Transdisciplinary Engineering: A Paradigm Shift
C. Chen et al. (Eds.)

doi:10.3233/978-1-61499-779-5-269

Research on Attractive Factors of Electric Motorcycle Design

Ziheng ZHANG[1], Wei DING, Jianxin CHENG, Junnan YE and Tengye LI
School of Art, Design and Media, East China University of Science and Technology, China

Abstract. Abstract goes herElectric motorcycle has become the most popular vehicle for people to travel in the short distance due to its convenience and the environmentally friendly design. With the development of the renewable energy techniques, the electric motorcycle was designed to obtain more flexibility compared to the traditional generation. Considering the situation where the product just appeared and also has fewer restrictions in design, all the designers are now sharing a common struggle about how to meet users' expectation. Kansei Engineering focuses on investigating how people respond to products in emotion and incorporating emotional reaction in product design. Therefore, Kansei Engineering serves as a very effective approach to address the emotional need of users from products.This study is to find out what interests the users in the electric motorcycle by survey. Specifically, the users will be asked to select the most attractive electric motorcycle among all the pictures to locate which part in motorcycle is able to catch their eyes and also give several Kansei words to describe it. Each Kansei word for each product will be scaled according to Liszt table. Then, with collected data, Quantification Theory Type I (QTT-I) will be applied to explore the association between design style and attractiveness. This paper is aimed at providing a design style methodology that is suitable for the brand new product with high degrees of freedom through Kansei Engineeringe.

Keywords. Electric motorcycle, Kansei Engineering, Quantification Theory Type I (QTT-I), Product design.

Introduction

The electric-powered motorcycle is widely welcomed by the consumers as a type of green vehicles. Based on the collected data, the production and inventory of electric motorcycle in China have kept annually increased in recent years and have also reached the first position in the world [1]. Apart from the booming domestic market, the immense potential of the electric motorcycle can also be found in the worldly market. Given that more and more attention has been paid to the environmental issues especially in the developed country, the electric motorcycle with nearly no pollution is facing the golden opportunity to make the stunning development. To satisfy the demand of the market, some corporate giants in the field of motorcycle like Yamaha and Honda have already launched the new product of electric motorcycles to open up the international markets. In America, the demand for electric motors has also increased every year. However, the American consumers have their different

[1] Corresponding Author, Mail: dw.6789@163.com

understanding of this product. Some of them treat riding the electric motorcycles as a sort of entertainment and exercise, while the others also use them for the short journey. As the global center of the manufacturing, China has become the hugest market of electric motorcycles production and distribution due to the distinct advantages of prize and quality. On the other hand, the domestic electric motorcycles factories excessively concentrate on the producing work but relatively neglect the designing part with the barely independent design team. Therefore, the lack of designing capacity leads to they can simply imitate the appearance of the lightweight motorcycles produced by international brands without independent and scientific design [2].

Thus, under the premise of the current technology, the style of electric-powered motorcycle still needs to study around the user preferences [3]. It is the key to design research for the designers to clearly get the form factors of the automobile modeling which improved user satisfaction. Except for the source of transportation, the electric motorcycles also represent the sentimental demand of beauty for the consumers. Thus, it is essential for the designers to make the satisfied design according to the personalized needs figured out from the comprehensive market research. From this perspective, the Kansei engineering should be an effective method which is able to help the designers to understand the consumers' sentimental demand more objectively. The principle and method of using the Kansei Engineering, which can effectively discover and evaluate the vehicle form of attractiveness, and accurately capture the user perceptual image, so as to provide a positive reference for the modeling designer [4-10]. This report is mainly aimed at establishing a research method of designing the outlook of electric motorcycles with the help of Kansei engineering, so that the designers can obtain the more accurate understanding of consumers' preference related to the appearance of electric motors.

1. Method

The pattern of the experiment in this study is indicated in the following contents.

1. Collect the Kansei words and sample pictures related to the appearance of the electric motorcycles and select the typical products and Kansei words through the conclusion of questionnaire survey.
2. According to the analysis of the appearance, pick up the main features and conduct the experiment of Kansei evaluation associated with the table of semantic differential.
3. Conclude the collected data from the experiment of Kansei evaluation and apply the least square method to conduct the quantitative and qualitative analysis to attain the partial correlation coefficient [11].
4. Summarize the reflection relationship between Kansei images and design elements and figure out the design method related to the appearance of electric motorcycle based on the Kansei evaluation.

1.1. Selecting the representative samples

During the investigating and survey, 30 samples which are suitable for the research are picked out from relevant magazines, manufacturer's catalog, websites and forums.

After the considerate group discussion, the ultimate 17 samples are finally decided as indicated in the following pictures (see Figure 1).

Figure 1. The samples of electric motorcycle.

