

EVALUATION OF PERCEIVED PRODUCT QUALITY FOR THE INTEGRATION IN AUTOMOTIVE INDUSTRY SUPPLY CHAIN

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ABSTRACT

Automotive Companies have to gather a holistic set of information regarding their products from their customers. In order to be holistic, the set of information needs to contain performance and feature oriented requirements as well as subjective criteria like sensory quality perception.

The purpose of the presented study is to define consumers' affection on perception clusters and components in terms of its importance into the whole perception and its design factors such as shapes, arrangement, layout or color.

The paper presents the Identification study for perception clusters of a compact car interior with 139 probands. The assessment focus was on haptical and optical perception. Furthermore, the study obtained information from users and the retailers' by focus groups and generated a survey questionnaire evaluating perception of quality in interior components of a car. The sample consisted of 320 car users who responded to a questionnaire that assessed the effects of perceived product quality and overall satisfaction on car users purchase intentions. Moreover, the most important components for each perception cluster were defined and the most important attributes were evaluated.

Based on results, this work will help to develop a new methodology which allows to gather and to describe customer requirements holistically and to relay them for a customer orientated product realization within the Supply Chain of the automotive industry.

Keywords: perceived product quality; supply chain; customer requirements, perceptual identification; in-car components.

1. INTRODUCTION

The preferences of consumers when they buy a car are changing, absolute quality no longer acts as a positive differentiator, it becomes mandatory. Nowadays, consumers' choice is based on many decision criteria, and perceived quality is becoming increasingly prevalent for product success, especially for the highly competitive markets of automotive industry (1, 2). Perceived quality is the result of the cognitive and emotional comparison of a customer's conscious and unconscious experiences, and thus expectations towards a product, and the actually realized product attributes in a specific use situation (3). In this situation, companies' objective has to be the offer of high-quality products that are also perceived as high-quality by the customer.

The problem becomes more complex as cars are products consisting of many parts and perceived quality is in the hands of many suppliers. The expressed customer requirements and the realized technical criteria of each assembly have to be matched continuously.

Furthermore, the poor predictability of customer's requirements causes distortions in the information flow, which can lead to disturbances up and down the supply chain.

However, the different considerations of client perception lack a systematic process that takes into account and integrates all the participants in the supply chain (4). The major automotive manufacturers meet the demands of a single client and transfer them to technical documents, which are then transmitted to the supply chain. The problem arises if the suppliers are not aware of the original context of the client's demands, since in this case quality perception is misinterpreted.

For safeguarding the production of attractive quality of products the perceived quality information have to be integrated into the product development process. Therefore the customer information has to be objectified into a product specification. This is possible by dividing the customers' perception into five stages: *Overall impression, perception cluster, quality attribute, descriptor* and *technical parameter*.

This paper reports two experiences of identifying customers' perception of quality on car interiors in order to achieve a better understanding of the automobile market and all the supply chain.

In the first study, the identification of *perception cluster* is presented. Participants evaluated the interior of a real car for detecting relevant clusters and components in the perceived quality of the whole interior.

The second experiment presents the *overall impression* and *quality attribute* stages. In this part a questionnaire based on literature review and on focus groups was developed. With this tool, we carried out a set of interviews with SME's, automobile dealers and customers, considering the influence of: a) particular components in the overall perception of the interior; b) component features. Finally, the main factors of user's impressions and the relationship between factors and users groups are analyzed using statistical techniques.

2. METHODS

2.1. Definition of perception clusters in a real car

In the following section, the context of perception clusters in an overall perception structure will be described (5). The first interaction of a customer with a product is reflected in the overall impression. The overall impression does not focus on product details or components, because they have only little influence for the customers' impression. The overall impression represents the basis for detailed multi-sensorial analysis on product perception. Taking factors like brand image, price or product harmony into account, no conclusions about the real causes of a customer judgment can be made by the overall impression (6).

For further description of the overall impression, perception clusters have to be defined. They represent product components that are perceived together as one unit. On the one hand on the level of superposition of senses (e.g. congruence in acoustics and haptics) and on the other hand through human sensory perception with one sense (e.g. tune of acoustic). For products with many product parts and components like airplanes or cars the definition of perception clusters is inalienable to divide products into manageable areas of interest. Mismatches within the cluster perception by the customers have negative influence on their judgment and the overall impression.

