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Research on Evaluation Method and Application of Product Design Scheme Based on Multiple Physiological Characteristics

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Abstract: *Under the increasingly fierce competition in the product market, more and more product styles are available for consumers to purchase, and product appearance is also an important part of product attraction. In the stage of product development, designers often use the existing evaluation methods to evaluate the user's preference for product design schemes, but the existing subjective evaluation methods are ambiguous, and the evaluation indexes in the objective test method are single. With the deepening of research on physiological signals in reflecting emotions, it has become a trend to measure users' emotions through physiological characteristics. In this paper, multiple physiological indexes are used as the evaluation index of product scheme. Aiming at the problem that the subjective evaluation is not objective and accurate enough, and the evaluation index in the experimental evaluation method is single, based on the experimental method, the changes of physiological indexes under different emotional preference schemes are explored, and the physiological evaluation index system is established. By constructing a product design evaluation method with multiple physiological characteristics and verifying the feasibility of the method, the product design scheme is optimized more objectively and accurately, which provides an effective theoretical basis and method reference for the preference evaluation of product appearance design scheme.*

Keywords: *Product Design Evaluation, Multiple Physiological Characteristics, Emotional Preference, Product Appearance Evaluation*

1. Introduction

Research shows that the appearance of the product often plays a decisive role when consumers purchase products. Good design products can occupy the market and help enterprises achieve economic success [1]. With the development of social economy and the rise of online shopping, people are more inclined to convenient online shopping than traditional consumption patterns. In online shopping, a good product appearance can enhance the attractiveness of the product to consumers, thus arousing consumers desire to consume.

2. Besearching Background

2.1. Application of Multiple Physiological Indexes in Research of Product Preference

Emotion is the same as the definition of emotion, that is, different mental states caused by external things. This kind of psychological state not only includes the subjective experience expressed in available language, but also is accompanied by internal physiological changes. Emotional design as a means of product design, the user's emotional expression of the product through the product design elements on the product, so that the product to meet user functional requirements, but also to meet the emotional needs of users, so as to achieve user satisfaction. People's emotions are complex, changeable and vague. It is difficult for companies to accurately and comprehensively grasp users' emotional needs and emotional experiences in the process of emotional evaluation of research products. Therefore, in the field of emotion measurement, many scholars have done a lot of research on the application of physiological characteristics in emotion: Hu studied the user preference of intelligent wheelchair through a variety of physiological signals, which laid a foundation for realizing the user preference path [2]. Nie et al used ECG, respiration and skin electrical detection equipment to collect the changes of the above physiological

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signals under four basic emotions, and concluded that the recognition rate of the combination of three physiological indicators in emotion recognition was higher than that of a single physiological indicator [3]. Chen et al used the support vector machine to classify the emotion recognition model by fusing the characteristics of various physiological signals such as pulse, skin electrical response, respiration, and skin temperature, indicating that the use of multiple physiological signal fusion can effectively identify emotions [4]. From the relevant research can be found that physiological signals can not only be used as an effective indicator to detect changes in mood, it can also reflect the user's preference for the product by detecting the change of physiological signals in the product preference evaluation.

2.2. Selection and Analysis of Physiological Index of Product Appearance Preference

The methods of emotional measurement mainly include psychological measurement and physiological measurement. The psychological measurement method is to investigate people's current emotional state in the form of a questionnaire, while the physiological measurement method is mainly to study the physiological neural signals generated by users' emotions from a physiological perspective. This paper intends to select four physiological indicators of eye movement signal, skin temperature, ECG and pulse as the physiological indicators of product appearance preference experiment. The reasons for selecting indicators and specific content are as follows.

The eye movement signal is a physiological electrical signal caused by eye movement. Chen studied the aesthetic eye movement of the subjects'bedroom cabinets, and showed that for more preferred furniture, the subjects gazed for a longer time [5]. The number of fixations increased significantly and the pupil dilation was greater; other studies have also shown that the pupil diameter, the number of blinks and the number of fixations can reflect the emotional state and cognitive characteristics of the subjects [6,7]. Therefore, this study selected blink rate (count / s), fixation time, average fixation time, fixation times, maximum pupil diameter, and average pupil diameter as the physiological evaluation indicators of eye movement characteristics in the emotional preference evaluation of product solutions.

Skin temperature is also an important indicator in the field of emotion recognition. Miao by subjects under different emotions skin temperature changes in the study found that emotional relaxation, fingertip blood flow increased skin temperature, tension increased sympathetic excitability, fingertip blood flow decreased skin temperature decreased [8]. Therefore, this study selected the mean skin temperature as the physiological evaluation index of skin temperature in emotional preference evaluation of product scheme, the unit is Celsius (°C).

Electrocardiogram (ECG) refers to the electrical changes that occur during cardiac activity. This change can be measured by placing sensors on the surface of the human body. Heart rate and heart rate variability are often used to identify emotions in the field of emotion recognition. Eight time domain physiological indexes such as mean R-R interval, difference of adjacent R-R interval, standard deviation of R-R interval, standard deviation of adjacent R-R interval and five frequency domain physiological indexes such as low frequency power, high frequency power, low frequency / high frequency are effective emotion recognition indexes [9,10]. Therefore, the average heartbeat interval, average heart rate, heart rate low frequency high frequency ratio(H-LF / HF) and adjacent heartbeat interval difference(AHID) are selected as the physiological evaluation indexes of the product scheme emotional preference evaluation center.

