The Design evaluation in the process of product design and planning  

based on Kansei Engineering

Kai-Shuan Shen  
Department of Fashion Design  
TOKO University  
2F., No. 77, Sec.2, Yanping N. Rd., Datong Dist., Taipei City 10346, Taiwan (R.O.C)  
creativekevin2001@hotmail.com http://dfd.toko.edu.tw/index.php/introduction-teacher

Abstract: - The objective is to develop a system based on Kansei Engineering to allow preference-based design to be applied to practical product planning and design towards general system goals. Then, in order to execute expert evaluation in this study, we interviewed eleven experts by the EGM to determine the semantic structure of attractiveness from the interviews of experts showing the hierarchy of the relationship between the types of appeal or appeal factors, the reasons for users’ preferences, and specific characteristics of CROSSOVER B-CAR interior. In addition, we also performed user evaluation by surveying 931 users through a questionnaire and analysed it by statistics. The Kansei Engineering-based system which integrates product design and planning is developed for assisting product developers and designers to finish practical assignment of crossover B-car interior.

Key-Words: - design process, design evaluation, product management, product design, psychology of design

1 Introduction

Product design today cannot be viewed as a stand-alone process [1]. Furthermore, besides product design itself, product planning activities, such as “product idea refined” and “market requirements refined” are often considered and should be integrated into the process of product design. Hence, an integrated system is urgent for designers to develop a product that satisfies performance, customer requirements, and evaluative criteria.

General processes of product planning lack a conscientious and careful evaluation from user and expert, which made a great impact on product development. In addition, general processes of product design fall short of overall product plan of strategy and consideration from market niches. Hence, a system which can integrate the processes of product design and planning is needful for product designers and developers. Furthermore, during the design process, full knowledge and information have to be available for supporting designer to make decision. Hence, a system used as a solution to represent domain-specific knowledge is also necessary. The proposed system in this study attempted to provide a strategic way to solve the problems by finding out the features and appeal of the target product from expert and user evaluations.

On the one hand, experts’ preferences can be viewed as leaders’ opinions. On the other hand, consumers’ preferences can be considered as the reflection of the market. Hence, consumers’ preferences and inclinations should be considered as early as possible during design and planning. In this study, preferences were investigated according to the “appeal” of crossover B-car interior in this study. More specifically, “appeal” can range from an abstract idea, such as “exquisite and quality”, to specific element, such as “quality fabrication and material”. We attempted to form criteria to evaluate the “appeal” of CROSSOVER B-CAR interior. In dealing with the issue of integrating product design and planning, evaluation plays an important role. The design evaluation process can help to control the design quality [1].

Kansei Engineering is applied to integrate the process of product design and planning. Furthermore, the key assignments of Kansei Engineering are to find out the attractive criteria
and parts. We hypothesize that CROSSOVER B-CAR interior possess special appeal that other types of car interiors do not have. Hence, this research studies the origins of the various appeal factors. In addition, we attempts to find out the attractive parts in CROSSOVER B-CAR interior because we argue that the popularity of CROSSOVER B-CAR interior lies in certain appeal elements in it. After gaining the criteria, relative user and expert evaluation can be performed to activate the Kansei Engineering-based system for product design and planning.

In dealing with the issue of integrating product planning and design, Kansei Engineering-based design evaluation plays an important role. This paper presents a preference-based evaluation and expert-leading system developed to assist product designers in evaluating possible design solutions and design decision during the process of product design and planning. In addition, this study is materialized through qualitative methods of observation, data collection, and the EGM and quantitative method of basic statistic analysis and QTTI, which are applied during the stage of “input” and “product idea refined”.

2 Design Target & Design Case
Among all the divisions of car types, the B-Car division, as one of the major competitive field for Taiwan automobile industry, should catch up with the Crossover tide even more. The new data shows that the sales volume of crossover new cars achieves 2.2 million automobiles in 2005. In addition, over 50 types of crossover cars, which were most reformed from SUV, were newly presented in the public in 2006.

