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HOW CAN PSYCHOMETRIC METHODS BE USED IN THE DESIGN OF AN ADEQUATE PRODUCT SOUND?

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ABSTRACT
Sounds from products are a very essential part of the perceived quality. Although the Product Sound should not be treated as an isolated phenomenon, it makes sense in many cases to optimize this characteristic to improve the overall perceived quality and thereby the user satisfaction with the product. For the development or redesign of the sound from a product a model for the working process called the "Product Sound Wheel" has been created. The use of test panels plays an important role in this connection, and some viewpoints will be given concerning methods and techniques. A practical application of the model for optimizing a typical consumer product from the "white goods family" will be discussed. Finally, an outline will be presented for future research work within a new project on human perception of sound.

1 - INTRODUCTION

The quality of a product perceived by users and other observers in the vicinity of the product depends on a number of product attributes such as appearance, response to user activities, function, noise/sound, weight, smell, taste/flavor, and tactile characteristics. We talk about the sound quality, the visual quality, the tactile quality, the quality of user interfaces, etc. [1].
Although the Product Sound should not be treated as an isolated phenomenon, it makes sense in many cases to optimize this characteristic to improve the overall perceived quality and thereby the user satisfaction with the product.
Product Sound can be considered as information, which is relevant in relation to sounds in e.g. the user interfaces of the product/system, but Product Sound can also be considered a part of the total experience using a product/system, which is a more marketing-oriented approach.
The overall objective in product development is to utilize future consumers' attitudes, expectations, and preferences so that the sound from a product becomes a positive attribute to the user instead of an annoying problem. As all hearing persons can perceive acoustic quality and thus can be said to be experts, there is a great need for good acoustic design and development. Totally, this represents a special opportunity to make sure that the product has the desired success with the users.

2 - MEASUREMENTS INVOLVING HUMAN SUBJECTS

Often listening tests are regarded as subjective tests, but in practice this concept needs a gradation. According to purpose and carrying out listening tests may be both subjective and objective [2]. We distinguish between *affective tests* and *auditive measurements*.
Affective tests are subjective listening tests, the listeners' preferences are asked for. Generally the results will depend on the group of people and in what circumstances you ask. Subgroups of these kinds of test are market analyses and preference tests. Special kinds of preference tests are tests in which the annoyance concept is included. Ordinarily selected groups of persons are used, who are representative in relation to the properties you want to examine. Experts and trained listeners are normally not considered representative and are typically not used in this connection. The main purpose of this kind of test is to provide information of human beings' liking/disliking in a given context.

Auditive measurements – If the purpose of the listening test is to find out how a certain property of the sound is perceived by hearing it is an objective or analytic test. It is required that the property to be assessed can be described or exemplified objectively and in such a way that all listeners have a clear and unambiguous understanding of the property of the sound they are to listen for. Usually experts or trained listeners are used for such tests. Objective measurements where human beings are used as measuring instruments are also called "perceptive measurements". Within food research the concept "sensory analyses" is used, and in connection with listening tests the concept "auditive measurements or analyses" is used. As regards the auditive measurements it could be asserted that the main purpose is to provide information of the sound or a certain quality of it, as it is perceived by hearing.
The differences between the two types of test are illustrated in Fig. 1 [3].

