

# Study of Middle-Aged and Youth Users' Preference for Smart Homes

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**Abstract.** Nowadays Smart home will optimize traditional life style and life habit, it brings brand new experience and feeling, and it will become future's main life style and life habit. But now smart home products are still at start-up period of product's development life cycle. What functions can attract consumption and are necessary? What functions are necessary but have no attraction? These function demands of users are not understood thoroughly. So far, there is no much study to differentiate varieties of function demands of smart home. In addition, their preference for requirements of smart home is different as different groups are different in consumption psychology and consumption behavior. For example, the consumption behavior of middle-aged group is rather conservative and youth group is active in thinking and likes to buy some new products and try new life. Therefore how to position the development of relative smart home products according to different target groups is an important subject needed to think.

This study tries to employ positive and negative questionnaire survey form to survey on users' requirement satisfaction degree to obtain key properties of attracting two consumption groups based on Kano Model theoretical basis and the study objects are middle-aged and youth consumers. Traditional Kano model overlooks users' uncertain thinking, and for a question having uncertain choices, questionnaire design must be conducted combining with fuzzy theory. Besides, as the range of smart home industry is too wide, in this study the author takes smart home air healthy products as an example, conducts user interview about home air purifier, collects expert and experienced product designer's suggestions, screens out 10 secondary indexes to build key properties of home air purifiers and judges the property and category of 10 functions by Kano model to infer middle-aged and youth consumers' demand preference difference for home air purifier thus finally providing references for future's smart home products according to analysis results.

**Keywords:** Smart homes · Fuzzy-Kano model · Air purifier · Target group

## 1 Background and Motives

With the fast growth of sensor chip, big data, cloud computing, internet of things and mobile internet, people's daily life combines with smart life technology closely. In recent years, China released a series of policies, listed smart home in 9 major fields of

demonstration projects clearly to establish emerging industries aiming to improve people's life quality by the promotion of intelligent life technology. And related software and hardware innovative application and products are developed. Range of intelligent home products includes intelligent light system, health care, security guarding, monitoring system and internet home appliance system and other new fields.

With the development of sensing and interaction technology, intelligent products are embedded in all kinds of home devices, and these hardware products constitutes a multi—functional hardware system. Software system and hardware system are integrated to build a smart management system with strong multi-functions. Comfort, safety, happiness and other elements are added into home life application to design vision, smelling, hearing, touch and heart moving smart home life products to make home living environment more safe, comfortable, healthy, energy-saving, happy, warm and sweet by control, scene, linkage, study, adaptation, analysis, strategy and other functions and it can even improve life quality and art yearning.

Smart home will optimize traditional life style and life habit, it brings brand new experience and feeling, and it will become future's main life style and life habit. Smart home has characteristics of safety, automation, health and entertainment. By far, there is no much study to differentiate what can attract consumption and is necessary and what is necessary but has no attraction among multi-functions of smart home. In 1984, Noriaki Kano, a professor of Tokyo University of Science, proposes the concept of Kano model. In this study, the author figures out the demands of users based on Fuzzy-Kano Model and survey questionnaire data to obtain key elements of attracting consumers. Fuzzy-Kano Model combines Kano model and fuzzy theory. Compared with traditional Kano model, fuzzy theory must be used to count fuzzy weight for uncertain question evaluation. In this study, air healthy products of smart home are taken as an example, survey on home air purifier is conducted, expert and experienced product designers' suggestions are collected, and present 10 functions are selected to explore key elements of home air purifiers. In this study, Kano model is tried using to account for the properties of these 10 functions to provide references for future users and system providers. In addition, as different consumption groups are different in consumption psychology and behaviors, they have different preferences for functions of smart home. For example, middle-aged group is conservative in consumption behavior; while youth group is active in thinking and likes to buy some new products and try new life. Therefore, how to position development of smart home considering different target groups is an important project needed to think.

