Research on the Design of Portable Desktop Air Purifier based on Kansei Engineering

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ABSTRACT Following societal events involving air, such as haze and COVID-19, Chinese people's need for air purifiers has skyrocketed. The matching degree between the appearance of air purifier and the user's subjective preference becomes an important factor affecting the user's purchase decision. In this paper, we utilize the portable desktop air purifier as an example of how to address customers' perceptual needs in the air purifier's product appearance design, based on the Kansei engineering. We established product sample space through market research and literature reading, extracted product design elements, collected perceptual image words, then used semantic difference method to measure users' perceptual needs, and obtained key perceptual image words by factor analysis. Then partial correlation analysis is conducted on the results of the above methods to determine the translation link between design elements and perceptual image space, and a set of design methodologies for a portable desktop air purifier based on Kansei engineering was obtained. Finally, a genuine development project is used to validate the method's practicality. The findings of this study not only aid in the design and development of air purifiers but also provide research ideas and methodologies for air purifier appearance design to fulfill the perceptual needs of consumers.

INDEX TERMS Kansei Engineering, air purifier, factor analysis, industrial design

I. INTRODUCTION

With the rapid development of China's industrialization at the expense of the environment, environmental pollution is becoming more and more serious. Since 2013, frequent haze has occurred in Beijing, Tianjin, and Hebei region of China [1]. In the same year, China began measuring and evaluating air quality, and people were increasingly concerned about air quality [2]. As a result, China's air purifier market began to explode. China has achieved great accomplishments in environmental pollution control in recent years, with the frequency of haze significantly reduced. Since 2018, the Chinese air purifier market has transitioned from rapid expansion to stable development [3]. However, people who are allergic to pollen and dust mites transmitted through the air still need air purification. In 2020, novel coronavirus spread rapidly around the world, leading to a significant increase in public awareness of preventing airborne viruses [4]. And because of COVID-19, people are restricted from going out and staying indoors for longer. The demand for air purification in the indoor environment is growing again.

At present, the research on air purifier mainly focuses on in-depth research on product purification technology and hardware structure innovation [5]. Previous studies on air purifiers from the perspective of product design mainly focus on user experience and interaction design and are closely related to the Internet. Products based on basic functions can no longer meet the needs of consumers [6]. Under the impact of COVID-19, users have higher requirements for the functionality and availability of air purifiers. At present, the air purifier market is gradually changing from enterprise to user[7]. Apart from external considerations such as marketing strategy, product look is one of the most important aspects influencing consumers' purchasing decisions, assuming that product functionality and usability are comparable[8]. Zhang Liying comprehensive analysis of air purifier industry overview and market prospects but also pointed out the necessity and urgency of air purifier product modeling design[9]. And in
the air purifier market, portable desktop air purifiers are more favored by consumers [10]. At present, previous studies on the appearance design of air purifiers are mainly medium-sized vertical air purifiers, while there are few studies on the appearance modeling of portable desktop air purifiers. Desktop products are at the user's fingertips, and the actual use of close to the user of the product, compared with large and medium-sized, and the actual use of far away from the user of the product need to pay more attention to the appearance of the product modeling, and for the appearance of the modeling requirements are higher. Moreover, users' emotional resonance and perceptual cognition of desktop products will also affect their purchase decisions[11]. However, there are few types of research on the effect of user's perceptual demand on the appearance design of air purifier.

