

Research on the design of food delivery car based on emotion and axiomatic theory

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Abstract: With the acceleration of social rhythm, people's demand for take-out food is more and more vigorous. At the same time, the progress of science and technology also makes the intelligent food delivery car come into our life. However, how to design the car in modeling and function has become a new problem. This paper proposes a method based on the combination of emotional design and axiomatic design theory, which maps the emotional needs of users to the design of food delivery cars by scientific methods. While paying attention to the functional needs of the car for users, it also pays attention to the emotional needs of users, so that the food delivery car has more market competitiveness. Finally, the design of the car is compared with the existing products in the market. The results show that the method is more in line with the expectations of users in functional modeling and emotional experience.

1. Introduction

With the improvement of modern science and technology and the enhancement of people's consumption ability, product design has gradually changed from enterprise led to user-led [1]. However, only designing products to meet the basic needs of users can not meet the increasingly fierce market competition. It is an essential basis for product development and design at this stage to pay attention to the emotional needs of users and take this as the starting point to transform them into a reasonable product design scheme.

In the principles of design, Professor Nam P. Suh of MIT proposed the axiomatic design theory, which is a scientific design decision-making method [2]. The axiomatic theory provides an adequate theoretical framework for product design, which helps designers avoid too subjective product design in the process of design, so as to make scientific and effective product decision-making and provide a rational design scheme for product innovation design. Lindholm D studied the problem of design decision. Through the split and merge of axiomatic design process, the concept of design process decision tree was deduced, which provided another possibility for axiomatic design [3]. Guenov MD established the decomposition model of complex products, combined with the structured representation method of judgment matrix, expressed the mapping relationship of AD, so as to identify potential conflicts in design [4].

However, the axiomatic design also has its disadvantages. It pays too much attention to the mapping of functional product requirements to product design, but it can not guarantee the emotional needs of users for products, failing to ensure whether the product design results meet the expectations of users. In the design process of the food delivery car, in addition to the guidance of scientific design theory, designers also need to grasp the emotional needs of users, including the basic functions. This requires designers to investigate and analyze the emotional needs of users, to avoid relying on their own experience to judge the needs of products simply. In this paper, first of all, three levels of emotional design are used, including instinct level, behavior level, and reflection level to obtain the user's demand for the product, to ensure the user's emotional experience. Then the axiomatic design is used to map the product needs to the design of the food delivery car, to maximize

the guarantee that the design results of the food delivery car meet the functional and emotional needs of users.

2. Product emotional needs analysis

This section describes how to extract design elements of user requirements from emotional design. The user's emotion is often changeable and complex, and there is no fixed and unified form. The definition of emotion is also different, because of the different background cultures. However, the factor patterns that cause emotion have generality and regularity. Emotional design is the purpose of using these patterns to cause people's reactions [5]. Donald Norman divides user's emotion into three levels, including instinct level, behavior level, and reflection level [6]. Correspondingly, the three levels can be expressed as aesthetic appeal, basic appeal and meaning appeal, as shown in Figure 1.

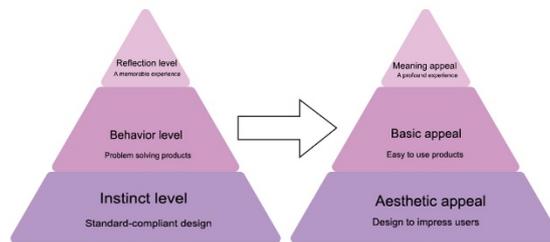


Figure 1. Three levels of emotional design.

2.1 Instinct level

Users will generally feel a product with their emotional expectations. The instinct level is the first level for users to verify whether the product is consistent with their expectations in terms of vision and other feelings before they deeply understand a product, which is the most direct response of users to the product. Generally, in the design of this part, the aesthetic appeal of users should be considered, and the product should be placed in the cultural and environmental background of the target audience to ensure that the initial impression of users on the product will not be excluded. The main design factors to be considered include modeling, materials, colors, processing technology, and cultural background.

