SHIFTING PARADIGM: TOWARDS A COMPREHENSIVE UNDERSTANDING OF QUALITY

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Abstract

The development of competitive products is not a question of unique and expensive features but of best quality for money. Yet, defining quality from a customer's perspective and realizing it throughout the product development process is complex. The elicitation of customers' perception and correlating product attributes is recently subject to studies and research projects in industry and science. The common aim is to identify the product parameters responsible for a costumer's judgement. Still, these efforts are scattered and examining individual cases. A common understanding as well as a framework for distinct research and application is still missing. Besides its history, current research and arising challenges, the paper at hands shall emphasize the need for a change in the understanding of product quality and propose a comprehensive framework to handle quality perception especially on an industrial level. This will help to define the relevant attributes and specifications, form a common platform for parties involved in product development and, hence, guide further research.

Keywords: User centred design, Organisation of product development, Multisensory product experience, Perceived quality

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1 INTRODUCTION

The development of attractive and competitive products is not always a question of unique and expensive features but of best quality for money. This implies defining quality as the conformance of customers' needs and requirements with the product's design and performance. However, defining quality from a customer's perspective and realizing it throughout the product development process is a fuzzy and arduous task. Although customer orientation has become key element of almost every strategy, companies hardly ever know how a customer perceives and evaluates their product. To date, "soft"-factors and influencing elements such as customers' experience, word of mouth, brand or product image and the complexity of human perception are acknowledged in importance and relevance for a product's success and as such part of the quality evaluation. Yet, a comprehensive approach to address those elements in product development is missing. This can also be ascribed to the fact, that there is no widely recognized understanding and framework for Perceived Quality in literature and certainly not in industrial application.

The elicitation of customers' perception and correlating product attributes is recently subject to several studies and research projects in industry and science (Schmitt, 2014). The overall aim is to identify the product parameters responsible for a costumer's judgement. Still, these efforts are scattered and examining individual cases. Besides its history, current research and arising challenges, the paper at hands shall emphasize the need for a change in the understanding of product quality and propose a comprehensive framework to handle quality perception especially on an industrial level. This will help to (1) define the relevant attributes and specifications, (2) form a common platform for parties involved in product development and, hence, (3) guide further research.

The paper is structured as follows. In chapter 2 the history and current challenges regarding Perceived Quality will be given to emphasize the need for change. Therefore, existing deficits in literature (2.1) as well as problems from industrial use (2.2) will be elaborated. In chapter 3 a suitable framework for a comprehensive approach towards optimizing perceived product quality is given. Chapter 4 concludes the paper and gives an outlook on further research.

2 CURRENT VIEW ON PERCEIVED PRODUCT QUALITY

Exploring the history of product quality, there are several publications and models referring to its multidimensional character. The subjective evaluation by the customer is usually addressed by the Perceived Quality. Challenges arise in the theoretical discussion about definitions and approaches as well as in practical application within industrial development processes.

2.1 Scientific challenges: defining quality from the customers' perspective

Since the beginning, the definition and deployment of quality principles in modern product development were influenced by various factors, but most of all by the dilemma of finding an equilibrium between product cost and fulfilment of customer's requirements. At the end of the 20th century attempts to manage quality mainly focused on quality inspection, designing for quality or capturing voice of the customer. Eventually, differentiation in approaches to the "quality problem" segregated quality aspects into the different views, methodologies, disciplines and dimensions.