The development of the automobile industry pursuing low energy consumption, multi-purposes, large interior and comfortable space is to do something after a social-economic phenomenon of high oil prices, limited living spaces and the arising of leisure concepts. Hence, a Crossover vehicle is no longer just a form of body pieced together but a new generation of a car type to satisfy coming consumers’ purchasing psychology.

A crossover car has distinctive style different from a sedan, MPV and SUV but integrates their advantages to create a new division in consumptive market. The crossover trend has gradually spread to the automobile market and industry in Taiwan. Modern people’ lives are rich in variety so they have to join various kinds of activities. Hence, a Crossover Style, design for the type of life, can adjust the interior space to manage differ needs and let small car have similar interior space of large car. Hence, we can see that either the features of appearance or functions of Crossover Car can fit the new generations’ consumptive psychology.

The design idea of Honda MM originates from the concept of maximizing the interior room and minimizing mechanical space. Therefore, Honda Fit, as the type of small car, can perform large interior space. Then, the interior design of Honda Fit considers the needs of all members in the car, including a driver and passengers.

2 Review of Literature
2.1 Product design and planning process
Product design process includes four steps: idea development, product screening, preliminary design & testing, and final design [12]. In this study, we explore the first two steps. Idea development means product idea developed which could originate from customers, competitors, or suppliers. In addition, product screening means product idea evaluated which needs to consider operations, marketing, and financial requirements [12]. In this study, besides product design process, we also explore product planning process because the integration of the two processes was expected to be performed in this study. The system in this study is divided into five stages according to the foundation established by Geschka [3]. He proposed that idea generation in product planning and development includes search for interesting market niches, broad idea generation for new product, concept development, technical development and improvement of concept (Geschka, 1983). In addition, the framework of the system is originated from “product planning cycle” validated by [16].

2.2 Semantic evaluation
In this study, semantic evaluation plays a critical role in the process of product planning and design. It is important to design and engineer cars to make users feel satisfied so human sensibilities should be focused in order to create an attractive and preferable car interior. This study uses the semantic method to evaluate the impressions users perceive from a car interior. As a result, the evaluation structure of interior preferences and the relationship between subjective impressions and design elements can be clearly revealed. Semantic description is widely used for evaluating the impressions of an architectural environment. Shimizu et al [14] proposed the foundations for establishing a simulation procedure for evaluating car interior impressions. In addition, the SMB (semantic environment description)-method is a structured method for measuring the impressions of a vehicle interior because the method is easy to administrate, has high reliability and validity, and provides useful knowledge for design, engineering and marketing[7].

2.3 Kansei Engineering
Kansei Engineering is a design method based on semantic evaluation. The term “Kansei Engineering” comes from director of Japan Mazda Car Company in 1986, whose address it in a conference of world automobile technology, managers’ conference of U.S.A automobile industrial and class speech in Michigan University. He stressed on that car have to contribute to creation of culture for extending the theory of car culture. Japanese scholar Nagamachi brought out a new consumer-oriented technology of product development-Kansei Engineering. He defined Kansei Engineering as the technology of transforming consumers’ feeling, demands, and impressions to product into the elements of design and production function [10]. More specifically, Kansei engineering is used to grasp vague demands of the consumer, and develop the car based on the user’s word. This was based upon the analysis data showing a relationship between human impressions and interior design [6].

There are four main aspects which Kansei Engineering explores: (1) how to grasp the consumer’s feeling (Kansei) about the product in terms of ergonomic and psychological estimation, (2) how to identify the design characteristics of the product from the consumer's Kansei, (3) how to build Kansei Engineering as an ergonomic technology, and (4) how to adjust product design to the current societal change or people's preferences trend [9].

“Kansei” is similar to a semiotic system, which is designed to determine human’s affection and preferences. Hence, from the aspect of Kansei Engineering which can leads a user-centered design study, what kind of feeling a product can brings to users is a very important issue to designers. For example, Nagamachi [11] used the method of Kansei Engineering to find a hierarchy of the values in a customer’s life. In addition, subjective evaluations were carried out by semantic differential methods, and then analysed by using multivariate analyses [6].

