

# Research on the Form Design of Mini Car in Perceptual Consumption Times

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**Abstract.** Except for the basic function to replace walk, current customers also desire mini car can reflect the trends of the time. So it has been an important consideration for enterprises to meet customers' emotional needs. The research will understand the preference for mini car production among different age groups of consumers in depth by Miyoku engineering theory. Evaluation Grid method provides a way to analyze attractive factors of the products among related researches on Miyoku engineering, which extracts the median original evaluation (customers' demands), the lower specific reason (product details) and the upper abstract reason (users' emotions) by deep interviews to experts and thus sorts out the structure network map of the evaluation of the products from respondents. At last, the quantification theory I establishes a functional relationship between the abstract upper emotions and the specific design details in the kansei data, and analyzes the influence weight among the attractive factors. Four attractive factors related to mini car were concluded. Among such attractive factors as "fashionable", "delicate" and "elegant", red car color maximally stimulates the consumer's positive emotions while the thick car body has the greatest negative correlation with the "light" attractive factor. The innovation method proposed by this research can rapidly obtain user's needs, shorten the overall operation steps and improve the development efficiency. Meanwhile, the method can be effectively used in other industrial product designs.

**Keywords:** Product design · Kansei engineering · Miyoku engineering · Quantification theory type I · Minicar · Form design

## 1 Introduction

Car has a long history, the French who liked to use gas invented the gas car, the British who were proud of Watt invented the steam car driven by a steam engine. It was the internal-combustion engine, which produced power by the detonation between the volatile fuel and air, started the car times indeed. Consumers' needs on car were only the function of instead of walking during the material poverty period, even buying cars was an entertainment of the high-society people. Ordinary people have had cars with the development of modern science and technology as well as the improvement of quality of living. Customers choose their favorite style among various car categories on the market according to the work demand, interests, personality characteristics and

values. The function difference among new products introduced by major manufacturers has been increasing ambiguous. Fashionable appearance, comfortable driving experience have been the key factors of successful marketing. As household bulky item, car reflects or symbolizes the status of consumers. Customers regard the products as their own specialty to represent themselves.

The consumers behavior is divided into 3 basic stages by famous marketing master Kotler Philip [1]: the first stage is the consumption of amount that people pursue the merchandise they can afford to buy and buy; the second is the consumption stage of quality, which means seeking genuine goods at a fair price, distinctive and high-quality merchandise; the third is perceptual consumption stage which pays attention to the emotional experience of shopping and interpersonal communication, it takes the personal preference as the standard of purchase decision and gives more emphasis on “emotional value” than “functional value”. Therefore, in the age of perceptual consumption, everyone has the tendency of subjective perceptual consumption. They hope to enjoy the shopping process. They pursue grade, status and a sense of pleasure from the heart. In recent years, mini car has been paid attention to and loved by more and more people under the environmental-friendly design concept, their fashionable and sunny style especially caters to the aesthetic taste and cultural quality of young group.

Due to the features of flexibility and agility and compact appearance, The mini car (Fig. 1) can meet the consumer’s various requirements such as work and leisure. Different from the mechanical and calm appearance of commercial vehicles, the appearance of mini car can be freely matched according to the preference of users to achieve easy replacement as phone covers. As household transportation mini car is very suitable for mini life, housewives can buy food, go shopping, pick up kids and take them on short distance driving on the mini car through the mini street. It can effectively relieve a serious problems such as difficult driving and hard parking in the first-tier cities which have the problems of traffic jam. At the same time, with the increase of life cost and work competitive pressure, urban white-collar workers can purchase their favorite transport in the mini-car market where the price is relatively low and the quality is fine. After one day’s tired work, stylish and cute appearance of mini car can relieve the user’s inner pressure. Meanwhile, the rising oil prices and pressure brought by family expenses have opened up new market demand for mini car. Customers’ demands on products have been improved from the satisfaction of material to psychological and emotional levels. The first impression of the new product appearance greatly affects the consumer’s purchase preferences. The form, color and material of new product reflect the appearance style of product, the basic function and operation and brand influence, so the attractive appearance of the mini car will lead to consumer recognition and emotional resonance. Therefore, how mini car design can attract captious consumer and exploring the inner attractive factors of the customers have been focused on research by the car designers and related practitioners.