Users' perceptual needs refer to their appeal for a certain product, including dissatisfaction with existing products and potential needs for future products [12]. People usually study users' perceptual demand through Kansei engineering. Kansei engineering is a technology that systematically excavates people's feelings towards products and converts them into product design elements. The basic hypothesis of its research is the relationship between product form features and users' perceptual demand [13]. In the study of non-physical products, Lian Jiayi built a product service system design model integrating the theoretical methods of Kansei Engineering, and proposed the content and method of service optimization design of shared bike service system according to users' emotional demands for product service system. Guided by user perception[14]. Wang Qianqian proposed a service design framework method based on Kansei Engineering and Kano model, and verified its validity and feasibility. In terms of physical product research, it can be divided into three aspects of product color, material and modeling. By extracting perceptual intention information and color design samples of products[15]. Wu Tianyu and Zhao Yigan proposed a product color perceptual design method by using the method of hybrid kansei engineering[16]. Feng Yajuan applied kansei engineering theory to analyze the influence of material physical characteristics on perceived difference, and established the connection between abstract perceptual intention words and material key physical characteristics. Based on the principles and methods of Kansei engineering[17]. Hu Weifeng et al. studied the mapping relationship between automobile modeling feature lines and perceptual image words, and the results guided the modeling design of OFF-road vehicles, so as to improve the matching degree between the modeling design of off-road vehicles and perceptual image[18]. In the study of the perceptual demand for air purifiers, Liang Jing [19] used semantic difference (SD) experiment combined with eye movement experiment to obtain users' cognitive and perceptual needs for air purifier outlet design, and obtained users' preference for air purifier outlet location. Bai Renfei and Zhang Junxia [20] analyzed the influence of five design elements on users' perceptual cognition from the perspective of product modeling based on the theory of inferential Kansei engineering and SD experiment. Shi Yaojun and Sun Mingming [21] obtained the average value of perceptual semantic elements on the basis of the SD experiment, extracted perceptual elements of intelligent air purifier design, and improved the form of air purifier. As mentioned above, some scholars have conducted several studies on air purifiers based on the Kansei engineering method, indicating that it is feasible to use this method to study air purifiers. However, the number of design elements extracted from the studies so far is less, and there is no scientific quantitative analysis on the translation between perceptual needs and design elements. On the other hand, because the volume of air purifier products varies widely between application ranges, affecting product appearance, different design element extraction requirements should be employed for products of various volumes. However, the samples of air purifiers were not strictly classified in the study domain in previous studies, and the wide range of research had an impact on the research outcomes.

Based on the concept of Kansei Engineering, this study takes the design of portable desktop air purifier as an example to explore how to meet the perceptual needs of users in product appearance design. In this study, SD experiment, FA and quantitative and qualitative analysis were combined to complete the translation of perceptual needs and design elements, and a design and verification method for portable desktop air purifier was proposed. The focus of this paper is how to meet the perceptual needs of users in appearance design without evaluating the functionality and usability of products. The specific research steps are shown in Figure 1.
II. ESTABLISHMENT OF PRODUCT SAMPLE SPACE AND EXTRACTION OF DESIGN ELEMENTS

A. ESTABLISHMENT OF PRODUCT SAMPLE SPACE

The establishment of product sample space for portable desktop air purifiers is divided into three steps. The first step is to determine the product research domain, the second step is to collect and sort out relevant product samples through investigation and screen out products that do not meet the research domain, and the third step is to screen representative products from 67 product samples by Delphi method.

1) DETERMINE THE RESEARCH AREA

The focus of this study is to determine the impact of user's perceptual demand on the air purifier in three aspects: shape, color, and material. Through investigation, we found that the air purifier products of various brands have a high identity in color and material. The color is mainly black and white gray and the material is mainly ABS plastic. Therefore, this study takes modeling design as the main research object, material and color as the auxiliary research object. But the product research domain needs to be further explained.

In terms of applicable area, air purifiers are mainly divided into three categories: large, medium, and small. The general applicable area of large and medium-sized air purifiers can reach 30 m\(^2\)-50 m\(^2\). Small air purifiers are mainly desktop air purifiers, with a general applicable area of less than 10 m\(^2\). The portable desktop air purifier studied in this paper belongs to a small air purifier in terms of volume. Figure 2 shows the dimensions of some portable desktop air purifiers according to market research and statistics. As can be seen from Figure 2, the length and width of most portable desktop air purifiers are between 50mm-250mm, and the width of a small number of purifiers with a length of 250mm-300mm is also between 100mm-200mm.

2) PRODUCT SAMPLE DATA SORTING

The study's product samples were obtained through an online shopping platform. In the beginning, as many air purifier products as possible were collected, and afterward, items not related to the research field were excluded, yielding 67 product samples. The background and trademark of the sample picture are eliminated to eliminate brand interference and too many colors, and the sample is decolorized, just keep only the lightness of the color. Figure 3 is an example of the final product sample effect.

