www.cadanda.com
Computer-Aided Design AND APPLICATIONS

Product Appearance Design Based on Consumers' Kansei Image and Fuzzy Kano Model Satisfaction Evaluation - Case Study of Air Purifier

Yixiang Wu[1]

[1]Yiwu Industrial and Commercial College, Yiwu 322000, Zhejiang, China, 3316162376@qq.com

Corresponding author: Yixiang Wu, 3316162376@qq.com

Abstract. In the product design, it's crucial to accurately judge the consumer preferences on appearance images, thereby frequently these superior product designs that embody consumer psychological perception could get more attention. Therefore, "kansei images" of air purifier appearance were imported into "C-FKQ Quality Model" entitled with particular "quality attributes" to explore the relationship between kansei images and customer satisfaction in this article. Firstly,16 kansei image adjectives were selected as evaluation index items, subsequently, the 16 kansei image adjectives were categorized as 5 high-attractive qualities, 7 low-attractive qualities and 4 indifferent qualities according the scores degree. And secondly, the air purifier design style with the highest priori-ty is then selected, the creative thinking design methods including basic style information, landscape and biological association are applied to capture the product characteristics and define the air purifier design style direction. Lastly, the determined scheme C gets significantly higher score than the other four schemes in terms of the comprehensive evaluation score, indicating that air purifier product designed in scheme C successfully realized the combination of natural image and actual product design, effectively convey a natural and environmentally friendly feeling to consumers, thereby enhancing green product features and appeal.

Keywords: Household air purifier; continuous fuzzy kano model; kansei image; appearance images
DOI: https://doi.org/10.14733/cadaps.2021.1186-1209

1 INTRODUCTION

Over the past several years, the air quality situation has become more and more worrying. It is proven that this air inside the homes can be more dangerous than compared to outside air [38]. As a consequence, after the "smoke-type" and "photochemical smog-type" pollution periods, modern people are entering the third pollution period marked by "indoor air pollution", which may contribute to increasing prevalence of asthma, autism, childhood cancer, medically unexplained

symptoms, and perhaps other illnesses [47]. Admittedly, poor indoor air quality (IAQ) within and around buildings and structures has been linked to sick building syndrome, impaired learning in schools, reduced productivity and quality of life [39]. In this scenario, out of health considerations and the distribution and deepening of green concepts in the whole society, more and more people started to attach importance to green creative products with the improvement of living standards, among which the green product category represented by air purifiers emerged in modern green product market [10].

Air purifiers assist to remove impurities in the air we breathe. For example: dust, pollen, pet dander, smoke, mold spores, and other airborne pollutants. Most air purifiers use a woven material to capture particles as they try to pass through. An air purifier with excellent performance must not only guarantee the quality of the purified air, but also convey a green, pollution-free lifestyle for humans in the product designs. It is mainly in view of the fact that with the awakening of consumer product concepts, consumers' pursuit and longing for the fit between product concept design and functional design are becoming more urgent [1; 17; 44]. At the same time, as life quality continuously increases and social values gradually become open and diverse, people transit from material to spiritual enjoyments, pursuing fashion and beautifying oneself have become a significant aesthetic tendency in modern time. Particularly, consumer demand level rises from low to high, consumers pay attention not only on qualities and functions, but also on art, culture, symbol, individual satisfaction and joyful spirit of products. Undoubtedly, it is affirmably that the function of air purifiers should also reflect the green product appeal and emotional perception contained in the product design itself, which is what consumers are striving for.

The content of research is mainly divided into the following parts: Chapter 1 is the introduction, focusing on the close relationship between the current indoor environment and the function of the air purifier and the perceptual image of consumer products; Chapter 2 conducts a literature review, and Chapter 3 constructs a continuous fuzzy Kano quality model to explore the relationship between product perceptual images and consumer satisfaction; Chapter 4 compares the classification results of the continuous fuzzy Kano model with the results obtained by the SD experiment to master the optimal design evaluation and charm index of household air purifiers. And finally, the full text is summarized.

2 LITERATURE REVIEW

Nowadays, as life quality continuously increases and social values gradually become open and diverse, people transit from material to spiritual enjoyments, pursuing fashion and beautifying oneself have become a significant aesthetic tendency in modern time in which consumer emotions are stronger, consumer demand level and contents are various. Design directed by emotional content can be regarded as the heart of current design practices, research, and education [6]. In another word, emotions are "felt" and can play significant roles during product interactions, such as impacting the decision of whether or not to buy [16]. Khalid [20] pointed out, "the decision to buy can be momentary, so consumer demands can then be created very quickly, while other demands are long established." Relying on individual judgment and preference, consumers buy products which can fulfil their subjective consciousness. Likewise, air purifiers, as a equipment by highly lessening the quality of allergens in mid-air provide fresh air, and a good lifestyle which not only should have cool appearances, satisfying functions and high qualities, but also can bring consumers psychological satisfaction are demanded in market. What consumers actually want are high-quality products which symbolize individual character, taste, identity and position. Under such situation, exploring consumer demands, expectations and preferences in the design process of air purifier production is necessary and significant. However, it can be challenging to measure consumer preferences and emotions on products and risky to develop new products. It has been estimated that up to one third of new products fail at the launch stage [5]. So it can be clear that it is crucial to capture their emotional feedback on the products, because consumers tend to make decision-buying increasingly emotionally, avoiding the rational processing of large quantities of information [21]. Thus, a growing number of companies are willing to focus on conducting research on the

relationship between consumer emotions, references and new products; in order to design more attractive products and satisfy consumer expectations, consumer preferences and emotions on new products shall be learned. Moreover, it is of significance that product designers are sufficient for designing attractive new products, because attractiveness of new products themselves plays a key element impacting consumers' purchasing decisions [43]. However, it is absolutely not easy to scale consumer references and emotions on products.

Towards the trend that consumers' emotional perspectives become more and more important in products designs, Kansei Engineering and relevant researches have been largely promoted and consumers' subjective emotional demands are valued in product design. As a customer-emotion-oriented new product developing technology, Kansei Engineering is defined as "a technology which materializes consumer emotions and images on products into design elements" [31], it is successfully applied in actual product design and has already been widely used in product design to explore the relationship between consumer emotions and product design elements. Owing to the fact that human emotions are extremely subjective, circumstance-related and individual, an accurate measurement of consumer emotions is generally impractical. In this regard, to consolidate consumer's emotional requirements, Kansei engineering advocators suggested a new perspective on human emotions, i.e. the use of Kansei words or adjectives to represent various emotions [32]. Relation between product design elements and product kansei images are explored in Kansei Engineering. The general idea is: firstly, define consumer emotional demand space and product design space; secondly, select proper adjectives for products among numerous adjectives and match them with test samples; thirdly, inquire consumer emotions through Semantic Differential Method and establish the relationship between consumer demand space and product design elements. But after all, only consumer emotions rather than preferences on products can be found with such evaluating method, so the products designed in such process may only have limited power to impact consumer satisfaction.

Researching consumer satisfaction plays an important role in early stage of product development, consumer subjective feelings about product are key affecting elements to consumer satisfaction, therefore, it is significant to find out affecting elements to consumer satisfaction and categorize consumer demands. Kano et al. [18], made a two-dimensional diagram to present the relationship between consumer satisfaction and fulfilling demand degree. On basis of consumer reactions, indexes are categorized with Kano Model as: must-be quality, one-dimensional quality and attractive quality. According to this theory, products with attractive qualities can make consumers satisfied while products without attractive quality can not [19]. Generally, attractive qualities are not expected and not expressed by consumers. They can bring "surprise" to consumers sometimes. If one-dimensional qualities are realized, consumer will feel satisfied, otherwise, customers will not [23]. Investigating consumer demands with Kano Model is an important part in new product development and innovation process. consumer comments are meaningful for new product development because consumer demands evaluation affects the success of new product development for target consumers. Rashid et al. [33] and Hwang et al. [14] used Kano Model and Kano Regression Method, verified consumer preferences, satisfaction and emotional experiences inspired by social and cultural products. The results of their researches offered designers with a better cognitive approach about how to design better products to meet consumer demands.

Like material demands, emotional demands on style design are also human demands in essence, it is not difficult to understand that Kano Model can be applied in emotional area of style design. Yao et al. [45] based on Kano Model Categorization Method and categorized emotional demands of style design as must-be quality, one-dimensional quality and attractive quality. Design emotion is represented and expressed with adjectives. Design emotional qualities correlate closely with design characteristics, about product style design, through investigating the relationship between style design characteristics and emotional demands, it can be judged that which design characteristic leads to what emotion and which emotion belong to which quality level. Yadav et al. [42] evaluated beauty elements of vehicle appearance in their researches, during evaluation

process, participants were asked to evaluate 12 beauty elements of vehicle appearance in Kano Bidirectional Questionnaire.