2.2 Behavior level

The behavior level focuses on the realization of product functions and the user experience in the process of using the product. Emotional design of products is not merely to achieve a certain function but to express its function in a reasonable and simple way. Its core is to optimize human-computer interaction behavior, conform to ergonomics, and improve the comfort and fluency of using products.

2.3 Reflection level

The reflection level consists of many factors, including instinct, behavior, culture, education and personal experience. The reflection layer is the conscious thinking of the product after the user experiences the product. It is also the resonance with the product on the ideological level and the blending in the emotional experience. Designers in the design of reflection layer should consider based on the situation, starting from users, reflecting on culture, combining with aesthetics, and integrating into life. To sum up, the model of emotional design requirements is obtained, as shown in Figure 2.

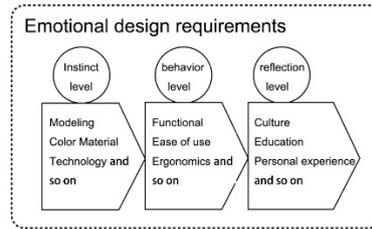


Figure 2. Emotional Design User Requirements

3. An axiomatic design model combining emotional design requirements

Through the analysis of three levels of emotional design, the emotional needs of users at each level are obtained. These elements are taken as user needs, combined with axiomatic design, the user needs are reasonably mapped to product design. The design process of axiomatic design is considered to be composed of user domain, functional domain, structural domain and process domain. Each domain has its own elements, which correspond to customer needs (CNs), function needs (FNs), design parameters (DPs) and process variables (PVs) [7]. Axiomatic design standardizes the design process and enables product design to be carried out in a scientific way [8]. The mapping relationship between functional domain, structural domain and process domain is "Z", and the system framework designed by axiom is shown in figure 3.

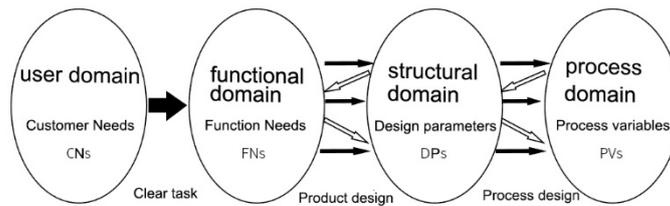


Figure 3. Axiomatic Design Framework

In the process of axiomatic design, the quality of a product design decision depends on two basic design axioms.

3.1 Independence axiom:

Functional needs are independent design parameters, only affect their corresponding functions. The relationship between FNS and DNS can be expressed in mathematical expression as follows: $\{FN\} = [A] \{DP\}$, $\{FN\}$ represents functional requirements, $\{DP\}$ represents design parameters, and $[A]$ represents design matrix. In most cases, the number of functional needs is the same as the number of design parameters, which is called the ideal case. When the number of functional needs is greater than the design parameters, it is called coupling design. When the number of functional needs is less than the design parameters, we call it redundant design.

3.2 Information axiom:

Based on the first independent axiom, minimize the content of information and reduce the complexity of design. Its function can provide quantitative measurement for the designated product design, so as to select the scheme with high design value.

The key of axiomatic design is to transform the design language: Transforming the needs information proposed by users into the engineering language needed by design developers [9]. After the designers extract, analyze and conceptualize the user's needs through the emotional design method, the designer uses the standardized way to show the user's desired functions in a parameterized and structured approach for better product design. The model from emotional design to axiomatic design is shown in Figure 4.

