Research on Modeling Design of Ear Thermometer Based on User Image

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Abstract. The purpose is to enable users to obtain a better perception experience and enhance the user's perceptual needs recognition of the appearance of the ear thermometer. The method is guided by the kansei engineering theory, through quantitative analysis of perceptual needs evaluation and eye tracking test. Obtain the mapping relationship between the vocabulary representing the sexy image and the modeling features of the ear thermometer, and conduct the example design of the product form of the ear thermometer based on user needs. Conclusion The design practice verifies that the ear thermometer design method based on user image preference has high feasibility. Provide product development directions for related companies and designers.

1. Introduction

A product perceptual design is a product development technology that prioritizes consumer imagery, a product design technology that transforms consumer perceptions or images of products into new product design elements, and continues to develop and optimize[1]. Su Jianning[2][3] and others put forward an optimal design method based on the perceptual image through the future development direction of the product. Djatna[4] Data carried out the construction of perceptual space based on fuzzy quantitative theory and carried out product development. Feng qing[5] ting uses the semantic differentiation method and semantic variables to obtain the perceptually perceptual relevant data of the target product, summarizes the user needs with the data statistics, and performs perceptual design. Based on the perceptual characteristics of consumers, Wang Xinting[6] integrates the theory of object knowledge classification, thus establishing modeling knowledge base and designing the scheme. The use of Kansei engineering theory to integrate multi-disciplinary domain knowledge to obtain design elements has gradually attracted widespread attention. Zhang Yue[7] conducted a perceptual demand survey on consumers. In order to obtain the perceptual needs of consumers for product packaging, key design elements that affect consumer emotions were extracted through eye movement test indicators and consumer perceptual needs; and And through quantitative class theory and The the relationship between design elements establishes a mathematical model for packaging design. Feng Yixiong[8] and others conducted in-depth research on performance-oriented customized products, and combined the sensory image evaluation method in product research, using EEG to collect signal from the user's sensory image, and used this as the main basis to verify the product's performance. Based on the sensitivity of user, Qian Hao[9] combined the product image bionics method with fuzzy evaluation method. By screening the perceptual vocabulary pairs, the mathematical matrix was established and analyzed to obtain the mapping relationship between the characteristics of the biomimetic and the
product modeling elements, and the user's comprehensive evaluation value of the scheme is used to improve and optimize the design scheme. Yuan Shuzhi[10] and others used the Kansei engineering method to establish a perceptual index evaluation system. According to the fuzziness of perceptual engineering evaluation, a comprehensive evaluation model combining intuitive fuzzy set theory and TOPSIS method was established, and a multi-image evaluation method for human-machine interface based on Kansei engineering was proposed. To quantify people's sensibility to things or products through statistical methods, the key point is how to accurately grasp consumers' sensibility to products and establish the relationship between sensibility and product elements.

At present, due to the continuous development of technology, people's awareness of medical care is constantly improving, the Minamata Convention restricts mercury-containing products, and the spread of new coronavirus pneumonia. A variety of new electronic thermometers are rapidly entering user 'life, and attention should be paid to the improvement of the user' perceived experience brought about by related products. This article uses the theory of Kansei engineering to take the ear thermometer as the research object, through qualitative and quantitative analysis, establishes the modeling feature mapping relationship, obtains the user's perceptual image modeling features, guides the innovative design of the ear thermometer, and provides a new design idea.

2. Product samples and emotional vocabulary selection

2.1. Image sample screening

Ear thermometer samples are widely collected on websites at home and abroad. During the collection process, 180 samples were collected based on research principles, diversified product shapes and suitable image angles, and interference factors such as trademarks were removed by using image processing software. According to the first impression of the product, the approximate shape classification was carried out, finally, 50 sample pictures were retained. In order to further select samples, a research group (industrial design students, 10 males and females) was organized to classify 50 sample into 10 categories. According to the classification results, the similarity was described by formula (1), where $S = \frac{F}{T}$, which represents the similarity of the two pictures, $F$ represents the number of times two samples appear in the same category, $T$ represents the number of times the same sample appears in the same category. According to similar situations, 10 samples were finally selected as shown in Figure 1.

$$S = \frac{F}{T}$$

![Figure 1. The finalized representative 10 ear thermometer samples.](image)