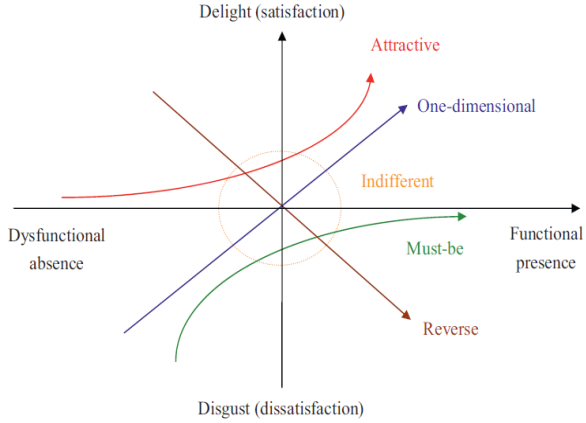

Figure 1: An illustration of the kano model.

According to evaluation results, it was found that consumer demands could be captured more accurately with Fuzzy Kano Model (FKM), and that importing FKM in dealing with consumer emotions was more objective and fairer than importing Kano Model. Their researches were beneficial for designers in recognizing these beauty elements of vehicle appearance and putting their efforts in improving attractive qualities and increasing consumer satisfaction, influential for customers in accepting vehicle appearance.

Hartono and Tan [13] points out that Kano Model was helpful to Kansei Engineering in services, they also introduced a comprehensive framework consisted of Kano Model and Kansei Engineering. Kano Model was applied and inserted in Kansei Engineering to reveal the relationship between service qualities and consumer reactions. In case studying, Kansei Engineering is applied to capture and transfer consumer emotional demands, Kano Model is used to assist Kansei Engineering and deeply explore the relationship between service elements and consumer emotions. Kansei Engineering promotes emotion elements to merge with product design elements, but it cannot tell influences of different emotion elements on purchasing decisions. Tama et al. [35] combined Kansei Engineering and Kano Model in their study to improve design of ceramic souvenirs and better meet consumer expectations. In their study, they categorized or sorted emotion adjectives in accordance with Kano Model, then they calculated and analyzed the emotion adjectives which affected consumer satisfaction the most and developed such adjectives as key for further design. Llinares and Page [27] suggested to insert Kano Model into Kansei Engineering while studying different influences of consumer feelings (emotion attributes or emotion adjectives) on buying real estate decisions.

However, it's obvious that most consumer demands were only categorized in traditional Kano Model, and as a result, the uncertainty of participant's thoughts was ignored in quality attribute categorization process [42]. For customers who are not sure about their answers to a certain product attribute, investigation data achieved with Kano Model on such customers is not accurate [3; 9; 46]. Lee and Huang [24] developed Fuzzy Kano Model Questionnaire, uncertainty of and inaccuracy of consumer demands were further handled. Definitive answers were provided in traditional Kano Model Questionnaire while vague answers are given in Fuzzy Kano Model Questionnaire so that consumer demands can be captured more accurately with Fuzzy Kano Model. Compared with traditional Kano Model, Fuzzy Kano Model Questionnaire can express consumer feelings better and assist designers in understanding consumer demands more accurately [25]. Nevertheless, Kano Model is still a kind of qualitative analysis method in which discontinuous problems are not considered. In fact, the relationship between fulfilling consumer demands and

consumer satisfaction, especially their symmetric and nonlinear relationships which occupy a major portion of Kano Model, cannot be exactly reflected by only calculating Kano Model indexes. Such linear scoring system may weaken importance of consumer evaluations and consumer demands. Moreover, it may decrease designer attention on consumer demands and cause disadvantages in competition [34]. Then, continuous Fuzzy Kano Model (C-FKM) was established on basis of Kano Model and FKM theory [40], which integrates fuzzy technique and quantitative analysis method into Kano Model at the same time, thereby contributes to better explore the close connection between consumer demands and product design elements, and further provide them with high-quality product design.

In summary, in view of the good performance in dealing with consumer demand and satisfaction, the C-FKM has been widely used in various product designs to help product designers and R & D personnel better explore the close relationship between customer satisfaction and consumer demand in production design [3; 24; 46], but few studies have applied the C-FKM method to the design of air purifiers. Therefore, this article applies the C-FKM to deal with the relationship between emotional perception and consumer's satisfaction, this article intends to apply the fuzzy Kano model to the design of air purifiers, in order to integrate the green perception embodied in air purifier products into the design of air purifiers and other green products to achieve consumption interaction and contact between consumer demands and air purifier design. And besides, on the other hand, air purifier design also combined with Lenovo's innovative thinking to satisfy customers' freshness, a new product form is designed afterwards. With this regard, this study aims to: (1) apply C-FKM to quantitatively carry on research about the product design style of customer preference. (2) introduce a new morphological element (biological simulation) and associative creative thinking based on popular product images and related deterministic design elements. (3) define the prototype of the product form. (4) verify the creative design results from the client's point of view. (5) integrate the Lenovo Creative Thinking method to the design scheme of the continuous fuzzy KANO model. The application of the evaluation model can be used as an effective auxiliary tool for designers or decision makers to enter into substantive design and scheme decisions.

3 MATERIALS AND METHODS

It was well-found that consumer demands could be captured more accurately with Fuzzy Kano Model (FKM), and that importing FKM in dealing with consumer emotions was more objective and fairer than importing Kano Model. However, as far as the question that FKM is inefficient to better achieve the deep matching between consumer needs and product evaluation, we can see that result obtained from statistical method of FKM is a kind of linear scoring system which may weaken consumer evaluations and importance consumer demands [9; 27]. In this scenario, C-FKM integrates fuzzy technique and quantitative analysis method into Kano Model at the same time, which is much helpful to design an air purifier product that meets the customer's psychological perception and responds to the customer's needs. Therefore, this article firstly conducts an in-depth analysis and comparison of the customer's product demand and psychological perception of the air purifier, and also analyze the FKM and C-FKM to compare the results through two models. In the design process of household air purifier, product kansei images were investigated with C-FKM, the relationship between product kansei images and consumer satisfaction was explored. Main contents of the study are: 1. Summarize kansei image adjectives as evaluation items, explore quality attribute categories of evaluation items with C-FKM, verify quality attributes according to participant answers to bidirectional questionnaire of with-function and without-function questions. 2. Conduct kansei image investigation, count and analyze participant "kansei images" and "preference degrees" on test samples. 3. Compare and analyze results of C-FKM categorization and SD test, verify the best design evaluations and attractive indexes for household air purifier. 4. Make a usage of C-FKM model and FKM to quantitatively discuss the product design style of customer preference. 5. Applying the Lenovo creative thinking method to integrate the design

scheme of the continuous fuzzy KANO model for designers or decision makers to enter into substantive design and scheme decisions.

3.1 Stage 1: Establishing C-FKM

Step 1: selecting product kansei image adjectives

Kansei Image Adjectives			
Harmonious with Household Space	Original	Modern	Rational
Minimalistic	Excellently Designed	Creative	Friendly
Eye-catching	Delicate	Technological	Lovely
Environmentally-Friendly	Intelligent	Interesting	Convenient

Table 1: Selected kansei image adjectives.

The purpose of the study is to explore influences of product kansei images on consumer satisfaction. In order to select suitable evaluation adjectives for evaluation test, a large number of relevant kansei adjectives and evaluation adjectives were collected from relative research literature (including Kansei Engineering, product image, household air purifier researches). Since a wide evaluation dimension was covered in the test, considering difficulty of the questionnaire and burden on participants, not too many adjectives should be selected; moreover, give consideration to bidirectional questionnaire design of "Kano Quality Model", kansei image adjectives should not be oversimplified. The "kansei image adjectives" selected after being discussed by Focus Group are shown in Table 1.

Step 2: determining the crucial attractive factors

Traditionally, the Kano's questionnaire (TKQ) attribute classification is conducted by means of a lot of bidirectional questions to differ attributes availing cross-pairs, in which the questions on both sides are described as the opposite statements. Obviously, this method forces people to passively choose one answer, which leads to the final survey results that largely ignore the uncertainty of consumers' perception of products. For instance, when people need to choose the answer from the product survey which lists five choices including "satisfied", "It must be that way", "It is indifferent", "It can live with it that way", "dissatisfied", it is sure that survey result will become quite exclusive. It's clear that TKQ permitted only one answer to ask customers of product feeling as depicted in Figure 2, interviewee who select ignore or forget may have various answers or an equivocal way. Nevertheless, multiple choices are allowed

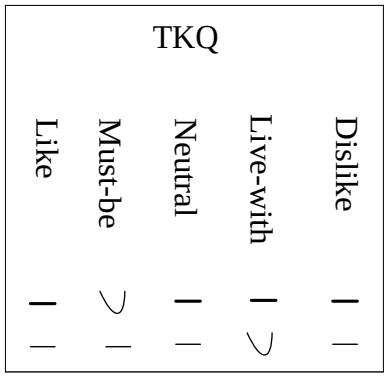

Figure 2: Single answer for TKQ.

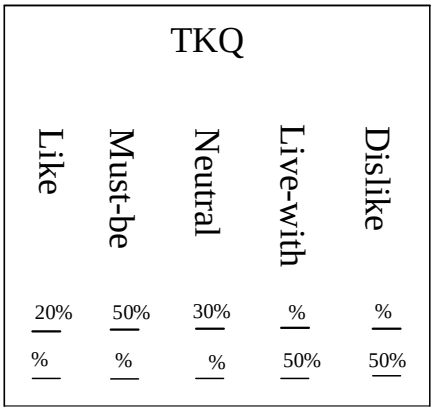

Figure 3: Multiple answers for FKQ.