1.2. Sifting and deciding the Kansei words

The appearance of the motorcycle is one of the significant factors for the consumers when they select the electric motorcycles and the subjective feeling will also be created by them for the overall appearance. The main tasks for this stage are to collect, sift and analyze the words which can describe this subjective feeling so that it can provide enough data for the further research. Through the various ways like online survey and brainstorm, over 100 Kansei words in total are collected. Then, the words with opposite meaning are matched together and 30 pairs of the Kansei words are finally obtained. Furthermore, the questionnaire including these 30 pairs of the words is created to sift out the representative Kansei words. To guarantee the accuracy of the investigating, the respondents are required to have the basic knowledge of the electric motorcycles. Finally, 26 students majoring in industrial design are decided as the respondents and each of them is demanded to pick out 10 pairs of Kansei words which are able to describe the characteristics of the appearance of the electric motorcycles. As a consequence, 3 most selected pairs are fashionable vs. retro, flexible vs. steady as well as strong vs. soft.

1.3. Analysis of significant elements of appearances

Given that the appearance of the electric motorcycles is an integral design, it is exceedingly difficult for the designers to make the targeted design. Therefore, to pick out the key point of designing the appearance design must be divided into several parts to conduct the different analysis. 18 respondents are requested to observe the representative samples selected by themselves one by one and point out 3 parts which are most attractive to them. From the compilation of the views held by the respondents, 3 most attractive parts are picked out as the significant attractive items (see Table 1).

Table 1. The choice times of every attractive items.

attractive items	choice times
Headlight	17
Front face	15
Tailstock	15
Headstock	14
Front mudguard	10
The turn light	8
Rearview mirror	5
Cushion	3
Baseboard	3

According to the selected three appearance parts, they are further divided into couples of “design elements”. Therefore, 3 main attractive items and 12 design elements are concluded to attain a classification table (see Table 2).

Table 2. The classification table. Maked A1-A4,B1-B4,C1-C4 for every design elements.

A: headlight	B: front face	C: Tail-stock
A1: Circular arc	B1: square	C1: square
A2: separated in V shape	B2: straight line with sharp angle	C2: lifted tail with sharp angle
A3: circular curve on the head	B3: steam line shape	C3: lifted tail without sharp angle
A4: eye shape on the head	B4: shape of plump curve	C4:plump shape paralleling with the ground

1.4. The experiment conduction of the Kansei evaluation

Combining the 3 pairs of Kansei words sifted from the early stages with the 17 types of electric vehicle samples, the table of semantic difference can be established, which classifies the 3 pairs of Kansei words into 7 levels and scores for: 7,6,5,4,3,2,1.Each sample corresponds to one table of semantic difference to make the questionnaire. The experiment of Kansei evaluation is conducted by the questionnaire which concludes 17 types of electric motorcycles(see Table 3).

During the process of the survey, the respondents make their subjective evaluations to the appearance of these 9 types of electric motorcycles from level 1 to 7. Based on the data from this Kansei evaluation, the average scores of these 17 types of samples related to each pair of Kansei words can be calculated (see Table 4). Due to the restriction of the article length, the example "strong vs. soft" is listed below.

Table 3. The questionnaire of Kansei evaluation.

Fashionable	7	6	5	4	3	2	1	**Retro**
Flexible	7	6	5	4	3	2	1	**Steady**
Strong	7	6	5	4	3	2	1	**Soft**

1.5. Data analysis

To conduct the further analysis of how deeply each appearance element can affect the Kansei attempting of the consumers, the Quantification Theory I is applied to calculate the corresponding average grades of Kansei words to each design element as well as the correlation coefficient between each of the appearance features and Kansei words [12,13]].

At first, it is necessary to establish the "01" matrix (The matched sample is labeled as 1 while the unmatched is labeled as 0) based on the situation of each sample to indicate the average grades related to Kansei evaluation of the sample "strong" (see Table 4).Then the solution of this mathematic model is with the help of Matlab and the category scores of the catalogs can be shown below (see Table 5).

Table 4. The "01" matrix and the average scores of the samples.

No.	average scores	**A1**	**A2**	**A3**	**A4**	**B1**	**B2**	**B3**	**B4**	**C1**	**C2**	**C3**	**C4**
1	1.88	1	0	0	0	0	0	0	1	0	0	0	1
2	1.79	0	0	1	0	0	0	0	1	0	0	0	1
3	2.02	1	0	0	0	0	0	1	0	0	0	0	1
...	...	...	...	...	...	...	...	...	...	...	...	...	...
17	2.45	1	0	0	0	0	0	0	1	1	0	0	0

Table 5. The QTT-I results of "strong vs. soft" .

attractive items	**design elements**	**CS**[a]	**PCC**[b]
Headlight	A1: Circular arc	-0.544	0.381
	A2: Separated in V shape	0.306	
	A3: The circular curve on the head	-0.899	

Front face	A4:The eye shape of the head	-0.211	0.686
	B1:Square	-0.552	
	B2:Straight line shape with sharp angle	1.053	
	B3: Steam line shape	0.771	
	B4: Plump curve	-1.354	
Tail-stock	C1: Square	-0.754	0.589
	C2: Lifted tail with sharp angle	0.949	
	C3:Lifted tail without sharp angle	-0.003	
	C4: Plump shape	-0.754	

Note: [a] Category scores, [b]Partial correlation coefficients.