Kansei Engineering is utilized in the automotive, electrical appliance, construction, clothing and other industries [9]. For example, Nissan, Mazda and Mitsubishi were eager to implement Kansei Engineering and they began to produce many kinds of newly designed passenger cars [9]. In addition, Kansei Engineering can also be used for studying car interior style and design detail such as how the design of a meter or a steering wheel can affect humans’ feeling while using them. [6] attempted to explore styling or design specification of car interiors by Kansei engineering, especially regarding the speedometer and steering wheel of a passenger car.

3 Research Objectives
The authors attempted to build a preference-based evaluation and expert-leading system developed to integrate the process of product design and planning through Kansei Engineering. In addition, this study also probes into users’ need inside a vehicle and propose draft resolution to interior design, space utilization and function variation for Crossover B-car developers’ reference. Furthermore, the
critical appeal factors, their specific characteristics, and their reasons for user preferences should be identified and the relationships among them to be established in this study. In addition, the different weights among these “reasons” and “characteristics” to the “appeal styles” should also be quantified through statistical analysis.

4 Research Procedures &Method

This study based on Kansei Engineering can proceed with the process of auto interior style and design. Subjective evaluations, depending on different ways of semantics, then, were analysed through Multivariate Statistical Analysis. Then, the relation between impressions and specific characteristics can be found out for activating this study.

We apply both qualitative and quantitative research method to the system of product design and planning. To make a qualitative assessment, we collected data from authoritative articles, analysed CROSSOVER B-CAR interior by ourselves, and interviewed experienced car users. In addition, we applying the EGM (The Evaluation Grid Method) to determine the structure of appeal through arranging the letters obtained from interviewing experts. The results of the EGM can be also used to design a questionnaire. Then, to make a quantitative assessment, Quantification Theory Type I analysis is applied to analyse the importance of appeal. We also discuss the relationship between appeal factors and attractive parts. The results were used to determine design specification for designers and developers.

This study can be divided into 5 stages according to general process of product planning. The following research methods are explained in sequence by the 5 stages, including the stage of “input”, “product idea refined”, and “product approved”, “Market requirement refined”, and “development initiated”. This study reveals the first two stages due to limited space (Fig. 1).

4.1 Input

In the “Input” stage, collecting ideas through various ways could be most important. Then, 3 critical study assignments have to be finished by the corresponding research methods, including “Data collection”, “Observation”, and “Market analysis”.

4.1.1 Data collection

Data collection” proceeds to gather initial data mainly for collecting important information and ideas related to interior design and functional variation for Crossover B-Car in Taiwan. Then, we gathered adjectives relative to interior space and function design of Crossover B-Car through specialized media such as automobile magazines or web sites for the interview. Then, after gathering the adjectives, they were generalized and arranged for the EGM in the next stage. In addition, auto-related descriptive phrases and professional terms were also collected to assist in preparing for the expert interview in the future. Then, the collection of design case was helpful to make designers instantly understand the design target and can be referred during the process of product developing.

4.1.2 Market analysis

In order to conducting market analysis, we collected relative quantitative data from all Crossover B-Car in the market in Taiwan and focus on the information about interior space and function design. In particular, the measurement of wheelbase, interior width and height were also collected for further analysis and product development.

4.1.3 Observation

Then, observation in person was performed to experience car interior design rather than just read it from publications. Hence, investigation on the spot was executed through personally experiencing interior and recording the information of interior design and functions of Crossover B-Car from different manufacturers.

4.2 Product Idea Refined

In the stage of “product idea refined”, the method of Kansei Engineering is used to refine the product idea collected from the previous stage.

4.2.1 Expert evaluation

Kelly [8] developed the repertory grid method to grasp the mechanism of people’s
understanding and recognition of their surrounding, especially in human relationship. This method is conducted through an interview and asks what the similarities and differences are between two objects form participants’ responses.

The EGM was applied during the stage of searching for the attractive parts of a product through experts’ inclination to help determine the design criteria, and a quantitative aspect evaluation applied to provide information on consumers’ preferences to design details. EGM makes it possible to codify the mechanism of their reasoning into a hierarchic structure. This method is called the “Evaluation Grid Method (EGM)”. The EGM is a deep interview method in which paired comparisons and interpretive structural modelling are used for structural identification.