In the Fuzzy Kano questionnaire (FKQ), one can bidirectionally assign a percentage to the corresponding answers, with 1 being their total sum. In above example, the product's functional factor can be described as $s=[0.2,0.5,0.3,0,0]$ in Eq. (1)

$$s=[0.2,0.5,0.3,0,0] \tag{1}$$

As showed in Figure 3, FKQ makes usage of flexible way to allow interviewee with personalized standard to answer questions, as well as other answers of same issue. It's demonstrated that both TKQ and FKQ use functional and dysfunctional model to ask customers of product feeling [22]. However, comparatively speaking, it will be more reasonable and realistic to use the membership function on the basis of fuzzy logic to express the degree of their feelings based on their own choices, in this way it will sufficiently reflect the complex thought of an individual [12].

According to the experience of the literature [8], we let U and V be the universal set of positive and negative questions and set $P=\{P_1,P_2,...P_p\}$ and $N=\{N_1,N_2,...N_n\}$ as the sets of p and n linguistic variables on U and V ,respectively, which jointly construct a $p\times n$ evaluation sheet of a two-dimensional quality model. And also, we can use $\{F_{sk},k=1,2,...,r\}$ to indicate a sequence of random fuzzy sample on the both set U and V. Hence, we then assign linguistic P_i and N_j with normalized memberships $m(P)_{ki}$ and $m(N)_{kj}$ for each F_{sk} separately. Let $S_{kij}=m(P)_{ki}\times m(N)_{kj}$, and $T_{kh}=\sum hcatS_{kxy}$ be the sum of all S_{kxy} of those cells(x,y) classified into the h^{th} Kano category in the Kano evaluation table ($h.cat$ represents the h^{th} category). And then, we follow the research of Madzík and Peter [28], the maximum value of $\sum_{k=1}^{r}\{T_{kh}\}_\alpha$ is named the FKM of the attribute, in which α is a significant classification level (i.e. $\alpha-cut$ that is defined as expression (2):

$$\{T_{kh}\}_\alpha=\begin{cases}1 & if\ T_{kh}\geq\alpha\\ 0 & else\end{cases} \tag{2}$$

A noteworthy instance in "when attributes are sufficient, what about customer satisfaction?", and the other "when attributes are insufficient, what about customer satisfaction?" can expound the difference in TKQ and FKQ. The answer options in FKQ include "dissatisfied", "live with it", "indifferent", "must-be", and "satisfied". By the large, the product attributes can be determined through the 25 combinations in the evaluation table (Table 2). They are "attractive", "one-

dimensional", "must-be", "indifferent", "reverse", and "questionable". As above, it can describe the answers "sufficiency" and "insufficiency" to the product's attractive factor as $suf=[0.7,0.3,0,0,0]$ and $ins=[0,0,0.1,0.3,0.6]$. As a result, a fuzzy relation matrix S can be obtained as matrix (3).

Criteria/attributes		Insufficiency				
		satisfied	It must be that way	It is Indifferent	It can live with it	Dissatisfied
sufficiency	satisfied	Q	A	A	A	O
	It must be that way	R	I	I	I	M
	It is Indifferent	R	I	I	I	M
	It can live with it	R	I	I	I	M
	dissatisfied	R	R	R	R	Q

Table 2: Kano evaluation table.

$$S=\begin{bmatrix} 0 & 0 & 0.07 & 0.21 & 0.42 \\ 0 & 0 & 0.03 & 0.09 & 0.18 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix} \tag{3}$$

On the basis of identifying two-dimensional attribute classification in matrix S ,we can select something as follows:

$$T=\left\{\frac{0.28}{A},\frac{0.18}{M},\frac{0.42}{O},\frac{0.12}{I},\frac{0}{R}\right\} \tag{4}$$

To discover a more pleasant classification, we usually the standard a-cut to obtain $\{T\alpha\}$,here we can set $\alpha\geq 0$,that is when the attribute membership function is greater than or equal α ,this attribute is "1", otherwise the value is "0".In view of the fact that the different participants may represent the different feelings towards the degree of the sufficiency of attributes, the FKQ model takes the individual with the highest frequency. When the final scores are identical and cannot be distinguished, the prior ity of evaluation is $M\succ O\prec A\prec I$ [15].

On the whole, FKQ is more reasonable than the TKQ when discovering a more pleasant classification [11; 37; 41]. However, a notable fact which above result obtained from the statistical method of FKM is a kind of linear scoring system which may weaken consumer evaluations and importance of consumer demands is should noticed [4; 36]. For the reason that, we integrates fuzzy technique and quantitative analysis method into Kano Model simultaneously, that is Continuous Fuzzy Kano Model (C-FKM) [40], and then applies C-FKM to explore the relationship between product kansei images and consumer satisfaction in the design process of air pursier.

In C-FKM Questionnaire, participants only need to select a standpoint as their answers to questions. For instance, about a particular question, if a participant's opinion is between "enjoy" and "expect", and such opinion slightly inclines to "enjoy", then he or she may select 4.7 score as a final answer. 75 university students and product designers were investigated with the questionnaire. 65 effective questionnaires were collected and divided into two categories according to profession areas of participants: 56% was of product design area and 44% was of non-design profession areas (science and engineering, management, social science). For an individual

consumer, importance of different kansei images is different, similarly, for different consumers, importance of a particular kansei image are different either. In the study, participants were asked to score 1~9 for importance of "harmonious with household space", as shown in Figure 4.

According to Kano Model, 25 combinations in Kano Evaluation Table can contribute different consumer satisfaction values [41]. Tan and Shen [36], Chen and Ko [4] imported a kind of "influence value" to show contributions of the combinations on consumer satisfaction. They believed the proportions of "must-be quality", "one-dimensional quality" and "attractive quality" are 2, 1 and 0.5. In upper right quarter of Table 3, influence values decline clockwise (from "must-be quality" to "one-dimensional quality" and then to "attractive quality"). Influence values of cell 3 and 5 -- pure "must-be quality", 1 and 5 -- pure "one-dimensional quality", 1 and 3 -- pure "attractive quality" are 1, 1 and 0.5 [40].

Contents in lower left quarter of Table 3 is a reverse of contents in upper right quarter. Since positive answers always seem more powerful than negative ones, so influence values of the reversed section were assumed as half of influence values of positive answers. After researching, Wu and Wang [40] believed that when influence values were divided by the maximum value among them, a standard influence value matrix can be achieved, as shown below:

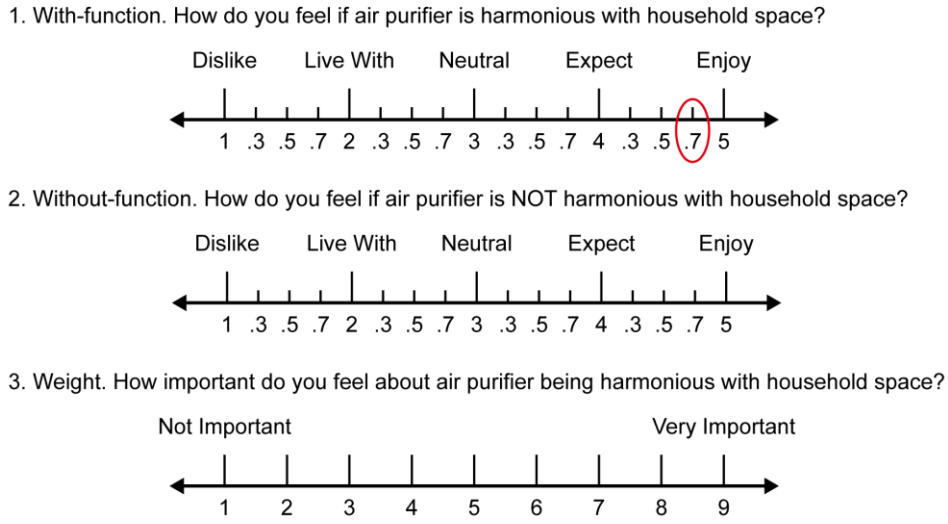

Figure 4: C-FKQ test example (harmonious with household space).

Functional	Dysfunctional				
	Enjoy	Except	Neutral	Live with	Dislike
Enjoy	0	0.4	0.5	0.6	1
Except	-0.2	0	0.1	0.15	1.8
Neutral	-0.25	-0.05	0	0.2	2
Live with	-0.3	-0.075	-0.1	0	1.6
Dislike	-0.5	-0.9	-1	-0.8	0

Table 3: Influence values of the combinations.

$$NIV = (v_{ij})_{5\times5} = S = \begin{bmatrix} 0 & 0.200 & 0.250 & 0.300 & 0.500 \\ -0.100 & 0 & 0.050 & 0.075 & 0.900 \\ -0.125 & -0.250 & 0 & 0.100 & 1.000 \\ -0.150 & -0.038 & -0.050 & 0 & 0.800 \\ -0.250 & -0.450 & -0.500 & -0.400 & 0 \end{bmatrix} \quad (5)$$

Wu and Wang [40] defined C-FKM as: On basis of a participant answers to kansei images, membership degrees of consumer preferences can be aggregated with following formula:

$$u_{nij} = m(F_i)n \times m(D_i)n \quad (6)$$

Suffix "n" refers to participant; the first "n" refers to membership degree of the i^{th} answer to with-function question while the second "n" refer to membership degree of the j^{th} answer to without-function question.

