Design of Sleep-Aided Eye Mask Based on Kano Model

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Abstract. With the development of modern society, people’s pressure is increasing and the quality of sleep is also declining. Having a good sleep is the most basic way to maintain good health. The rise of intelligent products promotes the market of intelligent wearable devices, and more and more people begin to pay attention to the business opportunities of "sleep market". Kano model, as a research method of user requirements, can classify and prioritize user requirements, therefore this paper proposes the product design process framework based obtaining requirements by a Kano model. First, the investigation of "sleep market" was discussed, analyzed. Second, brainstorming method and a Kano questionnaire have been used to identify the demand. 31 valid questionnaires were collected and used to calculate the Better-Worse coefficient which was used to rank the obtained demands. Final, using the classified demands to guide the product design of sleep-aided eye mask.

1 Introduction

In recent years, affected by the fast pace of life and the increasing psychological pressure, there are increasingly sub-health people with sleep disorders. The most basic way to keep healthy is to improve the quality of sleep to get a good rest. In the past four years, the majority of people who consult sleep disorders through Chunyu doctor platform are young people aged 20 to 29 \cite{1}. In China, the insomnia problem of people living in the first-tier cities is more serious.

The development of science and technology has brought many new products related to sleep, such as sleep aid application, smart bracelet for monitoring sleep, smart earplug, etc. Eye mask is an important derivative of sleeping. The function of eye mask is to wear it on the eyes to protect or block the light because of everyone's differently sensitivity. Many people will wear an eye mask for travel sleep or nap in daily life. With the continuous development of the industry, eye mask is no longer a common shade cloth which has gradually become an intelligent sleep aid tool.

In addition to sleep problems, some eye diseases such as xerophthalmia which is caused by facing the computer screen for a long time every day are also very common modern diseases. Medicine has proved that eye hot compress can promote the blood circulation around the eyes, and reduce the symptoms of eye fatigue. If the patients with xerophthalmia can persist doing it, it will greatly help to alleviate the discomfort, and for ordinary people, it also has a certain preventive effect \cite{5}.

Kano model is used to classify and prioritize customer requirements to analyze consumers’ perceived satisfaction concerning different function quality elements. Inspired by the "Dual-factor Theory" proposed by Frederick Herzberg, an American psychologist in the early years, Noriaki Kano, a professor at Tokyo University of technology, proposed Kano model \cite{2}. A Kano model is a good tool to study user requirements which can reflect the non-linear relationship between product performance and consumers’ satisfaction.

Therefore, in the second part of this paper introduces the product design method of sleep-aided eye mask (SAEM) based on Kano model. In the third part, using SAEM product design as the carrier shows the framework and procedure of design by this method. Firstly, the research situation of "Sleep Market" was discussed, then the existing related products had been enumerated, analyzed.
and compared with the advantages and disadvantages of these products. Secondly, the data had been collected by making and distributing Kano questionnaire, and used to cross analysis to classify requirements and calculate the Better-Worse coefficient to study users' satisfaction with quality elements. Finally, the obtained requirements were used to orient the product design direction. 3D modeling and prototype were used to present the final product renderings.

2 Study of requirements analysis based on Kano

2.1 Marketing research

According to the research, the eye masks on the market can be divided into two categories: ordinary heating eye mask and intelligent eye mask. Table 1 lists some properties, advantages and disadvantages of various products. The user generated content of various websites is used to get the user's evaluation of different eye mask products, which shows that although people have high expectations for intelligent eye mask, they are more willing to accept a cost-effective eye mask that can help sleep at present. Through investigation and interview, the target population of the product is determined, as shown in Table 2.

Table 1. Properties, advantages and disadvantages of various eye mask products.

| Type                        | Price         | Working principle | Advantages                              | Disadvantages                                      |
|-----------------------------|---------------|-------------------|-----------------------------------------|---------------------------------------------------|
| Disposable heating eye mask | Under 10RMB   | Chemical reaction | Independent packaging, portability and hygiene | High cost of long-term use, non-environmental protection |
| USB heating eye mask        | 60 to 120RMB  | Resistance Heating| Reuse                                   | Unworkable without the power bank                  |
| Intelligent eye mask        | Over 249RMB   | Complex circuit   | Intelligent detection, intelligent wake-up, etc. | Large volume, high price and imperfect technical support |

Table 2. Target users.

