Research article

Fuzzy theory analysis on imagery modeling of wearable bracelet in the urbanian health management

Ruoyi Zhao[1], Ying Gao[1,*], Xingmin Lin[1], Ye Tian[2,*], Xiu Chen[1], Luting Xia[1] and Yuqiong Jie[1]

[1] Department of Art Design, Zhejiang Gongshang University, Hangzhou 310018, China
[2] Department of Civil Engineering and Architecture, Zhejiang University, Hangzhou 310058, China

* **Correspondence:** Email: gaoying@zjgsu.edu.cn, cetianye@zju.edu.cn.

Abstract: The purpose of this research is to evaluate the imagery modeling of wearable bracelets. Twelve kinds of smart wearable bracelets with the biggest market share were taken as the research samples. Firstly, by means of questionnaire survey, the factor analysis was utilized to assess the survey results. And 6 groups of adjective vocabularies were selected to describe the imagery modeling of smart wearable bracelets, as neat and good-looking, individuality and interesting, elegance and tasteful, gorgeous and diversiform, technology and quality, popular and economical. At the second step, the evaluation of 12 smart wearable bracelets in 6 groups of adjective vocabularies was calculated with triangle fuzzy theory. The costumers in Hangzhou City were taken as the research target and divided into three categories as elderly silver population, white-collar workers and physical fitness youth. Based on the user matching hypothesis, a questionnaire survey was conducted again. Smart bracelets with concise, popular, economical, technological, recognizable imagery were applied in elderly silver population group. Smart bracelets with good-quality, gorgeousness, elegance and taste were more suitable for the group of urban white-collar worker. The smart bracelets with neat, good-looking, personalized, interesting characteristics showed great physical fitness to youth group. The analysis on the survey results show that assessment on the imagery modeling of smart wearable bracelets for three costumer groups is consistent with the user matching hypothesis. The investigation will offer reference for the designers and manufacturers to develop products purposely. The research results of this study can help the consumers to rationally use the smart bracelet and form a personal health database, so that the government can optimize the allocation of medical resources and build a better medical service system.

Keywords: smart bracelet; adjective vocabulary; factor analysis; triangular fuzzy theory; healthy care

1. Introduction

With the progress of science and technology, people's living standards improve continually. Under this circumstance, the intensity for people to do manual labor in their daily life gradually reduce.

In 2000, the World Health Organization (WHO) pointed out in its survey report that the top ten causes leading to death in developed countries around the world were mainly related to lifestyle and environmental. Among them, about 850,000 deaths could be attributed to lacking of exercises. On the contrary, keep sporting can prevent hypertension, obesity and other health problems. Therefore, sport has a positive impact on human health, disease prevention and mortality reduction [1] in 1996, the US Department of Health and Human Service (US DHHS) proposed various health benefits of sport. It is thus clear that sports have become an important means to promote the national health. At the same time, it also has significant benefits to save the national health care costs and medical expense.

Along with social progress, especially the change of working mode and traffic mode, the sedentary lifestyle is becoming the main lifestyle of most of the people. Moreover, the modern life is characterized by less movement and excessive nutrition, many white-collars suffer from long-term working pressure and lacking of sport which result in deterioration of body function, sharp weight increase and sub-health. And it causes hypertension, diabetes, metabolic syndrome and other diseases, resulting in the increase of social medical costs. Therefore, health problems have called more and more concerns among people. At the same time, under the impact of the aging society and the change of family structure, more and more elderly people have to live alone, and their health conditions cannot be timely informed. With the help of smart bracelets, the elderly people and their children can learn their health status anytime and anywhere. It is also possible to bridge an interaction between the elderly people and their children which will increase the spiritual comfort of them.

With the continuous development of artificial intelligence and information technology, modern people's lifestyle, health needs and medical care concepts are changing constantly. The social concern on medical problems is also increasing. A series of advanced, convenient and humanized medical concepts appear gradually. Smart bracelets can be used as a combination of sports equipment, fitness equipment, and information and entertainment terminal with intelligent network which can provide customers more perfect medical services and better medical experience.

In recent years, the rapid progress of wearable devices gradually improves the convenience of people's life. Small household medical equipment such as wearable pedometers, sports bracelets, blood glucose meters, blood pressure meters and so on, have successfully overcome the shortcomings of the traditional medical system which has a tremendous impact on people's lives. People begin to use various convenient sensors or mobile apps to record data of their lives, such as the number of daily steps, the quality of sleep, and their performance in sports, etc., and then get feedback through data quantization [2]. In the meantime, through the measurement conducted by wearable equipment, users can know the daily exercise is sufficient or not which is helpful to establish a healthy lifestyle. Moreover, through the construction of relevant data platform, users can obtain more health information and carry out effective health management for themselves [3].

The wearable smart device defined by TRI topology industry research institute (2013) is a commodity which shows great convince for the consumers who is wearing it. This kind of product can promote the interaction between the application software and the consumers. Moreover, it is a kind of recorder that the consumers can hold their own sports and health care records, etc. [4]. According to the research of MIC, wearable devices provide situational awareness effect and user

health monitoring function which can reduce users' dependence on mobile phones (MIC, 2015). Flurry (2012) report points out that wearable smart products have become accessible devices through cross-platform links and integration with mobile phones, tablet, PC and other electronic products [5].