Single consumers satisfaction of a particular consumer demand can be obtained with mathematical aggregation of influence values which are scaled by corresponding membership degrees [40]. S_n can be weighted as:

$$S_n = v_{ij} \times u_{nij} \quad (7)$$

For an individual consumer, importance of different consumer demands is different, similarly, for different consumers, a certain consumer demand show different importance. Different consumers can give different importance evaluations for consumer demands with same Sn value. In order to analyse average influence of a particular consumer demand on overall consumer satisfaction, a single evaluation index can be used to represent average evaluation of all participants. Assume there are N participants, then EI value can be calculated with following formula:

$$EI = \frac{\sum_{n=1}^{N} w_n S_n}{N} \quad (8)$$

Product kansei images are human psychological feelings and shall relate to attractive qualities, but how correlated are they? The relationship between kansei images and attractive qualities or other qualities is fuzzy but not absolute. Major innovative ideas of this study are: on basis of C-FKM, correlation between product kansei images and consumer satisfaction was put forward for the first time, the weighted relationship between product kansei images and consumer satisfaction was explored. This study can help designers to analyze consumer demands more accurately and increase consumer satisfaction correspondingly in design process.

3.2 Stage 2: Product Kansei Images Test

Step 1: selecting test samples

In this stage, firstly, as many air purifier photos as possible were collected from appliance shopping malls, magazines, official websites of various brands and appliance shopping websites, then the photos were discussed by experts of Focus Group which comprised 5 product designers (over 5 years of business experiences) and postgraduates from relevant departments; secondly, according to product similarities, the photos were initially filtered, selected and categorized into four types: panel-type, cabinet-type, column-type and alien-type; thirdly, 20 representative samples were selected as test samples.

Step 2: SD test

Semantic Differential Method was used in this study to evaluate image styles of air purifier, this method quantifies participant feelings about product designs, on designated linguistic scale, participant feelings are judged and shown in corresponding scale marks, and then summarized and

analyzed. 20 household air purifier photos were selected as samples and participant references on different air purifier appearances were obtained with Likert Five-stage Scale Table. There are 5 feeling scales: enjoy, expect, neutral, live with and dislike, they respectively correspond with 1, 2, 3, 4 and 5. Through calculating average value of all participants, top 10 high-reference samples were ranked among 20 samples. After that, participants were asked to evaluate kansei images of the top 10 high-reference samples according to their subjective feelings. Scale standard of Kansei Images Questionnaire was set as Five-stage Likert Scale Table, -2~2 scores were given from left to right in the Table, -2 refers that a sample deviates far away from the kansei image, 0 refers to normal and 2 refers that a sample generates strong feelings which the kansei image represents. Kansei image evaluations of samples are shown in Table 4.

Sample	Kansei Image Adjectives				
	Technological	Lovely	…	Creative	The freshness of nature
	-2, -1, 0, 1, 2	…	…	…	-2, -1, 0, 1, 2
	-2, -1, 0, 1, 2	…	…	…	-2, -1, 0, 1, 2
	-2, -1, 0, 1, 2	…	…	…	-2, -1, 0, 1, 2
	-2, -1, 0, 1, 2	…	…	…	-2, -1, 0, 1, 2

Table 4: Product kansei image evaluation.

3.3 Stage 3: Creative Thinking Design and Evaluation Method of Design Scheme

An idea starts from scratch, it must undergo complex conceptual information reconstruction and processing, until the final result is presented. Dorst and Cross [7] indicates that the creative thinking process consists of multiple processes, and then further proposes that the design process is a thinking oscillation process in which designers focus on solving design goals, and the solution process of design schemes is a process of repeated divergence and convergence through thinking. Liu et.al [26] pointed out that the designer's thinking in the process of product styling is a process of repeated iterations of two forms of thinking that consists of divergence and convergence, which can transform consumers' abstract psychological needs into tangible design styling.

Through the fuzzy calculation process in stage 2, it can be clarified which design styles of air purifiers are attractive to the target users. Then, after determining the attractive design style of the air purifier, the creative thinking design evaluation of the air purifier design will be carried out next [2; 30]. To this end, an associative creative thinking process consisting of four steps was constructed at this stage, including (1) the choice of air purifier design style, (2) the association of air purifier design style, (3)the design features capture of the air purifier, (4) the finalization of design scheme.

The evaluation rule of the design plan is based on the subject’s feelings of green, environmentally friendly, natural and fresh,harmonious with household space, convenient and high-end,whose purpose is to observe the subject’s perception of the design plan. Therefore, in this stage, the questionnaire design is based on the fifth-order semantic difference scale, and the feeling degree of the design scheme in the five evaluation items is evaluated. Specifically, in the creative thinking design stage, a total of 5 air purifier design schemes are generated, and the

subject is asked to make a five-dimensional evaluation based on their subjective feelings of the 5 design schemes. The evaluation results are shown in Table 5.

Among them, the method of adjusting the weight of the design item evaluation project can be expressed by the following formula:

$$V_x = \sum_{i=1}^{n} W_i \bar{X}_i \tag{9}$$

Evaluation project	Evaluation scale					Design schem
	1	2	3	4	5	
Green and environmentally friendly						
Natural and fresh						
Harmonious with household space						
High-end						
Convenient						
Remarks: Scale 5 is the highest score, which means that the testers very much agree with the design scheme (pictured on the right) of the environmental protection, natural freshness, etc. Scale 3 means normal, and Scale 1 is the lowest score.						

Table 5: Evaluation project scale of design scheme.

As shown in formula (9), V_x represents the evaluation score of the design plan x, W_i represents satisfaction degree under the i[th] evaluation index($i = 1, 2, ...5$), $\bar{X}_i$ represents the average value of the feeling degree of all participants under the ith evaluation index of the design plan x.

4 RESULTS AND DISCUSSION

Firstly, 16 kansei image adjectives were selected as evaluation items and participant feelings were investigated with bidirectional Questionnaire (sufficient and insufficient qualities). Through calculation, influence degrees of kansei image adjectives on consumer satisfaction were verified and attractive quality elements were found among the 16 adjectives, results of C-FKM and FKM were compared. Secondly, 20 product samples were selected, participant "kansei images" and "preference degree" on such samples were evaluated with Questionnaire and then counted and analyzed, consumer preferences on appearance images were revealed. Thirdly, results of appearance image preference test and C-FKM quality categorization were compared and verified, it was proved that kansei images with attractive qualities are reliable and can be prior choices for air purifier design.

4.1 Study Priority of Different Product Kansei Image Attributes with C-FKM

Result analysis of FKM and C-FKM is shown in Table 4 which clearly shows that C-FKM is more effective than FKM. Take a participant's FKM Questionnaire for example, assume realizable function matrix as $X = [0.7, 0.3, 0, 0, 0]$, and unattainable function matrix as $Y = [0, 0, 0.5, 0.5, 0]$ to generate fuzzy interaction matrix. Correspond locations in fuzzy interaction matrix with locations in Kano quality attribute verification matrix, it can be told that membership degree vector of A, M, O A, and I are $ta = 0.7,\ tm = 0,\ to = 0\ and\ ti = 0.3$ Because a single evaluation element usually belongs to multiple Kano attribute categories, so threshold value is imported for filtering to obtain more

accurate and more reliable data. About α values, Meng Qingliang et al. [29] set different α values and found that the ideal α value was 0.4, such value ensures information being accurate and guarantees less information cross. For Kano attribute categories with membership vector t values bigger than α, set attribute vectors of such attribute type as 1, otherwise as 0. Repeat above steps, count participant demand tendency categories on products, the demand tendency with the highest frequency is the attribute category of the demand item. However, the relationship between consumer demand fulfilling degree and consumer satisfaction cannot be accurately reflected by only calculating Kano Model indexes; for instance, for questions about a particular demand, for with-function questions, participants select "neutral", for without-function questions, assume half participants select "dislike" and the other half select "neutral", it means that half participants consider such attribute as must-be while the other half consider it as indifferent; if frequencies of the two categories are the same, then from high to low, priorities of demand categories are: must-be quality, one-dimensional quality, attractive quality and indifferent quality; so this attribute can be determined as must-be quality; nevertheless, such linear scoring system cannot perfectly distinguish these two kinds of consumer demands because they share the same average score. Therefore, KFM did not perform satisfyingly on determining quality attribute categories of the 16 kansei images in Table 6.