## **2 Demand Category Based on Fuzzy Kano Model**

### **2.1 Fuzzy Kano Model**

In 1984, Noriaki Kano, a Japanese famous quality management expert, Tokyo University of Science professor, is inspired by Herzberg's two-factor theory and proposes the concept of Kano model. Professor Noriaki Kano believes that two-dimensional model is needed to be adopted for quality cognition: objective representation characterized by

satisfaction in character and subjective feeling characterized by customer satisfaction, thus obtaining non-linear relationship between user satisfaction and product/service performance.

Figure 1 is Kano analysis model. Horizontal ordinate represents realization rate of user demand and vertical coordinate represents satisfaction degree of users.

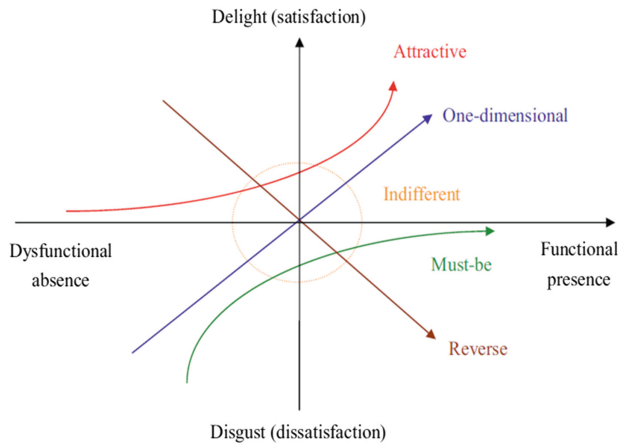


Fig. 1. An illustration of the Kano model

Users'one-dimensional requirements: such quality elements generally change in linear relationship. If products and services provided by enterprises have more characteristics and functions, then users will be more satisfied. When products and services provided by enterprises don't include such characteristics and functions, users will not be satisfied. The products and services with this kind of quality elements are rather excellent, but they are not necessary quality element, it is more possible that users'requirements on some quality elements are fuzzy but they hope to get them.

Attractive requirements curve in the figure is product and service property which is quite unexpected. Users will not clearly express the desire for this kind of quality elements, at the same time they will not expect excessively. But this kind of quality element is uncommitted benefit provided by enterprises for users. If products or services provided by enterprises include this kind of quality element, user will be satisfied, thus improving users' loyalty index.

Must-be requirements curve means users will have dissatisfaction emotion when the products and services provided by enterprise don't include this kind of quality element; on the contrary, when such quality elements like products and services provided by enterprises represent fully, products and services are qualified, users will not have dissatisfaction emotion. At the same time, even the presentation of this kind of quality elements surpass the users' demand, it will not cause the improvement of users' satisfaction degree, because in users' eyes these quality elements are most fundamental elements that products and services should have.

Indifferent requirements: this kind of quality elements are those elements users don't care. Whether the products and services satisfy the elements will not cause users' satisfaction or disaffection.

Fuzzy Kano model demand category method mainly targets at the character that customers' satisfaction degree for demand is fuzzy. Certain fuzzy satisfaction degree value in the range from zero to one represents customers' satisfaction degree for products' survey items, which makes customers' demand category survey more accurate. In order to differentiate customers' demand category better, Matzler etc. made revised Kano model demand category evaluation table. Kano model designs 2 questions which are positive and negative for product property. Customers' demand category for product property is obtained by analyzing Kano's questionnaire table filled by customers. It is seen from Table 1 that "M" represents must-be requirements, "O" represents one-dimensional requirements, "A" represents attractive requirements, "I" represents insignificant requirements, "R" represents reverse requirements and "Q" represents question requirements. Values of all items of demand satisfaction degree range from zero to one.