3) PRODUCT SAMPLE SCREENING

As mentioned above, 67 samples of portable desktop air purifiers were preliminarily selected through investigation and collection. Because the sample size is large and this study focuses on modeling research, the Delphi method [22] is used to screen the representative samples in the sample library and determine the final product sample library. An expert group of five product designers is involved in this process. Designers have a high capacity to identify, and their product modeling classification can be more precise. Finally, the products are sorted into eight groups, with each category receiving a representative product sample. After that, 8 samples are chosen (Table 1).

| Sample Number | Figure | Sample Number | Figure |
|---------------|--------|---------------|--------|
| 1             | 5      |               | 6      |

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B. DESIGN ELEMENTS EXTRACTION OF PORTABLE DESKTOP AIR PURIFIER

This study focuses on modeling, supplemented by material and color. When extracting the overall modeling elements, this study considers that each product sample may not occupy all the features of the modeling form [23], so the extraction of the overall product modeling elements is carried out on the basis of the established product sample space with representative modeling in the research area. Second, product design features are frequently classified as discrete or continuous attributes [6]. The discrete attribute denotes the selection of classification among a limited set of factors, such as the kind of air outlet and the material classification. Continuous attributes, such as the aspect ratio, usually have some regularity to measure and the variables are continuous. In this study, morphological analysis was utilized to extract modeling elements based on the above analysis [24]. The morphological analysis establishes product modeling aspects in a straightforward and easy-to-understand manner, allowing for the combination of continuous and discrete data. In Kansei Engineering research, it is the most widely used technology.

The design aspects of portable desktop air purifier products are classified into 3 categories after splitting the design elements and extracting the essential analysis items: modeling elements, color elements, and material elements. The modeling elements are divided into 2 categories: overall modeling and component features. There are 6 categories in total: 5 subcategories of facade modeling and one subcategory of cross-section modeling. There are 3 types of component features: air outlet, air inlet, and switch adjustment. There are 9 categories in all, including 4 subcategories of air exit and air inlet and 1 subclass of switch adjustment. Color elements and material elements both have 2 subcategories respectively. A total of 19 product design element categories are extracted. Table 2 shows the subordination and specific categories of design elements. The smallest design element unit is coded for aspect expression.

| TABLE 2   |
|-----------|

| Design Elements | Graphic Feature Analysis and Numbering |
|-----------------|---------------------------------------|
| Overall modeling | Length to height ratio | 1 > \( \frac{1}{3} \) (A1) |
| Facade | Center of gravity | Center of gravity downward (B1) |
| | | Center of gravity centered (B2) |
| | | Center of gravity upward (B3) |
| | Outline | Shrinkage (C1) |
| | | Vertical (C2) |
| | | Right-angle (D1) |
| | | Small rounded corner (D2) |
| | | Large rounded corners (D3) |
| | At the bottom of the round corner | Right-angle (E1) |
| | | Small rounded corner (E2) |
| | | Large rounded corners (E3) |
| | Cross-section | Shape | Round (F1) |
| | | Rounded square (F2) |
| | | Right Angle square (F3) |
| | | Rounded rectangle (F4) |
| Component features | Air outlet | Form | Grid (G1) |
| | | Lattice (G2) |
| | | Vortex (G3) |
| | | Strip (G4) |
III. PERCEPTUAL NEEDS MEASUREMENT AND TRANSLATION OF PERCEPTUAL NEEDS AND DESIGN ELEMENTS

A. PERCEPTUAL IMAGE SPACE EXTRACTION

1) PERCEPTUAL WORD COLLECTION

By collecting consumers' feelings and comments on portable desktop air purifiers, and reading the literature to find relevant words describing such products, more than 100 perceptual words about portable desktop air purifiers were collected. Then, similar words were classified and summarized to extract representative words. Finally, 26 perceptual words describing portable desktop air purifier were obtained (Table 3).

| Perceptual words |
|------------------|
| Graceful         |
| Exquisite        |
| Clean            |
| Smooth           |
| Comfortable      |
| Relaxed          |
| Textured         |
| Crafts           |
| Stylish          |
| Versatile        |
| Elegant          |
| Firm             |
| Lovely           |
| Practical        |
| Atmospheric      |
| Youthful         |
| Vigorous         |
| Bionic           |
| Simple           |
| Interesting      |
| Intimate         |
| Mellow           |
| Unique           |
| Technological    |
| Innovative       |

This study uses Delphi method to determine the final perceptual image space. The designer expert team evaluates the preliminary perceptual vocabulary and determines 6 perceptual vocabularies. Then, 6 perceptual vocabularies and words with opposite meanings are formed into perceptual image phrases, and the final perceptual image space is obtained (Table 4).