Nevertheless, it is recognized by many authors that quality has a multidimensional structure. Traditionally customers' Perceived Quality has been seen as one of those dimensions. One of the first depictions of Perceived Quality was made by Shapiro (1970), as he described purchase behaviour. At the macro level, the term "product quality" has been identified as a key variable for the competitiveness (Steenkamp, 1990). Consequently, at the micro level product quality is the major driver for the manufacturers and the consumers. The notable definition of product quality as "fitness for use" is credited to Josef Juran. According to Juran, "fitness", thereby, is defined by the customer. Another description of quality perception provided by Olson (1972) defines Perceived Quality as a two-stage process: the first stage includes customer's judgment based on available cues and forms. Subsequently, user forms their quality impression based on their interpretation of those cues and forms. The cues are delineated as intrinsic and extrinsic. Henceforth, intrinsic cues are a part of the product and cannot be changed without changing the physical characteristics of the product itself. Conversely, the extrinsic cues are those attributes, which are not a part of the physical product. According to Olson's study,

intrinsic cues occur to be more accurate indicators of quality than extrinsic. Rather representing "manufacturing" point of view, Crosby (1980), defined quality as "conformance to requirements". However, according to Crosby, requirements may not always fulfil customer's expectation, as perception and expectation differ from expression. Hence, with the many independent attempts to define quality, probably one of the most distinctive was performed by the Taguchi (1986). Taguchi defines quality as "the losses of society caused by the product after its delivery" and as "uniformity around the target value". Product development, according to Taguchi, consists of Product Quality (what customers desire) and Engineering Quality (what customers do not want). In the first case, customers desire functionality or appearance of the product and in the second customers dislike high running cost, pollution or functional variability (Taguchi et al., 2005). Describing the Eastern influence on product development, one has to mention Kano (1984), who presented a model with three levels of quality elements: "must-be", "one-dimensional" and "attractive". Kano defined customer satisfaction as the result of the company's performance according to all three of these. There is to say that nowadays, the Kano model is widely implemented in practice across various engineering domains and particularly in the automotive industry.

Garvin (1984) introduced an inclusive model of quality with the five approaches: transcendent, product-based, user-based, manufacturing-based and value-based. Additionally, Garvin pointed out that views on quality are different from the point of "marketing people" and "manufacturing people." The first type usually prefers user-based or product-based approach, because they see a customer as a referee of quality. Accordingly, "manufacturing people" see quality as "conformance to requirements." The clear existence of the conflict identified in these two views. To minimize the effect of such a conflicts to communication strategies, Garvin proposed to shift quality approach as a product moves from the early design stage to the production stage. Finally, he defined eight dimensions of quality: performance, features, reliability, conformance, durability, serviceability, aesthetics and perceived. According to Garvin, Perceived Quality is a subjective dimension, which derives from incomplete information about product attributes and cannot be adequately assessed. Later on, views on Perceived Quality as a subjective and non-assessable part of the product quality were developed further, mainly by the "marketing people". Monroe and Krishnan (1985) define Perceived Quality as "perceived ability of a product to provide satisfaction relative to the available alternatives". Steenkamp (1990) admitting inconsistency and lack of the empirical proof for the existing (by that time) definitions of Perceived Quality, proposed a framework for developing a new definition of Perceived Quality. His framework presents the following quality dimensions in the context of value: Perceived Quality involves preference; it is neither objective nor subjective; Perceived Quality exists in the product consumption.

There are several "marketing – oriented" definitions of Perceived Quality that focus mainly on the customer. Mitra and Golder (2006) interpret Perceived Quality as "perception of the customer" and oppose it to the term "objective" quality. Such a view on Perceived Quality derives from the earlier research of Zeithaml. Her interpretation defines Perceived Quality as a subjective customer's judgment regarding overall product superiority. According to this, Perceived Quality is different from objective quality (Zeithaml, 1988). The similar view expressed by Aaker (2009) defining Perceived Quality as "the customer's perception of the overall quality or superiority of a product or service with respect to its intended purpose, relative to alternatives. Likewise, Castleberry and McIntyre (2011) explain Perceived Quality as "…a belief about the degree of excellence of a goods or service that is derived by examining consciously and/or unconsciously, relevant cues that are appropriate and available, and made within the context of prior experience, relative alternatives, evaluative criteria and/or expectations". Taking a look from the distance, many of those approaches share similar vocabulary, ideas or notions (see Figure 1).