**Table 1.** Kano model requirement category evaluation table

Positive questions	Negative questions				
	Like	Go without saying	Don't care	Tolerable	Dislike
Like	Q	A	A	A	O
Go without saying	R	I	I	I	M
Don't care	R	I	I	I	M
Tolerable	R	I	I	I	M
Dislike	R	R	R	R	Q

**2.2 Fuzzy Kano Model for Customers' Demand Category Method**

Among traditional Kano model survey, testers give a single answer to a positive or negative question, which overlooks testers' uncertainty of thinking. When customers give uncertain answer for product property, survey data on this part of customers by traditional Kano model is not correct. Considering uncertainty of customer satisfaction degree, fuzzy Kano model demand category method is proposed.

Fuzzy Kano model and traditional Kano model are used to survey on customer satisfaction degree by employing positive and negative questionnaire table and the biggest difference lies in the design of survey questionnaire. One most satisfied answer is permitted to chose for positive and negative questions in traditional Kano questionnaire, and fuzzy Kano questionnaire permits customers to have fuzzy satisfaction degree value for dozens of survey items(percentage form is employed, and the value is between zero and one, and the sum of the line elements is one). Traditional Kano model and fuzzy Kano model questionnaire survey table are seen in Tables 2 and 3.

**Table 2.** Traditional Kano questionnaire survey table

XX Function of products	Like	Go without saying	Don't care	Tolerable	Dislike
Realizable	√				
Unrealizable					√

**Table 3.** Fuzzy Kano questionnaire table

XX Function of products	Like	Go without saying	Don't care	Tolerable	Dislike
Realizable		0.7	0.1	0.2	
Unrealizable			0.8	0.1	0.1

For traditional Kano model (Table 2), customers tick in certain item to represent that they agree to this item, and other blank places are expressed by zero. Realized function matrix is supposed to be  $X = [1\ 0\ 0\ 0\ 0]$ , unrealized function matrix is  $Y = [0\ 0\ 0\ 0\ 1]$  and interaction matrix  $S$  is generated. Matrix  $S$  is compared with Kano model category evaluation table, “one” in matrix  $S$  corresponds to “O” in Kano model category evaluation table. Therefore, the demand category for this property of the product is one-dimensional requirement. Fuzzy Kano model is similar to traditional Kano model method in data process, and the basic steps are as follow:

Certain tester's fuzzy Kano questionnaire table (Table 3) is taken as an example, realized function matrix is supposed to be  $X = [0\ 0.7\ 0.1\ 0.2\ 0]$ , unrealized function matrix is  $Y = [0\ 0\ 0.8\ 0.1\ 0.1]$  and generated fuzzy interaction matrix is.

Above fuzzy interaction matrix  $X^T Y$  is one-to-one correspondent to Table 1, and subordinated vector  $t_a = 0$ ,  $t_m = 0.1$ ,  $t_o = 0$ ,  $t_i = 0.9$  of A, M, O and I are known.

$$X^T Y = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0.5600 & 0.0700 & 0.0700 \\ 0 & 0 & 0.0800 & 0.0100 & 0.0100 \\ 0 & 0 & 0.1600 & 0.0200 & 0.0200 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

As the same factor attributes to varieties of Kano property category at the same time generally. In order to obtain more accurate data and more reliable data, threshold value  $\alpha$  is introduced to screen out data in subordinated vector  $T$  of demand category obtained from fuzzy Kano questionnaire. For the valuing of  $\alpha$ , most scholars employ comparison method, Meng Qing Liang etc. (2013) found that  $\alpha = 0.4$  is the most ideal valuing by setting a different value for  $\alpha$ , thus guaranteeing the undistortion of information and less intersection of information. In this paper, according to opinions of Meng Qing Liang etc., threshold value  $\alpha = 0.4$  is set. According to threshold  $\alpha = 0.4$ , data in subordinated vector  $T$  of fuzzy Kano demand category is screened out; and when subordinated vector  $T$  value of Kano property category is bigger than  $\alpha$ , property vector of this property category is set to represent by “1”, otherwise represent by “0”.

Count each tester's demand preference category for products by repeating above steps and the highest preference frequency for products is demand category corresponding to this product character. If two kinds of categories are same in frequency,

demand categories are must-be requirements, one-dimensional requirements, attractive requirements and indifferent requirement according to priority order from high to low.