| TABLE 4 PERCEPTUAL IMAGE SPACE |
|--------------------------------|
| Practical - Unpractical        |
| Textured - untextured          |

TABLE 3 COLLECTION OF PERCEPTUAL WORDS

| Perceptual words |
|------------------|
| Graceful         |
| Exquisite        |
| Clean            |
| Smooth           |
| Comfortable      |
| Relaxed          |
| Textured         |
| Crafts           |
| Stylish          |
| Versatile        |
| Elegant          |
| Firm             |
| Lovely           |
| Practical        |
| Atmospheric      |
| Youthful         |
| Vigorous         |
| Bionic           |
| Simple           |
| Interesting      |
| Intimate         |
| Mellow           |
| Unique           |
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2) SEMANTIC DIFFERENCE EXPERIMENT

**1° DESIGN**

The scale of perceptual evaluation was established by SD experiment. A pair of perceptual vocabulary pairs were placed at the left and right ends of the scale, and the scale was divided into five levels, with scores marked from left to right, 2, 1, 0, -1, and -2 respectively. A score of 2 means "very left-leaning", a score of 1 means "quite left-leaning", a score of 0 means "neutral", a score of -1 means "quite right-leaning", and a score of -2 means "very right-leaning". The score of perceptual evaluation of each sample was obtained by asking the subjects to fill in the scale, and their perceptual preference for the sample was obtained, as shown in Table 6. This study was carried out by sending out questionnaires and conducting a network survey. Table 5 is an example in the questionnaire. The sample image is on the left, while the vocabulary group conveying perceptual images and their evaluation criteria is on the right. Subjects need to observe the sample on the left, judge its perceptual images, and check the corresponding score on the right. Furthermore, due to the picture's fixed shooting angle, some crucial design features of the product are not visible. A comparable perspective is configured in the lower right corner of the image for such samples to illustrate the design elements (Fig. 4).

**TABLE 5**

| Evaluation of perceptual image | Sample 1 | Sample 2 | Sample 3 | Sample 4 | Sample 5 | Sample 6 | Sample 7 | Sample 8 |
|-------------------------------|----------|----------|----------|----------|----------|----------|----------|----------|
| Practical-Unpractical         | 1.056    | 0.865    | 0.427    | 1.034    |
| Comfortable-Awkward           | 1.029    | 1.067    | 0.573    | 0.753    |
| Firm-Fragile                  | 0.888    | 0.820    | 0.753    | 0.921    |
| Textured-untextured           | 0.787    | 0.438    | 0.539    | 0.461    |
| Exquisite-Coarse              | 0.787    | 1.124    | 0.528    | 0.213    |
| Smooth-Blocked                | 0.820    | 1.169    | 0.697    | 0.539    |

**B. FACTOR ANALYSIS OF PERCEPTUAL IMAGE SPACE**

A large amount of data is not conducive to effective analysis. To grasp the main factors of perceptual image vocabulary, it is necessary to reduce the dimension of perceptual image space. FA is a method of quantitative analysis of implicit variables. By using factor analysis, the quantitative data of
perceptual image space can be condensed into several factors, the minimum number of factors that can explain the most information can be calculated, and the factor loading of each perceptual image space on the factors can be compared. Finally, we can find out the perceptual image space to grasp the main factors.

1) SOFTWARE AND PROCEDURE

SPSS (Statistical Product and Service Solutions) is often used for data statistics and analysis, data prediction and decision making. SPSSAU is an online SPSS analysis software, which is more intelligent than SPSS software installed on the computer.

The statistical results were imported into SPSSAU for factor analysis, and the maximum variance rotation method was used for rotation, so as to find out the corresponding relationship between factors and perceptual image space. Finally, the variance explanation rate table (Table 8) and the Factor loading after rotation table (Table 9) were obtained.