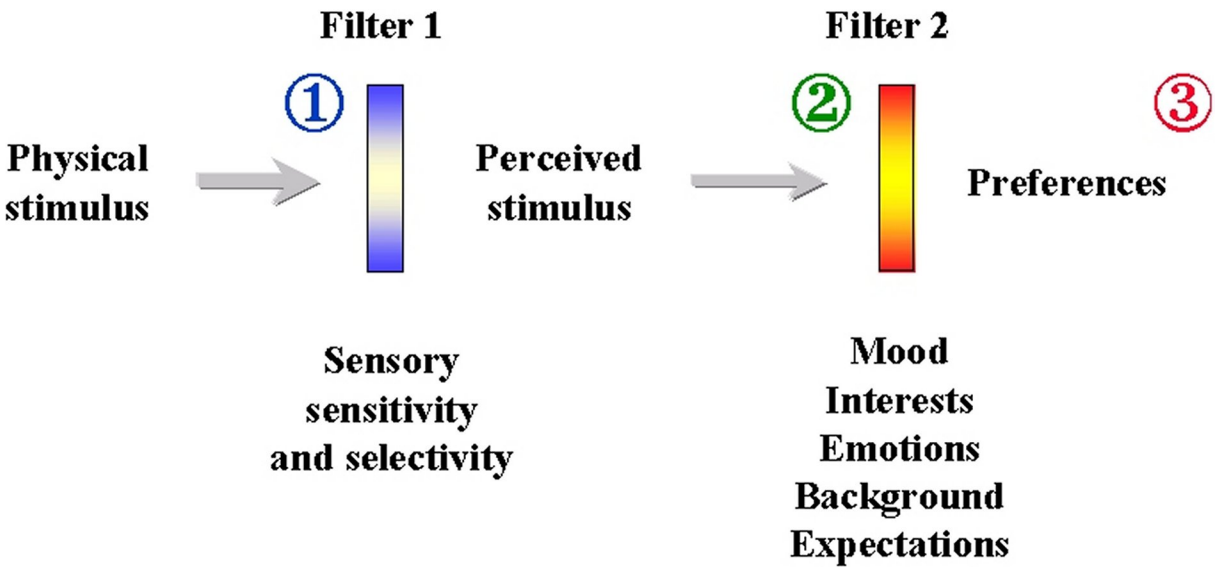

Figure 1: Relations between physical measurements (measurement point 1), perceptive/auditive measurements (measurement point 2), and affective tests (measurement point 3).

In measurement point 1 we can carry out physical measurements by means of technical measuring equipment (microphones, sound level meters, analyzers, etc.). These measurements are strictly objective. Filter 1 illustrates our senses, and in measurement point 2 we can make an objective measurement with humans as measuring instruments (perceptive measurement). In this measurement point the major part of psychoacoustics has its source. We are dealing with an (objective) auditive measurement, and preferences are not asked for.
Filter 2 illustrates the subjective part of humans' perception of the surroundings. In measurement point 3 we perform the affective tests, included in this preference measurements and examination of noise annoyance. Generally, as stated the result depends on the context in which the examination takes place and will typically be influenced by a large number of parameters, included in this stimuli from other senses as well as attitude and social factors.
Ideally there is a distinct division between auditive measurements and preference measurements, and it is important to distinguish between them when listening tests are planned, carried out, and interpreted. In practice there will be a certain overlap, and it is not always clear where the dividing line between the two kinds of test lies. This may lead to unreliable and incomparable results. Valid generalizations based on listening tests require that you are certain of these differences.

3 - METHODS FOR EXAMINATION OF PRODUCT SOUND

For the development or redesign of the sound from a product a model for the working process – called the "Product Sound Wheel" – has been created, see Fig. 2 [4]. The use of test panels plays an important role in this connection, and some viewpoints concerning practical methods and techniques will be discussed in the following.
The entry to this model consists of an initial working phase ("collection of information"). The purpose of the initial phase is to obtain an insight into the product category, including the position of the product in the category, especially the importance of the product category in the practical user situation, quality

dimensions of the product category, and the sound universe of the product category and the specific product, as experienced by the consumers.
Another purpose is to chart a general course of the product sound development by means of the model based on an understanding of the significance of the product and the product sound to the user consumer, and hence to the manufacturer.
To obtain this qualified insight into the product category and the sound universe to which the product or brand belongs, it will be appropriate to perform the analysis in three steps:

- Analysis of the *practical use* of the product and its adjacent sounds giving the following output:
  - A description of the typical practical use, i.e. the situations and the environments where the consumer has his/her attention directed towards the product and its sound.
  - A description of the acoustical conditions of the practical use situations.
  - A list of the operating, action, and signal sounds of the product.
  - For certain types of products it may also be relevant to describe the consumer's decision-making process and the situation related to the purchase decision, especially if the product sound plays a part in this connection.
- Analysis of the *quality dimensions* of the product giving the following output:
  - A description of the significance of the product to the consumer in the relevant environments and situations of practical use.
  - A description of the central user-experienced quality dimensions for the product and the product category, included in this, if relevant, the image views of the most significant competitors of the product.
- Description of the *sound universe* of the product giving the following output:
  - Analysis of what sounds are significant in the consumers' experience as regards product category and product/brand, and what importance the sounds have regarding the consumers' experience of the product, and hence what part the sounds play in the consumers' life in the widest sense. On this basis it is concluded what objective and subjective dimensions can be used to assess alternative sounds at listening tests.

