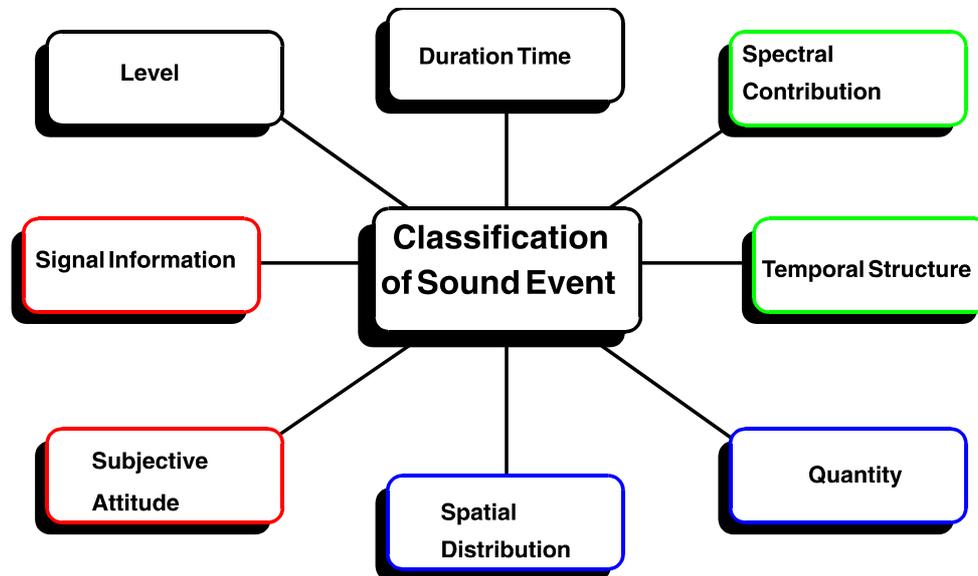
The following paper includes a description of investigations in the objective evaluation of sound judgement. It is combined with the presentation of some industrial tools, such as sound description libraries or multi-media acoustical data bases.

## **2. THE LANGUAGE OF SOUND**

Whenever a product is used in daily life, it emits a characteristic sound. This sound can be regarded as a specific kind of language which the product employs to tell the user something about itself, e.g., its position, its task, its status of operation, and its quality. In addition that sound contributes significantly to the "character" of a product. A customer who has the choice between several products will thus strongly be influenced in his decision by the product sound. In the daily use of the product the sound will significantly contribute to the satisfaction of the user.

Noise is judged subjectively and this judgement is also described subjectively. Additionally, sound means not only an acoustical event, but also transfers information. This may include aspects of quality, functionality, danger, environment and may be divided into main categories as shown in Fig.1 /1/. The described items deal with perception. Another part of the story is the technical realization. Here, the language of sound normally is reduced to an “objective“ single

value measure. Something that is significantly different from subjective evaluation. Subjective parameters are best determined statistically because of the variability of human responses to a particular (acoustical) situation. It is difficult and means a complex tasks to describe (“objective“) parameters from them. For this purpose, an objectively based and aurally-equivalent sound measurement technology is useful.



**Fig. 1:** Parameters relevant for the classification of sound using human hearing

Therefore, the main objective must be the integration of all relevant information for the subjective evaluation in the technical measure. This requires the understanding of the key factors of sound language dependent on particular tasks. For example, the time structure and spectral distribution of an acoustical event, the contextual situation, but also the information included in the sound. It also requires in any case the consideration of human hearing as it is possible when using binaural technology /2/.

We are still in an early step of understanding the characteristics of this particular “language“. Basis research work has to be undertaken at it is done for example in the European Research Project OBELICS for the objective evaluation of interior car sound.

An effective and optimal design of product sounds has been hindered until now by the fact that the structures of the specific product "languages" are not yet understood. The most prominent branch confronted with this problem is one of Europe's most important industries - car manufacturers. Hence, the overall goal of OBELICS is to develop methods for an objective evaluation of car sounds.

New methods and tools for sound design and sound engineering will be made available within this project. They will lead to a more effective development process and to more sophisticated products. Firstly, the development process of new cars will be sped up, and, due to the availability of target sounds for specific car categories and advanced design methods, the process of sound design can be better integrated into the early development phase of cars.

The project includes an exploitation of auditory perceptual spaces set up from interior noises of passenger cars as well as identification and validation of descriptors as used by

psychoacousticians, car makers, and customers to describe and to scale parameters of these spaces. To this end, multidimensional-scaling and factor-analysis procedures will be applied to auditory judgements produced by a pool of representative listeners. Auditory descriptors as used by car makers and customers in this regard will be identified through interviews and be validated via perceptual polarity profiles. A cross-comparison with psychoacoustic parameters will be performed.

The results of the perceptual investigations will be correlated with physical indicators. This important step builds the bridge between perception and physics: signal analysis methods will be developed which allow a prediction of perceptual attributes.

Based on the experience in this context the following conclusion is valid: Because sound events and their evaluation are extremely complex and depend on the contextual situation, a practicable procedure of the work on sound language must always be task- (or product-) orientated: No "general" description using one single index for all purposes will be possible.