This study mainly discusses the consumer’s preferences for the shape of mini car in the age of perceptual consumption and establishes new emotional needs of consumers in the new era. By using Kansei Engineering methods user’s feeling and emotion can be converted into specific design specification. The Kansei Engineering technology which originated in Japan in 1970s can provide reference in the early stage of new product’s development and design [2]. At last, the abstract upper emotional vocabulary



**Fig. 1.** Smart (source:<http://china.smart.com/>)

and lower specific design elements in the experimental data were analyzed using quantification theory type I. In the research, the functional relation between the customers' emotional intention and design elements was concluded, in addition, the weight relation of influence among attractive factors was analyzed. The paper expected to provide the related industries with mini car and designers a designing reference to improve the attraction to customers when developing new products.

## 2 Literature Review

### 2.1 Kansei Engineering

Kansei Engineering was developed as a consumer-oriented technology for new product development. It is defined as “translating technology of a consumer’s feeling and image for a product into design elements” [3]. In 1998, the Japanese Institute of Kansei engineering was established, and the Miryoku engineering became part of it. Miryoku engineering was a research developed by Masao Inui and Japanese scholar Junichiro Sanui in referring to the book *The Psychology of Personal Constructs* written by clinical psychologist Kelly, which provides the designers a method to make the customers’ fuzzy perceptual cognition become specific when executing product development [4]. It was understood that some ways to choose products by customers and the experience of successful product design can catch the products’ attractive essence, thus a design full of attraction would be created. The method clearly discussed the similarity or difference relationship in the comparison between object A and B mainly by individual interviews, thus the individual qualities of target objects were sorted out. The attraction factors will be the key points to successful products if they can be obtained in the products design and development as well as applied and transformed to actual product aspects, so the extraction of charm has been worked on finding by many designers in the design process.

The Evaluation Grid Method provides an analytic approach to product attractive factors with theory basis among the related researches in Miryoku Engineering,

providing stimulation according to the category of the theme and in the form of depth interviews to know the customers’ feeling about the products’ charm, making the participants have obvious feeling difference after the comparison of preference degree among participants, so the participants’ original concept to the subject will be known, thus leading to the participants’ more definite analyzing the original evaluation concept and connecting its upper abstract concept with lower specific description, and then a network diagram of participants’ evaluation structure of products will be sorted out.

The theoretical basis of the Miryoku Engineering is mainly in the following three points: basic theory, modeling (Research and analysis) and design [6]. As shown in Table 1.

**Table 1.** Theoretical basis of Miryoku Engineering (Sources: Ujigawa, 2000)

Area	Peculiarity	Concept and theory	Method
Basic Theories	Definition		
	Recognition	Inclusive recognition	
		Pattern recognition	
	Learning	Fashion, Character goods	
Value system	Reference groups		
Modeling	Structure identification	Depth interview	Evaluation grid method
			Paired comparison
	Parameter identification	Composite effect	Regression analysis
	Segmentation	Cluster analysis simulation	Conjoint analysis
	Forecasting		
Design	Planning	On-site thinking	Scenario marking
	Design Strategy	Positioning	Cognitive Map
	Materializing	Prototype creation	User participation