C-FKM integrates fuzzy technique and quantitative analysis method into Kano Model at the same time. Compared with FKM, C-FKM can help designers to optimize attributes while establishing EI values. C-FKM is established on starting value of EI: when EI value ≥ø (e.g., EI ≥0.1), consumer demands shall be satisfied. When EI ≥0.1, five items in Table 6 -- harmonious with household space, environmentally friendly, intelligent, convenient and delicate -- are categorized as attractive qualities by C-FKM. This was same with KFM categorization; furthermore, it was also verified with C-FKM that EI value of original was 0.114, minimalistic was 0.106, technological was 0.118, excellently designed was 0.131, creative was 0.121, friendly was 0.103 and lovely was 0.108, they were all higher than 0.1 so that they were categorized as attractive qualities. Although EI values of the 7 items were higher than 0.1, they were only as high as being attractive qualities but not being outstanding ones. These 7 items were categorized as indifferent qualities by FKM because most participants favored all attributes, such like "indifferent qualities" and other attributes, this led high frequency of "indifferent qualities"; however, although the 7 items were categorized as "indifferent" by FKM quality investigation method, they still had attractive tendency to a large extent. It is exactly because different opinions of other consumers were ignored by such linear scoring system and different categorization results were caused, so it is obvious that KFM can not accurately distinguish consumer demands. When $EI < 0.1$, 4 items in Table 6 -- rational, eye-catching, modern and interesting -- were categorized as indifferent qualities by C-FKM. This is same with FKM categorization results, so it can be told that as EI values decrease, quality categorization results of C-FKM and FKM are same.

Compared with FKM, C-FKM can help designers to optimize attributes while establishing EI values. The effect is not obvious to study differences of kansei image adjectives with FKM to improve consumer satisfaction. While studying kansei image adjectives with C-FKM, not only quality attributes of kansei image adjectives can be determined, but also contribution degrees of kansei image adjectives on improving consumer satisfaction can be revealed. In this study case, a difficulty designers had to face was to rank quality attributes of same category. In early stage of product development and design, if designers want to integrate 5 attributes into household air purifier, they will find it is difficult to determine which 5 attributes are better among the 12 ones. Luckily, contribution degrees of kansei image adjectives on improving consumer satisfaction can be revealed by studying kansei image adjectives with C-FKM. As shown in Table 6, according to C-FKM categorization results, there are 12 attractive quality attributes, EI values of 5 attractive qualities -- harmonious with household space, green and environmentally friendly, natural and fresh, convenient and high-end are high and of the other 7 attractive qualities are low, therefore, designers can integrate attractive quality attributes with high EI values into design of household air purifier.

4.2 Cross Analysis of Appearance Image Preferences and Kano Quality Categorization

Semantic Differential Method was used in this stage to evaluate design intentions and styles of air purifier, this method quantifies participant feelings about product designs, on designated linguistic scale, participant feelings are judged and shown in corresponding scale marks, and then summarized and analyzed. In this study, product photos were initially categorized and similar product categories were abstracted according to product similarities, 20 household air purifier photos were selected as samples and participant feelings were quantified with Questionnaire combing Likert Five-stage Scale Table.

Attributes	FKM	C-FKM		
	Category	EI	Category	Priorities
Harmonious with household space	A	0.237	High Attractive	3
Original	I	0.114	Low Attractive	9
Minimalistic	I	0.106	Low Attractive	11
Rational	I	0.021	Indifferent	16
Natural and fresh	A	0.246	High Attractive Attractive	2
Eye-catching	I	0.098	Indifferent	13
Technological	I	0.118	Low Attractive	8
Green and environmentally friendly	A	0.298	High Attractive	1
Modern	I	0.080	Indifferent	15
Excellently Designed	I	0.131	Low Attractive	6
Creative	I	0.121	Low Attractive	7
Friendly	I	0.103	Low Attractive	12
Lovely	I	0.108	Low Attractive	10
High-end	A	0.193	High Attractive	5
Interesting	I	0.097	Indifferent	14
Convenient	A	0.230	High Attractive	4

Table 6: Attribute priorities of kansei images.

From the standpoint of Product Semantics, almost all appearance designs have their own quality attributes and styles. As a matter of fact, design image of a product is usually an overall feeling generated from interaction of many complicated factors; therefore, the key point of appearance design analysis is how to further analyze consumer preferences and demands on household air purifier design according to C-FKM quality categorization results achieved in stage 1. Moreover, consumer perception factors are often involved in household air purifier design styles so that the discussion focus of this part is how to quantify consumer feelings on basis of certain reference samples. 20 household air purifier samples listed in Table 7 were used in air purifier design image SD test and then test results were analyzed, as shown in Table 7. According to analysis results, the highest average SD value was 4.25 of Sample 16 and the lowest was 1.7 of Sample 3. Consumer preferences on different household air purifier appearance designs can be distinguished through quantified SD values.

The 16 kansei image adjectives selected in stage 1 were combined with top 10 samples with high average SD values, scores were counted in accordance with Likert Five-stage Scale Table "-2, -1, 0, 1, 2", image semantics of product samples were investigated. Image compositions of samples with high preference degrees can be shown with the 16 kansei image adjectives, furthermore, top 5 kansei adjectives about appearance can be abstracted to describe overall feelings the samples generate for consumers. Take Sample 2 for instance, top 5 kansei adjectives are: harmonious with household space -- average SD value was 0.95, original -- 1.05, minimalistic

-- 1.35, modern -- 1.5, excellently designed -- 1.1; so these top 5 kansei adjectives can be used to describe consumer subjective feelings about Sample 2.

4.05	4.25	3.75	3.35	3.3
S 14	S16	S2	S17	S18
				
3.25	3.2	3	3	2.9
S 4	S7	S6	S15	S12
				
2.85	2.9	2.85	2.8	2.75
S 13	S 5	S20	S19	S8
				
2.7	2.65	2.65	2.15	1.7
S11	S 1	S10	S9	S3
				

Table 7: Average SD values of 20 test samples.

Table 8 and other materials were integrated on basis of SD test results of 10 samples mentioned above, cross analysis of appearance image preferences and Kano quality categorization was carried out, as shown in Table 8. About appearance designs preferred by consumers, the proportional relationship among their corresponding evaluation attributes, quality categories and attractive elements were explored. Take Sample 16 for instance, the reason it was preferred by participants was because it brought subjective feelings generated by 5 quality items: harmonious with household space, original, Environmentally Friendly, eye-catching and creative. According to C-FKM quality categorization results, such 5 quality items were 4 attractive qualities and 1 indifferent quality; 10 samples listed in Table 8 were comprehensively analyzed, it was found that the product designs which were preferred by consumers comprised at least 3 attractive qualities; according to FKM quality categorization results, top 5 samples with high preference comprised at least 1 attractive quality. Bottom 5 samples comprised 0 attractive quality because it was difficult for FKM to accurately define consumer demands when data differences among two or more categories were tiny. But through importing EI values by C-FKM, not only grades of attractive qualities can be revealed, but also quality attributes can be determined more accurately. Meanwhile, it was verified by consulting analysis results that the kansei adjectives with attractive qualities did have dominating effect on consumer preferences.

Sample	Top 5 kansei Images	C-FKM Categorization	FKM Categorization
S16	harmonious with household space Original Green and Environmentally Friendly Eye-catching	High Attractive (2) Low Attractive (2) Indifferent (1)	Attractive (2)

	Creative		
S 14	harmonious with household space Original Eye-catching Green and Environmentally Friendly Creative	High Attractive (2) Low Attractive (2) Indifferent (1)	Attractive (2)
S 2	harmonious with household space Original Minimalistic Modern Excellently Designed	High Attractive (1) Low Attractive (3) Indifferent (1)	Attractive (1)
S 17	Original Minimalistic Friendly High-end Convenient	High Attractive (2) Low Attractive (3) Indifferent (0)	Attractive (2)
S4	Original Natural and Fresh Modern Excellently Designed Convenient	High Attractive (2) Low Attractive (2) Indifferent (1)	Attractive (2)
S 18	Original Eye-catching Technological Excellently Designed Creative	High Attractive (0 Low Attractive (4) Indifferent (1)	Attractive (0)
S 7	Eye-catching Creative Friendly Lovely Interesting	High Attractive (0) Low Attractive (3) Indifferent (2)	Attractive (0)
S6	harmonious with household space Minimalistic Modern Rational Technological	High Attractive (0) Low Attractive (3) Indifferent (2)	Attractive (0)
S15	Original Eye-catching Friendly Lovely Interesting	High Attractive (0) Low Attractive (3) Indifferent (2)	Attractive (0)
S12	Original Eye-catching Excellently Designed Creative Interesting	High Attractive (0) Low Attractive (3) Indifferent (2)	Attractive (0)

Table 8: Cross analysis of appearance image preferences and kano quality categorization.

4.3 Transformation from Natural Image to Product Modeling Design

Through the aforementioned fuzzy calculation results, five highly attractive air purifier sensibility images can be obtained. Overall, the air purifier design feelings preferred by consumers are as follows: green and environmentally friendly, harmonious with household space, natural and fresh, convenient and high-end. This stage attempts to transform consumers' five attractive features into actual product design. The design process includes the following five steps.

Step 1: Choose the design style of the air purifier with the highest priority. In the third stage, this study selected the three top-priority design styles that are in harmony with natural and fresh, home environment, and green environmental protection to transform into product design schemes.