| Qualification condition | Describe                                      |
|-------------------------|------------------------------------------------|
| Age                     | 15 to 40                                       |
| Expectations for products| Practicability and cost performance            |
| Attitude to scientific and technological products | Willing to purchase if it meets the functional expectation and the product price is reasonable. |
| User roup characteristics | High pressure on study and work                |
|                         | Using eyes for a long time                     |
|                         | Difficulty falling asleep                      |
|                         | Suffer from myopia, xerophthalmia and other eye diseases |
|                         | Sensitive to light                             |
|                         | Frequent long-distance travel                  |

2.2 Function satisfaction evaluation based on Kano

The brainstorming method had been used to obtain the requirements of SAEM which were divided into five categories by cards sort, as shown in Table 3. Kano model was used to classify the acquired requirements. The setting of the questions of the questionnaire needs to designed based on the Kano two-dimensional model of quality respectively, and five options were set for each question (Table 4). On the one hand, it is used to measure the user's response to the existence or absence of one function quality element; on the other hand, it can skillfully eliminate invalid questionnaires.

The requirements results can be divided into the following types: Must-be Quality (M), One-dimensional Quality (O), Attractive Quality (A), Indifferent Quality (I), Reverse Quality (R) and Questionable (Q) (Table 5).
Table 3. Keywords of customer requirements.

| Modelling       | Feature             | Storage          | Interactive quality | Science and technology          |
|-----------------|---------------------|------------------|---------------------|---------------------------------|
| No pressure on the eyes | Washable | Aromatherapy | Social sharing | Wireless control |
| Solid           | Reuse               | usable           | Mobile application | Repeated charging |
| Light-proof     | Hot pack            | Having storage box |                   | Intelligent monitoring |
| Adjustable      | Pattern             |                  |                    | Sleep wake up |
| Portable        | Texture             |                  |                    |                   |
| Detachable      |                     |                  |                    |                   |

Table 4. An example of Kano questionnaire.

| Question                                                                 | Option                      |
|-------------------------------------------------------------------------|-----------------------------|
| Product with the function (e.g. If the sleep mask does not cause pressure to the eyes, how do you feel?) | ○ Satisfied ○ Must-be ○ Indifferent ○ Tolerable |
| Product without the function (e.g. If the sleep mask cause pressure to the eyes, how do you feel?) | ○ Satisfied ○ Indifferent ○ Tolerable |

Table 5. Kano evaluation matrix.

| Product without the function | Satisfied | Must-be | Indifferent | Tolerable | Dissatisfied |
|-----------------------------|-----------|--------|-------------|-----------|--------------|
| Product with the function   | ○         | ○      | ○           | ○         | ○            |
| Satisfied                   | Q         | A      | A           | A         | O            |
| Must-be                     | R         | I      | I           | I         | M            |
| Indifferent                 | R         | I      | I           | I         | M            |
| Tolerable                   | R         | I      | I           | I         | M            |
| Dissatisfied                | R         | R      | R           | R         | Q            |

In addition to directly observing the result list to obtain some requirements information, by calculating the Better-Worse coefficient by equation (1), (2), the impact of function quality element on customers’ satisfaction can be given.

\[ \text{Better} = \frac{A + O}{A + O + M + I} \]  
\[ \text{Worse} = \frac{- (M + O)}{A + O + M + I} \]

The value of Better is a positive number, which means that if a product provides the function quality element, the consumers’ satisfaction will be improved. The larger the positive value is, the stronger the effect of improving customer satisfaction will be; The value of Worse is negative, indicating that if the product does not provide the function quality element, the consumers’ satisfaction will be reduced. Similarly, the greater the negative value is, the stronger the effect of decreasing customer satisfaction will be; Therefore, according to the Better-Worse coefficient, the function quality element with higher absolute score of coefficient should be implemented first.

Generally, in order to express these requirements more clearly, these requirements data can be put in the coordinate system. The abscissa is the Worse coefficient and the ordinate is the Better coefficient, which can more intuitively reflect the characteristics of each type of requirements.

After determining the demand priority, the orient of designing product had been decided. Making multiple product solutions, the design of the optimal scheme which was chosen from various concepts by the comprehensive evaluation will be refined. Autodesk Fusion 360 will be used to build 3D model, and prototype of the product will also be made.