According to the 2008 China Wearable Equipment Industry Market Situation and Industry Development Trend Analysis, for the users who had ever some understanding of smart wearable devices, 68.9% of the users said they would consider buying wearable equipment the number of whom is more than two times of the users that would not. Relevant data indicates that Chinese consumers have a very strong desire for smart wearable devices. For consumers who would buy smart wearable equipment, 35.6% can accept the price within 300 RMB, 28.6% between 300 and 500 RMB, 16.7% between 500 and 1000 RMB, and 19.1% can accept smart wearing device above 1000 RMB. From the price distribution, it can be seen that the distribution of consumers covers both the general public and the high-end business people. At the same time, consumers still focus on the cost performance and the user experience. Smart wearable devices mainly include smart bracelet, smart watch, smart clothes, smart glasses and so on. Among them, the smart bracelet has the highest popularity as the usage complexity of smart bracelet is relatively lower and the price is cheaper. Therefore, this study takes smart bracelet as the research object and the objective of this study is to understand consumers' psychological feeling about smart bracelet and grasp consumers' preference trend.

Smart bracelet is also called smart band, which is a kind of electronic product can be worn on human body. In daily life, smart bracelet, as an assistant health tool, can provide a continuous monitoring on chronic diseases. It may monitor, record, summarize and analyze data for a long time, and make full use of the data to learn the law of personal movement. The personal database formed by the smart bracelet can play an important role in assisting disease treatment, reasonable sports arrangement and guiding healthy life, and improve the happiness index of urban population.

When wearable smart products integrate lifestyle with science and technology, they will become easier and easier to use. Therefore, the influence of the material selection of smart bracelet on the environment and society in the consumer's cognition, the product "modelling" characteristic is the most effective [6]. Good modelling and comfortable wearing experience play an important role in consumer behavior. According to the perception on consumer psychology, the buying decision firstly depends on the product appearance [7]. In 1972, Mckellar made a five-sensory survey on imagery. Among them, the visual imagery shows highest proportion which demonstrates its great influence [8].

A study exploring the most influential factors on stimulating the consumer's pleasant emotion in aesthetic characteristics shows that modelling factor can directly and effectively affect consumer's perception of emotion [9]. Nowadays, the research on wearable sports bracelets focuses on the modeling of wearable devices and smart watches. In the study of ergonomics theory, Wang Zhen (2014) analyzed and designed the size, function realization and interface interaction of smartwatch based on the knowledge and experience of human engineering and design. Jin Wenkui and He Renke (2018) used three-dimensional anthropometric technology to obtain more detailed data and information of the human body, so as to improve the suitability of wearable product modeling design. Ruan Weiyu (2016) quantitatively and qualitatively studied the gender orientation of the appearance elements of watches by using the gender perspective of analytic hierarchy Process (AHP) , and provided guiding principles for designers to add corresponding gender attributes in their designs. Tian Tian (2009), based on kansei Engineering, proposed a set of thinking modes and methods for the design of women's watches based on product images jointly formed by modeling genes, color collocation and other factors. Wang Yuqi (2015), Chen Manru et al. (2016), Huang Cheng et al. (2014) also used kansei

Engineering method to obtain the correlation matrix between consumers and product samples, then analyzed and extracted the design elements of product samples, so as to provide reference for the optimization of wearable devices and smart watches. Thus, it can be seen that it is an effective method to use factor analysis and fuzzy theory to study the modeling of sports bracelets, which is helpful for enterprises and designers to grasp users and market demands quickly and accurately.

Although there are some studies relate studies related to smart bracelet, most of them most of them are conducted from a perspective of are conducted from a perspective of market. A research performed on. A research performed on overall modelling image and consumer psychological feeling is rare. The purpose of this research is listed as follows:

(I) Some questionnaires were designed based on the adjectives of the smart wearable bracelets. Through factor analysis and triangular fuzzy number calculation, the imagery evaluation on the modeling characteristics of 12 kinds of smart wearable bracelets was clarified.

(II) The factor analysis and triangular fuzzy calculation are used to evaluate the adjective vocabulary. The integration and generalization on the analysis results is helpful to understand consumers' willing in using wearable bracelets. Furthermore, the designers of wearable bracelets can translate consumers' feelings and intentions into design elements and provide more details for design reference. Then the designers can design the most suitable products to meet needs of consumers and market.

(III) The research on the imagery modeling can help to analyze the consumption intension for the brand and appearance of smart bracelets based on the classification of different urban consumer groups. The consumers can choose the smart wearable bracelets more reasonably and learn their physical conditions accordingly, which is helpful to form a healthy life. The private health data collected by the smart bracelet can inform the consumers of their health states at the first moment. Meanwhile, the smart bracelet will help to popularize the health consciousness and form good habits for people. Moreover, the smart bracelet can be used to handle aging problems in assisting the elderly to prevent diseases by detecting potential chronic diseases earlier. In other words, the smart bracelet can improve the quality of life for old people and reduce the cost of medical care in both time and money.