2.2. Perceptual vocabulary screening

A large amount of perceptual vocabulary was collected from relevant research literature and research materials, and 160 suitable vocabularies were collected. After the classification and summary of the research team, 50 perceptual words were obtained and 25 pairs of perceptual words were formed. In order to further refine the 25 perceptual vocabulary pairs, the KJ method was used to extract the perceptual vocabulary. After extraction, 6 groups of perceptual vocabulary pairs were finally obtained, as shown in Table 1.
Table 1. 6 groups of vocabulary after screening.

| Safe-dangerous | Soft-hard | Lightweight-heavy |
|----------------|----------|--------------------|
| Technological-backward | Soothing-nervous | Exquisite-rough |

3. The mapping relationship between perceptual image vocabulary and key modeling features

3.1. Evaluation of styling image

Taking the 10 representative image samples and 6 sets of perceptual image vocabulary selected above as the evaluation experimental materials, a total of 50 testers (undergraduate and graduate students majoring in industrial design) were selected. The testers evaluated through their subjective feelings. The experiment was conducted in the form of a questionnaire. The Semantic Differential (SD) 7-level scale was used to grade the emotional vocabulary. There are 7 levels in total, -3~3,0 is neutral, which means no special feelings, -3 and 3 corresponds to the two ends of the scale, representing the weakest and strongest feelings. After sorting out the results of the questionnaire, the average value of image evaluation is obtained, as shown in Table 2.

Table 2. The average value of each image evaluation of representative samples.

| Target sample | Safe-dangerous | Soft-hard | Lightweight-heavy | Technological-backward | Soothing-nervous | Exquisite-rough |
|---------------|----------------|----------|-------------------|------------------------|-----------------|----------------|
| Sample 1      | 0.77           | 1.22     | 0.11              | 0.36                   | 1.22            | 1.76           |
| Sample 2      | 1.99           | 2.24     | 0.24              | 1.51                   | 1.09            | 1.21           |
| Sample 3      | -1.82          | -1.84    | -1.2              | -1.5                   | -1.44           | -1.6           |
| Sample 4      | -1.88          | -2.62    | -2.04             | -2.42                  | -2.48           | -2.46          |
| Sample 5      | 1.03           | 0.51     | 2.44              | 0.22                   | 0.26            | 1.61           |
| Sample 6      | -1.22          | -1.04    | -1.26             | -1.4                   | -0.82           | -1.74          |
| Sample 7      | 0.8            | 1.32     | 2.36              | -1.22                  | 0.8             | 0.4            |
| Sample 8      | 2.22           | 2.06     | 1.1               | 2.52                   | 2.02            | 1.92           |
| Sample 9      | -1.38          | -0.62    | 1.14              | -1.8                   | -0.94           | -1.98          |
| Sample 10     | -0.28          | -0.8     | -0.58             | 0.76                   | 0.88            | 0.42           |

3.2. Evaluation results of styling imagery

The perceptual value is the preference of each adjective. The positive value indicates that the sample is biased toward the positive adjective; the negative value indicates that the sample is biased toward the negative adjective in the perceptual direction. According to the data obtained by the above-mentioned perceptual image evaluation experiment, the sample 8 is outstanding in terms of safety, technology, soothing and refinement, sample 2 is outstanding in softness, sample 5 is more representative in terms of portability, and sample 1 is balanced in all aspects. The overall performance is sample 8> sample 2> sample 5> other samples.

3.3. Eye tracking experiment

Psychological research shows that vision can help humans obtain 80% of the outside world's information, and can make preference judgments on gazing things, and can effectively obtain users' mental activities through eye-tracking technology[11]. This eye-tracking experiment equipment uses experiment-related data recording and analysis software such as the German SMI RED desktop eye tracker and experiment center. After screening, 10 sample pictures were processed by removing color, uniform background, uniform size and other influencing factors, numbered from 1 to 10, as shown in Figure 1. In this experiment, a total of 20 subjects with normal eyesight were recruited, and relevant operation guidance was given to them to ensure the smooth progress of the experiment. This
experiment was divided into two phases. In the first stage, ten sample pictures were arranged on the same plane. After eye movement calibration, the subjects were free to observe the picture of the sample for 30 seconds. In the second stage, the positions of the 10 sample pictures arranged on the plane were reordered and used as experimental materials. After eye movement calibration, observe the sample pictures on the plane for 30 seconds again. The eye-tracking experiment process is shown in Figure 2.

Figure 2. Subjects are conducting eye tracking experiments.