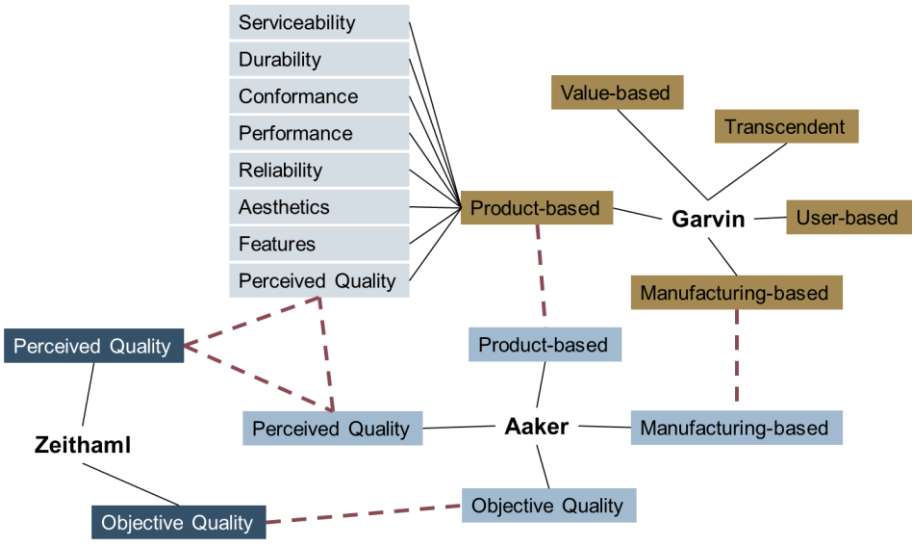

Figure 1. Schematic illustration of the connections of selected Perceived Quality theories (Stylidis et al., 2015)

Although these theories summarize different aspects of what Perceived Quality is about, most of them, however, remain fuzzy. Apart from Steenkamp (1989), they do rarely refer to the actual identification of product attributes or cues that contribute to the product judgment by the customer. What can still be noted is that…

- …Perceived Quality significantly influences the customer's opinion and, therefore, has an impact on the purchase decision and the customer satisfaction.
- …the perception of quality characteristics is a subjective process and happens consciously as well as unconsciously in order to satisfy evident and hidden customer needs.
- …due to the scrappiness of information gathered from the customers, Perceived Quality is often based on the comparison of quality characteristics according to purpose of usage and expectations. This comparison can either be direct or based on experience.
- …besides the objective and physical design of the product, the main influence factors of Perceived Quality are the individually given purpose of usage, aesthetics, environmental influences, brand name and, for instance, the company's reputation (Lieb et al., 2008).

It can also be stated that the greater amount of approaches towards quality models and Perceived Quality are either driven by the market research or represent manufacturing side of product development. They provide no ideas about elicitation and/or objective assessment methodology regarding product attributes that comprise Perceived Quality. Seeing that, the transition from case/industry thinking to the vision of product development as utilization of process patterns and incorporation of Perceived Quality concerns in product design at all stages is a major but necessary shift. Current challenges in industry confirm such thoughts.

2.2 Industrial challenges: designing perceived quality

To make a complex product - such as an automobile - successful in the competitive global market, manufacturers have to ensure highest standards of both manufacturing quality and Perceived Quality (Petiot et al., 2008). Speaking about premium and luxury segments of the automotive industry, the idea of "zero-defects" is adapted by the majority of players in these segments. The vision of the nearly perfect built-in quality stands for the manufacturing quality dimension to follow the highest standards, but still makes it just an entry ticket to the premium segment. Today, it is perfectly understood by automotive manufacturers that quality perception is at the forefront of customer's attention and has a highest influence on purchasing behaviour. However, identification and mapping attributes that represent Perceived Quality is the on-going challenge for researchers and practitioners (Ren et al., 2013; Burnap et al., 2015). This process is arduous due to the subjective nature of many attributes and absence of robust methodologies for translating the voice of the customer into technical specifications. Additionally, customers often have difficulties expressing their opinions about a product with a high level of complexity such as a premium vehicle. Given these points, designers and engineers need to strike a balance in representation of Perceived Quality attributes. But current application of tools and

usage of data throughout product development even increases mismatch or selective over-engineering rather than committing efforts towards customers' appreciation (see Figure 2).