2. Literature review

For the research of sports bracelet, Zhang Hao discussed the algorithm of optimizing wearable device [10]. The improvement of the monitoring technology helped to enhance the user experience effect and reduce the energy consumption of sports bracelet. Yunboon Cho et al. also designed a new step-counting detection algorithm for wristband-type wearable devices [11]. Borazio M. et al. used wearable device to collect relevant data of 42 patients in the sleep experiment. Then the calculation was performed according to the estimation principle of the sleep stage (ESS), and the sleep quality analysis results of the patients in the sleep experiment were finally obtained [12]. In terms of design innovation, Chen Guoqiang et al. took smart watch as an example to explore product design from a new dimension by combining eight evolution modes of TRIZ technology system and Kano model [13]. Wang Hao applied the design psychology theory to analyze the emotional design factors, and put forward a series of methods for emotional design of wearable medical devices [14]. In addition, some wearable Bracelet design research was conducted for special user groups, such as aging population. It can be seen that although the current research on wearable sports bracelets is involved in all aspects, the study on the visual psychological feelings of different consumers with different shapes, colors and materials based on an objective research method is still not sufficient. Through the questionnaire

survey, the evaluation on the visual imagery of wearable bracelet based on factor analysis and fuzzy theory is helpful to shorten the distance between designers and consumers on the shape recognition of wearable sports bracelets, which can improve the efficiency in product development and benefit the enterprises, designers and consumers accordingly.

Factor analysis is used as a method to simplify complicated data [15]. Brown defined factor analysis as "the statistic method in which the amount of factors are decided to explain the relation between a group of variances, and a factor is the combination of multiple related variables, so they can be used to measure identical features" [16]. By using this method, researchers can simplify a group of variables that can reflect the nature, state and characteristic of things, and can be used to reflect the intrinsic nature of things and determine the essential characteristic of things. Among the research of modelling, the shape contour of smart bracelet is transformed into data by factor analysis method, and the model intention characteristic value is obtained by linear analysis mode [17].

Fuzzy theory is always applied for studying and processing information and data, which is proposed by Zadeh. It mainly includes the fuzzy set theory, the fuzzy logic, the fuzzy inference and the fuzzy control, etc. Rigorous mathematical method is usually utilized in fuzzy analysis to deal with imprecise and fuzzy data and solve the decision problem under fuzzy environment [18]. Essentially, fuzzy logic must be used to describe the quality of things. Fuzzy logic can manage fuzzy and rigorous judgement in mathematics adopts a fuzzy wording scale instead of traditional measuring scale to manage the variability of human thinking. Similarly, tri-angular fuzzy numbers are used here to quantify linguistic variables, including the intensity of consumers' needs [19]. Fuzzy set theory is the quantification of fuzzy concepts, mainly dealing with the fuzziness of psychological feeling of some subjects, extends the membership of an element in a set to generalize the number of arbitrary value in (0,1) [20].

3. Research methods
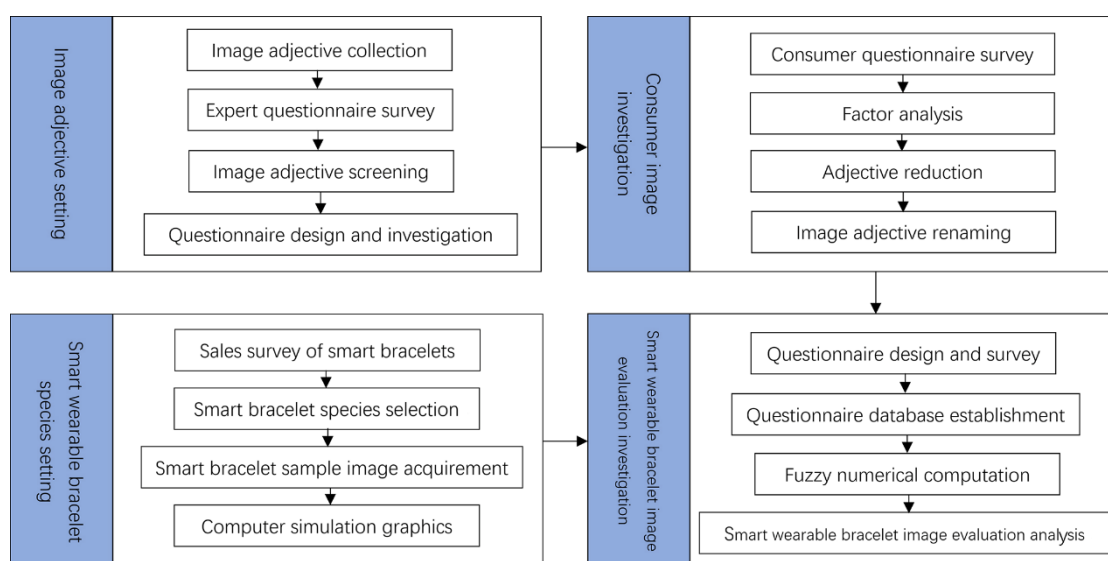
The major research process is shown in Figure 1.

Figure 1. Research flowchart.

3.1. Step 1

At the first step, 140 organized vocabularies were selected as the adjective vocabularies of design intention. The 140 adjective vocabularies were furtherly filtered down to 40 by 10 sports enthusiasts. Twelve smart bracelets with the biggest market share were chosen as the research samples, including XiaoMi (XM), Misfit Shine (MS), Misfit Vpaor (MV), Misfit Ray (MR), Fitbit Alta (FA), Fitbit Charge (FC), Fitbit Flex (FF), Fitbit Flex Metal (FM), Amazfit (AM), HuaWei B32 (HW), Amazfit Huami (AH), Lexin Ziva (LZ). They are numbered randomly and shown in Table 1.