Quality attributes determine the perceived quality of a perception cluster. They are represented by multi-sensorial product characteristics. The definition of a quality attribute requires a scalability of its characteristic. If there is no scale for an attribute, it still can be

divided into sub-attributes (e.g. surface => surface slippery). The stage between perception clusters to quality attributes manages the first detailing of a product regarding perception. Companies can avoid over-engineering and are able to focus on customer relevant product attributes.

For gathering conscious and unconscious information five different methods can be used: free interviews, observation during interaction, the “think-aloud”-method, workshops in small-sized groups or empirical studies.

The chosen method for the identification of perception clusters was a free single interview. The decision was made against a standardized and automatically analyzable questionnaire because of the influencing character of this answering type. The probands should give their own opinion in their own expression and should not be affected by pre-formulated phrases. A combined observation by an interviewer as well as with different cameras allowed the retrospective examination of points of interest in the interview (see Fig. 1). This approach delivers a holistic set of customer expression.



Fig. 1. Perception Cluster Interviews

The foundation of this approach was the “think-aloud”-method which can be applied in different settings. The range of settings can be varied from presenting products by pictures, videos, sounds to the interaction with the real product. Customers articulate their associations and opinions absolutely free and unfiltered. This method delivers besides the gathering of information about enthusing or frustrating product attributes general knowledge about the product. For example the handling and usability can be surveyed. The gathered expressions represent the thought-process sequentially and thereby facilitate the disclosure of causality within the customer’s assessment procedure by the product developers (7).

As an observation object a compact car of Ford was used. The 2010 Ford Fiesta Titanium as four door version was presented to the customers. The car interior is quite complex, so the observation object was reduced to the front cabin (starting at the B-pillar), including driver and front passenger. The focus was on the identification of haptical and optical perception clusters.

The study was applied in a standardized, reproducible setting and lasted 10 days, with approximately 14 time-slots per day. In circa 20 minutes lasting interviews 139 mainly German probands, aged between 18 and 60 years, were interviewed. The sample size allowed differentiated analysis in nine evaluation groups. (Table 1).

Name of Group	Participants
Gender Male	118
Gender Female	21
Age "Young" (< 29 years)	107
Age "Experienced" (> 28 years)	32
Car Type "Compact Car"	48
Car Type "Other"	91
Frequency of driving "seldom"	91
Frequency of driving "often"	48
Total participants	139

Table 1. Evaluation Groups of Participants

The probands were placed on the driver seat, whereas the interviewer sat in the back row behind the front passenger. The probands were not able to start or drive the car, but the electricity system was working. The interaction of the probands with the car was documented by the interviewer as well as out of three camera positions and with audio. (see Fig. 1)

2.2. Customer research about the perception of quality in the interior of automobile

Main Components and Features affecting the overall Perception Quality

The objective of this part of the study was to ascertain the aspects related to perceived quality from the standpoint of the internal and external client (dealership professionals who pick up on end-user opinions and the actual end users). This part of the study included focus groups and interviews with SMEs, automobile dealers and with users of medium and high end cars (Fig. 2 shows one of the focus groups discussions).



Fig. 2. Focus groups Interviews with dealership professionals

A focus group is a qualitative data collection method effective in helping researchers detect the needs and preferences of a community or subgroup. Focus groups were chosen as the means of data collection because existing knowledge on the topic was insufficient for the development of a survey instrument and because they offered the potential for beneficial interactions among participants in the group (8).

The information collected was used to design a questionnaire that focused on the most important ensembles of the car, according to the opinion given by the discussion groups, and based on the results of the previous work done on the *definition of perception cluster*.

Formulation of the questionnaire and data collection

Many researchers have studied specific aspects of different product features, including styles and colours (9, 10), but there is few information concerning an overall concept model of perceived quality in automobile interiors based on users (11).

In this work, a questionnaire was designed for a quantitative study to obtain information on the characteristics (safety, ergonomics, design, etc.) which impact the most in perceived quality. This questionnaire was used to validate the information obtained in the discussion groups with users and experts. Moreover, the characteristics of the parts were defined in greater detail, in each case offering different design options for the user to choose the one that represented a greater perception of quality.

To prepare the definitive questionnaire, an initial draft was designed. This first draft was validated with the participation of 65 users (car owners). The initial results were used to determine the sample size necessary to obtain significant results in the final survey.