The goal of the EGM is to extract consumer language in order to understand the evaluation items and the structure of the network of factors. This is also a method used to comprehend how consumers evaluate product value through in-depth interviews with individual experts. Through the process of investigation, what consumers perceive and where their value exists are analysed. Using the structure of the semantic visualized hierarchy, from the abstract to the concrete, we can visualize and solidify the structure of consumer values through the original evaluation composed of upper-level and lower-level items. [13] improved the repertory grid method into the EGM in two processes. First, the objects to be compared are assessed, and participants are asked to answer what is good or bad as well as their likes and dislikes about them. Second, the meaning or conditions of their answers were clarified through additional questions.

Successful results were obtained in a similar study of “The Evaluation Method for Product Form Attractiveness Based on Miryoku Engineering” [2]. In our study, the EGM was used to capture the appeal factors, and a hierarchical diagram of the appeal factors for CROSSOVER B-CAR interior was constructed.

Expert subjective evaluations can be performed depending on different ways of semantics and analysed using the EGM analysis. Initially, the EGM is a peculiar evaluative method to capture critical information from the individual in-depth interviews of experts. Then, attractive aspects and detailed design attributes in the auto market can be determined from the EGM. In addition, the relation among an impression, style and trait can be found out and comprehended.

In this study, the participants of the in-depth interview were automobile professionals, car owners and people with the expertise and professional knowledge of the subject, such as editors of magazines and veterans of working on cars. Then, they were asked with questions of preferences for Crossover interior design and functions by the following procedures. In addition, besides the experts’ abstract description, their specific reasons and details were also especially focused on.

The procedures of the EGM were as followsings: (a) twenty-seven sample cards with pictures and names, containing twenty-seven individual car models with car interior, were selected for interview. In addition, auto catalogues or images are also used as prompts or comparison among different cars if experts don’t have clear impressions to certain types of cars. (b) These twenty-seven car models were grouped into three stacks according to the participants’ preferences from high to low. (c) The interviewer first let the experts express their abstract meaning with adjectives to the three stacks in respectively and then asked them the specific reasons and details about their preferences. (d) The original evaluation items were obtained by asking the participants about the images and their reasons in grouping them in the three stacks. Each original evaluation item was then processed to form its corresponding “upper-level” and “lower-level” concepts. “Upper-level” means that words are more abstract in the hierarchical structure of semantics while “lower-level” means that the words in it are more specific.

The structure of every participant’s evaluation items was constructed using the processes described. The original evaluation item, chosen in accordance with the focus of this paper, are “flexible and innovative space usage”, “comfortable and convenient”,

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“fashionably designed”, “economical and useful”, “customized for consumers’ needs”, “technical”, “extraordinarily experienced”, and “innovative and extraordinary”. In addition, after recording and arranging what they describe, the first hand data can be helpful to make questionnaires.

4.2.2 User evaluation

What kind of feeling car interior design can deliver to users is a very critical issue which a car interior designer must understand and concern. Further, Kansei Engineering is applied to evaluate users’ impressions on car interior such as their feeling for roomy or oppressed space. In order to provide necessary assistance for designers, this study develops a survey-analysis system to measure the degree of intensity of humans’ impressions on CROSSOVER B-CAR interior.

4.2.3 The Design of a Questionnaire

In this study, user evaluation can be performed through conducting a survey through questionnaires. Then, the questionnaire survey was analysed for determining the weights of the surveyed critical elements from users’ mental images to the interior design and functions of crossover B-Car. Finally, the initial proposals were proposed based on the most proper suggestions of sets composed of mental images and functions from the stage of “input” and “product idea refined”, such as former statistic results and suggestions.