**2.2 Quantification Theory Type I**

Theory of quantification, as a branch of multivariate analysis, began in the 1950s. Originally it was only applied in “sociology of measurement”. With the extensive application of electronic computers after the sixties, it was increasingly applied in the field of natural science [7]. Japanese scholar Chikio Hayashi first invented four non-parametric theory of quantification, which can easily handle quantitative data by multivariate analysis [8]. Quantification theory type I are extensively applied in relevant researches of Kansei engineering. Designers regard consumers’ perceptual evaluation as criterion variable and design elements as explanatory variables respectively. The relationship between the two variables is established by the regression equation, which guides the creative workers’ designing. To improve customers’ satisfaction, Schütte and Eklund [9] took the rocker switch on the vehicle as example to describe the product areas from the physiological and semantic perspective by kansei engineering

method, meanwhile collected the data from 71 persons to carry out linear regression analysis in the dimensional matrix of quantification theory I. The results provided design reference to the three major car manufacturers in Sweden. Qiu and Omura [10] applied quantification theory I and factor analysis to carry out perceptual evaluation experiment on name card design as well as introduced the establishment of the emotion design system by the characteristic combiner automatically generating design combination. On the basis of quantification theory I and principal component analysis, Bahn and Lee [11] proposed developing and using an emotional design framework to identify important emotional characteristics of users and systematically integrate them into product design attributes. Zhang and Vertiz [12] proposed that automobile interior coordination has got more and more attention by customers. Kansei engineering is an emotional way to quantify the relationship between design elements and customers' emotion. This paper continued the previous research findings of indoor coordination of commercial trucks as well as investigated and surveyed the user's emotions in the several visible elements of commercial truck by category classification method. Quantification theory I was applied in this paper to describe the relationship between visible kansei image and design elements. The results showed that the truck driver's "elegant" and "preference" feelings are strongly affected by the trimmed material, shape, color, window size and map bags. The results also showed the difference between the different emotions of the truck drivers and design engineers.

### 3 Research Subject

Mini-car (Fig. 1) is an important branch and application of the automobile family and it plays an important role under the social background of energy shortage and environmental pollution. Therefore, this case study takes the front styling of mini car as example. With the gradual maturity of basic technology and manufacture, the function difference of different cars is getting smaller and smaller. Consumers shift the focus of attention from the function to the emotion. This enables users to pay more attention to the appearance of the car and psychological and emotional satisfaction. Mini car with trendy appearance can better realize the convenience of urbanism.

### 4 Research Method and Process

The research combined qualitative with quantitative method to explore the form design of mini car. The experiment can be divided into two stages. In the first stage, ten high-involvement experts were selected to determine the original reasons of preference and aversion by the evaluation grid method of Miryoku engineering. The abstract upper factors and specific lower factors were asked to sort out the structural map of evaluation. In the second stage, the quantitative linear regression method was used to analyze the influence relationship and the weights of the factors of various strata in the previous stage.

### 4.1 Miryoku Engineering Method

#### 4.1.1 The Collection of Experimental Samples

As the size of mini car is big, the pictures were presented to the respondents in order to collect the true feelings of consumers. 18 clear mini cars with a front 45° angle were selected from network, magazines, related journals and other channels. Meanwhile, the background color and emblem mark were removed by photoshop in case of the emotional and visual interference. The picture size is 21cm × 30cm (Fig. 2).

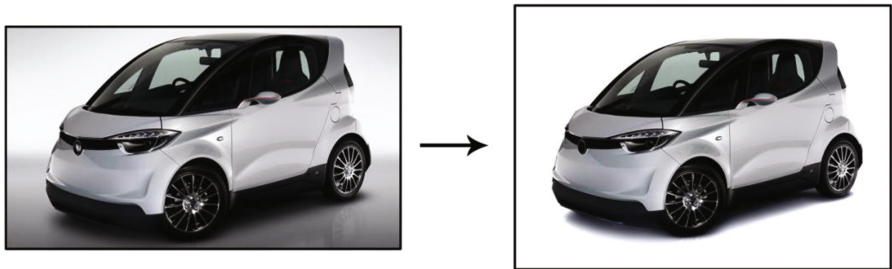


Fig. 2. Revised picture of the mini car sample

#### 4.1.2 The Selection of Respondents

The collected sample pictures in observation are not enough to evaluate the preferences of mini car from the perspective of consumers. The driving experience, age, the plan and wish to buy mini car were very focused on in selecting respondents. The following five experts were determined after considering the life background of the consumers (Table 2) (Fig. 3).