## **SIGNAL ANALYSES CONSIDERING HUMAN HEARING**

Analyses for task-orientated solutions as suitable basis for the unambiguous communication about sound has to include the characteristics of human hearing and subjective judgement. In this context, signal analyses includes

- the aurally equivalent playback of sound measurements
- the analytical representation in the way "What you see is what you hear", for example using the hearing model by SOTTEK /3/
- the determination of relevant signal components using filter techniques etc.
- the definition of target sounds.

The aurally-equivalent playback including a calibrated measurement chain means a necessary prerequisite for most tasks dealing with the improvement of sound or sound quality.

An essential feature of the auditory model developed by SOTTEK is the calculation of excitation distribution over time. This is obtained as a function of two variables (frequency and time) from the curve of the sound pressure function and provides a basis for calculating psychoacoustic values. It takes into account the time and frequency resolution of human hearing and enables in consequence an appropriate processing of non-steady signals.

Based on this analysis it is normally possible to derive suitable parameters to describe particular characteristics of sound events.

This may include conventional measures (e.g. bandpass SPL), psychoacoustic parameters or relative approaches.

## **THE DESCRIPTION OF SOUND**

In general, the following questions have to be answered in order to get a suitable description of a particular sound characteristic

1. Which are the verbal descriptors for subjectively perceived annoying sound chairs and which sensitive descriptors (such as sharp, continuous, rough) correspond with them?
2. Which are the physical measures that describe the annoying sound?

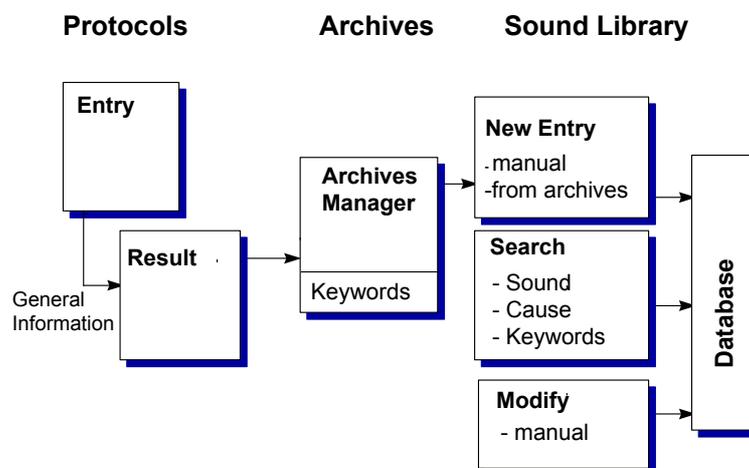
3. What is the correlation between sensitive and physical descriptors?
4. In which way the communication about the subjective judgement may be improved in order to receive an unambiguous discussion about the annoying sound?

Currently, for the description of sound mostly two approaches are used: The definition of target sounds and the set-up of sound library:

**Target sound** means the definition of relevant sound parameters and its limit values on one hand and/or the set-up of a target sound samples based on signal synthesis. Its definition requires - aside from an appropriate measurement and analysis technique - excellent expert knowledge and communication with the customers (for example combined with time- or rpm- synchronous comparison of several sound samples). This procedure ensures that all involved people talk about the same sound characteristics when discussing a particular acoustical „feature“. The expression „sportive sound“ for example may differ absolutely from customer to customer: While the one may imply a high frequent “Formula one“ attribute, the second sees sportive sound as a matter of low-frequent booming. Additionally, there is often a third category of customers that understands sportiveness in our context as a question of roughness. This example should clarify, in which way the definition and aurally-equivalent playback of a target sound means a necessary communication tool.

Target sounds are only one possibility for sound description especially useful in sound quality and sound design. The second one is the set-up of a **sound library** especially for annoying sound shares. Such a library builds a bridge between a subjective and “objective“ description of sound events. It may consist of sound samples, analysis diagrams and a database including several information such as operational conditions, particular application and so on /4/. In line with the VDI guideline VDI 2563, which includes verbal descriptions of typical interior noises, a catalog of noise descriptions was set up especially for sound emitted by small-size electric motors. It includes a classification of the relevant spectral ranges and the appropriate types of analysis. A draft is shown in Table 1 (Appendix).

This can be extended as required within the framework of further projects an integration into a sound library concept as shown in fig. 2 is also possible. Based on keywords suitable description, analyses or corresponding signal characteristics (such as frequency range) may be determined unambiguously for (new) sound samples.



**Fig. 2:** Sound library concept

Additionally, comprehensive investigations have been carried-out for exhaust systems, which include both the communication about annoying sound shares and their sound design /5/. There resulted a list similar to this shown in table 1 describes annoying sound shares. The project also lead to some design principles for particular sound characteristics.

## FUTURE DEVELOPMENTS

An understanding of the language of sound that is appropriate for acoustical engineering is in the early beginning. That means, comprehensive research work for the determination of the key factors for sound evaluation is required. This probably will be focused on particular applications while a global solution will not be possible.

Another future development maybe the set-up of a multimedia sound library including sound, video and database modules. Such a sound library could be combined with an easy-to-handle binaural measurement device for trouble shooting and trouble solving. A complete solution may also include the possibility for analyses in a worldwide networking environment that allows nearly online communication about particular sounds and their definition.

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