Pulse is a rhythmic pulse of the body. Researchers have conducted physiological experiments on emotion recognition by selecting pulse rate, pulse interval difference and pulse heart rate variability of pulse characteristics. The results show that it is feasible to use pulse signal for emotion recognition [11-12]. The average pulse rate, average pulse interval, pulse interval difference, low frequency and high frequency of pulse (P-LF / HF) were selected as part of the physiological indexes of emotional preference evaluation of product scheme.

2.3. Construction of Initial Evaluation Index System of Multiple Physiological Characteristics

Based on the key steps of analytic hierarchy process, this study constructed a multi-physiological feature evaluation system. In the comprehensive evaluation of product scheme, the analytic hierarchy process expresses the attributes of each evaluation index by dividing different levels, and according to the main factors that need to be considered in the evaluation target and the subordinate relationship between the factors. The initial evaluation system of product design scheme with multiple physiological characteristics is established as Figure 1.

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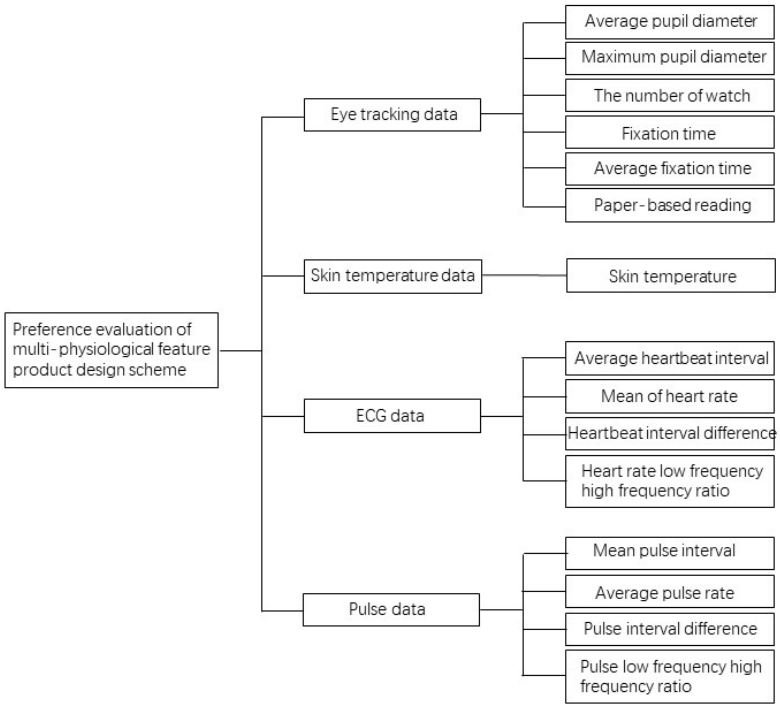

Figure 1: Initial evaluation system of product design scheme with multiple physiological characteristics

3. Experimental Design

On the basis of determining the initial evaluation system, the overall framework of the multi-physiological characteristics product scheme evaluation method in this study is summarized as Figure 2.

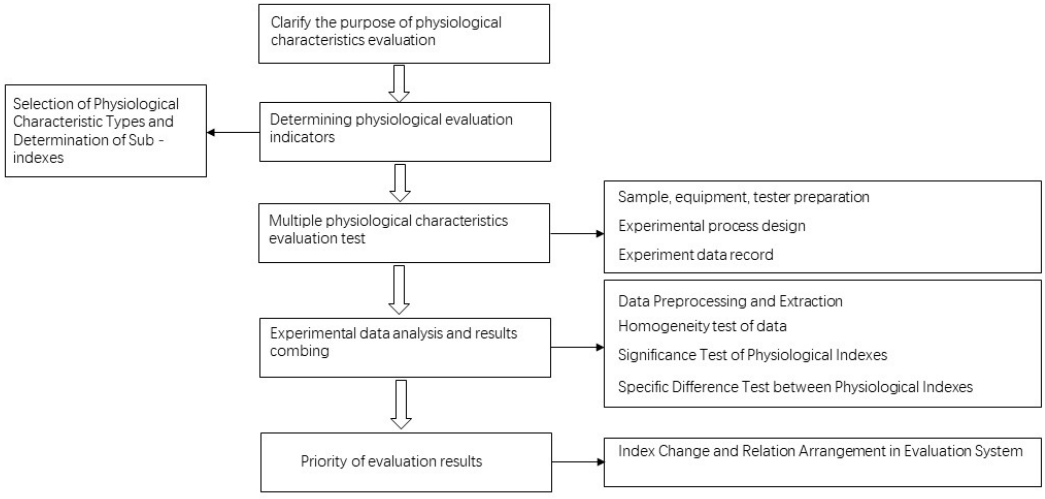

Figure 2: Evaluation method framework

3.1. Selection of Experimental Subjects

The main research content of this experiment is the effectiveness index in the multi-physiological index evaluation system under different preference product design schemes. In this experiment, the male and female subjects each accounted for half of the total number of experimental subjects. The number of subjects was 20 and all of them were graduate students, aged between 23 and 27 years old. The corrected visual acuity or uncorrected visual acuity was above 1.0, and there was no history of eye diseases such as color blindness, astigmatism, color weakness, no history of heart disease and mental illness. All

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subjects participated in this experiment voluntarily. The reliability of the data results of the physiological experiment depends largely on the subject's own physical condition. Therefore, the subjects should maintain adequate sleep and rest before the experiment and maintain physical and mental pleasure.