Table 1. Research samples.

No.	Name of Smart Bracelets	Code	No.	Name of Smart Bracelets	Code
1	Xiao Mi	XM	7	Fitbit Flex	FF
2	Misfit Shine	MS	8	Fitbit Flex Metal	FM
3	Misfit Vapor	MV	9	Amazfit	AM
4	Misfit Ray	MR	10	HUAWEI B32	HW
5	Fitbit Alta	FA	11	Amazfit Huami	AH
6	Misfit Charge	FC	12	Lexin Ziva	LZ

No.1 XM   No.2 MS   No.3 MV   No.4 MR   No.5 FA   No.6 FC

No.7 FF   No.8 FM   No.9 AM   No.10 HW   No.11 AH   No.12 LZ

3.2. Step 2

The second survey was conducted using a questionnaire designed by Likert five-point scale method. The five evaluation levels were involved in the scale as very unsuitable, unsuitable, ordinary, suitable and very suitable. A total of 118 effective questionnaires were recalled. In them, 48 questionnaires were obtained from male respondents and 70 from female. At this step, 40 adjectives were filtered through factor analysis using a commercial software, SPSS. A further factor analysis on 40 adjectives was conducted with discriminant. The analysis results show that a total of 20 adjectives have the absolute value of factor load quantity (factor loading) higher than 0.6. And the second factor

analysis is conducted on these adjective vocabularies. The adjective vocabularies were regrouped into 6 groups and renamed according to the characteristics of them.

3.3. Step 3

To help consumers to choose wisely, semantic variables are often evaluated to assess the importance of the user's needs and the order of the production selection. The design scale questionnaire is carried out using the 7-level semantic variables with 3 angle fuzzy scale. Linguistic variables for Very low with Triangular fuzzy number is (0,0,1), Low is (0,1,3), Medium low is (1,3,5), Medium is (3,5,7), Medium high is (5,7,9), High is (7,9,10), Very high is (9,10,10). The survey respondents ranged from 18 to 60 years old and they had extensive experience in digital products use. A total of 82 questionnaires were recalled successfully, in which 35 from male and 47 from female. Consumers can score according to their subjective imagery. For the entire semantic scale, the corresponding triangular fuzzy value can be used to describe the relationship between the potential characteristics of a smart bracelet and the semantic wording membership. The particularity of the triangular fuzzy number lies in its membership function, the probability distribution is to form a triangle [21]. Suppose $\tilde{t}$ to be a triangular fuzzy number in the Membership function $\mu i(X)$, which is represented as $\tilde{t} = (t_1, t_2, t_3)$, and when t_1, t_2 and t_3 are real and $t_1 \leq t_2 \leq t_3$.

In order to obtain detailed analysis data, the fuzzy number in the membership function can be converted to crisp value by defuzzification. The maximum set and the minimum set were mostly used. In this paper, the weights of the two trigonometric numbers were calculated to deduce the absolute utility value. The absolute value UT of the triangular fuzzy number $\tilde{t}_i$ can be calculated as:

$$\text{UT}(\tilde{t}_i) = \frac{\left[\frac{(\tilde{t}_{i3} - x_{min})}{((x_{max} - x_{min}) + (\tilde{t}_{i3} - \tilde{t}_{i2}))} + 1 - \frac{(x_{max} - \tilde{t}_{i1})}{((x_{max} - x_{min}) + (\tilde{t}_{i2} - \tilde{t}_{i1}))}\right]}{2}, \tag{1}$$

$$i = 1, 2, \ldots \ldots n$$

3.4. Step 4 experiment hypothesis

3.4.1. Hypothesis 1: urban elderly silver population

According to psychology of consumers, the decision to buy depends on the stimulation provided by the products [22]. According to the "Hangzhou statistical Bulletin on ageing in 2017" which was issued by Hangzhou Civil Affairs Bureau, the elderly population in Hangzhou had reached to 1,671,800 by the end of 2017, and the proportion of the elderly population in Hangzhou had increased from 17.54 to 22.16% within six years. From 2011 to 2017, the number of elderlies over 60 years old had increased by 449,000. It can be seen that the elderly population in Hangzhou is continuously increasing, and aging is inevitable. Under this background, the problems related to health care, medical treatment, health promotion of the elderly silver population have become increasingly prominent. Taking regular exercise helps to improve the physical and mental health of the elderly. The point of exercise is not to prolong life, but to improve the quality of life in the old age [23]. Therefore, through continuous exercise, the elderly silver population can improve their body functions, health conditions, and have the ability to live independently. Moreover, it can achieve a balanced state of mind and body, and improve their life happiness. According to the

"Upgrading Data on the consumption of the elderly" released by Alibaba Group, the elderly is paying more attention on spiritual needs, such as cosmetics, outbound travel, new forms of fitness, etc. The consumption of the urban elderly shows an obvious upward trend. The purchase growth in cosmetic and sports equipment has a rapid growth. Through observation and interview, the ability of the elderly to learn and accept new things is relatively poor due to the degradation of physiological function. Therefore, the function and display product for elderly should be as simple as possible. In general, with the development of Chinese economy and the improvement of living standards, the elderly pays more attention to physical health problems. And at the same time, they pursue fashion and quality of life, which makes them younger in psychology. Summarily speaking, the imagery of smart bracelets produced for urban elderly silver population should be simple, high-quality, economical, easy to read and operate.