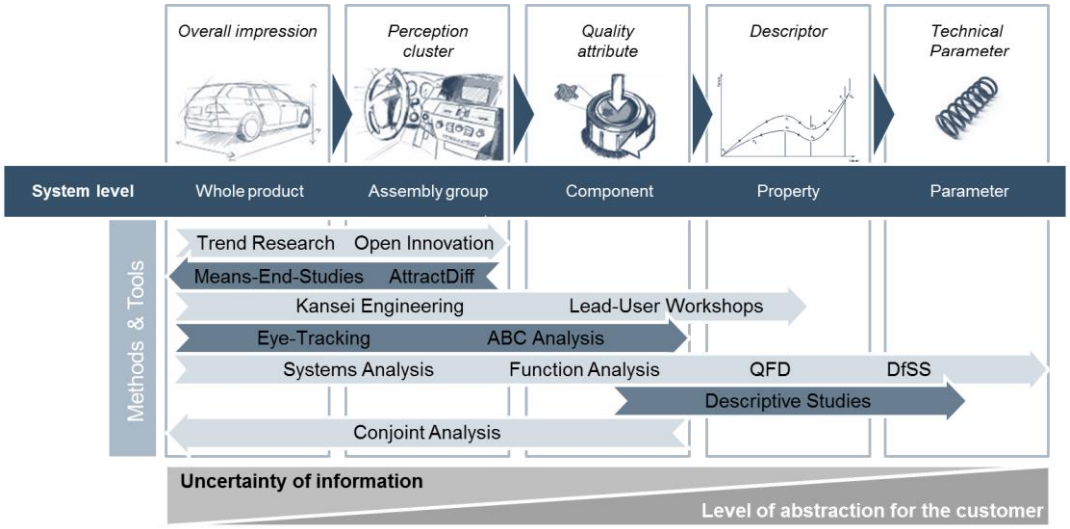

Figure 2. Application of methods and tools on different product levels

Such a fuzzy basis often creates information asymmetry (Connelly et al., 2011). With the application to the product development process, information asymmetry can cause wrong prioritization of perceptual design attributes between designer and customer as well as between the designer and the engineer. At the organizational level, information asymmetry appears due to different terminology, organizational structure, divergent knowledge or internal corporate culture used in OEM practice. Previous studies (Stylidis et al., 2016) have shown that information asymmetry is detrimental to a product's success on the market and reduction of such asymmetry should increase Perceived Quality of the vehicle. Next to those different levels of information shown in Figure 2, the elicitation and use of information is as widespread (see Figure 3) forming individual silos of information and again asymmetry.

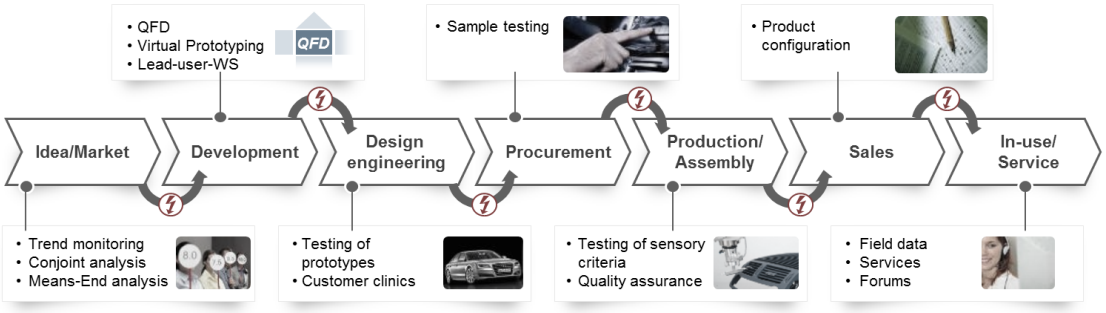

Figure 3. Application of tools at different stages of the product life cycle

In combination (detail level and allocation in process) this forms an even greater asymmetry and hinders customer orientation and efficient design of perceived and appreciated quality. An example from the automotive industry will be used to elaborate this problem.