### TABLE 8

| Factor Number | Eigenvalues | Variance explained rate % | Accumulation % | Eigenvalues | Variance explained rate % | Accumulation % | Eigenvalues | Variance explained rate % | Accumulation % |
|---------------|-------------|---------------------------|----------------|-------------|---------------------------|----------------|-------------|---------------------------|----------------|
| 1             | 3.889       | 64.821                    |                | 3.889       | 64.821                    |                | 2.789       | 46.482                    |                |
| 2             | 1.459       | 24.313                    | 89.134         | 1.459       | 24.313                    | 89.134         | 2.559       | 42.653                    | 89.134         |
| 3             | 0.463       | 7.719                     | 96.853         | -           | -                         | -              | -           | -                         | -              |
| 4             | 0.138       | 2.306                     | 99.159         | -           | -                         | -              | -           | -                         | -              |
| 5             | 0.040       | 0.672                     | 99.831         | -           | -                         | -              | -           | -                         | -              |
| 6             | 0.010       | 0.169                     | 100.00         | -           | -                         | -              | -           | -                         | -              |

### TABLE 9

| Adjective         | Factor Loading |
|-------------------|----------------|
| Practical - Unpractical | 0.067          |
| Comfortable - Awkward | 0.539          |
| Firm - Fragile    | 0.163          |
| Textured - untextured | 0.831          |
| Exquisite - Coarse | 0.959          |
| Smooth - Blocked  | 0.926          |
| Practical - Unpractical | 0.932          |
| Comfortable - Awkward | 0.800          |
| Firm - Fragile    | 0.911          |
| Textured - untextured | 0.408          |
| Exquisite - Coarse | 0.233          |
| Smooth - Blocked  | 0.006          |

2) FACTOR EXTRACTION

The purpose of factor analysis is to extract a few common factors to explain the factor model. If too many factors are selected, the significance of applying FA will be lost. According to the factor extraction criteria, the factor whose characteristic root is greater than 1 and the cumulative contribution rate is more than 85% is taken as the common factor [25].

According to Table 8, the eigenvalue of factor 1 is 3.889, and the variance explanation rate after rotation is 46.482%; the eigenvalue of factor 2 is 1.459, and the variance explanation rate after rotation is 42.653%, and the cumulative variance explanation rate of the two factors is 89.134%. The variance explanation rate represents the proportion of information that can be extracted from analysis items by factors. The proportion of information that can be extracted from perceptual image space by factors 1 and 2 is nearly 90%, which can represent most of the information. So, factor 1 and factor 2 are extracted as the main factors.

Secondly, factor loading represents the degree of relationship between factor and analysis item. When the absolute value of factor loading of analysis item to factor is higher than 0.4, it indicates that there is a corresponding relationship between item and factor; when it is lower than 0.4, the corresponding relationship is small. As can be seen from Table 9, among the factor loading of factor 1, "exquisite - coarse" has the best correspondence with factor 1, and the rest are "smooth - blocked", "textured - untextured", and "comfortable - awkward". But, the factor loading of "practical - unpractical" and "firm - fragile" are both less than 0.4, which means the corresponding relationship is not obvious. In the factor loading of factor 2, the perceptual image space "practical - unpractical" and the corresponding relation of factor 2 is best, the rest of the "strong - fragile", "comfortable - awkward", "textured- untextured". But "exquisite - rough" and "smooth - blocking" factor loading is less than 0.4, which means there's less correspondence with factor 2.

Then, as shown in Table 8, the variance explanation rates of factor 1 and factor 2 after rotation are 46.482% and 42.653% respectively, and the explanation rate ratio of the two factors is close to 1:1. Therefore, the item with the
largest loading coefficient among the two factors is extracted as the key item. In factor 1, the "exquisite -- rough" items are extracted, and in factor 2, the "practical - unpractical" items are extracted.

After extracting the factor, combining it with the score of perceptual words in the SD experiment, the two perceptual words "practical" and "exquisite" are finally determined by the Delphi method.

C. FILE FORMATS FOR GRAPHICS

The translation of design elements and perceptual image space is mainly divided into three steps. The first step is to assign values to the analyzed design elements, the second step is to analyze the partial correlation between design elements and perceptual vocabulary, and the third step is to select an appropriate amount of design elements according to the principle of correlation.