Table 2. Group of tested experts

Name	Age	Profession	Driving experience
Miss Wang	24	Animation designer	3 years
Miss Qiao	33	Real estate marketing manager	11 years
Mr Zeng	29	Dress designer	7 years
Mr Fan	37	Enterprise white-collar	5 years
Miss xie	28	College teacher	5 years

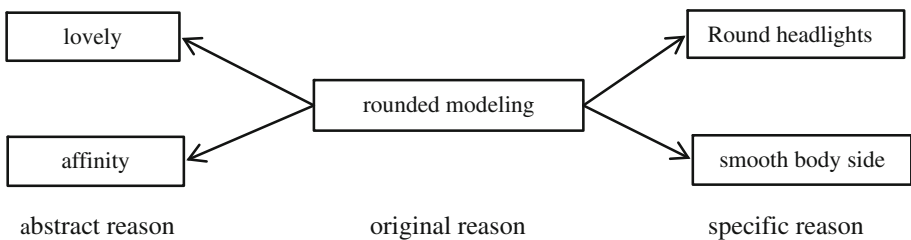


Fig. 3. A single evaluation project construction chart

### 4.1.3 The Procedure of Evaluation Grid Method

#### 1 Interview equipment and personnel preparation

After determining mini car as research theme, the interview samples such as product pictures, text were printed and then placed on the table. There were one main questioner, one record person and one photographic video person.

#### 2 Identifying the original evaluation items

The respondents were interviewed in-depth individually with the above-mentioned data. The respondents were asked to compare 18 mini cars and explain the original reasons for preference. For example:

**Ask 1:** “What do you think of Sample 13 as compared with Sample 17?”

Answer: “I prefer sample 17.”

**Ask 2:** “why do you prefer sample 17?”

Answer: “because it’s rounded”

#### 3 Asking the relationship between the upper and lower levels

After determining the original reasons for preference, the upper abstract reason (Ladder up) and the specific details characteristics of its composition (Ladder down) were asked.

(1) Ladder up: The upper abstract reason of the original evaluation project “rounded modeling” obtained from the second procedure was unceasingly asked.

**Ask 3:** “why do you prefer “rounded modeling”

Answer: because “rounded modeling” looks very lovely and affine

(2) Ladder down: Basing on “rounded modeling”, the respondents were unceasingly asked the specific design elements to analyze the physical property for reference.

**Ask 4:** What design factors make you feel “rounded modeling”?

Answer: “the smooth body side” and “round car headlights”

A median original evaluation project was sorted out in the above two steps. A three-level architecture of upper-level abstract reason and lower-level concrete reason is in the following.

#### 4 Sorting out personal evaluation construction chart

All the evaluation construction projects of the respondents can be asked in turn according to above steps. A complete evaluation construction chart of each respondent can be concluded by three-tier connection and arrangement.

#### 5 Sorting out the overall evaluation construction chart

Simplifying and classifying the personal evaluation construction chart of all respondents. Gathering the overlapping vocabulary and calculating the overlapping times to conclude the final overall evaluation construction chart of mini car.

## 4.2 Quantification Theory Type I

### 4.2.1 Collection of Data

The above-mentioned attractive factors and their hierarchical structure were made into a questionnaire. The abstract reason and specific reason were defined as the dependent variable and the independent variable in the regression model respectively. The semantic vocabulary of the abstract reason is determined to be “fashionable” “refined”

“elegant” and “dexterous”. A point table with five orders from -2 to 2 was carried out by SD semantics [13] to quantify the customers’ psychology feelings of the 18 mini cars. Design items are the body color, body proportions and car headlamps. The design category was determined as Table 3. The questionnaires were distributed in the network, and 100 data were collected. Finally, the final score was perceptually evaluated by averaging method. The perceptual evaluation matrix shown in Table 4 was obtained.