Figure 4 shows the simulation of the left trunk segment of a station wagon from the premium segment. Next to the hydraulic, the hinge, the sealing and the taillight, several spot welds are visible alongside the trunk opening as well as on the outer body line. According to OEM standards, especially in the premium segment, all sorts of fasteners shall be hidden to keep a monolithic image and not disturb aesthetics or design. Additionally, customers shall picture the car as robust. "Small" and "scattered" spot welds on a car frame which weighs several kilos don't appear very solid to a common customer lacking the technological knowledge.

OEMs know that. And detecting such flaws of Perceived Quality is often part of special audits. But these are usually done late in the development process or for benchmarking and learning issues. Findings have to be integrated into design rules for upcoming projects.

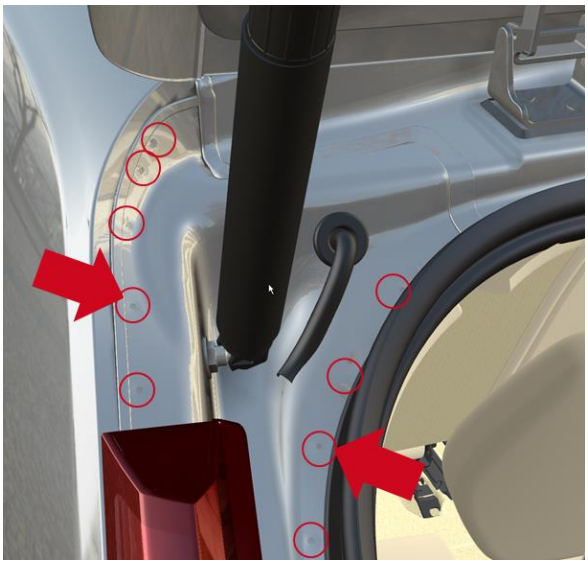

Figure 4. Visibility of laser spot welds

Still, flaws like this occur. While various types of spot welding, e.g. resistance spot welding (RSW) and laser spot welding (LSW), assessment are well established, the verification methods for the perceived quality and appearance prediction remains absent. As a result, the majority of premium and luxury automobile manufacturers simply hide attributes derived from the manufacturing process (e.g. spot welds) as non-compliable with the visual quality of the vehicle. The example from Figure 4 shows a CAD model with visible spot welds at the early design stage. The question of choice is between keeping a laser brazing as joining technique or to replace it with the spot welding. The spot welds (type RSW) are visible and create problems to the visual appearance of the vehicle. The solution would be to hide those spots just because they do not communicate “good quality”. Still, no valid basis for evaluation and decision-support exists.

The struggle is imminent. Caused by individual perspectives, goals and insufficient communication. Lacking a shared basis or framework and therefore a mutual and comprehensive customer-oriented view on the product. Hence, Perceived Quality cannot be addressed part by part, but has to be determined and evaluated cross-departmental from the beginning.

Yet, the example only illustrates optical issues in a confined product area. Taking into account all customers' senses as well as interaction and appearance of all product features, the extent of the challenge at hand becomes obvious.

3 TOWARDS A NEW UNDERSTANDING AND FRAMEWORK

Reviewing the existing literature showed the deficits in a comprehensive understanding and approach towards Perceived Quality. Yet, several contributions underlined the difference in customers' perception and companies' implementation. The subjective impression on which a customer bases his evaluation effects all 'objective' quality dimensions. Therefore, compared to e.g. Garvin's comprehensive list of quality dimensions, Perceived Quality can rather be seen as the customer's view on all other dimensions, than as an isolated term (see Figure 5).