In order to measure the weights of the attributes and their importance in CROSSOVER B-CAR interior, the best eight attractive criteria for the attractiveness of CROSSOVER B-CAR interior, were chosen and determined from the original evaluation items using the EGM. We were able to create a questionnaire using the setting of the attribute items and categories using these data. In order to quantify the range of items and to give a score or the categories of the appeal of crossover B-Car by Quantification Theory Type I, the questionnaire was created from the arrangement described below using the setting of the attribute items and categories (Table 1). Then, the questionnaire was modified after asking experts for their opinions and issued to those who have bought Crossover B-Cars or who have inclination to purchase them in the future.

Based on the EGM, this study used 8 attractive criteria for surveying consumers’ inclinations toward “flexible and innovative space usage”, “comfortable and convenient”, “fashionably designed”, “economical and useful”, “customized for consumers’ needs”, “technical”, “extraordinarily experienced”, and “innovative and extraordinary” of car interior. Then, this study adopted snowball sampling, which means that some interviewees are randomly selected for the execution of the survey. Then, the interviewees are asked to provide other ones belong to target population, which this study may interview in the future.

The following are the typical questions in the questionnaire: 1. How do you rate the importance of “technical” with the following items, “digitization”, “3C”, “lifelike”, and “technical metallic sense”? (Please evaluate them by the importance, scoring the most important as “5” and the least important as “1”). 2. In the aspect of “technical”, which trait do you feel “technical metallic sense” should apply to? (Please choose one from the following categories: “metal elements”, “blue LED’ unique personality”, and “digital sound effect”).

4.2.4 The analysis of questionnaire survey

This study also adopted the Quantification Theory I method as a tool to analyse the importance of the appeal factor of Crossover B-Car interior. Quantification I method was used to analysed the relationships between the subjective evaluation scores and design elements. (Jindo, 1997) This technique is also generally used in Japan to examine the relationship between quantitative data (the scores in this work) and qualitative data (the design categories of the samples evaluated). By using the multiple linear regression methods, Hayashi’s Quantification Theory Type I [4] can statistically predict the relationship between a response value and categorical values. Moreover, in product design, Hayashi’s Quantification Theory Type I can also be used to evaluate the weights of the factors form users’ preferences [5][15].
The statistical method can be widely applied to research analysis especially for Kansei Engineering. Nagamachi [9] introduced that Quantification Theory Type I is an excellent technique which is feasible to construct the relationships between design elements and Kansei images. This study also adopted the Quantification Type I method as an analysis tool of the appeal of a CROSSOVER B-CAR interior. In addition, upper-level and lower-level items were measured and quantified using the importance-level of the original evaluation. Using this method, we were able to analyse the importance of appeal. In addition, the importance of upper-level and lower-level items to the original evaluation were measured and quantified. In particular, the partial correlation coefficients indicate the extent to which each design element contributes to an explanation of the evaluation adjective concerned [6]. In this study, the technique of Quantification Theory Type I was transferred to a type of mathematic formula and was executed through Excel Macro for statistical analysis.

5 Discussion & Results
5.1 Input
5.1.1 Observation
It is significant for studying interior design from user experience and feeling in person rather than merely from the information of pictures and text. Hence, this study plans to form a group for visiting CROSSOVER B-Cars, whose members include people who have specialized automobile knowledge, long driving experiences, design backgrounds, plans to purchasing them, and interests in them or own them.

After the study group directly experienced the chosen eight cars belonging to different brands, the comprehensive comparison and evaluation was analysed by three selected aspects, including “the quality of interior design”, “the functions of collection and storage”, and “technology”.

5.1.2 Data collection
In this study, we collected various and abundant information related to the subject, including supportable literature and design cases, which have shown in this study. Finally, we collected 521 vocabularies from professional media and publications related to car interior designs and functions. In addition, we generalized them as the following form shown in Table 2 and used them for making check list for the interview.

5.1.3 Market analysis
Besides previous study providing relative qualitative analysis toward market, quantitative analysis to the measurement of CROSSOVER B-CAR interior space was performed through investigating the distributions of CROSSOVER B-Cars in the market. The following distribution charts were produced to show basic statistic results of general car interior space in the market.