3.2. Selection of Experimental Materials

Through various channels, we collected 50 pictures of air purifiers of various brands common in the domestic market of China, as well as 50 pictures of air purifiers displayed on the websites of well-known enterprises. Photoshop software was used to process the 50 experimental materials uniformly. The background color was white, and the image size was 100 × 100 mm, all in JPEG format. The brand logo on it was removed to avoid the subjects choosing the product they liked because of the brand. Through the form of a questionnaire, the subjects were asked to delete 50 pictures based on their own preferences. Finally, 40 pictures were selected as experimental materials, of which 4 were pre-experimental practice materials and 36 were formal experimental materials. Before the start of the experiment, a preference questionnaire was distributed to the subjects. The subjects were required to score all the formal test materials according to the five-point scoring method. Then the questionnaire was statistically analyzed. According to the comprehensive scoring score from high to low, 16 pieces of high preference and 16 pieces of low preference were selected.

3.3. Experimental Equipment and Environment

During the experiment, only the experimenter and the subjects were kept in a state of no interference, and moderate temperature and light conditions were maintained.(1) Tobil3.0 eye tracker, which is equipped with a desktop display, can collect relevant eye movement data when subjects look at the experimental materials presented on the desktop display.(2) ErgoLAB3.0 emotion measurement software. In addition to recording and analyzing the above Tobil3.0 eye tracker data, the software is also connected to three physiological wireless devices : ECG, skin temperature and pulse to receive and analyze the physiological signals of these three devices.() Wireless physiological equipment : ECG wireless sensor, the device is connected with three patches attached to the corresponding parts of the subjects chest, used to detect ECG data; PPG pulse wireless sensor, the device is worn in the earlobe of subjects, used to detect the pulse of subjects; SKT skin temperature wireless sensor, the device is worn in the right index finger, used to detect the skin temperature. (4) Display device: a desktop computer equipped with ErgoLAB3.0 emotion measurement software, the display is used to present the experimental materials for the participants to watch during the experiment, and the experimenter can observe the changes of the physiological data of the participants. Experimental equipment are shown in Figure 3.

Figure 3: Physiological data acquisition equipment

3.4. Experimental Process

This experiment on high preference degree of 16 product scheme image coding, respectively, a1, a2, a3... A16, on the low degree of preference of 16 products scheme picture encoding, respectively, b1, b2, b3... b16. Studies have shown that by visual stimulation to induce emotions, if the continuous presentation of positive or negative pictures in the course of the experiment and then to assess the emotional subjects, the assessment effect will be more significant. [13]The display process is shown in Figure 4.

Before the formal experiment, each participant was given a separate explanation of the experimental precautions and experimental procedures. Then the main experimenter helped the participants to wear physiological data acquisition equipment. After debugging, the eye calibration of the eye tracker began. After the instrument adjustment is completed, the pre-experiment begins to familiarize them with the experimental process and environment. During the experiment, the subjects need to focus on the display of the experimental material until the end of the experiment prompts appear on the screen. At the end of

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the pre-experiment, the participants were free in the laboratory for 5 min and could not stare at the electronic device with the screen for a long time. After the rest, the formal test, formal test precautions and pre-experiment the same.

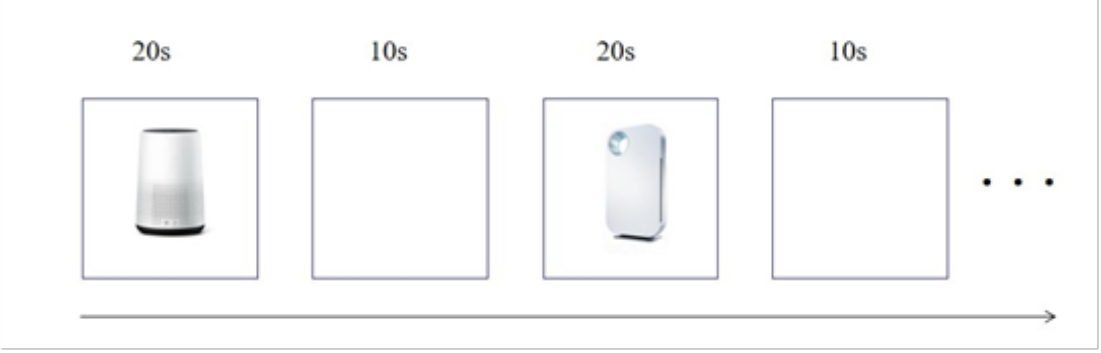

Figure 4: Experimental material picture presentation sequence diagram

4. Experimental Design

4.1. Preprocessing of Physiological Signals

For eye movement signal processing, loss data compensation and signal noise reduction are required. The maximum gap length of data compensation is compensated by 75 ms, and the eye movement signal is denoised by sliding mean filtering. Because the ECG and PPG signals are very weak, they are very susceptible to external noise. The white noise in the ECG signal is removed by moderate wavelet denoising, and the power frequency interference is removed by band-stop filtering. The cut-off frequency is 50HZ. The sampling frequency of eye movement signal is 29HZ, ECG sampling frequency is 512HZ, pulse sampling frequency is 64HZ, skin temperature sampling frequency is 32HZ.