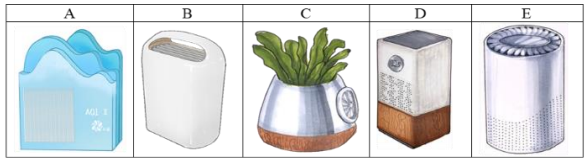

Figure 5: Several different design options.

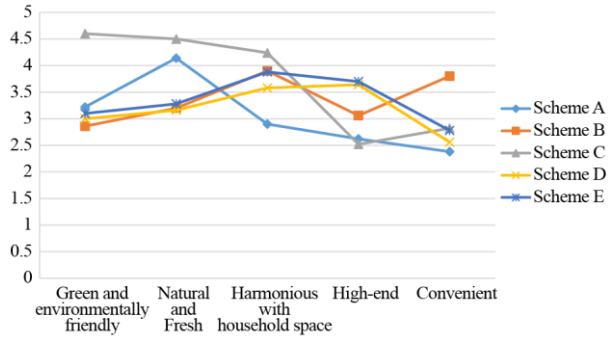

Figure 6: Evaluation score of different design options.

Step 2: Product style association is divided into: basic style information, landscape and biological association.

(1) Basic style information: It can describe the green, environmentally friendly, natural and fresh design style coordinated with the home environment. This resulted in a series of associative concepts: imagery of bamboo forests, fruits, floral fragrances, seaside, ...

(2) Landscape: One can associate his surroundings with his thoughts. Think about the ocean, nature, and then evolve into ocean waves, water waves, tree leaves, clouds in the sky.

(3) Biological simulation: Through biological simulation, one can maintain the associative thinking of the prospect to express the design concept. For example, there are flying white gulls on the sea, and white shells on the beach. Through the simulation of these organisms, the design prospects can be efficiently expressed.

Step 3: Product feature capture. It is to extract the design features from the pictures that are associated with the step 2. For instance, extracting the local shapes of waves from the ocean, clouds and wind in the sky, which can be used to design features of product shapes.

Step 4: Determine the design plan. Integrate the product features captured in step 3 with the product design plan.

Immediately after, in order to better explore the transformation of natural material images into tangible product styling, thereby increasing the perception of "green" products and the enhancement of environmental protection awareness among consumers and potential consumers, a series of creatively designs through the above 4 steps are tried, and finally five design plans as shown in Figure 5 is established.

4.4 Evaluation on Design Scheme

In order to comprehensively summarize the design scores of the above air purifiers, 50 air purifier consumers were invited to rate the five air purifier design proposals for each evaluation item. With regards to this, combined with the popular characteristics of the air purifier extracted above, the subject's feelings about the freshness of nature, convenient, harmonious with household space, green and environmentally friendly, and high-end sense are used as evaluation indicators. And then, 50 testers are needed to evaluate the above five design schemes according to their subjective perception of the air purifier design in five dimensions to obtain the tester's feeling and satisfaction with the product designs. In the end, we get the change trend graph of the average score evaluation of all design schemes in 5 different dimensions, as displayed in the Figure 6.

As shown in Figure 6, by comparing the average values, it can be clearly found that the average value of scheme C is the largest at 3.74, indicating that the subjects are most satisfied with scheme C. At the green environmentally friendly level, scheme C which divides the air purifier into two layers, the upper part is made of ceramic material, and the lower part is made of wood material has the highest score among all air purifier design schemes, which is mainly reflected that scheme C weakens the sense of metal and plastic of general household appliances, largely highlights the green temperament brought by the product. In addition, scheme C also scores the highest in terms of natural freshness and home environment coordination. On the one hand, scheme C combines air purifiers with plant images, which weakens the air purifier's presence and looks more like flowers basin, not machine, thereby injects a fresh and natural feeling to consumers' indoor life. On the other hand, the design of scheme C greatly improves the environmental experience of home life because it is more in line with the warmth of family life. However, in terms of high-end sense, scheme E has the highest score, indicating that the design of scheme E could have a strong sense of high-end. Also, in terms of convenience, scheme B has the highest score, indicating that scheme B may be the most convenient in daily usage.

Feasibility level criterion	Scheme A M±SD	Scheme B M±SD	Scheme C M±SD	Scheme D M±SD	Scheme E M±SD	F	P
Green and environmentally friendly	3.22±1.200	2.86±1.125	4.60±0.571	3.00±1.088	3.10±1.147	20.154	0.000***
Natural and Fresh	4.14±0.990	3.20±1.088	4.50±0.678	3.16±1.037	3.28±1.107	9.745	0.000***
Harmonious with household space	2.90±1.035	3.90±0.995	4.24±0.938	3.58±1.052	3.88±0.982	63.738	0.000***
High-end	2.62±1.176	3.06±0.956	2.52±0.953	3.64±0.985	3.70±1.074	9.261	0.000***
Convenient	2.38±0.967	3.80±1.050	2.82±1.119	2.56±0.993	2.78±1.036	8.674	0.000***

(Notes: *p<0.05, **p<0.01, ***p<0.001)

Table 9: The average value (M) and standard deviation (Sd) of the design schemes among five feature indexes.

In Table 9, we compare the significant difference levels of the testers' performance values under the five perceptual image evaluation indicators for different design cases. According to the results of single factor analysis of variance and comparison of average values, it can be clearly found that the significance level P of all the design schemes in the five evaluation indicators is less than 0.001, which shows that investigators have significant differences in scoring the five characteristic indicators under different design schemes.

	Green and environmentally friendly	Natural and fresh	Harmonious with household space	High-end	Convenient	The total score

W. V	0.298	0.246	0.237	0.193	0.230	3.718
W. V. A	3.220	4.140	2.900	2.620	2.380	
W. A. A	0.960	1.018	0.687	0.506	0.547	
W. V. B	2.860	3.200	3.900	3.060	3.800	4.028
W. A. B	0.852	0.852	0.924	0.591	0.874	
W. V. C	4.600	4.500	4.240	2.520	2.820	4.618
W. A. C	1.371	1.107	1.005	0.486	0.649	
W. V. D	3.000	3.160	3.580	3.640	2.560	3.811
W. A. D	0.894	0.777	0.848	0.703	0.589	
W. V. E	3.100	3.280	3.880	3.700	2.780	4.004
W. A. E	0.924	0.807	0.920	0.714	0.639	

Table 10: Evaluation weight values of design schemes.

Indeed, according to the results of the questionnaire survey of the continuous fuzzy KANO model, the perceptual images of household air purifiers preferentially transform the five consumer-preferred perceptual images including the fresh and nature, green and environmentally friendly, high-end, harmonious with household space and convenient. Subsequently, after obtaining the satisfaction values of the above five perceptual images, the testers scored five perceptual images for the five air purifier design schemes, and then, the average score of each scheme and the satisfaction value of 5 perceptual images are weighted and calculated to obtain the comprehensive evaluation score value of all air purifier design schemes. Finally, the optimal design sequence of the air purifier design is determined according to the size of the comprehensive score value.

Through the calculation of formula (9), we can get the satisfaction weight (EI) and the mean value of perceptual evaluation ($\overline{X}$) corresponding to the semantics of the five design styles as shown in Table 10.

According to consumers' comparison of the order results of the optimized design cases among the five models, their ranking results are as follows: C(4.618)>B(4.028)>E(4.004)>D(3.811)>A(3.718). As shown in Figure 7, the overall score of scheme C is significantly higher than the other four scheme options. It transforms the natural image to real air purifier designs, so that the shape and material elements of the natural image and the material image are integrated into the design concept, which effectively improves the natural and environmental protection concepts and feelings exactly required by users and consumers, and thus strengthens the home air purifier's green product features and attractiveness.

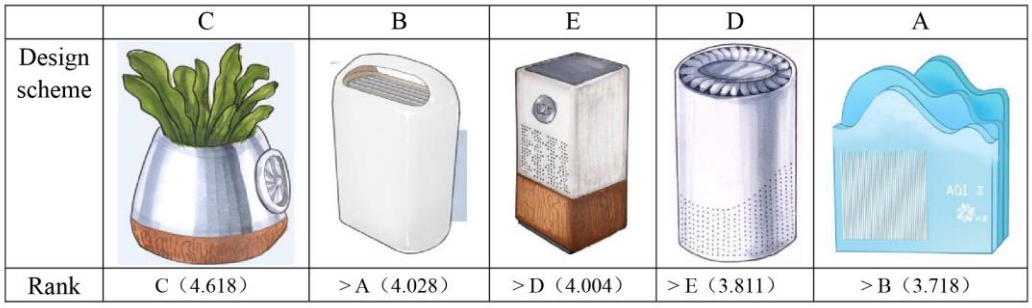

Figure 7: Ranking of product design scheme scoring results.