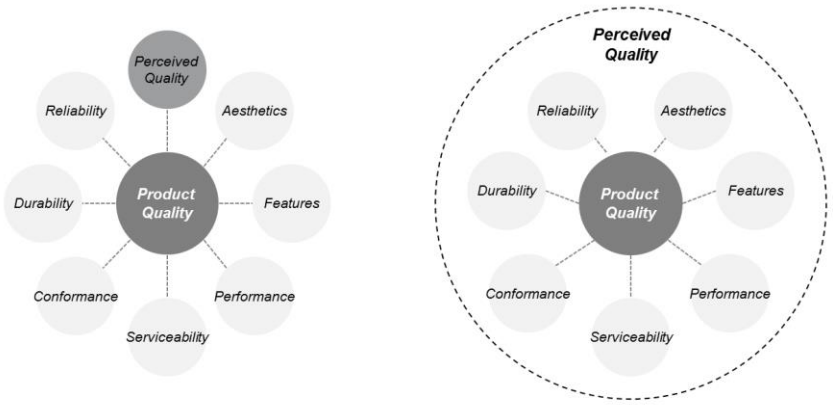

Figure 5. Perceived Quality as a holistic perspective not a dimension

From the engineering point of view, the domain of the Perceived Quality is a place where space, form, sound and material intersect with human experience. In the automotive industry during the product development process, the vehicle architecture space is usually handled and described by product attributes and their specifications; e.g. fuel consumption, active safety, noise, durability and many others. A typical automotive OEM uses around 40-120 top-level attributes depending on organization and structure. The product attributes are responsible for requirements fulfilment, vehicle behaviour and design. Product attributes are involved in both – complete vehicle requirements and also in system and component requirements. Characteristic of Perceived Quality can be defined differently depending on the OEMs strategy, DNA or target group. Even though, the scope of Perceived Quality is to secure the correct meaning, authenticity and execution of the complete vehicle. The ultimate goal is to execute all components and system solutions of the vehicle in a way that final product will be perceived by the customer as intended. For a premium OEM this might be luxury and value, for an OEM producing sports cars it might be speed and control. Perceived Quality indicates the conformity of the target group's requirements and expectations with the realized product features.

There is to mention that creation of a vehicle with high Perceived Quality is not the biggest challenge for the premium and luxury segment of the automotive industry. This can always be achieved with increased product cost. The initial challenge in balancing Perceived Quality attributes regarding existing technologies, innovations, product development time cycle, production systems and project budget, means: picking the right and relevant product attributes.

The dilemma of creating meaningful and accessible discussions about Perceived Quality is created by the absence of a common vocabulary that would provide a shared frame of reference. To form a basic structure and communication platform the Perceived Quality Framework (PQF) was found, based on work from Stylidis et al. (2015). Aim was a clear heuristic structure for robust discourse around the theme of product quality, to establish a shared basis for dialogue towards optimizing Perceived Quality. PQF highlights the interdependencies between technical characteristics of the product and customer's perceptions. The framework was built upon the results of semi-structured interviews with senior designers, managers, and engineers of two luxury automotive manufacturers and five European and North-American premium segment OEM's. All companies develop vehicles but within different characteristics. All companies are global market players. Partially, the data included information received from numerous semi-formal discussions with the professionals from leading UK and German luxury and premium vehicle manufacturers. The study explored processes regarding customer's requirements definition and understanding dimensions of Perceived Quality in each OEM. Additionally, various types of document attributes, structure descriptions, and working instructions have been studied. As a result, Perceived Quality attributes can be structured and decomposed to the "ground" level (see Figure 6). Consisting of elements like gap width, exposed fasteners, materials or force-stroke curves of operating elements. Once defined, those can be used for internal and inter-department communication to form a general and mutual understanding between departments and disciplines.