3.4.2. Hypothesis 2: urban white-collar workers

The white-collar class is an important concept in the study of social structure, which refers to a group with middle living standard and property status [24]. Based on Chinese economy, social and cultural development level, some experts point out that a reasonable Chinese white-collar class should have a per capita annual income of 80,000 to 400,000 RMB. The white-collars have stable economic income and greater autonomy in consumption. And the consumption structure of white-collars indicates that they care more about spiritual life than the substantial life. And it has shifted from survival consumption to developmental and enjoyable consumption. Moreover, the consumption type of white-collars is in the transition period from tradition type to modern type. As a new first-tier city, the economic development level of Hangzhou is very high. The white-collars in this city earn well, and most of them can save money. Although there are advanced consumption concepts and developed commercial resources in Hangzhou, while the most of the white collars still have traditional consumption concepts of diligence and thrift. Meanwhile, although the modern consumption consciousness is gradually raising, the consumption pattern of white-collars is still dominated by rational consumption. The newly released research report, Survey Report on Living Conditions of White-collar Workers (2018), shows that the working time of white-collars in Hangzhou ranks the top one in the list of Chinese cities, and it is the second time that the white collars of Hangzhou have been first in a row. According to the survey report on the living conditions of white-collars in Hangzhou, white-collar workers are under great pressure, and rarely exercise. They stay up late at night, and often skipping breakfast to get more sleep. Therefore, in the course of career development, most of white-collars are in sub-health state because of the excessive pressure and unhealthy lifestyle. In their daily lives, in order to keep the body in a good state, white-collars often wear smart wearable bracelets constantly to record health data. And under the guidance of mobile APP, they form reasonable exercise habits and lifestyle to keep healthy. Generally, white-collars are well educated, having rich scientific and cultural knowledge and higher self-cultivation. In their work, white-collars have a wide range of contacts and a fixed social circle. Investigations and research indicate that white-collars are fashionable, elegant and noble. Female white-collars usually have decent clothes and delicate makeup. Meanwhile, the male white-collars pay attention to the user experience of commodity and quality of product. The consumption pattern of this consumer group reflects the characteristics of good-taste, personality, quality and practicality. Female white-collar consumers love life and have stable and independent income. They pay attention to the quality of life, and pursue the beauty of health and happiness. Female white-collar works take of themselves, and want to enjoy the life. Therefore, smart bracelets with imagery of delicate, quality, personality and exquisite will be applied in this group.

3.4.3. Hypothesis 3: urban physical fitness youth group

According to the report of "Big Data on the state of Zhejiang National Fitness Activities in 2018" which is given by Zhejiang sports Bureau, the national strategies of "National Fitness" and "Healthy China" has been widely propagated and commended by government. The healthy lifestyle of "I exercise, I am healthy and I am happy" has been popularly recognized by the public in Zhejiang province. By the end of 2018, the proportion of people over 20-year-old who regularly participated in physical exercise was 28.1% of all the adults. But the it should be pointed out that this number has an increase of 3.5% over 2017.

Recently, Le Ke sports released a set of big data about the fitness of Hangzhou people. The date reveals that the exercise patterns of youth people are varied. It shows that, due to the nature of work, about 10% of young people choose to sport after midnight out of doors. There are also some people who suffer from insomnia because of the great pressure of work during the day, so they choose to exercise in gym to release the pressure right after dinner. It can be seen that bodybuilding has become more and more popular among young people in Hangzhou. According to the investigation and survey, in view of age, young adults between 20 and 39 years old are the major part of fitness population. These people pay great attention to their own health and weight status. And 39.5% of them often weigh themselves and record their weight [25]. The main reason for young people to keep sporting is to lose weight, then to be healthy and fitness. During the exercise, they often record their exercise status and calorie consumption through wearable devices. Through an observation and research of the fitness crowd, it is found that the wearable bracelet needs to be appropriately fitted to the human body during exercise, which can perfectly contact the wrist while have no influence on the movement of the wrist. Therefore, it is necessary to properly deal with the relationship between the material and shape of the product. At the same time, the wearable bracelet needs to be adapted to all kinds of sport states of the user, such as swimming, running and mountain climbing. So it needs to be small and not burdensome. Therefore, the wearable bracelet should have operation buttons as few as possible, which will reduce the complexity of the product. And at the same time, it will bring the user an immersive experience. In addition, young people prefer to accept new things and innovative products. Therefore, although smart wearable bracelets just emerge in the market for a short time, young users still fell familiar about it and tend to accept it very naturally. Meanwhile, for young people, the products that can reflect their unique personalities are more easy to be accepted. Considering the consumption patterns of the youth, the smart wearable bracelets should have optional wristbands with different colors, so that the youth can make different choices according to their moods and wishes. Generally speaking, this user group pays more attention to the personality, tendency, and quality of products. Therefore, the modeling imageries of wearable bracelets will be neat, individuality, quality and diversiform are applied in this area.