In the final survey, 320 Spanish men and women participated; the requirement demanded was that participants had driving license and their own car. The sample of participants was designed taking into account gender and age factors.

The results of survey provided knowledge on the attributes that represented higher quality in the parts of the different groups into which the interior of the car was divided. An order of priorities associated with perceived quality was established between the attributes of each part, (for example, sense of touch and layout of controls are the most important attributes in the steering wheel). Furthermore, the study obtained design criteria that helped to provide greater perceived quality in the parts of the automobile interior (for instance, rather soft touch in the steering wheel). These criteria took into account different user profiles (young/older people, male/female, model of the car they drive).

3. RESULTS

3.1. Definition of perception clusters in a real car

The applied qualitative method was a semi-structured interview, divided into four areas of questions: a) Free interaction; b) Clustering components; c) Interference analysis; d) Target perception clusters.

In the beginning, the probands had time for a period of free interaction with the car. The objective was to train them to articulate their first expressions and opinions, by applying the “think-aloud” method. Secondly in the interview, the probands clustered interior components, by choosing which belong together concerning haptics and optics in their opinion. They got habituated to probable clusters and got clue what binned components they prefer. Further questions to the reasons why they cluster these components, it was possible to get information what establishes a cluster from customers’ point of view. Afterwards, the interview observed interferences perceived by the probands. Reasons for interference were for instance different topography between parts, different colours or clearances/gaps. Combined with the customer judgment to an expressed interference it was possible to make a conclusion concerning which components should belong together to a cluster. Throughout the last interview part, the probands were asked to name their target perception cluster for a harmonious interior. This interview part gave them the possibility to reflect the before expressed results and to give based on this reflection a final set of preferred clusters.

In the analysis phase the customers’ expressions were semantically clustered. Therefore all documentation were analyzed and the words of the customers binned together. It had to be

checked if different expressions were used for the same components. A set of words for one component was established and the expressions of the customers could be linked to this set. For these linked expression a frequency analysis of each cluster could be applied. Thereby seven main perception clusters, by a defined threshold of 15 %, for the compact car were generated (Fig. 3): 1) instrument cluster panel, 2) dashboard, 3) steering wheel incl. stalk switches, 4) gear box connected to hand brake, 5) doors, 6) headliner and 7) foot well.

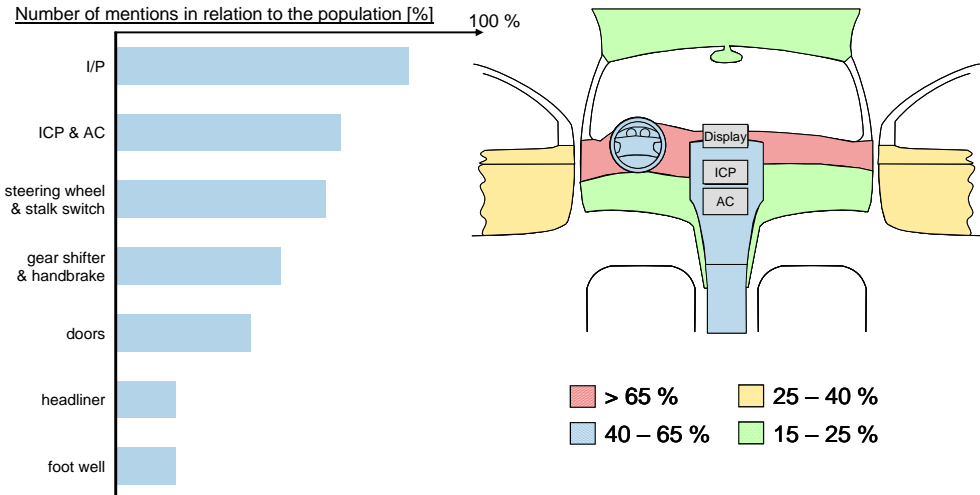


Fig. 3: Main perception clusters

Additionally, for each cluster interface components were evaluated, which should fit harmonically to the cluster regarding optical and haptical perception out of the customers’ point of view. Therefore the set of words for each cluster was used. All words which were expressed in connection to this set of words were analyzed. For example, should the dashboard and the top roll of the doors fit harmonic. On the one hand the colour and surface of both parts and on the other hand the designed line should be integrated from top roll to dashboard. That means no gap between door trim and dashboard should be visible.