### 3 Kano Model Is Used to Build User Home Air Purifier Requirements

Home living is an important place in people’s mind. People require home air to be clean and healthy and require a fresh and comfortable environment. Home air purifier not only exists because of its function of purifying air, and with the development over time, some new requirements occur and the design of air purifier evolves and changes. Besides the most basic air purifying function, nowadays air purifier has added some other functions, and the addition of each new function requirement aims to provide a healthy and comfortable indoor environment better for people. In another hand, air purifiers with different functions need to be chosen for different indoor air pollution situations and different people groups have different focuses on air purifier and different use methods. In order to study the requirement differences on home air purifiers of different people groups, an air purifier requirement Kano model is built to help finish the design in this paper.

Home air purifier function requirement table is designed starting from behavior and psychology feeling of youth and middle-aged people. Card category method, focus group method, questionnaire survey method and user interview method are adopted to obtain users’ requirement list. Finally 10 function requirements are screened out to explore key factors of a home air purifier referring to the suggestions of experts and experienced product designers. User requirement table is seen in the following table (Table 4).

**Table 4.** Function list of an air purifier

Grade1 index	Grade2 index	Description of index
Intelligent interaction	Remotely control air purifier by APP of a mobile phone.	A remote control can be replaced by a mobile phone with App installed to reach the function of operating air purifier by using Wifi, infrared ray or Bluetooth method
	Voice identification operation	Human can communicate with device smoothly. Voice identification operation can be converted to order of operating air purifier
	Operate with touch-sensitive panel	According to users’ operation thinking habit, actions of a user are anticipated and converted into the pictures of operating air purifier interface, which makes users experience products by intuition, experiences and easy operation

(Continued)

**Table 4.** (Continued)

Grade1 index	Grade2 index	Description of index
Healthy	Intelligent air purifying	Remove methane/PH2.5/peculiar smell/lampblack/secondhand smoke, plasmacluster and degerming
	Greenery energy saving	Greenery energy saving
	Real time detect air quality	It is connected with a mobile phone. Real-time indoor air quality is fed back to a user and “starting on” or “starting off” can be set according to air quality. Air quality is reported by voice and graphic change
Mobile and convenience	Mobile mode design	Mobile mode: how to innovate design methods like roller/hand-held
Modularized design	Modularized design: water changing device and filter net change etc.	Modularized design: how to modularize water changing device and filter net change etc.
Comfortable and affinity feeling	Mute/light mode/starting on method and vision presentation method etc.	Continual innovation in comfortableness, anti-interference and easy sleeping
Multi-function	Function expansion of air purifier	Multi-function such as: disguising as a flower pot, playing like a stereo and integrating humidification function.

The following Table 5 is the function requirement evaluation questionnaire table designed based on fuzzy requirement table. In the table, two-way questions about the attitude of having that function and the attitude without having that function are designed to obtain users' attitude at each requirement from different angles.

**Table 5.** Two-way question evaluation questionnaire table based on fuzzy Kano model

	1. Like	2. Go without saying	3. Don't care	4. Tolerable	5. Dislike
If modularized design is provided, what will you feel?	0.6	0.3	0.4		
If modularized design is canceled, what will you feel?			0.2	0.2	0.6

Face to face interview for answering the above questions is conducted. First explain function and specification, and then let testers choose the keys to the positive and negative questions about each function requirement. Conduct careful survey interactively during answering questionnaire questions to obtain real preference of users for

home air purifier requirements. Finally carry on the statistics for requirement information collected from users' requirement survey tables, make data table and obtain demand property of testers for home air purifier and classify it. Results of attractive requirements, one-dimensional requirements, must-be requirements and indifferent requirement are seen in Table 6.