5 CONCLUSION

As an important weapon to improve the indoor air quality in recent years, household air purifier products have increasingly received official attention from everyone, and the market environment

in which they are located is also increasingly fierce. In particular, consumers' awareness of product intentional design and product green perception continues to increase. Therefore, the matter that how does the design of household air purifier products reflect consumers' psychological needs and integrate consumers' emotional perception of products into product design is particularly important. Corresponding, in related methods and technologies, it is generally acknowledged that Kansei Engineering is mainly developed and applied in product design area while Kano Quality Model is limited in discussion and application of quality management. Since both methods aim at psychological feelings which were ignored before, therefore, the research ideas that combines "kansei images" with particular "quality attributes" by means of "Kano Quality Model" of quality management in air purifier design on purpose of learning about consumer preferences on appearance images is tried. This research applys the C-FKM to conquer evaluation disadvantages of traditional Kano Model and FKM and EI values were imported to optimize consumer demands, it was verified that consumer preferences on appearance images could be analyzed more accurately with C-FKM through studying air purifier case.

In stage 1, 16 kansei image adjectives were selected as quality attribute evaluation items, participant feelings were investigated with bidirectional questionnaire. Among the 16 adjectives, 12 were found with attractive quality attributes, such as natural and fresh and so on. It is found that consumers prefer to buy products with attractive appearances, the phenomenon in which mainly reflected in before they buy in air purifier, the natural and fresh appearance of a certain air purifier will make them feel refresh and neat, so that they will be attracted by the product and then a determined purchase decision is made. Therefore, designers can design air purifier appearance as abstract geometric shape to improve consumer satisfaction, make full use of three composition principles -- point, line and plane -- in combination and arrangement, add appearance changes at certain parts, applying kansei images such as green and environmentally friendly, natural and fresh to air purifier appearance design. Among 12 attractive quality attributes, 5 attractive qualities -- harmonious with household space, green and environmentally friendly, natural and fresh,high-end, and convenient -- have high EI values and the other 7 adjectives have low IE values, therefore, designers can firstly integrate the 5 attractive qualities with high EI values into household air purifier design. Take kansei image adjective "natural and fresh" as a example, a lot of people normally pursue high life quality, high quality and grade of appliances; when consumers found the appearance of an air purifier which conveys natural, green and fresh feelings, they will be hitted by such air purifier. In early stage of product development and design, designer will find it is difficult to determine which 5 attributes are better among the 12 ones. Luckily, contribution degrees of kansei image adjectives in improving consumer satisfaction can be revealed by studying kansei image adjectives with C-FKM. For instance, EI value of "green and environmentally friendly" is 0.298 and EI value of "high-end" is 0.193, so kansei adjective "high-end" with high attractive value can be prior choice for designers.

In stage 2, 20 product images were selected as test samples, participant preferences and kansei images were evaluated with questionnaire, and then counted and analyzed customer preferences on appearance images was discovered. Results of appearance image preference test and C-FKM quality categorization were compared, different influence degrees of kansei image adjectives with attractive qualities on consumer preferences were achieved. Samples with high preferences in SD test were combined with C-FKM quality categorization results through kansei adjectives, results of C-FKM quality categorization and SD test were compared and analyzed synthetically, it was discovered that there were different degrees of intersections between kansei image factors of high preference samples and attractive quality attribute items of Kano attractive qualities, so it was verified that attractive factors obtained from C-FKM quality categorization results are reliable and can improve effectively air purifier product attraction and consumer satisfaction on appearance design of air purifier.

In stage 3, the article first obtained five highly attractive air purifier sensibility images through the C-FKM method, which basically determined the design appeal of the air purifier that consists of the green environmental protection of the purifier, convenience, harmony with household space, the freshness of nature, and high-grade sense, and other product characteristics. The research

selected the five priority design directions that are natural, fresh, coordinated with the home environment, and green and environmentally friendly; and then select the air purifier design style with the highest priority, and use product style association methods, including basic style information, landscape and biological association, to achieve consumer style association of air purifier products, and try capture the product characteristics and define the air purifier design style. Finally, based on the aforementioned customer emotion perception and product feature analysis, comprehensively determine the product design concepts and ideas of the air purifier, and in order to explore the transformation of the natural material image of the air purifier into a tangible product shape, and then increase the product "green" consumers' psychological feelings and the "enhancement" of environmental protection awareness, the 5 design schemes have finally determined through creative design through the above steps.

In stage 4, 50 air purifier consumers are invited to evaluate the five air purifier design schemes identified above. The evaluation scale of the design schemes is based on the tester's evaluation of the freshness of nature, convenience, harmony with household space, green environmental protection and high-end feeling experience According to the obtained tester's feeling and satisfaction of the product design evaluation result, it can be found that scheme C has obtained relatively high evaluation scores in almost every evaluation index, and the maximum value of its comparison average is 3.74, which shows that nearly all customers are satisfied with scheme C. In terms of environmental protection, scheme C has the highest score, which is mainly because scheme C divides the air purifier into two layers, the upper part is made of ceramic material, and the lower part is made of wood material, which weakens the sense of metal and plastic of general household appliances, and the green temperament brought by the product is highlighted. In terms of natural freshness, scheme C has the highest score. It combines the air purifier with the plant, which weakens the air purifier's sense of presence. It looks more like a flower pot than a machine, bringing consumers a fresh and yet natural feeling. In terms of home environment coordination, the design of scheme C is suitable for the environment of home life. After obtaining the satisfaction values of the above five perceptual images, the tester scores five perceptual images for the five air purifier design schemes. The average score of all participants and the satisfaction values of the five perceptual images are weighted for comprehensive evaluation to calculate the design sequence of 5 air purifiers to optimize the design sequence. The final calculation results show that the overall score of scheme C is significantly higher than the other four schemes. This means that the air purifier product designed in Scheme C applies the shape and material elements of natural images and material images to the design concept, effectively allowing users and consumers to produce a natural and environmentally friendly feeling, thereby enhancing green product features and appeal.

Because of certain limitations, this study needs to be further improved. Firstly, during investigation of air purifier quality attributes, participants answered their bidirectional questionnaire on basis of kansei adjectives which are concise and comprehensive and can describe product image space in detail, so deviations might be caused while verifying Kano quality element categories of kansei adjectives. Future researchers can select detailed adjectives for questionnaire to achieve more accurate consumer feelings about products. Secondly, in analysis of preference degree on air purifier samples, some samples are of famous brands, even if brand information was eliminated, some consumers might still be affected while expressing their opinions, preference results comprised consumer subjective trends on brand products, there might be some deviations. Thirdly, product quality attributes do not remain same, they change with product category, time, race and other external elements. Changes of consumer demands are so fast that consumers consider them as attractive at first but soon as must-be; as time goes by, environment changes or competitors also own the attractive qualities, former attractive qualities may turn into one-dimensional qualities or must-be qualities; therefore, group consumer and time change can be discussed in future study.

Acknowledgments
This research was supported by Educational Science Planning of Zhejiang Province in 2021 (2021SCG177).

Yixiang Wu, https://orcid.org/0000-0001-7521-72

REFERENCES

[1] Bovea, M. D.; Ibáñez-Forés, V.; Pérez-Belis, V.; Juan, P.; Braulio-Gonzalo, M.; Díaz-Ávalos, C.: Incorporation of circular aspects into product design and labelling: Consumer Preferences. Sustainability, 10(7), 2018, 2311. https://doi.org/10.3390/su10072311

[2] Carayannis, E.; Coleman, J.: Creative system design methodologies: the case of complex technical systems. Technovation, 25(8), 2005, 831-840. https://doi.org/10.1016/j.technovation.2004.02.012

[3] Chai, C.; Bao, D.; Sun, L.; Cao, Y.: The relative effects of different dimensions of traditional cultural elements on customer product satisfaction. International Journal of Industrial Ergonomics, 48, 2015, 77-88. https://doi.org/10.1016/j.ergon.2015.04.001

[4] Chen, L.-H.; Ko, W.-C.: A fuzzy nonlinear model for quality function deployment considering Kano's concept. Mathematical and Computer Modelling, 48(3), 2008, 581-593. https://doi.org/10.1016/j.mcm.2007.06.029

[5] Cooper, R. G.; Kleinschmidt, E. J.: New products: what separates winners from losers? Journal of product innovation management, 4(3), 1987, 169-184. https://doi.org/10.1111/1540-5885.430169

[6] Demirbilek, O.; Sener, B.: Product design, semantics and emotional response. Ergonomics, 46(13-14), 2003, 1346-1360. https://doi.org/10.1080/00140130310001610874

[7] Dorst, K.; Cross, N.: Creativity in the design process: co-evolution of problem–solution. Design studies, 22(5), 2001, 425-437. https://doi.org/10.1016/S0142-694X(01)00009-6

[8] Florez-Lopez, R.; Ramon-Jeronimo, J. M.: Managing logistics customer service under uncertainty: An integrative fuzzy Kano framework. Information Sciences, 202, 2012, 41-57. https://doi.org/10.1016/j.ins.2012.03.004

[9] Foldesi, P.; Koczy, L. T.; Botzheim, J., 2007: Fuzzy extension for Kano's model using bacterial evolutionary algorithm. 2007 International Symposium on Computational Intelligence and Intelligent Informatics, Agadir, Morocco, IEEE, 147-151. https://doi.org/10.1109/ISCIII.2007.367379

[10] Freeman, R.; Liang, W.; Song, R.; Timmins, C.: Willingness to pay for clean air in China. Journal of Environmental Economics and Management, 94, 2019, 188-216. https://doi.org/10.1016/j.jeem.2019.01.005

[11] Ghorbani, M.; Mohammad Arabzad, S.; Shahin, A.: A novel approach for supplier selection based on the Kano model and fuzzy MCDM. International Journal of Production Research, 51(18), 2013, 5469-5484. https://doi.org/10.1080/00207543.2013.784403

[12] Haber, N.; Fargnoli, M.; Sakao, T.: Integrating QFD for product-service systems with the Kano model and fuzzy AHP. Total Quality Management & Business Excellence, 31(9-10), 2020, 929-954. https://doi.org/10.1080/14783363.2018.1470897

[13] Hartono, M.; Tan, K. C.; Peacock, J. B.: Incorporating Kano's model and Markov chain into Kansei engineering in services. Advances in the Human Side of Service Engineering, 2012, 399.