Finally the nine evaluation groups were compared. They showed a homogenous estimation of the analyzed seven perception clusters (Fig. 4). For group differences with more than 10 % further analysis were applied regarding possible differences in the interface components. No significant differences could be found.

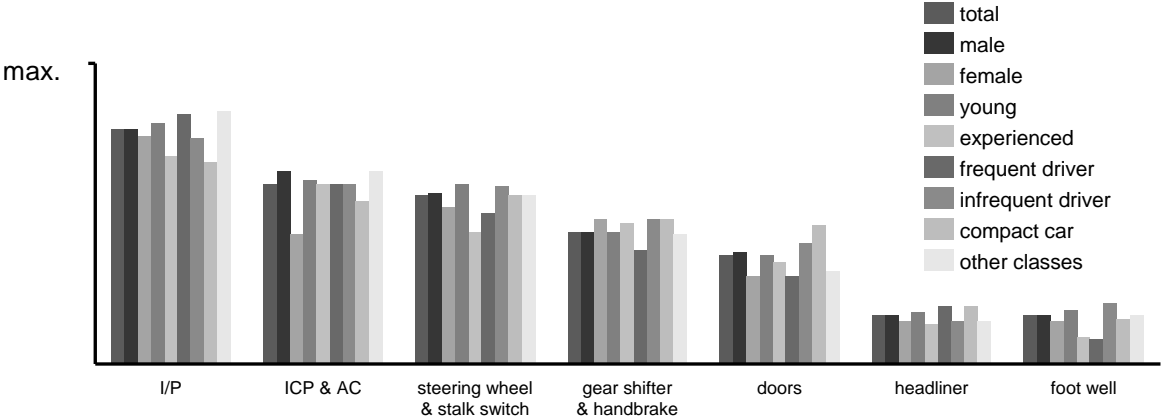


Fig. 4: Perception Clusters within Evaluation Groups

3.2. Customer research about the perception of quality in the interior of automobile

Focus Group

During the focus group phase the attributes of the perception quality were synthesized in order to reduce the number of variables for the survey.

In this section the most important ideas obtained in the study of the demands of the users were collected summarizing the most outstanding contributions and establishing relationships between the obtained information.

According to the focus groups interviews and literature, the most important elements in the overall quality perception and to which there are to pay special attention are: steering wheel, instrument panel, center stack and seats. Besides, this study obtained the most representative characteristics that users generally evaluate during the purchasing moment: the material type (if there is aluminium or plastic), possible noises, aesthetic, colours, controls, ergonomics or chromium plating quality.

Questionnaire for selection of product design attributes

The results from the survey analysis were focused on three aspects: quality concept for users, differences in perception quality based on different groups of users, and analysis of the most important parts and design elements.

Quality concept

For overall quality perception of automobile, 8 dimensions of user impressions were selected in order to make the users to choose which ones were associated with quality. The results were analyzed using ANOVA and Tukey's HSD test for post-hoc comparisons with significance levels of differences set at $p < 0.05$. Three groups with different importance levels (1 most important for quality and 3 least important) were obtained: 1) safety; 2) customer needs and expectations, comfort/ergonomics, high price/quality relationship, and durability; 3) aesthetic/design, material type and controls usability.

For quality perception in automobile interiors, 7 dimensions of user impressions were selected, and were analyzed in the same way obtaining four different groups (1 most important for quality and 4 least important): 1) comfort/ergonomics; 2) controls usability; 3) high price/quality relationship, compact/uniform, aesthetic/design, material type; 4) exclusiveness. Fig. 5 represents values of each dimension (the maximum value is 1) with a 95% Confidence Interval.