The table indicates the "CS" and "PCC" of the pair of Kansei words "Strong vs. Soft" obtained from the Quantification Theory I. By the same method, the quantitative analysis can also be conducted for the other two pairs of Kansei words.

The numbers in the column of "CS"and "PCC" displays the relationship between each design element and the importance of the Kansei words in expression, that is, the higher the grades are, the more significant effect this design element can make on the Kansei expression.

2. Results and conclusion

Based on the calculated results of quantitative analysis related to the Kansei words "Strong vs. Soft", the quantitative process of Kansei attempting can be analyzed. In terms of the analysis of "Grades of design elements", the score of "Straight line shape with sharp angle for the front face" is 1.053, which is the highest mark among the design elements. It indicates that if the straight line shape with sharp angle could be applied in the design of front face, the appearance of the motorcycle would approach to the Kansei word "Strong". On the other side, "The shape of plump curve" for the design of front face obtains the lowest score, which is minus 1.354. That is, this kind of design for the front face most approaches to the Kansei word "Soft". According to the calculated partial correlation coefficient, this coefficient for the front face is 0.686 which is the largest one. Therefore, the design of front face should be the most important factor in the expression of the Kansei words "Strong vs. Soft". While the second important one is the design of tail stock with 0.598 and the third one is the outline of the headlight. Then it can be figured out that if the design target tends to be "Strong", the straight line shape with sharp angle for the front face should be the most suitable. As to the other parts of the motorcycle, "V" model for headlight and lifted tail with sharp angle are both beneficial to attain the meaning of "Strong".

This research is concentrated on the appearance design of the light weight electric motorcycle through the experiment on the basis of kansei engineering to obtain the analysis result of how attractive each of the appearance features can be to people and how strong the relationship is among consumers' sentimental demand. Benefited from this research, the following similar design project related to the new product of the electric motorcycles can acquire more reliable theoretical support. From the quantitative calculation of the Kansei words, the more scientific technique is able to be applied by the designer to satisfy more sentimental demand of the consumers.

References

[1] Q. Zhang, *Reserch on electric bicycle design based on Kansei engineering*, Yanshan University, China, 2014.
[2] S. He, *Research on electric bicycle appearance design based on Kansei engineering*, Tianjin University, China, 2014.
[3] H. Hui-tang, *Study on the modeling factors influencing the shape design of electric vehicle*, China Academy of Art, MD, 2008, pp. 8-46.
[4] H. Asano, Miryoku Engineering Practice - Hot commodity production steps, Kaibundo publishing, Japan, 2002.
[5] P. Hekkert, Design aesthetics: principles of pleasure in design, *Psychology Science*, Vol. 48, 2006, pp. 157-172.
[6] C.-H. Chen, L.P. Khoo and N.F. Chen, Consumer Goods, in: J. Stjepandić et al. (eds.) *Concurrent Engineering in the 21st Century: Foundations, Developments and Challenges,* Springer International Publishing Switzerland, 2015, pp. 701-733.
[7] M. Peruzzini, S. Carassai, M. Pellicciari and A.O. Andrisano, Human-centred design of ergonomic workstations in interactive digital mock-ups, in *Advances on Mechanics, Design Engineering and Manufacturing*, 2016, pp.1187-1195.
[8] D. Chang and C-H. Chen, Understanding the influence of customers on product innovation, *International Journal of Agile Systems and Management*, Vol. 7, 2014, Nos. 3/4, pp.348–364.
[9] S. Fukuda, Z. Lulić and J. Stjepandić, FDMU – functional spatial experience beyond DMU?'. In: C. Bil et al. (eds.) *Proceedings of the 20th ISPE International Conference on Concurrent Engineering*, IOS Press, Amsterdam, 2013, pp. 431–440.
[10] J.-Y. Kuo, C.-H. Chen and J. Roberts, An Elicitation Technique for Customer Emotional Requirements Based on Multi-Sensory User Experience, In: M. Borsato et al. (eds.) *Transdisciplinary engineering: crossing boundaries. Proceedings of the 23rd ISPE Inc. International Conference on Transdisciplinary Engineering*, IOS Press, Amsterdam, 2016, pp. 1081-1090.
[11] Y. Ding, Research on small electric vehicle with Kansei engineering, *Journal of Art and design,* China, 2014, pp. 113-115.
[12] F. Zhang and J. Wang, Application of Kansei Engineering in Electric Car Design, Applied Mechanics and Materials, Vol. 437, pp. 985-989, 2013
[13] Y. Li, Based on the theory of quantification of product image design research, *Journal of Machine Design*, China, 2010, pp. 40-43.