4.2. Physiological Data Analysis and Index Screening

In order to obtain objective physiological indicators under product design schemes with different preferences, one-way ANOVA in statistics is needed to test whether the mean difference between two or more populations is statistically significant. Homogeneity of variance is the premise of variance analysis. Therefore, the degree of preference (Like-Dislike) is taken as the influencing factor, and the homogeneity of variance of the alternative indicators is tested by SPSS software. Product preference and eye movement index data were tested for homogeneity of variance. As shown in Table 1

Table 1: Test for homogeneity of variance of product preference and eye movement indicators

Eye movement index	Levene statistics	df1	df2	Sig
Average pupil diameter	0.001	1	18	0.977
Blink rate	0.044	1	18	0.836
Maximum pupil diameter	0.005	1	18	0.942
Fixation times	0.037	1	18	0.850
Fixation time	0.107	1	18	0.748
Average fixation time	0.360	1	18	0.556

Table 2: Repeated measures analysis of variance of product preference and eye movement

Eye movement index	F	Sig
Average pupil diameter	6.176	0.035
Blink rate	6.688	0.000
Maximum pupil diameter	0.873	0.375
Fixation times	5.863	0.039
Fixation time	14.427	0.004
Average fixation time	1.072	0.327

Through the homogeneity of variance test of eye movement data, it can be seen that the significance of the selected eye movement indicators is greater than 0.05, so all eye movement indicators have passed the homogeneity of variance test. Therefore, repeated measures analysis of variance was performed on

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eye movement indicators. The results of repeated variance analysis of product preference and eye movement indicators are shown in Table 2.

From the repeated measures analysis of variance of product preference and eye movement index, it can be concluded that the main effect of the maximum pupil diameter is not significant in the eye movement index with homogeneity of variance $F = 0.873$, $p = 0.375 > 0.05$, indicating that there is no significant difference in the maximum pupil diameter under different preference products. The main effect of the average fixation time was not significant $F = 1.072$, $p = 0.327 > 0.05$, indicating that there was no significant difference in the average fixation time eye movement index. Maximum pupil diameter and average fixation time of these two indicators do not have significant differences, can not effectively reflect product preferences, and therefore can not be used as a product preference evaluation. Mean pupil diameter, blink rate, fixation count and fixation time these eye movement indicators were less than 0.05, that is, these four eye movement indicators have significant differences, can effectively reflect product preferences. Therefore, these four eye movement indicators can be used as effective indicators of product preference evaluation.

Paired t-test was performed on effective eye movement indicators. The paired t-test results of product preference and eye movement indicators are shown in Table 3.

Table 3: Paired t test analysis of product preference and eye movement index

Eye movement index	Preference degree	t	P
Average pupil diameter	Like- Dislike	-2.485	0.035
Blink rate	Like- Dislike	8.288	0.000
Fixation times	Like- Dislike	2.421	0.039
Fixation time	Like- Dislike	3.798	0.004

The paired t-test analysis of eye movement indicators showed that there was a significant difference between the average pupil diameter $t = -2.485$, $p = 0.035 < 0.05$. The average pupil diameter in the case of like is smaller than the pupil diameter in the case of dislike. There was a significant difference between the blink rate $t = 8.288$, $p = 0.000$. The blink rate under the like situation is larger than the blink rate under the dislike situation. There was significant difference between fixation count $t = 2.421$, $p = 0.039 < 0.05$. The total number of times users stare at the product is greater when they like it. The significant difference between the fixation time is obvious $t = 3.789$, $p = 0.004$, indicating that the user has more fixation time for the favorite product.

The homogeneity of variance between product preference and skin temperature index was tested, and the analysis results are shown in Table 4.

Table 4: Product preference and skin temperature index variance homogeneity test

Skin temperature index	Levene statistics	df2	df2	Sig
Mean skin temperature	0.000	1	18	0.987

The homogeneity of variance between product preference and skin temperature index was tested, and the analysis results are shown in Table 4.

The results of variance homogeneity test of mean skin temperature showed that the selected skin temperature index was significant (> 0.05), so the skin temperature index passed the variance homogeneity test. Therefore, the next repeated measures analysis of variance for the skin temperature index is shown in Table 5.

Table 5: Repeated measures analysis of variance of product preference and skin temperature index

Skin temperature index	F	Sig
Mean skin temperature	3.633	0.089

It can be seen from the results of repeated measures analysis of variance that the skin temperature has a significant difference $F = 3.633$, $p = 0.089 < 0.05$.Therefore, the physiological index of skin temperature can effectively reflect the product preference.

Paired t test was performed on the skin temperature index, and the results are shown in Table 6.

Table 6: Paired t test analysis of skin temperature index

Skin temperature index	Preference degree	t	P
Mean skin temperature	Like- Dislike	1.906	0.089

It can be seen from the paired t-test results of skin temperature indicators that the significant difference between skin temperatures was $t = 1.906$, $p < 0.05$. It shows that the skin temperature in the

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case of like is higher than that in the case of dislike.