[14] Hwang, S.-H.; Tsai, I.-C.; Mitsuhashi, T.; Miyazaki, K.: The application of Kano model on exploring the attractive attributes of community culture products. Bulletin of Japanese Society for the Science of Design, 61(1), 2014, 127-136.

[15] Jain, N.; Singh, A. R.: Sustainable supplier selection criteria classification for Indian iron and steel industry: a fuzzy modified Kano model approach. International Journal of Sustainable Engineering, 13(1), 2020, 17-32. https://doi.org/10.1080/19397038.2019.1566413

[16] Jordan, P. W.: Designing pleasurable products: An introduction to the new human factors. Taylor & Francis, London and New York, 2000.

[17] Kaenzig, J.; Heinzle, S. L.; Wüstenhagen, R.: Whatever the customer wants, the customer gets? Exploring the gap between consumer preferences and default electricity products in Germany. Energy Policy, 53, 2013, 311-322. https://doi.org/10.1016/j.enpol.2012.10.061
[18] Kano, K.; Hinterhuber, H.; Bailon, F.; Sauerwein, E.: How to delight your customers. Journal of Product and Brand Management, 5(2), 1984, 6-17. https://doi.org/10.1108/10610429610119469
[19] Kano, N.: Attractive quality and must-be quality. Hinshitsu (Quality, The Journal of Japanese Society for Quality Control), 14, 1984, 39-48.
[20] Khalid, H. M.: A framework for affective customer needs in product design. Proceedings of the Human Factors and Ergonomics Society Annual Meeting, 46(12), 2002, 983-987. https://doi.org/10.1177/154193120204601210
[21] Kreutzer, R. T.; Merkle, W.: Die notwendigkeit zur neuausrichtung des marketing. Die neue Macht des Marketing, Springer, 13-17, 2008. https://doi.org/10.1007/978-3-8349-9562-9_1
[22] Kuo, C.-M.; Yuo, S.-H.; Lu, C. Y.: Integration of the Kano and QFD model in health food development: using black beans as examples. Quality & Quantity, 48(1), 2014, 225-242. https://doi.org/10.1007/s11135-012-9762-8
[23] Lee, M. C.; Newcomb, J. F.: Applying the Kano methodology to meet customer requirements: NASA's microgravity science program. Quality Management Journal, 4(3), 1997, 95-106. https://doi.org/10.1080/10686967.1997.11918805
[24] Lee, Y.-C.; Huang, S.-Y.: A new fuzzy concept approach for Kano's model. Expert Systems with Applications, 36(3, Part 1), 2009, 4479-4484. https://doi.org/10.1016/j.eswa.2008.05.034
[25] Lee, Y.-C.; Sheu, L.-C.; Tsou, Y.-G.: Quality function deployment implementation based on Fuzzy Kano model: An application in PLM system. Computers & Industrial Engineering, 55(1), 2008, 48-63. https://doi.org/10.1016/j.cie.2007.11.014
[26] Liu, Y. C.; Chakrabarti, A.; Bligh, T.: Towards an 'ideal' approach for concept generation. Design studies, 24(4), 2003, 341-355. https://doi.org/10.1016/S0142-694X(03)00003-6
[27] Llinares, C.; Page, A. F.: Kano's model in Kansei engineering to evaluate subjective real estate consumer preferences. International Journal of Industrial Ergonomics, 41(3), 2011, 233-246. https://doi.org/10.1016/j.ergon.2011.01.011
[28] Madzík, P.: Increasing accuracy of the Kano model – a case study. Total Quality Management & Business Excellence, 29(3-4), 2018, 387-409. https://doi.org/10.1080/14783363.2016.1194197
[29] Meng, Q.; He, L.: Fuzzy-Kano-based classification method and its application to quality attributes. Industrial Engineering Journal, 16(3), 2013, 121-125.
[30] Naes, T.; Nyvold, T. E.: Creative design—an efficient tool for product development. Food Quality and Preference, 15(2), 2004, 97-104. https://doi.org/10.1016/S0950-3293(03)00036-3
[31] Nagamachi, M.: Kansei engineering: a new ergonomic consumer-oriented technology for product development. International Journal of Industrial Ergonomics, 15(1), 1995, 3-11. https://doi.org/10.1016/0169-8141(94)00052-5
[32] Ota, M.; Aoyama, H.: Aesthetic design based on "kansei language". Initiatives of Precision Engineering at the Beginning of a Millennium, Springer, 917-921, 2002. https://doi.org/10.1007/0-306-47000-4_180
[33] Rashid, M. M.; Tamaki, J. i.; Ullah, A. S.; Kubo, A.: A proposed computer system on Kano Model for new product development and innovation aspect: A case study is conducted by an attractive attribute of automobile. International Journal of Engineering, Science and Technology, 2(9), 2010. https://doi.org/10.4314/ijest.v2i9.63850
[34] Setyo Rahaju, D. E.; Sari Dewi, D. R.: An approach to dealing with importance weights of customer needs and customer dissatisfaction in quality function deployment optimization. Advanced Materials Research, 931-932, 2014, 1636-1641. https://doi.org/10.4028/www.scientific.net/AMR.931-932.1636

[35] Tama, I. P.; Azlia, W.; Hardiningtyas, D.: Development of customer-oriented product design using Kansei engineering and Kano model: Case study of ceramic souvenir. Procedia Manufacturing, 4, 2015, 328-335. https://doi.org/10.1016/j.promfg.2015.11.048
[36] Tan, K. C.; Shen, X. X.: Integrating Kano's model in the planning matrix of quality function deployment. Total quality management, 11(8), 2000, 1141-1151. https://doi.org/10.1080/095441200440395
[37] Wang, C.-H.: Incorporating customer satisfaction into the decision-making process of product configuration: a fuzzy Kano perspective. International Journal of Production Research, 51(22), 2013, 6651-6662. https://doi.org/10.1080/00207543.2013.825742
[38] Wolkoff, P.: Indoor air pollutants in office environments: Assessment of comfort, health, and performance. International Journal of Hygiene and Environmental Health, 216(4), 2013, 371-394. https://doi.org/10.1016/j.ijheh.2012.08.001
[39] Wong, G. W. K.: Air pollution and health. The Lancet respiratory medicine, 2(1), 2014, 8-9. https://doi.org/10.1016/S2213-2600(13)70284-4
[40] Wu, M.; Wang, L.: A continuous fuzzy Kano's model for customer requirements analysis in product development. Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture, 226(3), 2012, 535-546. https://doi.org/10.1177/0954405411414998
[41] Xu, K.; Chen, Y. V.; Zhang, L.; Rui, L.: Improving design software based on fuzzy Kano model: A case study of virtual reality interior design software. The Design Journal, 22(sup1), 2019, 1983-1992. https://doi.org/10.1080/14606925.2019.1594923
[42] Yadav, H.; Jain, R.; Shukla, S.; Avikal, S.; Mishra, P.: Prioritization of aesthetic attributes of car profile. International Journal of Industrial Ergonomics, 43(4), 2013, 296-303. https://doi.org/10.1016/j.ergon.2013.04.008
[43] Yanagisawa, H.; Fukuda, S.: Design optimisation for customers' KANSEI requirement: application of interactive reduct evolutional computation to industrial design with curves. International Journal of Manufacturing Technology and Management, 10(4), 2007, 360-379. https://doi.org/10.1504/IJMTM.2007.012155
[44] Yang, J.-B.; Wang, Y.-M.; Xu, D.-L.; Chin, K.-S.; Chatton, L.: Belief rule-based methodology for mapping consumer preferences and setting product targets. Expert Systems with Applications, 39(5), 2012, 4749-4759. https://doi.org/10.1016/j.eswa.2011.09.105
[45] Yao, X.; Hu, H.: Emotional level research of product modeling design based on Kano model. Journal of Wuhan University of Technology (Information & Management Engineering), (5), 2014, 673-676.
[46] Yu, Y.; Xu, W.: Optimized configuration of manufacturing resources for middle and lower batch customization enterprises in cloud manufacturing environment. Complexity, 2020, 2020, 5619758. https://doi.org/10.1155/2020/5619758
[47] Zhang, J.; Smith, K. R.: Indoor air pollution: a global health concern. British Medical Bulletin, 68(1), 2003, 209-225. https://doi.org/10.1093/bmb/ldg029