According to the collected data, we took exterior length, width and height of CROSSOVER B-Car for drawing the distributions as the following: The wheelbase of CROSSOVER B-Car in Taiwan ranges from 2460mm to 2778mm. Then, the exterior length of CROSSOVER B-Car in Taiwan ranges from 3750mm to 4395mm. The exterior width of CROSSOVER B-Car in Taiwan ranges from 1642mm to 1837mm. The exterior height of CROSSOVER B-Car in Taiwan ranges from 1399mm to 1690mm. Furthermore, this study defines the similar interior space of CROSSOVER B-Car as wheelbase*width*high instead of actual interior space because most sellers would not rather provide actual size of interior space in Taiwan. The defined interior space sizes of different cars in the market.

Then, we made the chart by using car interior space / exterior length as two coordinates to compare the scales among different cars. Most CROSSOVER B-cars mainly massed in two areas in the chart, including the length of 3900~4100 mm and 4100~4400 mm in respectively. Then, the interior space volume of most CROSSOVER B-Cars ranges between 6000 mm$^3$ and 8000 mm$^3$. It is interesting that Benz B-Class has the largest wheelbase and interior space. However, the length of Benz B-Class is merely the eighth. Therefore, we can see that Benz B-Class attempts to maximize its interior space but avoid decreasing its mobility caused by exterior “length”. The result shows that the
interior space of Benz B-Class is larger than others. Then, the interior space of Skoda Fabia is the smallest.

From the analysis mentioned above, we can know the outline of interior size design in the market from these distributions, which are also helpful to provide useful information to the product development in this study.

5.2 Product Idea Refined

5.2.1 Expert Evaluation (EGM)

The study group first interviewed 5 experts with the ages between 37 and 55 years, who are all chief editors of auto magazines or newspapers with professional knowledge. In order to understand the appeal of car interior, interviews were conducted using the EGM. In addition, 9 Crossover B-Car owners were also interviewed by the study group, including three male and six female car owners with the ages between twenty-nine and 48 were interviewed.

We then created the evaluation structure from interviewing the participants using the EGM. Figure 2 shows the hierarchical diagram of the Crossover B-Car interior preferences of one participant by the EGM. In Figure 3, the numbers on the right side of the words indicate the number of times that the same opinion appeared. For example, in the original evaluation item, “innovative and extraordinary 9” means that the word “innovative and extraordinary” was listed nine times from 14 participants. The appeal factors of Crossover B-Car interior were determined according to the preference interview with the EGM.

A hierarchical diagram of CROSSOVER B-CAR interior preferences, as the results of this study, was determined by the EGM. In order to explore the issues related to car interior design, the greatest appeal of car interior was determined to be “innovative and extraordinary”, “technical”, “customized for consumer needs”, “economical and useful”, “fashionably-designed”, “comfortable and convenient”, “flexible and innovative space usage”, as determined from the evaluation items.

The user chooses car interior because of one of the following characteristics: “exquisite and quality”, “tasty”, “sporty and recreational”, “conforming to ergonomics”, “conforming to user habits”, “the space conforming user needs”, “sufficient illumination”, “endurable”, “worth more than its cost”, “safe and stable”, “customized for the needs of the specific population”, “customized for individual preferences”, “digitization”, “3C”, “technical metallic sense”, “outstanding sense of sight”, “outstanding sense of smell”, “outstanding sense of hearing”, “outstanding sense of touch”, “innovative”, “extraordinary”, “various and flexible interior room setting”, and “integrated and various ingenious collection and storage”.

In addition, Table 3 shows the ranking from the hierarchical diagram by the number of times the descriptions appeared. Table 4 also shows the best 3 “original images” selections from the hierarchical diagram by the number of times they appeared.

5.2.2 User evaluation

After expert evaluation, user evaluation was performed through a questionnaire survey. The personal information of consumers’ sex, age, education degree, marriage status, family members, and average monthly income were also surveyed.

The surveyed objects targeted to people who equip with the abilities or potential for purchasing cars. The content of the questionnaire is mainly for understanding users’ general needs, preferences and their reasons to car interior design and function variation. In addition, personal basic information such as social-economical status is also included. Furthermore, people who do not know the invested types of cars or have no experience of using them were excluded from this study. Then, people who had used crossover B-Cars for at least three months were considered to be enrolled in this study.