The homogeneity of variance between product preference and pulse index is tested, and the analysis results are shown in Table 7.

Table 7: Product preference and eye movement index variance homogeneity test analysis

Pulse index	Levene statistics	df1	df2	Sig
Average pulse rate	0.045	1	18	0.835
Average pulse interval	0.082	1	18	0.778
Pulse interval difference	1.070	1	18	0.315
P-LF / HF	0.198	1	18	0.661

Through the homogeneity test results of variance of pulse data, it can be seen that the significance of the selected pulse indicators are greater than 0.05, so all pulse indicators have passed the homogeneity test of variance. Therefore, the pulse index for the next repeated measures analysis of variance. The results of repeated variance analysis of product preference and pulse index are shown in Table 8.

Table 8: Product preference and pulse index repeated measures analysis of variance

Pulse index	F	Sig
Average pulse rate	0.120	0.737
Average pulse interval	6.792	0.028
Pulse interval difference	4.511	0.036
P-LF / HF	3.951	0.028

From the results of repeated measures analysis of variance, it can be seen that among the pulse indicators with homogeneity of variance, the main effect of the average pulse interval is not significant $F = 0.120$, $p = 0.737 > 0.05$, indicating that there is no significant difference in the average pulse interval under different preference products can not effectively reflect product preference, so it can not be used as an evaluation index of product preference. The significance of average pulse rate,pulse interval difference and low frequency and high frequency of pulse is less than 0.05, that is, these three indicators have obvious significant differences, which can effectively reflect product preference. Therefore, these three indicators can be used as effective indicators of product preference evaluation.

Paired t-test was performed between pulses with significant differences, and the results are shown in Table 9.

Table 9: Product preference and pulse index repeated measures analysis of variance

Pulse index	Preference degree	t	P
Average pulse rate	Like- Dislike	2.606	0.028
Pulse interval difference	Like- Dislike	-2.124	0.036
P-LF / HF	Like- Dislike	1.988	0.028

According to the paired t-test analysis results of the pulse index, it can be seen that there is a significant difference between the average pulse times $t = -2.606$, $p = 0.028 < 0.05$, indicating that the pulse beat frequency in the case of like is faster than that in the case of dislike. There was a significant difference between the pulse interval difference $t = -2.124$, $p = 0.036$, indicating that the pulse interval difference in the case of like is smaller than the pulse interval in the case of dislike. There was a significant difference between the low frequency and high frequency ratio of pulse $t = -1.988$, $p = 0.028 < 0.05$, which indicated that the ratio of low frequency to high frequency of pulse in the case of liking was smaller than that in the case of disliking.

Table 10: Product preference and pulse index repeated measures analysis of variance

ECG index	Levene statistics	df1	df2	Sig
Average heartbeat interval	0.001	1	18	0.981
Average heart rate	0.023	1	18	0.881
AHID	0.067	1	18	0.799
H-LF/HF	0.094	1	18	0.762

The homogeneity of variance between product preference and ECG index was tested, and the analysis results are shown in Table 10.

Through the test results of homogeneity of variance of ECG data, it can be seen that the significance of the selected ECG indicators is greater than 0.05, so all ECG indicators have passed the test of homogeneity of variance. Therefore, the ECG indicators for the next repeated measures analysis of variance. Product preferences and ECG indicators repeated measures analysis of variance results are

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shown in Table 11.

Table 11: Product preference and ECG index repeated measures analysis of variance

ECG index	F	Sig
Average heartbeat interval	0.689	0.428
Average heart rate	6.121	0.035
AHID	13.029	0.006
H-LF/HF	10.636	0.010

From the results of repeated measures analysis of variance, it can be seen that the main effect of the average heartbeat interval is not significant $F = 0.689$, $p = 0.428 > 0.05$, in the ECG index with homogeneity of variance, indicating that there is no significant difference in the average heartbeat interval under different preference products, which can not effectively reflect the product preference, so it can not be used as the evaluation index of product preference. The significance of average heart rate, adjacent heartbeat interval difference and low frequency and high frequency ratio of heart rate was less than 0.05, that is, these three eye movement indicators have obvious significant differences, which can effectively reflect product preference. Therefore, these three eye movement indicators can be used as effective indicators of product preference evaluation.

Paired t-test analysis was performed on ECG indicators with significant differences, and the results are shown in Table 12.

Table 12: ECG index paired t test analysis

ECG index	Preference degree	t	P
Average heart rate	Like- Dislike	-2.474	0.035
AHID	Like- Dislike	3.610	0.006
H-LF/HF	Like- Dislike	3.261	0.010

Paired t-test analysis showed that there was a significant difference between the average heart rate $t = -2.474$, $p = 0.035 < 0.05$, indicating that the heart rate in the case of like was slower than that in the case of dislike. There was a significant difference between the difference of heart beat interval $t = 3.610$, $p = 0.006$, indicating that the difference of heart beat interval in the case of like is larger than that in the case of dislike. There was a significant difference between the low frequency and high frequency ratio of heart rate $t = 3.261$, $p = 0.010 < 0.05$, which indicated that the ratio of low frequency to high frequency of heart rate in the case of liking was higher than that in the case of disliking.