3 Result

3.1 Data analysis

A total of 39 questionnaires were collected and 8 invalid ones were eliminated. Perceived satisfaction of every function quality elements was measured by a five-point Likert scale. Cross analyze was used to obtain the classification of each function quality element, and equation (1), (2) were used to calculate the Better coefficient and the Worse coefficient. Due to the limited space, the table only lists the top ten function quality elements (Table 6).
Table 6. Kano quality element classification and customer satisfaction coefficients (section).

| Element              | A. | O. | M. | L. | R. | Kano Quality Classification | Better | Worse |
|----------------------|----|----|----|----|----|-----------------------------|---------|-------|
| Adjustable           | 22 | 9  | 0  | 0  | 0  | A                           | 1       | -0.29 |
| Portable             | 15 | 11 | 5  | 0  | 0  | A                           | 0.84    | -0.52 |
| Wireless control     | 3  | 22 | 6  | 0  | 0  | O                           | 0.81    | -0.9  |
| Mobile application   | 0  | 20 | 3  | 8  | 0  | O                           | 0.65    | -0.74 |
| Reuse                | 17 | 3  | 6  | 5  | 0  | A                           | 0.65    | -0.29 |
| Detachable           | 17 | 3  | 0  | 11 | 0  | A                           | 0.65    | -0.1  |
| Hot pack             | 9  | 8  | 5  | 6  | 3  | A                           | 0.61    | -0.46 |
| Having storage box   | 17 | 0  | 5  | 9  | 0  | A                           | 0.55    | -0.16 |
| Repeated charging    | 9  | 6  | 11 | 5  | 0  | M                           | 0.48    | -0.55 |
| No pressure on the eyes | 0  | 15 | 16 | 0  | 0  | M                           | 0.48    | -1    |
| Social sharing       | 8  | 0  | 0  | 12 | 11 | I                           | 0.4     | 0     |

Then, the customer satisfaction is plotted on the x-axis (Equation (1)) and the customer dissatisfaction without a function is plotted on the y-axis (Equation (2)) (Fig. 1).

![Figure 1. Customer satisfaction distribution matrix.](image)

According to the Table 6 and Figure 1, there are some findings. For example, the ratio of “portable” for the “attractive”, “one-dimensional”, “must-be”, “indifferent” and “reverse” respectively was 15, 11, 5, 0, and 0. Among the five groups of data, the group with the highest vote was considered as the classification of this quality element. The coefficients of the Better and the Worse of this quality element respectively were 0.84 and -0.52, which means when the quality element exists, the impact on customers’ satisfaction is greater than when the quality existing does not exist. In the process of product development, the priority of functions is generally: M > O > A > I [3]. Therefore, the Must-be quality elements of the SAEM were “light-proof”, “repeated charging”, “no pressure on the eyes”. The One-dimensional quality elements of the SAEM were “wireless control”, “mobile phone application”. And the attractive quality elements were “adjustable”, “portable”, “reuse”, “detachable”, “hot pack”. These function quality elements will orient the SAEM designing.

3.2 Product design of SAEM

The consumers’ function quality elements had been used for the preliminary modeling design
(Fig. 2 (a)). Several concepts of "detachable" were displayed in Fig. 2 (b). Finally, a way to attach the heat module to the body of the SAEM with the metal button was chosen and to be refined (Fig. 2(c)).

(a) Preliminary sketch  
(b) Concepts of "detachable"  
(c) Final concept

Figure 2. Product sketches evolution.

The 3D model was made with Autodesk fusion360 software, Fig. 3 (a) is the overall perspective, Fig. 3 (b) is the exploded view of the product, and Fig. 3 (c) is the dimensional view of the product. Fig. 4 is the design of mobile application interface.

(a) Perspective view  
(b) Exploded view  
(c) Dimensions

Figure 3. Model drawing and dimension drawing of product.

The temperature of dry hot compress on eyes method is generally about 40 centigrade, 15 to 20 minutes each time [5], so the three levels of temperature of eye mask were set as 38 centigrade, 40 centigrade and 42 centigrade respectively, and the maximum duration of a single time is 30 minutes (Fig. 4 (a)). Fig. 4 (b) shows the social sharing interface of application. And the prototype was made (Fig. 4 (c)).

(a) Three levels of temperature  
(b) Social sharing interface  
(c) Prototype

Figure 4. Mobile application interface and prototype.

4 Conclusion

This paper shows the process of using Kano model to obtain user requirements, classify and prioritize requirements, and then apply requirements to product design. In this study, 16 function quality elements were obtained, and each quality feature was classified by cross analysis method, and which features had a greater impact on user satisfaction was evaluated. Then, the result was applied to design a user-centered product that meets the needs of users.

Kano model can evaluate consumers' perception of various functions, and then indicated the satisfaction value of various functions. Therefore, Kano model can be widely used in the early development and later iterative maintenance of products. Kano model can evaluate the acquired demand effectively, but there are some deficiencies in acquiring the potential demand. In the process of product design, a variety of methods of demand acquisition should be combined to obtain forward-looking demand data, so as to bring vitality to products and enterprises.

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