3.4. Eye tracking experiment results
According to the above eye-tracking experiment, many eye movement indicators have been obtained. Including eye-tracking area of interest (AOI), heat map (Heat Map), gaze time (Dwell Time [ms]) and other related gaze indicators, the experimental heat map is shown in Figure 3. According to the purpose of the experiment, the eye movement indicators are screened. Among the many eye movement indicators, gaze time, number of fixations, and saccades are the best indicators to reflect the attention distribution of the subjects. The Event Statistics module is used to export the relevant eye movement index data. According to the data, in terms of the average number of fixations, sample 8>sample 2>sample 5>other samples; in terms of average gaze time, sample 8>sample 2>sample 5>other samples; the results of the two eye movement indicators are consistent. It is consistent with the experimental results of the modeling imagery evaluation conducted previously. According to eye-tracking technology and cognitive psychology, when a subject observes freely, the greater the interest in a certain area, the longer the observation time for that area[12]. Through the above experimental results, it can be seen that the mapping relationship between the representative image vocabulary of the ear thermometer and the key modeling features is effectively established. The subjects' interest in Sample 8, Sample 2 and Sample 5 are significantly greater than that of other samples, Sample 8, Sample 2 and The characteristics of the ear thermometer model of sample 5 need to be studied and designed. The data of eye movement experiment are shown in Table 3.

Figure 3. Eye tracking experiment heat map.
Table 3. Likert scale of flow.

| Eye tracking indicators | Sample 1 | Sample 2 | Sample 3 | Sample 4 | Sample 5 | Sample 6 | Sample 7 | Sample 8 | Sample 9 | Sample 10 |
|-------------------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|
| Average number of fixations | 4.6      | 5.8      | 2.2      | 2.1      | 5.5      | 2.4      | 4.1      | 7.1      | 2.7      | 3.4       |
| Average gaze time/s     | 0.28     | 0.36     | 0.18     | 0.16     | 0.33     | 0.21     | 0.25     | 0.42     | 0.19     | 0.24      |

4. Examples of ear thermometer design

Through the above research, the user's preference of the ear thermometer shape is excavated, and the sample 8 shape is selected to carry out innovative product design. According to the difference between the perceived value of sample 8 and the modeling characteristics of sample 8 and other samples, the softness and form of the whole line were summarized. Integrity, the curved surface of the hand-held part hand-held and the fusion and coordination of the shape of the probe and the hand-held part. Attention should also be paid to the outstanding performance of other samples in perception mode. For example, the overall shape of Sample 2 gives a strong sense of softness. As an in-ear temperature detector, softness can bring good perception and user experience to users. Similarly, sample 7 is a light and representative form, and can also be used as a reference in the innovative design of odometer design. Based on the above, the innovative design of the ear thermometer design was carried out, and CINEMA 4D was used to build a three-dimensional model of the product, see Figure 4.

![Figure 4. 3D model design drawing.](image)

In order to verify whether the product design scheme meets the user's needs, the final effect diagram of the perceptual image evaluation sample was drawn, 30 questionnaires were distributed, 27 valid questionnaires were collected, and data statistics were carried out, and the average image evaluation value is obtained, as shown in Table 4. Through the image average value, we can see that the design scheme of the ear temperature gun product has a high score in the safety, technology, ease and refinement of the six groups of perceptual vocabulary, and the soft and light ones have also been improved to meet the design requirements summarized in the early stage. The rendering effect diagram is shown in Figure 5, and the actual user experience display of the design results is shown in Figure 6.
Figure 5. Rendering of the shape design of the ear thermometer.

Figure 6. Design results user actual experience display.

Table 4. Final product image evaluation average.

| Perceptual vocabulary          | Image evaluation average |
|--------------------------------|--------------------------|
| Safe-dangerous                 | 2.28                     |
| Soft-hard                      | 2.35                     |
| Lightweight-heavy              | 2.11                     |
| Technological-backward         | 2.47                     |
| Soothing-nervous               | 2.09                     |
| Exquisite-rough                | 1.82                     |

5. Conclusion
According to the user's perceived demand for the ear thermometer, combined with the eye movement test method, the abstract perceived demand is quantified as the design basis, and the mapping relationship between perceived image vocabulary and the key modeling features of the ear thermometer is mined, the perceived features of the product are extracted, the user's perceived image is obtained, and the innovative design of the ear thermometer is carried out based on the perceived image. The effectiveness of the modeling design method of ear thermometer based on the perceptual image is verified, which can provide a certain reference for the modeling design of similar products.

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