4.3. Relationship between Eye Movement Index and Other Physiological Indexes

On the basis of the above research, the correlation analysis of the effective objective physiological indexes of the selected product preference is carried out to obtain the positive and negative correlation between them. The Pearson correlation coefficient(PCCs)and the degree of correlation between the indicators are shown in Table 13.

Table 13: Pearson correlation coefficient and correlation degree

r	Correlation
$r<0.2$	No correlation
$0.2\leq r\leq 0.4$	Low correlation
$0.4<r\leq 0.7$	Moderate correlation
$r>0.7$	High correlation

The collected objective physiological data were input into SPSS software for bivariate correlation analysis. The Pearson correlation analysis results between eye movement indicators and physiological indicators are shown in Table 14 (a, b, c).

From the results of the Table 14, we can see that: (1) There is a significant moderate negative correlation between the average pupil diameter and the adjacent heartbeat interval difference that is, as the average pupil diameter of the subjects increases, the difference between the heartbeat intervals will gradually become smaller; (2) There is a significant negative correlation between fixation times and average pupil diameter, that is, with the increase of fixation times, the average pupil diameter will become smaller; (3) There is a moderate negative correlation between the average pulse rate and the average pupil diameter, that is, with the increase of the average pulse rate, the average pupil diameter will gradually become smaller; (4) There is a moderate negative correlation between the pulse low frequency and high frequency ratio and the fixation times, that is, with the increase of the pulse low frequency and

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high frequency ratio, the fixation times decreases gradually. (5) There is a moderate negative correlation between the average heart rate and the adjacent heartbeat interval difference, that is, as the average heart rate of the subjects increases, the adjacent heartbeat interval difference becomes smaller.

Table 14 a: Pearson correlation analysis between eye movement indexes and physiological indexes

		Average pupil diameter	Blink rate	Fixation times	Fixation time
Average pupil diameter	PCCs	1	-.263	-.725	-.057
	Sig		.265	.000	.811
Blink rate	PCCs	-.262	1	.231	.017
	Sig	.265		.328	.942
Fixation times	PCCs	-.725	.231	1	.158
	Sig	.000	.328		.505
Fixation time	PCCs	-.057	.017	.158	1
	Sig	.811	.942	.505	
Mean skin temperature	PCCs	.312	.313	-.383	-.387
	Sig	.180	.178	.095	.092
Average pulse rate	PCCs	-.594	-.158	.540	.036
	Sig	.006	.505	.014	.881
Pulse interval difference	PCCs	-.076	-.051	.034	-.230
	Sig	.752	.831	.887	.329
P-LF / HF	PCCs	.374	-.059	-.667	-.228
	Sig	.752	.831	.001	.333
Average heart rate	PCCs	.167	.124	-.021	.393
	Sig	.481	.603	.930	.087
AHID	PCCs	-.510	.027	.365	-.343
	Sig	.022	.912	.113	.151
H-LF/HF	PCCs	-.408	.035	-.018	.156
	Sig	.074	.882	.941	.511

Table 14 b: Pearson correlation analysis between eye movement indexes and physiological indexes

		Mean skin temperature	Average pulse rate	Pulse interval difference	P-LF / HF
Average pupil diameter	PCCs	.312	-.594	-.076	.374
	Sig	.180	.006	.725	.104
Blink rate	PCCs	.313	-.158	-.051	-.059
	Sig	.179	.505	.831	.806
Fixation times	PCCs	-.383	.540	.034	-.677
	Sig	.095	.014	.887	.001
Fixation time	PCCs	-.387	.036	-.230	-.228
	Sig	.092	.881	.329	.333
Mean skin temperature	PCCs	1	-.286	-.247	.414
	Sig		.221	.294	.069
Average pulse rate	PCCs	-.286	1	-.242	-.471
	Sig	.221		.305	.036
Pulse interval difference	PCCs	-.247	-.242	1	.240
	Sig	.294	.305		.309
P-LF / HF	PCCs	.414	-.471	.241	1
	Sig	.069	.036	.309	.
Average heart rate	PCCs	.352	-.321	.197	.157
	Sig	.128	.167	.404	.508
AHID	PCCs	.373	.400	.112	-.353
	Sig	.105	.081	.639	.127
H-LF/HF	PCCs	-.432	.107	.047	.012
	Sig	.057	.654	.844	.959

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Table 14 c: Pearson correlation analysis between eye movement indexes and physiological

		Average heart rate	AHID	H-LF/HF
Average pupil diameter	PCCs	.167	-.510	-.408
	Sig	.481	.022	.074
Blink rate	PCCs	.124	.027	.036
	Sig	.603	.912	.882
Fixation times	PCCs	-.021	.365	-.018
	Sig	.930	.113	.940
Fixation time	PCCs	.393	-.334	.156
	Sig	.087	.151	.511
Mean skin temperature	PCCs	.352	-.33	-.432
	Sig	.128	.105	.057
Average pulse rate	PCCs	-.321	-400	.107
	Sig	.167	.081	.654
Pulse interval difference	PCCs	.197	.112	.047
	Sig	.404	.639	.844
P-LF / HF	PCCs	.157	-.353	.012
	Sig	.508	.127	.959
Average heart rate	PCCs	1	-.682	-.355
	Sig		.001	.125
AHID	PCCs	-.682	1	.436
	Sig	.001		.055
H-LF/HF	PCCs	-.355	.436	1
	Sig	.125	.055	