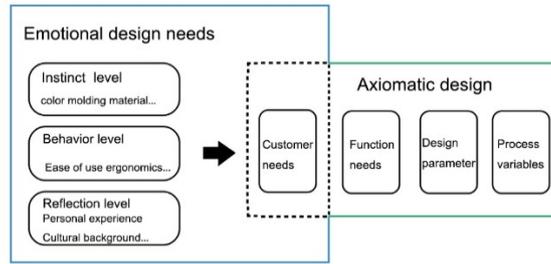


Figure 4. Emotional design to axiomatic design model

4. A case study of food delivery car design.

4.1 Analysis of emotional needs in the design of delivery car

Analyze and investigate the users who have the demand for takeout. The target users are mainly divided into two categories. One is college students, whose needs are obtained through face-to-face interviews, and the other is mainly aimed at people who are not used to cooking. Demand is achieved through online questionnaires. A total of 100 questionnaires were distributed, and 81 valid questionnaires were obtained. The research mainly focuses on the three layers of emotional design: the instinct level, which tends to focus on the visual aspect, the behavior level, which tends to focus on the human-computer interaction function, and the reflection level, which focuses on the product personality and the emotional communication with users. The comprehensive statistical results of the two research methods are shown in table 1.

Table 1. Emotional design needs

Emotional design needs					
Instinct level		Behavior level		Reflection level	
Modelling	Novel	Function	location security	Culture	Symbolism
Material	Corrosion resistance		easy to use	Personality	Personality performance
Color	Easy to identify	Scenarios	Campus Residential Office building	Emotional Multichannel interaction	

4.2 Design of food delivery car based on axiomatization

In this part, we need to map the emotional needs of the product to the product design of the car through the principle of axiomatic design. First of all, emotional design is regarded as the user requirements and functional requirements of axiomatic design. The mapping relationship between functional requirements and design parameters based on instinct level and axiomatic design is as follows:

$$\begin{Bmatrix} F_1 \\ F_2 \\ F_3 \end{Bmatrix} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{Bmatrix} P_1 \\ P_2 \\ P_3 \end{Bmatrix}$$

In formula:

F_1 - Novel shape	P_1 - Different from the traditional design
F_2 - Corrosion resistance	P_2 - An antioxidant coating can be applied to conventional materials
F_3 - Easy to identify colors	P_3 - A certain visual recognition system in the formula

Product function will affect the design of product modeling. The emotional performance of products will also affect the stickiness of users to products, so it is necessary to further analyze the emotional needs of behavior level and reflection level that have an impact on product modeling.

F₄ - Convenient to take meal

P₄ - The modeling size of the product should be controlled within a certain range consistent with the human body (As shown in Figure 5)

F₅ - The delivery car can be used in many scenarios

P₅ - A certain vertical distance between the chassis of the delivery car and the ground (As shown in Figure 5)

F₆ - Corporate culture symbol

P₆ = Expression of visual recognition information

F₇ - Expression of emotional information

P₇ - Screen displays emotional information (As shown in Figure 5)

F₈ - Multi-channel interaction form

P₈ - Microphone, external amplifier, touch feedback and screen display

Second level mapping decomposition of F₄ in functional requirements:

F₄₁ - Positioning of the food delivery car

P₄₁ - Antenna setting of the delivery car

F₄₂ - Interactive function

P₄₂ - Design the operation and interaction interface corresponding to meal taking

F₄₃ - The safety of preventing taking meal by mistake

P₄₃ - Take meal by corresponding verification code

F₄₄ - The size of the body's position for taking food

P₄₄ - The design of the product shall conform to the size and size of the ergonomics

F₄₅ - Convenience of taking meal

P₄₅ - The setting of the position of the meal taking interactive interface should be convenient for the user to operate, and the interface should be as simple as possible. (As shown in Figure 5)

Through the above axiomatic theoretical analysis, the corresponding modeling parameters are obtained. The modeling design of the dining car is shown in the figure 6.

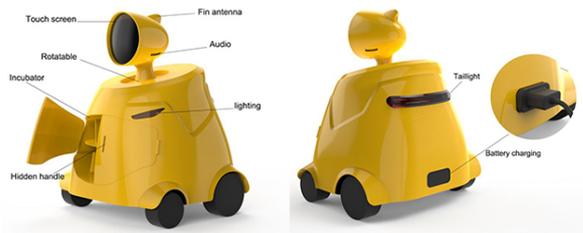
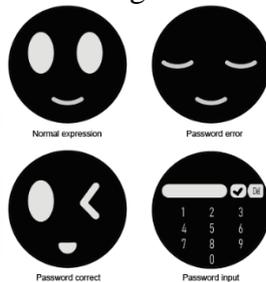
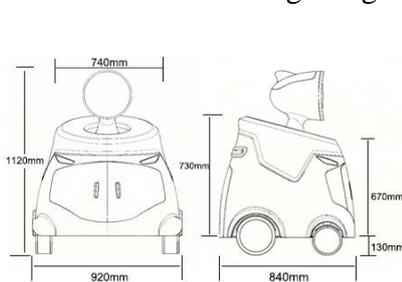