**Table 3.** Classification of design elements

Item	Category		
Body color (X1)	Blue (C11)	Red (C12)	Gray (C13)
Body proportions (X2)	Square modeling (C21)	Mellow modeling (C22)	Honest modeling (C23)
Headlamps (X3)	Round (C31)	Square (C32)	Organic form (C33)

The main reasons why the customers prefer mini car as well as the weight relation between the attractive factors and the design elements were calculated by Quantification theory I. Category score, complex correlation coefficient, coefficient of determination and partial correlation coefficient can be concluded by statistical analysis. Their calculation methods and representative significances will be briefly described in the following.

- (1) Category score: category score are on behalf of the relationship between the lower specific design elements and the median original evaluation. High value means the lower has a higher impact on the median. Meanwhile, the category score has positive and negative points. Positive values have positive impact on the median while negative values may have a negative impact. The calculation is as (1). Assume that the following linear model is followed by the reaction between the baseline variable and each item and category.





$$y_i = \sum_{j=1}^m \sum_{k=1}^{r_j} \delta_i(j, k) b_{jk} + \varepsilon_i, i = 1, 2, \dots, n. \tag{1}$$

$b_{jk}$  is a constant term which only depends on category of project.  $\varepsilon_i$  is a random error in the  $i$  sample

- (2) Multiple correlation coefficient R: The multiple correlation coefficient represents the overall influence of multiple variables on a dependent variable. Its value represents the correlation, which is used to measure the accuracy of the prediction. Sugiyama [14] proposed the relationship between the R coefficient and the reliability in the relevant research. As in Table 5:



**Table 4.** Kansei valuation matrix

N O .	Sample picture	Design elements									Evaluation value of kansei vocabulary			
		Body color (X1)			Body proportion (X2)			Car headlamp (X3)			fashi onab le	deli cate	eleg ant	Dex tero us
		C <sub>11</sub>	C <sub>12</sub>	C <sub>13</sub>	C <sub>21</sub>	C <sub>22</sub>	C <sub>23</sub>	C <sub>31</sub>	C <sub>32</sub>	C <sub>33</sub>				
1		1	0	0	0	1	0	0	0	1	2.38	2.75	2	3.75
2		0	1	0	1	0	0	0	1	0	3.25	3.75	3.13	3.13
3		1	0	0	0	0	1	0	0	1	2.25	2.5	2.38	2.13
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
1 8		0	0	1	1	0	0	0	0	1	2.13	2.63	2.38	2.38

**Table 5.** The relationship between R value and reliability

R value	Reliability
0.00–0.19	Predictive values showed a low correlation
0.20–0.39	Predicted values are correlated
0.40–0.69	Predictive values are strongly correlated
0.70–1.00	Predictive values are strongly correlated

The accuracy of the prediction can be measured by the multiple correlation coefficient of the sample R (namely the correlation between the predicted value and the measured value), which can be calculated by formula (2).

$$r = \frac{\sigma_{\hat{y}y}}{\sigma_{\hat{y}}\sigma_y} = \frac{\sigma_{\hat{y}}}{\sigma_y} = \sqrt{\frac{\sum_{i=1}^n (\hat{y}_i - \bar{y})^2}{\sum_{i=1}^n (y_i - \bar{y})^2}} \tag{2}$$