**Table 6.** Youth home air purifier requirement property category result

Factor	M	A	I	O	R	Q	Category
Remotely control by App of mobile phone	1	9		8			A
Voice identification operation		7	10	1			I
Operate using touch sensitive panel	6	4	9	6			I
Purify air intelligently	4	5	3	10			O
Greenery energy saving	3	1	5	7			O
Real-time monitor air situation	1	3	6	11			O
Mobile and convenient	3	4	12	2	1		I
Modularized	2	4	5	8			O
Comfort and affinity feeling	2	4	4	7			O
Function expansion		7	17				I

**Table 7.** Middle-aged people's home air purifier requirement property classification result

Factor	M	A	I	O	R	Q	Category
Remotely control by App of mobile phone	1	6	9	1			I
Voice identification operation	1	6	9	1			I
Operate using touch sensitive panel	3	4	8	3			I
Purify air intelligently	1	6	4	7			O
Greenery energy saving	9	4	3	5			M
Real-time monitor air situation	5	4	5	3			MI
Mobile and convenient	3	2	10	2	1		I
Modularize	3	2	8	5			I
Comfort and affinity feeling		8	3	7			A
Function expansion	1	4	12	1	2		I

Kano model classification method. For youth group, by statistics, it is known that attractive requirements are remote controlling by App of a mobile phone; one-dimensional requirements include 5 items, which are purifying air intelligently, greenery energy saving, real-time monitoring air quality, modularizing design and providing affinity feeling; indifferent requirements include 4 items, which are voice identification operation, operating by using touch sensitive panel, mobile convenience and function expansion. For middle-aged group, attractive requirements are comfort and affinity feeling; one-dimensional requirements are purifying air intelligently; there are 6 items of indifferent requirements: remotely controlling by App in a mobile phone, voice identification operation, operating by using touch sensitive panel, mobile convenience,



modularization and function expansion; and must-be requirements are greenery energy saving and real-time monitoring air situation. For the item of real-time monitoring air situation, must-be requirements and indifferent requirements have same statistic result; if frequencies of two categories are same, the priority of requirement categories are must-be requirement, one-dimensional requirement, attractive requirement and insignificant requirement in order from high to low. Therefore, real-time monitoring air situation is judged to be must-be requirement (Table 7).

#### 4 Discussion and Analysis on Results

Each question item is classified and its property is judged according to If Noriaki Kano professor thinks that life cycle of quality element is indifferent quality stage, attractive quality stage, one-dimensional quality stage and must-be quality stage. When products have certain new quality element, consumers are not familiar with it at the beginning; even this quality element exists, consumers can not aware it and feel there is no difference, then this time is indifference stage. After educating consumers over time, consumers feel satisfied for quality elements gradually, and this time is attractive quality stage. As Kano model needs property judgment, when frequencies of two categories are close, some information will lose if screening, thus the attitude of certain number of consumer groups will be overlooked; after all, for the same concept, different people have different cognition and acceptance degree. If transitivity description is used, the concepts with similar frequency type are more reasonable. Therefore using preferred transitivity description is more reasonable because the propaganda of this concept has no overwhelming advantages among users.

This study shows that products in the fields related to smart home are at introduction stage of product's life cycle. The products have not been accepted by market still; and consumers do not accept products still, waiting for system providers to educate consumers how to use in order to make consumers feel satisfied for products gradually. Undifferentiated qualities with same results among youth group and middle-aged group include 4 items: voice identification operation, using touch sensitive panel to operate, mobile convenience and function expansion. Deep problems involved in voice are large transformation of human-machine interaction. And users of function expansion can not produce good association, function expansion is not found to be valued so it needs to be publicized to make consumers understand it more. Touch sensitiveness and mobile convenience are insignificant for them, perhaps customers do not care them really because touch sensitiveness and mobile convenience appear in all kinds of products widely, users understand these two concepts and have operating experience but users attribute them in indifference property and it only shows that users have no interest in them really. Strengthening of touch sensitive design has no enough attraction for users but design of touch sensitiveness interface is close to life and makes products convenient to use. We should reduce cognition burden of users and design interfaces catering for users and we should not make users adjust their own habits to adapt your products.