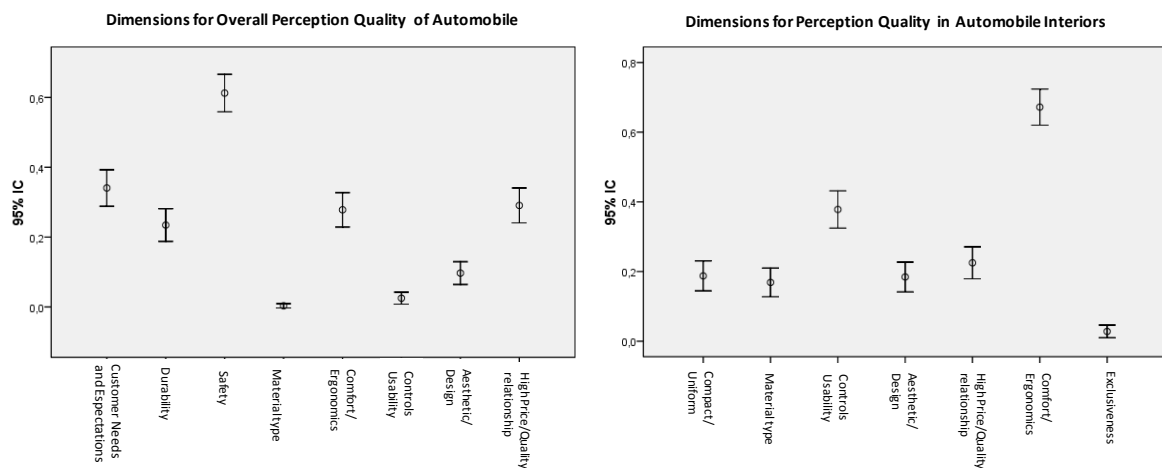


Fig. 5. Percentage of the Different dimensions with a 95% Confidence Interval.

Group Differences

Differences between groups of gender and age range (18-35 and older than 35) were analyzed. The existence of differences in the compared scores of each sub-group (for instance men and women) for each type of quality attribute (safety, aesthetics,...) were studied with chi-square tests with significance levels of differences set at $p < 0.05$.

Perception Quality for Overall Automobile			Perception Quality for Automobile Interior		
Attribute	Gender	Age	Attribute	Gender	Age
Customer needs and Espectations	✗	✗	Exclusiveness	✗	✗
Durability	✗	✓	Comfort/ Ergonomics	✗	✗
Safety	✓	✗	High Price/Quality Relationship	✗	✗
Material type	✗	✗	Aesthetics/ Design	✗	✗
Comfort/Ergonomics	✗	✗	Controls Usability	✗	✓
Control Usability	✗	✗	Material type	✗	✗
Aesthetics/Design	✗	✗	Compact/Uniformity	✓	✗
High Price/Quality relationship	✓	✗			

✓ = Significant relationship ($p < 0.05$).
✗ = Not significant.

Table 2. Summary table of results of the chi-square testing of gender and age for attributes of perception quality

The results as can be seen in Table 2 indicated, for overall perception of quality, significant differences between gender for attributes Safety (more important for women) and High pricing/quality relationship (more important for men). Differences between age ranges were found in Durability attribute (more important for younger users).

The differences found for attributes of quality perception for automobile interior were Compact/Uniformity (more important for women) and Controls Usability (more important for older users).

Analysis of the most important parts and design elements.

Through focus groups interviews of designers, salespersons, and customers the most important components of front cabin (not included seat and door panel) were: *steering wheel, dashboard and IP, center stack, gear shift and hand brake*.



Fig. 6. Steering wheel design elements

First, it was studied the importance of the different design variables for each element, and later the design criteria for each of the design variable. As an example of the results, the Fig. 6 shows the result for the steering wheel. The design criteria of the variables selected by the users are presented, besides the most important design variables are in red (feel/sense of touch and layout controls). This kind of analysis was carried out also for the rest of main components dashboard and IP, center stack, gear shift and hand brake.

4. CONCLUSIONS

The presented paper shows an industrial application to identify product relevant information of quality perception. However, the application still holds room for adaption. Applying all five stages of quality perception (*Overall impression, perception cluster, quality attribute, descriptor* and *technical parameter*) and in different branches of consumer products will advance its impact and prove its universality. Further studies for the application of the stage of quality attributes show that descriptive methods adapted from the sensory analysis deliver very detailed and nearly objective information from the source “customer”. This shows the possibility to objectify customer perception for industrial use.

The presented application and the strong integration of the customer (qualifying them to experts), with a minimal focus on product judgment and more on identification, reduces the influence of social, functional and aesthetical aspects, such as brand image and design. Nevertheless, a consideration of these factors has to take place within the discussion on perceived product value (12).

Besides, this paper presents a methodology to pick up on the user’s perception of quality, obtaining knowledge about which are the components and design variables where quality must be performed to implement it in the communication of the supply chain of the automotive industry.

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