- (3) The coefficient of determination (the square of the multiple correlation coefficient): The coefficient of determination is a modified value, which presents the interpretation amount of the total variation and is an important indicator to measure whether the forecasting ability of the model and the regression equation are effective or not. In this research, it is the degree of the charm of mini cars being explained by the abstract adjectives. Higher value means the charm of mini cars can be more strongly affected by this feeling, the probability of occurrence of the prediction error can be also reduced.
- (4) Partial correlation coefficient: higher partial correlation coefficient means this category effects more on the upper abstract vocabulary and the median primitive evaluation contributes more to the adjectives. In order to calculate the partial correlation coefficient, each item was regarded as a variable and formula 3 was regarded as the quantitative data of the  $i$  sample in the  $j$  item. In this way the correlation coefficient between an item and another item, item and the dependent variable as well as the correlation matrix  $R$  can be concluded, on the basis of which the partial correlation coefficient can be calculated.

$$x_i^{(j)} = \sum_{k=1}^{r_j} \delta_i(j, k) \hat{b}_{jk} \quad i = 1, 2, \dots, n; j = 1, 2, \dots, m \quad (3)$$

## 5 Analysis and Results

### 5.1 Hierarchy Architecture of Mini Car

Five experts expressed their own preferences for mini car, as well as the upper abstract reasons and lower specific reasons for preference by Evaluation Grid Method (EGM) of Miryoku engineering. The overall evaluation construction figure after sorting is as Fig. 4. It can be found that “body color and texture”, “body ratio” and “car headlights” are more likely to arouse consumers. Among the original reasons of “body color”, “beautiful red”, “colorful”, “distinct color block” and “bright texture” were analyzed by customers. The upper abstract reasons of “body color and texture” include “fashion”, “athletic” and “lovely”. In the second stage of the experiment, the abstract reasons were transformed into kansei vocabulary to score the high-involvement group. The original and specific reasons of the evaluation construction chart were translated into item and category respectively. The importance degree and relationship of the two were analyzed by quantification theory type I.

### 5.2 Quantification Theory Type I Analysis

The appearance charm design of mini car was analyzed by quantification theory I. Quantification theory type I is a commonly used research tool that transforms kansei image into design elements. The established mathematic model predicts the kansei