Depending on various elements such as resources, knowledge of product category, and sound universe the analyses may be performed with a more or less formal and structural data collection from the target groups. As a minimum the analyses ought to be made as "paperwork", i.e. the properties should be considered on the basis of own experiences without collecting data from consumers. The risk is, of course, that one does not obtain a qualified insight into the importance of the product and the product sounds to the experience of the target group.
The three steps of the analysis constitute altogether a description of "what the relevant quality-bearing/ leading sounds are, and what their characteristics mean to the individual product or brand compared to competitors and to the product category in general". It should be mentioned that to some product categories this might very well turn out to be a "negative property" understood in the way that the most significant sounds are annoying sounds and that the purpose will thus be to minimize sound annoyance by means of redesign of the product.

4 - THE PRODUCT SOUND WHEEL

After the initial phase where the relevant and necessary information has been collected, the work should continue according to the "Product Sound Wheel" model which we have developed during the last two years, see Fig. 2.
The outer path in the Product Sound Wheel describes the fundamental process of optimizing the Product Sound Quality. First, alternative sounds from a product, simulated sounds, or sounds from similar products are presented to a test panel. The panel gives its response either in answering forms prepared for statistical computations or directly, e.g. by setting sliders or pressing buttons. The same sounds are measured by analyzers, software, etc., and a number of metrics for each sound is the result. The metrics may be any relevant traditional noise measure or may be more psychoacoustically related as loudness, sharpness, fluctuation, strength, roughness, etc., or any combination of these.
By graphical or statistical methods the connections and correlations between the two kinds of measurements are sought, and usually it is possible to describe the preferred sound by objective metrics. By

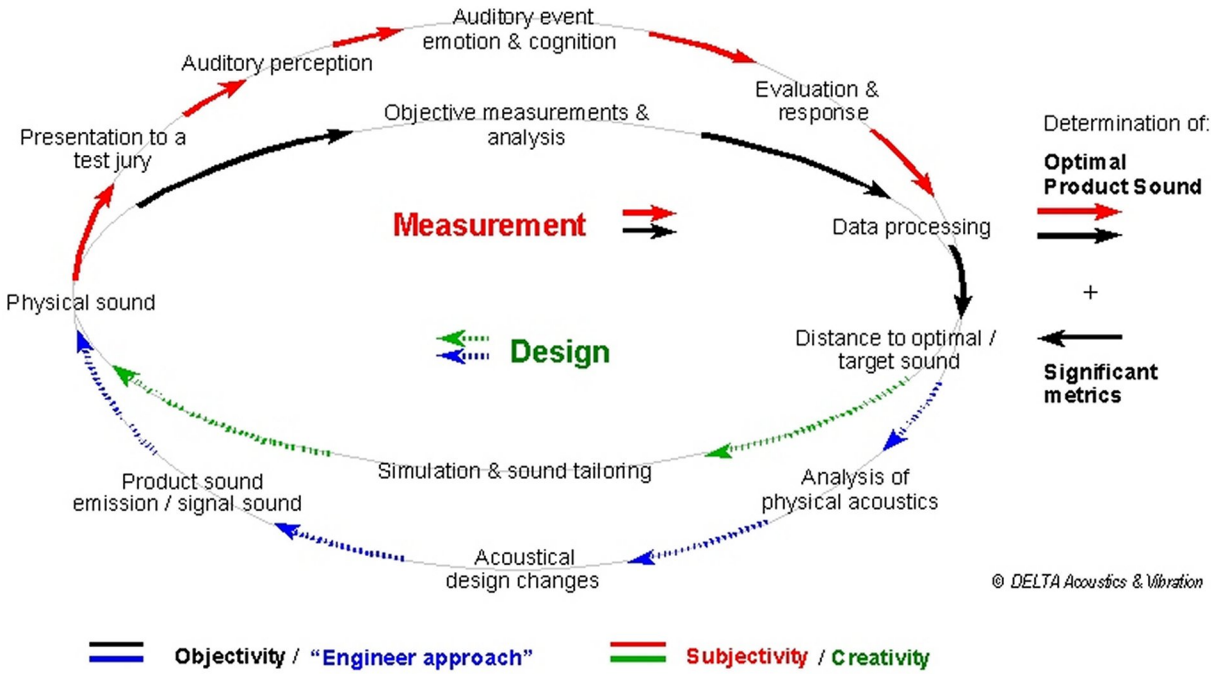

Figure 2: The Product Sound Wheel – a model for optimizing Product Sound Quality.

analysis of the physical characteristics of the sound-generating mechanisms, the necessary design changes to obtain the defined values of the metrics may be implemented. Tools for "sound tailoring or sound engineering", sound editing, and simulation exist, and the lower inner path is often an attractive shortcut to test different versions of possible sounds for further analysis or subjective tests.