1) ASSIGNMENT

On the basis of the screened and coded design elements, different design element units were assigned to the screened 8 samples. The assignment is summarized in Table 10.

| Sample Number | Facade Modeling | Design Elements Assignment |
|---------------|-----------------|----------------------------|
| Sample Number | Length to Height Ratio | Density |
| 1             | A2 B1 C2 D2 E3 F1 |
| 2             | A2 B2 C1 D1 E1 F3 |
| 3             | A1 B2 C1 D3 E3 F1 |
| 4             | A4 B1 C1 D3 E2 F1 |
| 5             | A3 B2 C1 D1 E1 F1 |
| 6             | A1 B3 C1 D1 E2 F2 |
| 7             | A1 B1 C2 D3 E1 F4 |
| 8             | A3 B3 C1 D1 E2 F2 |
| Sample Number | Form | Area | Location | Density | Area | Location |
| 1             | G3 H3 I2 J1 K5 L2 M3 N3 |
| 2             | G4 H1 I1 J2 K4 L4 M2 N3 |
| 3             | G1 H2 I4 J2 K1 L1 M1 N1 |
| 4             | G2 H3 I2 J1 K2 L3 M4 N2 |
| 5             | G3 H4 I3 J1 K3 L3 M4 N2 |
| 6             | G1 H2 I4 J1 K3 L2 M2 N2 |
| 7             | G4 H4 I3 J2 K5 L2 M3 N3 |
| 8             | G2 H2 I3 J2 K2 L2 M4 N2 |

2) PARTIAL CORRELATION ANALYSIS

Taking the design elements assignment table in Table 10 as the analysis item and the two perceptual words "practical" and "exquisite" extracted from the FA as the control variables, partial correlation analysis was carried out in SPSSAU. The correlation degree of product design elements to perceptual image space is shown in Table 11.

| Design Elements | Practical | Exquisite |
|-----------------|-----------|-----------|
| Length to Height Ratio | 0.186 | -0.293 |
| Center of Gravity | 0.588 | -0.023 |
| Outline | -0.390 | -0.182 |
| Rounded corners at the top | -0.738 | 0.291 |
| At the bottom of the round corner | 0.323 | 0.715 |
| Cross-section shape | -0.611 | -0.661 |
| Air outlet | -0.386 | -0.661 |
| Air inlet | -0.311 | -0.199 |
| Area | 0.099 | 0.374 |
| Form | -0.434 | -0.355 |
| Density | -0.214 | -0.391 |
| Air inlet | -0.016 | -0.430 |
| Area | 0.054 | -0.610 |
| Switch adjustment | -0.742 | 0.138 |
| Main color | -0.581 | 0.403 |
| Distinguish between lightness | 0.189 | -0.592 |
| Main material | -0.750 | -0.481 |
| Material number | -0.223 | -0.391 |

3) RESULT

According to the principle of correlation analysis, the correlation coefficient and degree follow the following law: When the absolute value of the correlation coefficient is less than 0.3, the correlation degree is irrelevant; When the absolute value of the correlation coefficient is between 0.3 and 0.5, the correlation degree is weak. When the absolute value of the correlation coefficient is between 0.5 and 0.8, the correlation is moderate. When the absolute value of the correlation coefficient is between 0.8 and 1.0, the correlation is strong. When the correlation coefficient is positive, the correlation is positive; When the correlation coefficient is negative, the correlation is negative.

In order to screen out appropriate design elements to facilitate the actual design and development work. In this study, design elements whose absolute correlation coefficient is greater than 0.5 are selected as elements related to perceptual images. The results are shown in Table 12 and Table 13.

| Design Elements | The "Practical" Correlation Coefficient |
|-----------------|---------------------------------------|
| Main material | -0.750 |
| Switch Adjustment | -0.742 |
| Rounded corners at the top of the facade | -0.738 |
The "Exquisite" Correlation

The main material elements are negatively correlated with the practicality, and matte material reflects lower practicality. Higher practicality, matte material reflects moderate practicality, which indicates that smooth material reflects R2 is the matte material, and R3 is the matte material. The multi-key button, and O4 is a one-key button. There is a display screen touch, O2 is the silkscreen touch, O3 is a while the other elements are negatively correlated.

The center of gravity of the facade is positively correlated, while the mode of switch adjustment is biased towards the one-button mode, the adjustment is biased towards the display screen, the rounded corners at the top of the facade are negatively correlated, and the practicality, indicating that when the mode of switch adjustment is biased towards the display screen, the practicality is strong, while when the mode of switch adjustment is biased towards the one-button mode, the practicality is weak.