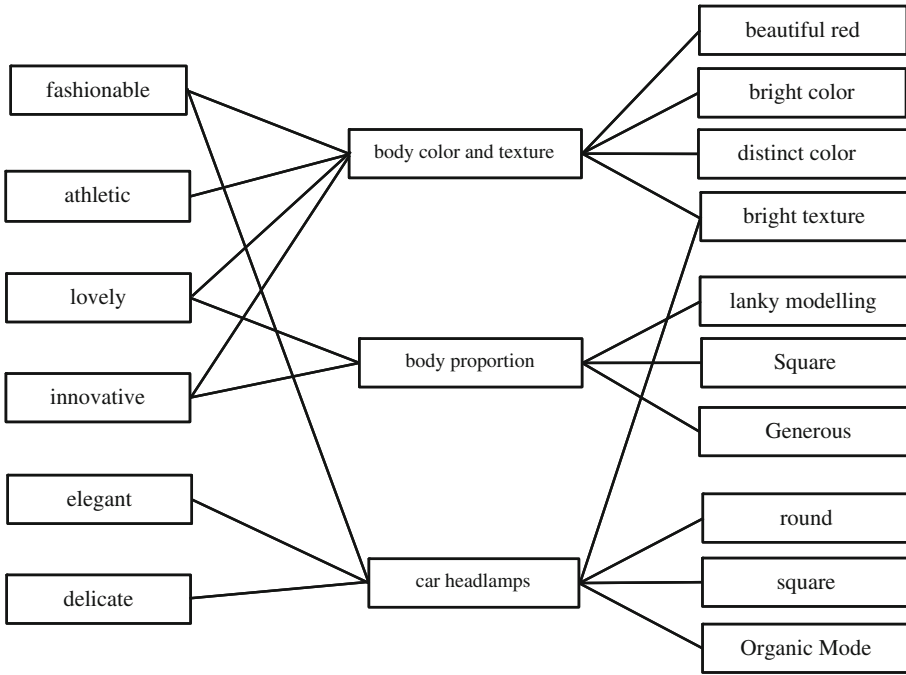


Fig. 4. The overall evaluation construction chart of the experts

evaluation of consumers more accurately. 100 people were surveyed in the network and 87 valid questionnaires were collected. The effective rate of the questionnaire was 87%. The corresponding complex correlation coefficient, constant term, partial correlation coefficient and category score of various perceptual adjectives of mini car are shown in Fig. 5.  $R$  is the complex correlation coefficient between the predicted and measured values.  $R^2$  is the decision coefficient.  $R$  and  $R^2$  of “fashionable” is 0.8369 and 0.7 respectively.  $R$  and  $R^2$  of “delicate” is 0.8681 and 0.7536 respectively.  $R$  and  $R^2$  of “elegant” is 0.8677 and 0.7529 respectively.  $R$  and  $R^2$  of “dexterous” is 0.6626 and 0.439 respectively. It can be found that the first three adjectives have a very strong correlation while the last adjective has a stronger correlation by comparing the relationship between  $R$  value and the reliability. Consequently, the experimental data is true and reliable.

### 5.2.1 Analysis on “Fashionable” Attractive Factor

According to the calculation results of quantification theory I, the biggest partial correlation coefficient of “body color” is 0.8054, which shows the greatest influence on “fashionable” of mini car. “Body color” includes “blue”, “red” and “gray”. “Red” scored the highest, which indicates that red body color strongest stimulates the customers’ “fashionable” emotion. While gray mini car category scored the lowest, indicating gray color may have a negative impact on the customers’ “fashionable” emotion.