4. Results and discussions

Through factor analysis, the top 20 adjective whose absolute value of factor loading exceed 0.6, are as the following: easy 0.696, presentable 0.671, conciseness 0.693, convenient 0.701, characteristic 0.742, vigorous 0.753, interesting 0.847, unique 0.717, tasteful 0.769, elaborate 0.614, luxurious 0.741, lightsome 0.642, advanced 0.687, diversiform 0.687, superior 0.709, exquisite 0.750, technological 0.629, quality 0.731, economical 0.738, popular 0.689. Through factor analysis and Bartiett spherical testing, it can be seen that KMO value is 0.896, indicating analyzing data is appropriate. Bartiett spherical test

value is 1475.425 (free dimension 190), a very significant one, representing there are common factors among the related matrices of the parent group (Table 2). There are 6 factors with the initial eigenvalue greater than 1 in the total variance, and the cumulative sum of variance is 74.099%. Through another factor analysis on the 6 components, the factors in each section are very clear and can be as a lexicon group. The six groups were neat and good-looking (N & G), individuality and interesting (I & I), elegance and tasteful (E & T), gorgeous and diversiform (G & D), technology and quality (T & Q), popular and economical (P & E).

Table 2. KMO and Bartlett's test.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.896
Bartlett's Test of Sphericity	Approx. Chi-Square	1475.425
	df	190
	Sig.	0.000

Through imagery evaluation of a variety of smart bracelets in 86 samples, the mean scores of visual evaluations are shown in Table 3 by fuzzy numerical operation.

Table 3. Mean value of image evaluation of 12 smart wearable bracelets.

Code	N & G	I & I	E & T	G & D	T & Q	P & E
XM	(4.7,6.3,8.3)	(3.3,5.1,6.9)	(3.9,5.8,7.5)	(3.6,5.4,7.2)	(4.6,6.5,8.1)	(5.2,7.1,8.6)
MS	(4.8,6.6,8.1)	(4.7,6.5,8.1)	(4.6,6.4,8.0)	(4.5,6.3,7.9)	(5.0,6.8,8.4)	(4.0,5.9,7.6)
MV	(3.5,5.3,6.9)	(4.3,6.0,7.6)	(4.4,6.1,7.8)	(4.1,6.0,7.6)	(4.5,6.5,7.9)	(4.0,5.7,7.4)
MR	(5.0,6.8,8.3)	(4.0,5.8,7.3)	(3.8,5.7,7.5)	(3.8,5.5,7.3)	(3.8,5.9,7.3)	(3.3,5.2,7.0)
FA	(4.4,6.1,7.6)	(4.2,6.0,7.6)	(4.2,6.0,7.7)	(4.2,6.0,7.7)	(4.2,6.0,7.7)	(4.4,6.3,8.0)
FC	(4.0,5.9,7.6)	(4.0,5.9,7.6)	(3.8,5.6,7.4)	(4.0,5.9,7.6)	(4.1,5.9,7.5)	(3.4,5.1,6.9)
FF	(4.2,5.8,7.0)	(3.9,5.4,6.9)	(3.9,5.4,7.3)	(3.4,5.2,7.1)	(4.1,5.9,7.6)	(4.1,5.9,7.4)
FM	(3.7,5.2,6.8)	(3.8,5.5,7.3)	(3.9,5.6,7.5)	(3.5,5.2,6.8)	(3.6,5.2,6.9)	(2.9,4.7,6.3)
AM	(4.7,6.5,8.0)	(4.9,6.7,8.2)	(5.0,6.8,8.3)	(4.6,6.5,8.1)	(4.5,6.4,8.0)	(4.1,6.0,7.7)
HW	(3.5,5.3,7.0)	(3.3,5.0,6.8)	(3.8,5.5,7.2)	(3.6,5.4,7.1)	(3.7,5.5,7.1)	(3.4,5.2,7.0)
AH	(2.6,4.2,5.9)	(2.7,4.2,6.0)	(2.7,4.2,5.9)	(2.6,4.2,6.0)	(2.8,4.4,6.1)	(3.2,4.8,6.5)
LZ	(3.0,4.6,6.2)	(3.1,4.5,6.5)	(2.8,4.4,6.2)	(2.8,4.5,6.2)	(2.9,4.5,6.3)	(3.2,4.9,6.6)

Note: Abbreviations for smart wearable bracelet species are referred to Table 1.

The visual evaluation of the species of smart bracelet were then sorted and diagrams were plotted with triangular fuzzy numbers (Figure 2). Figure 2 shows there is less difference between different species of smart bracelets in the visual evaluations of popular and economical, individual and interesting. However, the extents of different were greater in neat and good-looking, elegance and tasteful, gorgeous and diversiform, and technology and quality.

Mean value of smart bracelets modeling imagery evaluation is calculated by order, to obtain absolute validity value of 12 smart bracelets imagery evaluation (Table 4).

Table 4. The visual evaluation values of 12 species of smart wearable bracelets.