In the main material element R, R1 is the smooth material, R2 is the matte material, and R3 is the matte material. The main material elements are negatively correlated with the practicality, which indicates that smooth material reflects higher practicality, matte material reflects moderate practicality, and matte material reflects lower practicality.

Among the switch adjustment elements O, O1 is the display screen touch, O2 is the silkscreen touch, O3 is a multi-key button, and O4 is a one-key button. There is a negative correlation between the form of switch adjustment and the practicality, indicating that when the shape of cross-section tends to be round, smooth, and stable, it gives people a more exquisite feeling. When the shape of cross-section tends to be angular and unstable, the exquisite feeling decreases.

Among the form elements G of the air outlet, G1 is in grid form, G2 is in lattice form, G3 is in vortex form and G4 is in bar form. When the air outlet form tends to grid, lattice form, it will be more exquisite; It is less refined when it tends to scroll and strip forms.

In the area factor M of the air inlet, there are 4 features, from M1 to M4, which represent very small, small, moderate, and large area. The air intake elements are negatively correlated with the "exquisite" perceptual image, indicating that the smaller the air intake area is, the more exquisite it is, while the larger the air intake area is, the less exquisite it is.

There are 3 features in the lightness differentiation factor Q, which means that the number of lightness differentiation is 1 to 3. There is a negative correlation between the elements of lightness differentiation and the sense of exquisiteness. The less the lightness differentiation, the more the color tends to the sense of unity, and the more exquisite it appears. Conversely, it declines.

Among the position elements N of the air inlet, N1, N2, and N3 represent that the air inlet is located on the top, side, and bottom of the purifier in turn. The position of the air inlet is negatively correlated with the sense of exquisiteness. The
lower the position of the air inlet, the lower the sense of exquisiteness.

In the bottom rounded corner elements E of the facade, E1, E2, and E3 represent edges, small rounded corners and large rounded corners. The lower fillet elements are positively correlated with "exquisite", and the larger the relative size of the fillet, the more prominent the “exquisite” perceptual image.

According to the above research and discussion, a design method of portable desktop air purifier based on Kansei engineering is arranged, as shown in Figure 5.
V. PRACTICAL PROJECT JUSTIFICATION

In order to verify the design method in FIG. 5, this study relies on a horizontal project actually developed by an enterprise for verification. After discussion, the following design requirements can be summarized.

1) DESIGN REQUIREMENTS

The portable desktop air purifier developed in this paper should meet the needs of the general population, and be able to be used in home and office environments while focusing on students. The product needs to meet the requirements of small shape, easy to carry, put on the table to use, need to ensure the purification effect, do not consider the wearable micro air purifier, the traditional filter type purification.

2) SOLUTIONS WASH

In the design process of Scheme 1, Rhino software is used for modeling and Keyshot software for rendering. The scheme rendering and three views are shown in Figures 6 and 7.

3) DESIGN TEST

The image trend of the product and the perceptual tendency of each design element are judged by identifying the position of the design elements in scheme 1 in the perceptual image detection system.

4) DESIGN IMPROVEMENTS

Scheme 1 is improved to obtain Scheme 2 based on the aforesaid detection results (Figure 9). Figure 10 depicts the enhanced scheme's image detection. The company has also accepted the design scheme.

In this study, the design method of portable desktop air purifier was used for the actual project development. The products designed by this method were recognized by enterprises, and the usability of the design method of portable desktop air purifier was verified.
VI. CONCLUSION

In this study, the appearance design of portable desktop air purifier is studied by the theoretical method of Kansei engineering. On the basis of establishing product sample database and extracting product design elements. The SD experiment and FA were used to extract perceptual image space, and combined with qualitative and quantitative analysis, the translation relationship between product design elements and perceptual image was established, and the design method of portable desktop air purifier based on Kansei engineering was put forward. Finally, real design project experience demonstrated the usefulness of this method.

However, due to individual differences, the factors affecting consumers’ perceptual images are complicated, and the perceptual images in each period are also different. Coupled with the limitations of Kansei Engineering itself, the research on users’ perceptual needs still faces challenges. In addition, the design elements of discrete attributes and continuous attributes were assigned uniformly when we extract the design elements of the product. It is unknown to see if more scientific and feasible quantification can be reached if discrete and continuous attributes are addressed independently in future research. More rigorous research and verification are needed in the future.

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