The research uses the procedure of questionnaire survey and provides total 1100 questionnaires to return a total of 1003 copies of them with the 91.1% response rate. After deducting the questionnaires with incomplete or invalid answers, the 931 valid copies of questionnaires were taken in to account to achieve the 92.8% rate of effective questionnaires. Among these valid respondents,
there were 520 males and 411 females with the ages ranging from 31~55 years old.

The results of statistical analysis for the questionnaire survey were revealed as the following paragraph. Due to the limited space in this paper, the appeal factor of “innovative and extraordinary” was selected as the example in this study. Other appeal factors, including “extraordinarily-experienced”, “technical”, “customized for consumer needs”, “economical and useful”, “fashionably-designed”, “comfortable and convenient”, “flexible and innovative space usage”, can be analysed in the same way.

The first appeal factor to be classified was “innovative and extraordinary”, which included “innovative” and “extraordinary” in the upper-level assessment. A Crossover B-Car interior was classified as “innovative and extraordinary” if it gave the users this impression because of one of the two above-mentioned descriptions. In this study, the coefficient of determination ($R^2=0.696$), which was determined based on the results of the Quantification Type I Method indicates a standard reliability for our survey instrument. The appeal factor, “innovative and extraordinary” type, was most affected by “extraordinary”, with the highest partial correlation coefficient was “extraordinary” (Table 5). The categories included were: “different design of space variation”, “equipment which common cars do not have”, “additional decoration” “thoughtful storage”, and “changeable interior type”.

Table 5 shows the description statistics for each item. According to the Category Scores from Table 5, “changeable interior type” had stronger effect on “extraordinary” than the others did. In addition, “equipment which common cars do not have” had a stronger negative effect on it than the other categories. In addition, “customized for consumer needs” had the highest value of R square (0.720) among the 8 critical appeal factors, showing that the test reliability of this factor was the highest. It means that the results also showed that the participants had more of a feeling of identification toward the appeal factor of “customized for consumer needs” than they did toward other appeal factors.

According to statistic analysis, the important appeal factors with higher partial correlation coefficients are “extraordinary”, “sporty and recreational”, “the space conforming user needs”, “safe and stable”, “customized for the needs of the specific population”, “digitization”, “outstanding sense of touch” and “integrated and various ingenious collection and storage”. In addition, the important characteristics with highest category scores are “changeable interior style”, “vivid and brilliant color”, “real seats capable of leaning and adjusting”, “for daily use”, “design for enthusiasts of sport or recreation”, “the application of digital technology”, “a wild field of view” and “integrated storage”.

The results of expert and user evaluations were used to be referred for initial proposals.

6 Conclusions

6.1 Findings and managerial implications

The eight major appeal factors of CROSSOVER B-CAR interior, including “innovative and extraordinary”, “extraordinarily-experienced”, “technical”, “customized for consumer needs”, “economical and useful”, “fashionably-designed”, “comfortable and convenient”, “flexible and innovative space usage”, can be affected in varying degrees by particular reasons and characteristics.

Expert evaluation was performed using the EGM. The semantic structure of appeal from the interviews of experts shows the hierarchy of the relationship between the types of appeal or appeal factors, the reasons for their preferences, and the specific characteristics of CROSSOVER B-CAR interior. In addition, user evaluation was performed through the design of questionnaire. Through the demonstration of statistic analysis to question survey, the appeal impressions of CROSSOVER B-CAR interior to users were actually affected by specific characteristics by the degree of importance.

In this study, design assessment was materialized through expert and user evaluation and played a screening role in the product design and planning process. Furthermore, it means that the ideas of product design are
refined through experts’ and users’ preference so the designed products can be close to what they need and desire. In addition, in order to explore the design of car interior, we used a preference-based study to reveal the appeal of car interior.