Code	N & G	I & I	E & T	G & D	T & Q	P & E
XM	0.6236	0.4521	0.5354	0.5068	0.6147	0.6721
MS	0.6486	0.6406	0.6181	0.6267	0.6592	0.5149
MV	0.4745	0.5742	0.5822	0.5818	0.6077	0.4932
MR	0.6758	0.5409	0.5243	0.5233	0.5227	0.4246
FA	0.5837	0.5711	0.5654	0.5870	0.5518	0.5683
FC	0.5549	0.5565	0.5135	0.5702	0.5358	0.4153
FF	0.5994	0.5463	0.5525	0.5347	0.5992	0.5691
FM	0.4247	0.4623	0.4726	0.4344	0.4061	0.3446
AM	0.6350	0.6668	0.6714	0.6508	0.6011	0.5283
HW	0.4773	0.4405	0.5000	0.5043	0.4810	0.4267
AH	0.3326	0.3332	0.3248	0.3456	0.3371	0.3734
LZ	0.3836	0.3838	0.3545	0.3819	0.3545	0.3851

Note: Highest scores of species in each evaluation factor.

Table 4 shows AM (AMAZFIT) is generally top rated on each evaluation. It is particularly outstanding in the three aspects of individuality and interesting, elegance and tasteful, gorgeous and diversiform, which is also better in the other three aspects. MS (Misfit Shine) has the highest score in terms of technology and quality, and relatively general in terms of popular and economical. MR (Misfit Ray) and XM (Xiao Mi) score highly in terms of neat and good-looking, popular and economical.

Data in Table 5 shows smart bracelets in Group 1 are with modelling that are generally in line with technological, particular, individual and a sense of high-quality. This appearance of smart wearable bracelets in Group 1 is similar as roundness. The frame of MS and AW are quite conciseness, modern and fashion.

In Group 2, the shapes of smart bracelets are generally popular, economical and conciseness. The display screen of Group 2 can show large font and concise information. The smart wearable bracelets in Group 3 adopt lines in overall appearance, possessing a linear elegance, technological, and a sense of high-quality, full of modern scientific and technology sense. Generally, shapes of the smarts bracelets in Group 4 are simple, neat, sportive, elegance and diversiform with thin line. Smart

bracelets shapes in Group 5, are generally similar to the modern watch. The font on their display screens are simple, clear and easy to read.

It can be concluded from Table 5 that the evaluation value of modelling imagery of MS, MV, and AW are very similar, and they score highly in conciseness, elegance and modern technology. Above all, AM ranks first in individuality and interesting, elegance and tasteful, gorgeous and diversiform.

XM and FA share some similarities in in popular, economical and technology. XM ranks first in the respect of popular and economical. The evaluation of modelling imagery of FC and HW are very close, and they have high scores in modern technology, gorgeous and diversiform. MR, FF and FM are simple, neat, sportive and gook-looking. MR ranks first in view of neat and good-looking. AH and LZ share some similarities in visual evaluation. According to the questionnaire survey, these two smart wearable bracelets are in medium positions in all aspects. The respondents generally think that their display font is large and the information is easy to read.
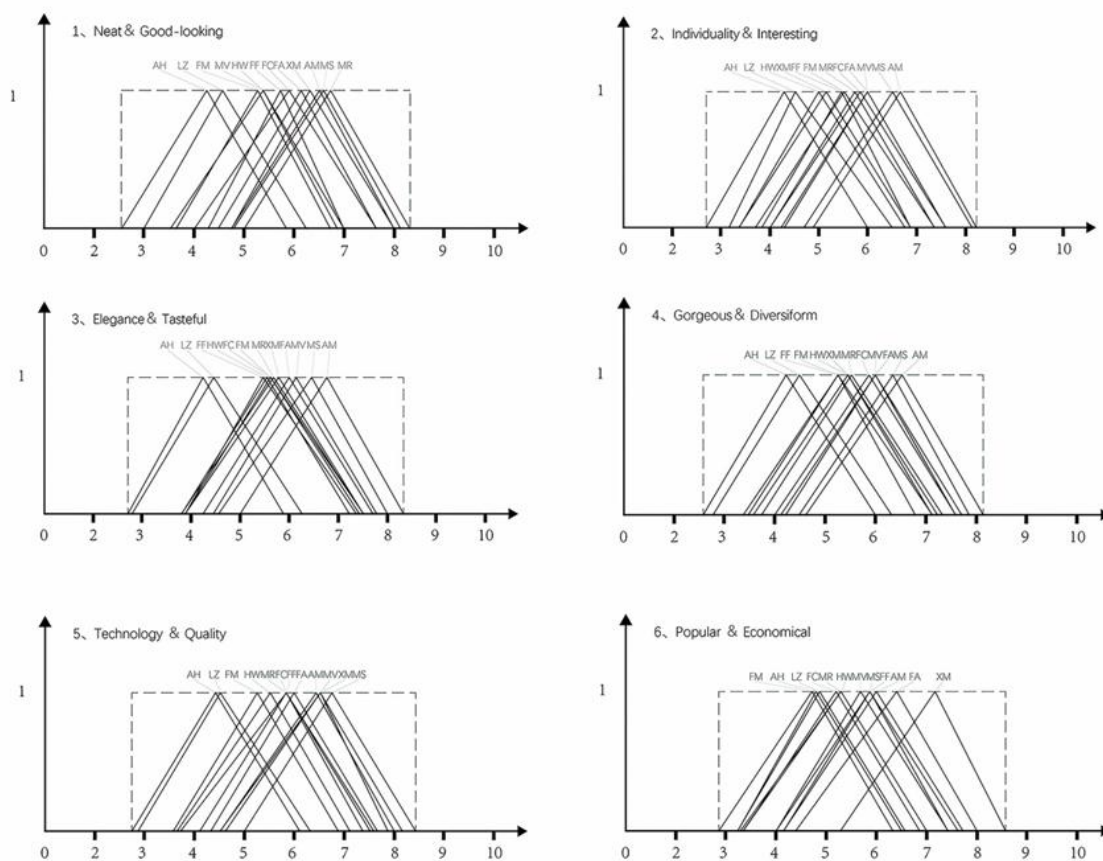