4.4. Establishment of Relationship between Product Scheme Preference and Multiple Physiological Indexes

In this study, during the viewing process of the air purifier product schemes with different preferences, the physiological indexes stimulated by the product schemes with different preferences changed significantly. The significant differences in physiological indicators are mainly as follows : (1) In terms of eye movement indicators, the difference between the subjects in the face of the favorite product plan and the disliked product plan is mainly reflected in : when facing the favorite plan, the average pupil diameter of the subjects is smaller， the blink rate is larger, the number of fixations is more and the fixation time is longer. (2) In terms of skin temperature index, the difference between the subjects in the face of the favorite product scheme and the disliked product scheme is mainly reflected in : when facing the favorite scheme, the mean skin temperature of the subjects is higher. (3) In the pulse characteristics, subjects in the face of favorite product solutions and do not like the difference between the product program is mainly reflected in : when facing the favorite program, the average pulse rate is higher, the pulse interval difference is lower, pulse low frequency and high frequency ratio is smaller. (4) in terms of ECG characteristics, subjects in the face of like the product program and do not like the product program is mainly reflected in the difference : when the face of like the program, the average heart rate is lower, heart rate low frequency high frequency ratio(H-LF/HF) is greater, adjacent heartbeat interval difference is larger. (5) In the relationship between eye movement parameters and other physiological parameters, there was a negative correlation between the average pupil diameter and the adjacent heartbeat interval difference, between the average pulse rate and the average pupil diameter, between the pulse low frequency and high frequency ratio and the number of fixations.

Through the above discussion and analysis, it can be concluded that when the subjects have a high preference for the product scheme they see, that is, ‘like the product design scheme’, the characteristics of physiological index changes are as follows : the average pupil diameter becomes smaller, and with the increase of fixation times, the increase of average pulse rate, the increase of adjacent heartbeat interval difference, the increase of blink rate, the longer fixation time, the increase of mean skin temperature, the decrease of pulse interval difference, the decrease of pulse low frequency and high frequency ratio, the decrease of average heart rate, the increase of adjacent heartbeat interval difference, the increase of heart rate low frequency and high frequency ratio. Vice versa.

Therefore, according to the above analysis results, the relationship between product scheme

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preference and multiple physiological indicators is established.

Suppose that the set of product design schemes is M = { m1, m2... mz }, and the subject is E = { 1, 2, 3... n }. The eye movement index is D = { d1, d2, d3, d4 }, Skin temperature index T = { t1 }, ECG index is G = { g1, g2, g3, g4 }, Pulse index is P = { p1, p2, p3, p4 }.Where d1 represents the blink rate, d2 represents the average pupil diameter, d3 represents the number of fixations, d4 represents the fixation time, t1 represents mean skin temperature, g1 represents the average heart rate, g2 represents the adjacent heartbeat interval difference, g3 represents the heart rate low frequency high frequency ratio, p1 represents the average pulse rate, p2 represents the pulse interval difference, p3 represents the pulse low frequency high frequency ratio.

The data set of the blink rate of the eye movement characteristic of the subject E under the scheme m1 is m1E = [d11, d12, d13... d1n], and so on. The physiological index data set of the physiological characteristics of the subject E under the scheme m1 to mz is obtained. Pairwise t test was performed on the same physiological index under each scheme. If the scheme m1 is compared with m2, d1 index ↑, d2 ↓ ∪ p1 ↑ ∪ g2 ↑, d4 ↑, t1 ↑, g1 ↓, g3 ↑, p2 ↓, d3↑ ∪p3 ↓, the scheme m1 is more popular. Among them, the more indicators of change, the more obvious the difference between the two schemes. ' ∪ ' denotes the adjoint relation.

4.5. Establishment of Multiple Physiological Characteristics Evaluation Method System

According to the significant difference of physiological indexes under different preference schemes in the above research, the final evaluation system of multiple physiological characteristics and the correlation between eye movement indexes and other physiological indexes are obtained as shown in Figure 5.