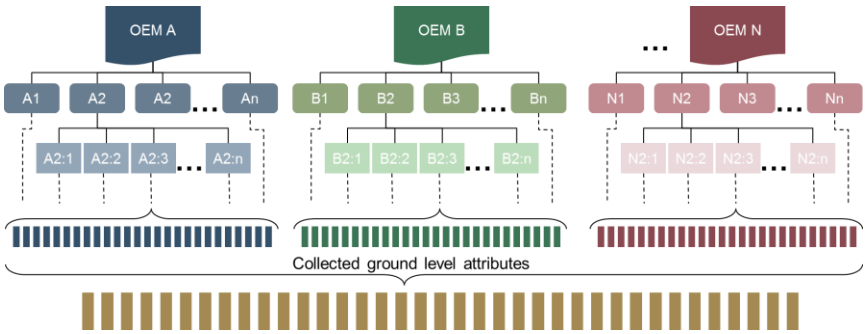

Figure 6. Perceived Quality Framework: company side

Second to the development side, the customers side has to be elaborated. This means, that connections between the product attributes and corresponding customer evaluations have to be drawn. To address this void, a category system based on four of the five human senses can be devised: visual, tactile, auditory and olfactory. All Perceived Quality relationships (attributes) can be described by a combination of these, as those are the preliminary human sensors for information. The fifth sense, taste, is of minor importance for the automotive industry for rather obvious reasons.
Relationships can for once be described single-modal (for each individual sense). Falk et al. (2009) already depicted exemplary descriptive sensory studies to elicit the perception and evaluation for the example of haptic perception. This way haptic, optic or acoustic impressions can be translated into specifications. But human perception is always multi-modal and the consideration of all senses during product development becomes indispensable (Haverkamp, 2009). Which means, that all influences between senses have to be regarded and investigated (see Figure 7).

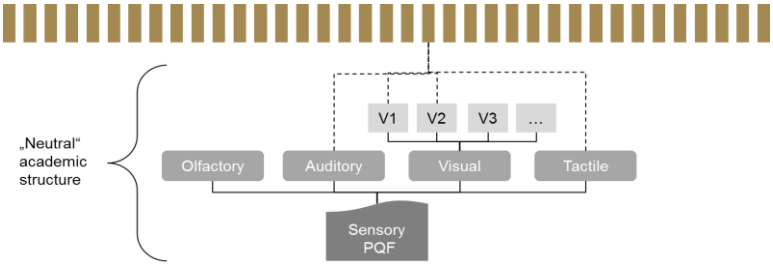

Figure 7. Perceived Quality Framework: customer side

Whereas the company side represents a product architecture, the customers side in its most elaborated form is a quantitative model of perception and evaluation of certain product attributes and characteristics; defining for example the multi-modal perception of roughness of a certain surface or the perception-relevant specifications for a force-stroke-curve of a button. Still, this model is subject to a severe numbers of studies yet to be conducted. But recent research exemplifies this approach and encourages continuation (Schmitt, 2014). Figure 8 shows the proposes integrated framework, connected by the central element of PQ attributes.