Figure 5. Size and expression of the food delivery car delivery car

Figure 6. Design results of food delivery car

Based on axiomatic theory, the modeling of the food delivery car is different from the traditional design. It fully considers the user's emotional experience, including novel appearance, convenient manipulation and emotional interaction. The main functions of each part of the delivery car are analyzed as follows:

The head part mainly includes touch screen, horn and fin antenna. The screen can be used for interaction, the speaker can feedback the voice results after the interaction with the user, and the fin-shaped antenna contains GPS, so that the user can locate the position of the dining car. The head of the food delivery car can rotate, which can deal with users in different directions in the actual use scenario, and can also add certain emotional effects to the food delivery car.

When the user enters the verification code on the screen, the door on the body will open automatically. When the dining car is driving on the road, the lights in front of the car body will play the role of lighting and steering, and the tail lights will play the role of steering and deceleration reminders. The charging port under the rear of the car can be used for charging.

Because the design of product modeling is subjective, it is an uncertain and complex process of design solution [10]. So when the delivery car is designed, compare it with the product on the market, as shown in Figure 7. The emotional needs obtained from the above research were selected as the

keywords for evaluation, and semantic word scale was designed, as shown in Table 2. Attitude was divided into six levels from negative to unexpected, corresponding to 1 to 6 points respectively. Finally, 20 regular takeout people were invited to review respectively. Get the average score, the higher the score, the better the product design.

The evaluation results are shown in Figure 8 below. The safety score of the product designed in this paper is 0.1 points lower than that of the other products. The specific score can be directly seen from the line chart. The total average score of each product designed in this paper is 30.3, which is better than that of the other product, which is 28.2. There is a big gap, especially in the novelty of modeling and emotional interaction.

Table 2. The main functions of each part of the food delivery car

Emotional needs	Negative attitude	A small amount of recognition	Basic recognition	Better recognition	Highly recognized	Unexpected degree
Novel modeling	○	○	○	○	○	○
Easy to identify	○	○	○	○	○	○
Safety	○	○	○	○	○	○
Ease of use	○	○	○	○	○	○
Suitable for various road conditions	○	○	○	○	○	○
Emotional interaction	○	○	○	○	○	○



Figure 7. The product on the market

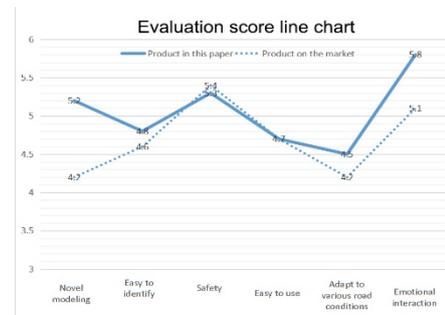


Figure 8. The product on the market

5. Conclusion

Good product design not only needs to have the product shape, which conforms to the esthetics characteristic but also needs to have a reasonable function and the emotion interaction way. Designers should not only deeply understand the use situation of the product, but also pay attention to the user experience, and comprehensively consider the product design from various aspects. This paper proves that emotional design is decomposed into three levels: instinct level, behavior level and reflection level. It is a feasible and innovative method to obtain users' emotional needs for products at three levels through investigation and then uses axiomatic theory to guide product design process scientifically. At the same time, the method based on the combination of emotional experience and axiomatic design theory is used to design the food delivery car. Through the comparison with the existing products on the market, it is shown that the food delivery car designed in this way is easier to meet users' expectations and improve users' emotional experience.

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