For youth group, attractive quality elements are remotely controlling air purifier by App in a mobile phone. There is some controversy in this aspect, and counting result

shows that the results of A and O are similar, so it is known that remotely controlling air purifier by App in a mobile phone is understood and known by users after long time propaganda. At present, remotely controlling air purifier by App in a mobile phone is at a stage transiting from attractive stage to one-dimensional stage, therefore attraction of remotely controlling air purifier by App among smart home products decreases. While middle-aged group is different, statistic result shows that comfort and anti-interference and affinity are attractive for middle-aged group. Air purifier can adjust automatically according to air quality and users' sleep status. As middle-aged group likes quietness, their anti-interference ability from outside environment in physics is worse, and they are not so good at operating smart mobile phones, they have no strong desire for remotely controlling home appliances by a mobile phone. Therefore this item is attributed to indifference property.

The item real-time monitoring air situation is attributed to must-be requirements among middle-aged group. The author understands from interview that middle-aged group believes that air purifier is a product used to purify air and it must have the function of monitoring air quality. But another part of middle-aged group has the attitude of indifference, it shows that quite a part of middle-aged group has not so high purchase passion for air purifier as youth group, their demand for air purifier is not very strong, their consumption idea is rather conservative, and their consumption impulse for unnecessary daily goods is not large, even some middle-aged group think that they do not need air purifier products, because they hold the opinion that nowadays air is polluted but it is not necessary to purify air indoor, they think natural air is good and purified air is not sure to be good and air pollution problem should be solved by government's strict control from root, and only improving indoor air has no much effects. Obviously there is misunderstanding and blind rejection psychology existing in their opinion on air purifiers. At present the function characteristics of an air purifier has not been accepted wholly by middle-aged group. It is needed to greatly publicize function characteristics of an air purifier and promote more middle-aged people to experience them by manufactures. The category of greenery energy saving is different among two groups. Energy saving consciousness is approved and popular among middle-aged people, and even it transits to must-be property.

For results of purifying air intelligently, the two groups both attribute it into one-dimensional requirement. Middle-aged people have different understanding degree for air purifying products, a part of people think it is attractive but insignificant when this character is not adequate; but users who have higher education background, higher income and like to contact new things are familiar with air purifier, therefore there is big difference among middle-aged group, statistic results show that frequencies of attractive requirements and one-dimensional requirements are similar, but one-dimensional requirements frequency of youth group is very prominent, which shows that although both two groups have desire for intelligently purifying air but their progress at the same stage is different.

Modularized design such as water changing device and filter net changing is desired very much for youth group. Taking Shanghai as an example, a filter net needs to be changed frequently, if not, it is better not to use air purifier because normal service cycle of a filter net is three months to six months therefore purchasing an air purifier is equal to purchasing purifying ability and purchasing a filter net, and a filter net needs to

be changed regularly. The net change is a complicated thing; and our filter net with modularized design is easy to change. Middle-aged group is not very clear about modularized design compared with youth group and they have no big interest in it.

## References

1. Kano, N., et al.: Attractive quality and must-be quality. *J. Jpn. Soc. Qual. Control* **14**(2), 39–48 (1984)
2. Liang, M.Q., Lin, H.: Quality property category method and application based on fuzzy Kano model. *Ind. Eng.* **16**(3), 121–125 (2013)
3. Jun, W.: *An Essential Guide of Smart 3.0 Smart Home*. Chinese International Book Publisher (2015)
4. Yang, X.Y.: Study on Customers' Satisfaction Degree of Mobile Phone Purchasers Based on fuzzy Kano Model. Academic Dissertation of Donghua University (2015). 61
5. Berger, C.: Kano's methods for understanding customer defined quality. *Center Quality Manage. J.* **2**(4), 3–36 (1993)
6. Tao, B., Zhongkai, L.: The important degree calculation method of customer demand based on Kano model. *China Mech. Eng.* **8**(4), 975–980 (2012)