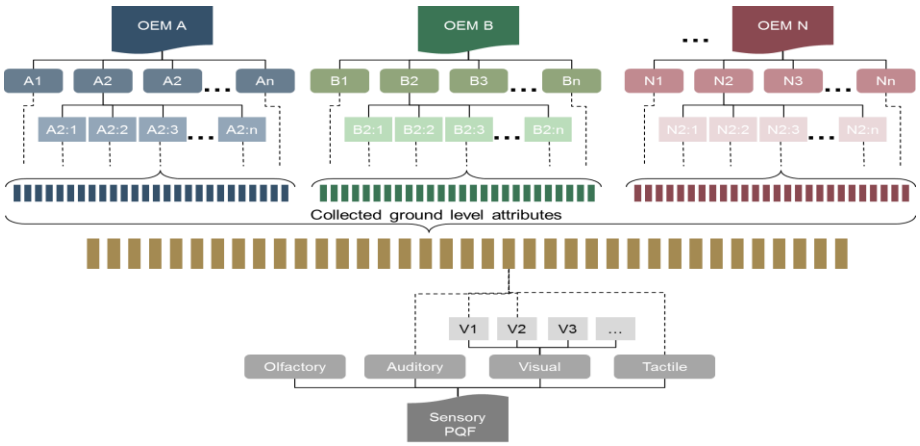

Figure 8. Integrated Perceived Quality Framework

To make it tangible, an example for interior surfaces is given in Figure 9. Surface roughness as one of the identified PQ attributes is attached to the general product architecture of a car, belonging to the interior section. As such, it is valid for all kind of components of the inner car.

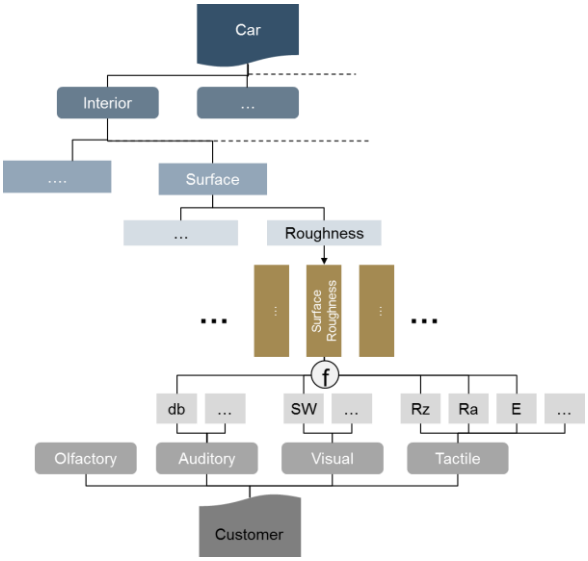

Figure 9. Example of surface roughness

On the customers side the perceived surface roughness can be modelled by a non-linear function of tactile, optic and acoustic values. That can be ascribed to the fact, that the perception of roughness is influenced by optic parameters (e.g. colour, structure) as well as acoustic elements (e.g. sound during finger movement). This way the perception can be modelled by terms like the example in equation (1).

$$Perceived\ surface\ roughness\ [interior] =$$

$$f(auditory, visual, tactile) = x_1 db + x_2 SW + x_2 R_z + x_3 R_a + x_4 \mathrm{E} \ldots + x_n N_n + \varepsilon_n \quad (1)$$

With db, SW, R_z, R_a, E and N_n being exemplary technical measurement values for auditory, visual and tactile properties and x_{1-n} being parameters determined by empirical studies. Of course, most of them are not linear equations, like in this fictive example, and will always carry an error term (ε_n) due to expected empirical fuzziness. But this way a quantitative connection between product architecture, product attributes and customers' perception and evaluation can be established.

4 CONCLUSION AND DISCUSSION

The presented understanding and framework for Perceived Quality aims at integrating customers' and companies' view on quality and therefore a faster and more resource-efficient way of realizing good quality from the customers' point of view. The vital prerequisite of this approach is, first, to understand Perceived Quality not as one dimension of product quality but as the only one perspective of a customer on a product with all its feature and surrounding elements. This includes not only physical properties but also services, brand image, usage and for example aging. Second, Perceived Quality can only be realized successfully, if it is seen holistically rather than individually for each component and department. Third, with a common vocabulary information asymmetry between customer and company as well as between different departments can be decreased. This would enable a systematic and successful product development. The presented approach shall serve as a basis and structure for upcoming research as further studies, especially regarding the customers' sensory perception, have to be conducted.

Yet, the presented approach stays as a proposal since only single elements have been verified in prior interviews or studies. On the one hand it is up to further research, whether the determined list of Perceived Quality attributes holds for all the automotive OEMs not to speak of other industries. On the other hand, modelling the perception and evaluation of product attributes requires extensive studies and the goodness of fit and universal applicability for individual parameters stays questionable, but the most reasonable attempt to investigate customers' quality perception.

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