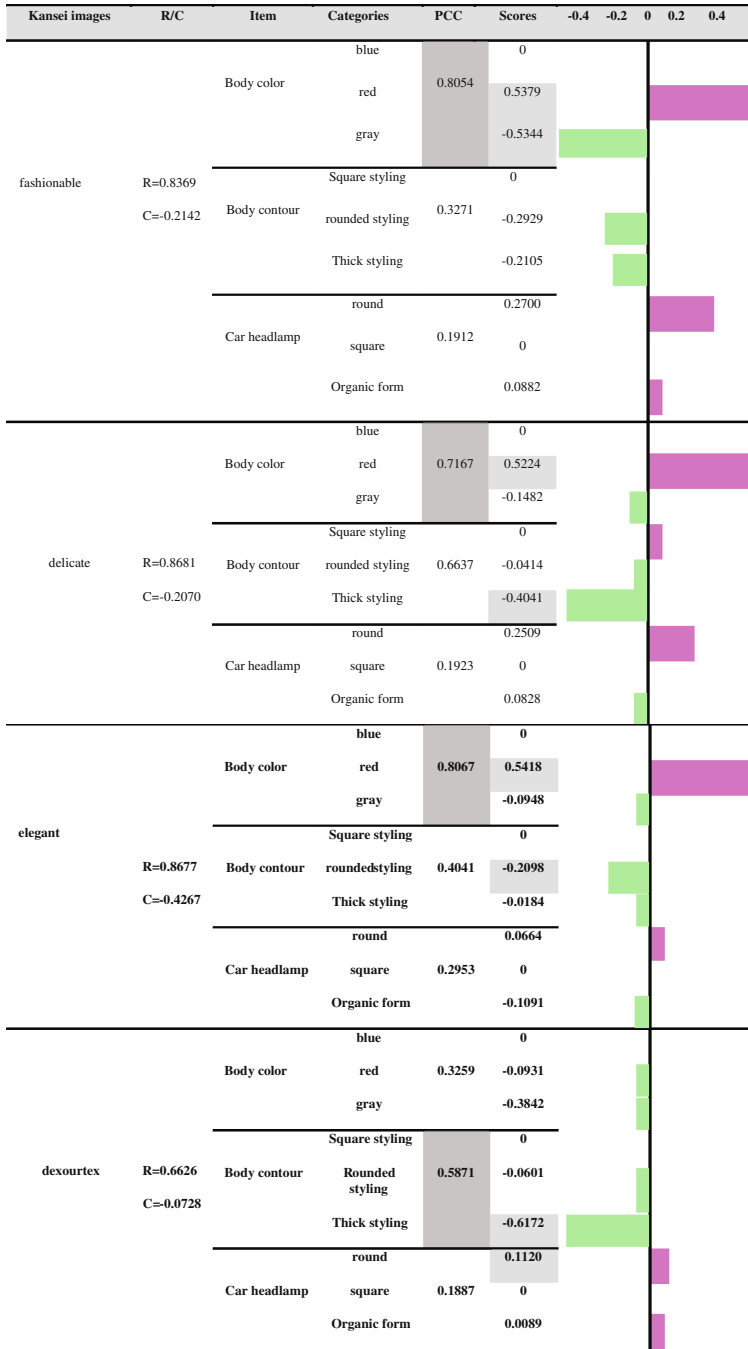


Fig. 5. Weight score of four attractive factors

### 5.2.2 Analysis on “Delicate” Attractive Factors

Among the “delicate” attractive factors, the maximum partial correlation coefficient 0.7167 belongs to “body color”, which converges with that of “fashionable” attractive factors. But the difference of partial correlation coefficient between the “body contour” and “body color” is not significant, which is 0.6637, indicating that both “body contour” and “body color” have a greater contribution to “delicate”. Red body color category got the highest marks while thick body contour category got the lowest, indicating that the bright red body also gives consumers the feeling of exquisite while thick body contours make consumers feel more bulky so that it has a strong negative correlation effect on the feeling of “delicate”.

### 5.2.3 Analysis on “Elegant” Attractive Factors

Among the “elegant” charm factors, red “body color” has the strongest influence on the positive emotion of the customers, while mellow “body contour” has the greatest negative correlation influence. Consequently, in order to create a feeling of elegant, the designers should choose square rather than mellow body contours.

### 5.2.4 Analysis on “Dexterous” Attractive Factors

“Round”, “car headlamps” has the most positive impact on “light” sensuality, but the category score is only 0,112. Relatively its influence is limited. “Thick” body contour category got a score of  $-0.6172$ , which has a strong negative impact on the dexterous feeling of the customers. Consequently, in order to make mini car more dexterous, the designers should try to avoid the use of thick body contours while consider the design of circular car headlamps in practical operation.

In summary, “fashionable”, “delicate” and “elegant” are all strongly positively influenced by red body color while “dexterous” is slightly positively influenced by round headlamps. It can be found that the consumers’ perception is greatly impacted by color choices in product design, which needs to be given enough attention by manufacturers and creative workers. On the other hand, if the designer intends to get more inspiration from the form, body color should be removed during the questionnaire survey so that the respondents can concentrate on the products’ overall shape and details. Then the association between the product shape and emotional intention can be fully obtained by quantification theory I, which provides the designers creative reference.

## 6 Conclusion

In this paper, the form design of mini car in the perceptual consumption times was discussed by Miryoku engineering method. With the he increasingly market competition, new products that accord with the sentiment intention of the customers should be constantly launched so that the enterprises can be in an impregnable position in the business. In this paper, an innovative method that combines design with the customers’ suggestion was proposed from the customers’ subjective point of view. Firstly, the upper abstract, median original and lower specific reasons were analyzed by evaluation grid method of Miryoku engineering. Four attractive factors such as “fashionable”,

“delicate”, “elegant” and “dexterous” were concluded. Then the influence degree of the median original reason (item) and the lower specific reason (category) was connected by statistical method, and the corresponding relation between the sensible vocabulary and the design elements is established by quantification theory I, which provides the designers with theoretical reference. With the customers’ emotional needs become more and more earnest, this research method can effectively increase the market share of new products and reduce the listing risk, and also applies to the research and development of other industrial products.

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