5 - A PRACTICAL APPLICATION

Some of the tools have been used in a project carried out together with a manufacturer of white goods titled "The future Refrigerator". The aim of the project was to:

- investigate and build up knowledge of the importance of product sound as to the consumers' experience of product quality
- examine the possibilities of increasing the consumers' experience of the perceived product quality by means of acoustical parameters

On the long view the aim was to be able to design new generations of products with a deliberate focus on acoustical parameters and more generally to be able to act in the market on the basis of a deeper insight into the significance on the consumers of the product sound.
Phase 1 of the project was to investigate the "sound universe of refrigerator products". This course was the basis of subsequent project phases in which sound design and test should be included.
Parallel to this phase an investigation was carried out dealing with sound nuisances among owners of the manufacturer's products and among his service staff. This project will not be dealt with here.
The investigation can be characterized as an explorative investigation of the sound universe of the product category "refrigerators" as perceived by the consumers. Thus, the investigation should primarily uncover what concrete sounds the consumers notice in relation to their refrigerators in different situations and at different times and in what ways these sounds can be said to be part of the general experience of product quality. On this background the continuous endeavors regarding product sound design can be delimited and focused. The following questions have to be answered:

- What product sounds from refrigerators are ordinarily experienced or noticed in the widest sense?
- In what user situations and at what times of day are the product sounds experienced?
- What importance do the product sounds have to the user in the user situations or at different times (positive/negative opinions of the product, as e.g. signals from or communication with the product, etc.)?

- What are the significant descriptors (subjective/objective quality dimensions) separating the product sounds from each other?

As consumers should be expected to be exceptionally little conscious of the product sounds of refrigerators in their everyday life, a qualitative data collection procedure was proposed. By means of focus groups the procedure:

- registers the spontaneous and immediate impressions, experiences, and perceptions of the product sounds of refrigerators;
- makes the respondents aware of their subjective experiences and records the impact of product sounds and their significance in everyday life;
- consolidates and qualifies the spontaneous and immediate data by supplementing these with conscious impressions, experiences, and perceptions of product sounds of refrigerators.

The advantages of this procedure are thus that both the spontaneous, immediate, and unconscious impressions and experiences could be recorded.
In addition to this a number of technical investigations have been made to give a "here-and-now sound picture" of a number of selected refrigerators. Some of these results will be mentioned during the presentation.
All the results shall be part of the manufacturer's basis for decisions regarding design of "the future refrigerator", especially with a view to product sound, but of course also in correlation with other demands to form, shape, materials, and the development of components and technology or even functionality, e.g. using a part of the front door as a computer screen with internet interface.

6 - CONCLUSION

In summation, a properly designed product sound is an effective form of communication providing information about the quality, function, and condition of a product. The optimization of product sound is a multidimensional process with physical, psychoacoustic, and psychological aspects.
Product Sound design tools are being used more and more to solve sound-related design problems and to develop products that yield a higher level of customer satisfaction. At the same time, product sound is emerging as an important marketing factor, as is the case with the famous Harley Davidson motorcycle sound, e.g. The proposed model – the "Product Sound Wheel" – is a useful aid in keeping product specifications as close as possible to the desired target values throughout the iterative process of product design.
Whether a product sound is attractive is not determined by the sound alone and its relation to the function, but also by what the user is accustomed to, what the competitors' products do, and not least important, what the surroundings are willing to accept [5].
So, when discussing perceived product sound quality we must accept that it is a multidimensional discipline. For the combined stimuli more research is needed in order to describe the total response as indicated in the paper.
In a new 5-year project called "Human Sound Perception" DELTA will work intensively with research on among others how to make measurements with test persons an efficient tool in the optimization of perceived product sound.

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