Figure 2. The triangular fuzzy numbers of the 12 species of smart bracelet in each visual evaluation. All abbreviations for smart bracelets are referred to Table 1.

Table 5. Five groups of smart wearable bracelet modelling images, with a similar comprehensive visual evaluation.

Group	Radar chart of the visual image	Grouping of the modeling features and images of the wearable bracelets
1.		
2.		
3.		
4.		
5.		

5. Experimental verification

The 12 smart bracelets with different imagery were applied to three major user groups from Hangzhou city and Likert five-point scale questionnaire was designed to verify the agreement of the experimental hypothesis and survey results. To study the imagery evaluations of consumers in three urban user groups for each smart bracelet, a total of effective80 questionnaires were recalled, in which 46 from male and 34 from female. Through the triangular Fuzzy utility value $UT(\tilde{t}_i)$ calculation, evaluation effectiveness value of 12 smart bracelets in three urban user groups was obtained.

Table 6. Evaluation effectiveness value of modelling imagery of 12 types of smart wearable bracelets in three urban user groups.

Product Code	Elderly silver population	White-collar Workers	Physical fitness youth group
XM	0.6836	0.5500	0.5758
MS	0.3447	0.5908	0.4851
MV	0.5054	0.5955	0.3741
MR	0.3343	0.5332	0.5840
FA	0.5779	0.5470	0.3520
FC	0.5004	0.5754	0.5573
FF	0.4551	0.5357	0.6593
FM	0.2664	0.3298	0.6061
AM	0.3464	0.6611	0.4701
HW	0.4783	0.5754	0.3542
AH	0.6048	0.5098	0.4276
LZ	0.5541	0.5211	0.4427

Evaluation statistics in Table 6 shows:

(I) Based on the experimental hypothesis, smart bracelets with imagery of neat, popular, economical, technology, readable are applied in elderly silver population group. The brands of XM, FA, AH and LZ possess high scores in evaluation utility values, indicating a good consentience with experiment hypothesis.

(II) The experimental hypothesis indicates that smart bracelets with imagery of elegance, tasteful, good quality, technology, gorgeous, elegance, individuality would be applied in the group of urban white-collar worker. Evaluation in smart bracelets, like MS, MV, FC, AM, HW, are with a high utility value, a good agreement with experimental hypothesis.

(III) Based on experimental hypothesis, the smart bracelets with imagery of neat, good-looking, individuality, interesting, gorgeous and diversiform are applied in group of physical fitness youth. The three smart bracelets as MR, FF and FM evaluated in this section possess high utility value and are completely consistent with experimental hypothesis.

6. Conclusions

This research results indicate that there exist high similarities in overall imageries of some smart bracelets. The bracelets in the same group is likely to be replaceable when in selection and application. According to this research, consumers' impression and psychological feeling on the shape of the smart wearable bracelets can help the manufacturers to clarify the product targeting on the market and user groups more specifically. At the same time, and upgrade the products function more purposefully based on different needs of the target users.

This study takes Hangzhou as the target area, and divides the user population in Hangzhou into three types of typical user groups according to their characteristics, such as elderly silver population, white collar workers group and physical fitness youth group. The imagery of smart bracelets for each group are as follows: neat and good-looking, individuality and interesting, elegance and tasteful, gorgeous and diversiform, technology and quality, popular and economical. Through imagery data, various kinds of smart wearable bracelets in the market can be more suitable for users. Nowadays, urban consumers pay more and more attention to their health problems. Under the emergence of social phenomena such as the coming of aging society, the increase of old people living alone, the obesity cause by less movement, and the increase of sub-healthy population caused by the increase of work pressure, all these problems lead to the need for a product that can monitor and record physical conditions at all time. The data collected by the smart wearable bracelets can conduct real-time supervision and report on consumers' health which will offer important data reference for doctors, and provide more convenient and targeted medical services or customers. Therefore, a rational use of the smart wearable bracelets can help the government to save medical resources and make a reasonable allocation of medical resources, so as to build an effective medical service system and improve the physical quality of all the people. Generally, smart wearable bracelet is a health supervisor, which can always remind you to pay attention to your physical health, focus on self-health management, and urge you to develop healthy, scientific and reasonable living habits. Thanks to the common characteristics of urban consumer groups, this research system can be applied to cities around the world. The concept of healthy life management will be adopted in more countries and known to more people all over the world.

Acknowledgments

Conflict of interest

The authors declare that there are no conflicts of interest.

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