6.3 Future research
Design evaluation plays a critical role in the process of product design and planning. In addition, design evaluation is often involved with the issues about users or consumers’ complicated motivations. In addition, our urgent work will explore design strategy and decision-making in the process of product planning and design for the follow-up study.

References:


Figure 1. The system based on Kansei Engineering for the process of product design and planning
Figure 2. The selected hierarchical diagram of Crossover B-Car interior preference one participant by the EGM

Figure 3. The selected hierarchical diagram of Crossover B-Car interior preference by the EGM

Table 1. The setting of the attribute items and categories

<table>
<thead>
<tr>
<th>Original Evaluation</th>
<th>Upper Level</th>
<th>Lower Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Of fashionable design</td>
<td>Sporty recreational</td>
<td>A sporty steering wheel</td>
</tr>
</tbody>
</table>

Table 2. The form of vocabulary collection

<table>
<thead>
<tr>
<th>Adjective</th>
<th>Design specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Comfortable</td>
<td>Adjustable rear seats</td>
</tr>
</tbody>
</table>

Table 3. The ranking from the hierarchical diagram by the number of times the descriptions appeared.

<table>
<thead>
<tr>
<th>Original images</th>
<th>Upper Level (reasons)</th>
<th>Lower Level (specific attributes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flexible and innovative space usage 14</td>
<td>Extraordinary 22</td>
<td>Metal elements and steps 25</td>
</tr>
<tr>
<td>Fashionably and aesthetic 14</td>
<td>Outstanding sense of sight 21</td>
<td>Mix and match 24</td>
</tr>
<tr>
<td>Extraordinary experiencing</td>
<td>Exquisite and quality 21</td>
<td>Smoothly manipulating 23</td>
</tr>
<tr>
<td>Convertible and convenience</td>
<td>Customized for individual preferences 20</td>
<td>Changer and useful material 22</td>
</tr>
<tr>
<td>Innovative and extraordinary</td>
<td>Conforming to regulations 19</td>
<td>Quality fabrication and material 21</td>
</tr>
</tbody>
</table>

Table 4. The best 3 “original images” selections from the hierarchical diagram by the number of times they appeared

<table>
<thead>
<tr>
<th>Classified</th>
<th>Original images</th>
<th>Reasons (upper level)</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>Flexible and innovative space usage 14</td>
<td>Integrated and various suspension collection and storage 19</td>
</tr>
<tr>
<td></td>
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<td>Various and flexible interior zones setting 17</td>
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<tr>
<td>Second</td>
<td>Fashionably and aesthetic 14</td>
<td>Exquisite and quality 21</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tasty 19</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sporty and recreational 17</td>
</tr>
<tr>
<td>Third</td>
<td>Extraordinary experiencing 11</td>
<td>Outstanding sense of sight 21</td>
</tr>
<tr>
<td></td>
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<td>Outstanding sense of small 21</td>
</tr>
<tr>
<td></td>
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<td>Outstanding sense of bearing 13</td>
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</tbody>
</table>

Table 5. “Innovative and Extraordinary”

<table>
<thead>
<tr>
<th>Innovations</th>
<th>Categories</th>
<th>Partial Category</th>
<th>Partial Correlation Coefficients</th>
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</thead>
<tbody>
<tr>
<td>Innovative outer match</td>
<td>Innovative outer match</td>
<td>0.695</td>
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<tr>
<td>Mixed scent aromatic</td>
<td>Revolutionary captured emotion cluster</td>
<td>0.612</td>
<td></td>
</tr>
<tr>
<td>Revolutionary captured emotion cluster</td>
<td>Revolutionary captured emotion cluster</td>
<td>0.612</td>
<td></td>
</tr>
<tr>
<td>Different design of space variation</td>
<td>Equipment which common cars do not have</td>
<td>0.612</td>
<td></td>
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<tr>
<td></td>
<td>Additional decoration</td>
<td>0.629</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Thoughtful storage</td>
<td>0.631</td>
<td></td>
</tr>
<tr>
<td>Extraordinary</td>
<td>Changeable interior style</td>
<td>0.765</td>
<td></td>
</tr>
</tbody>
</table>

R = 0.634 |
R Square = 0.415