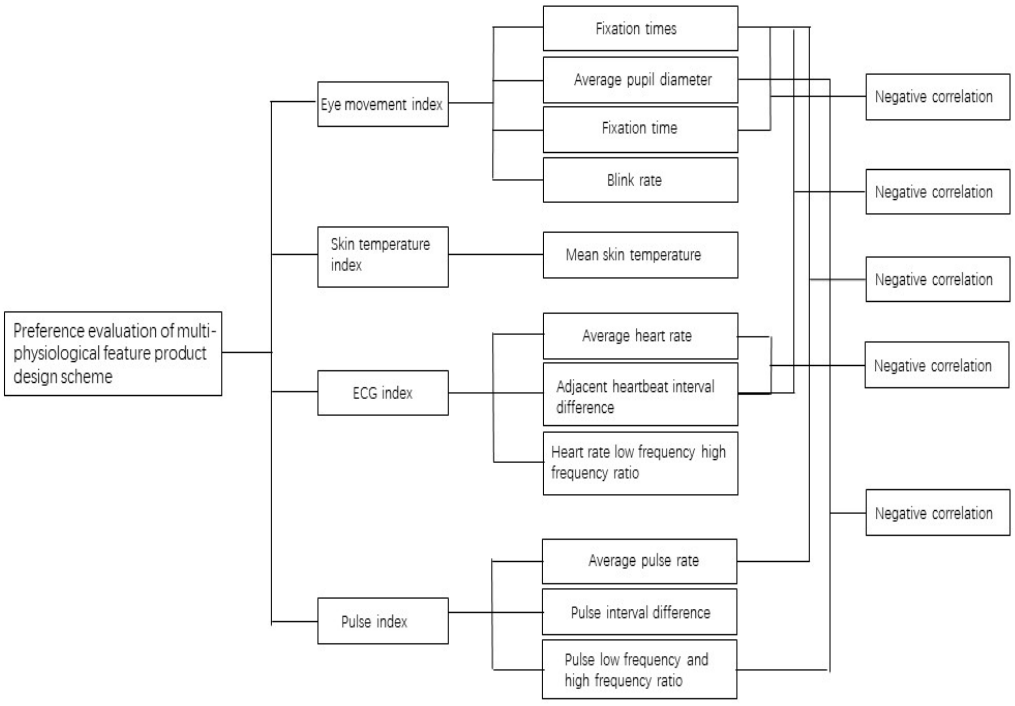

Figure 5: Final evaluation system of product design scheme with multiple physiological characteristics

Combining the experimental research process of physiological index change under different preference product schemes, data analysis process and the relationship between product preference and physiological index, the preference evaluation method of product design scheme with multiple physiological characteristics is summarized. The framework of preference evaluation method of product with multiple physiological characteristics is shown in Figure 6.

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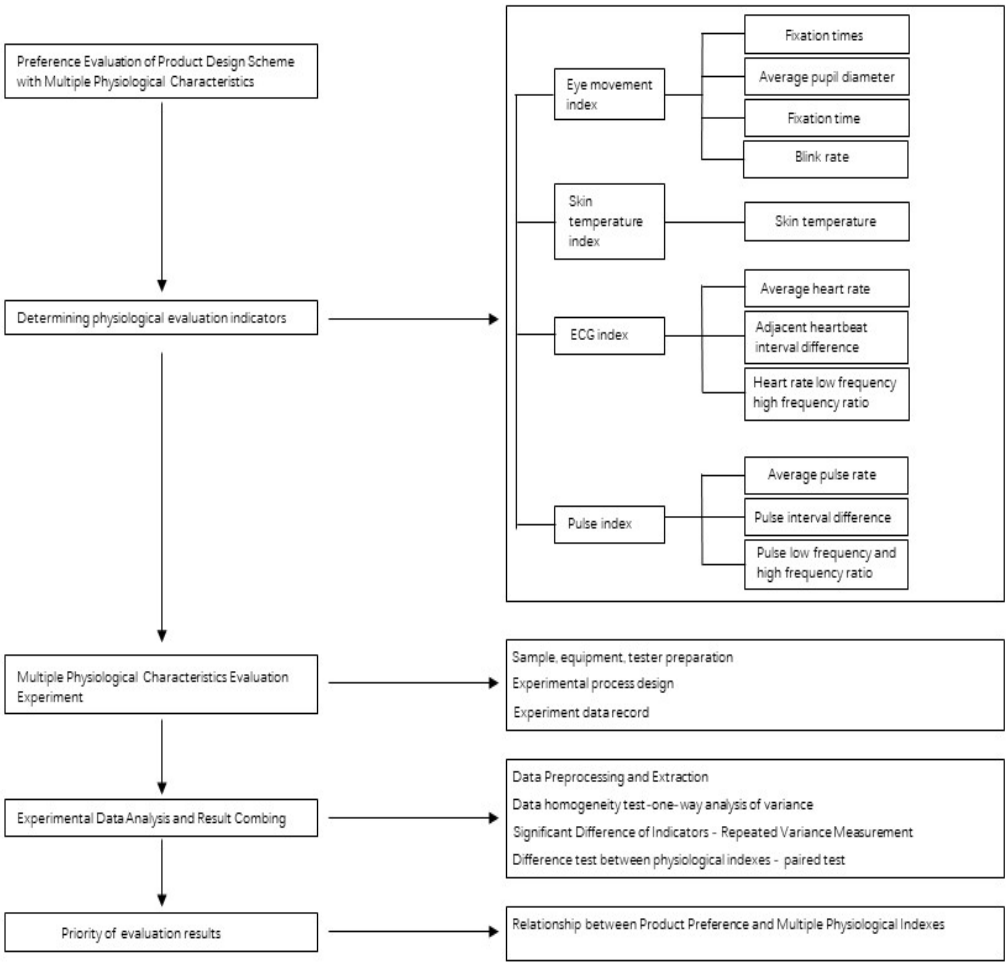

Figure 6: Method framework of product preference evaluation with multiple physiological characteristics

5. Conclusions

When watching different preference product schemes, there are significant differences in the physiological indexes of the subjects. When watching different schemes, the physiological indexes of significant changes are divided into the following aspects : eye movement characteristic indexes include average pupil diameter, blink rate, fixation times and fixation time; physiological characteristics of skin temperature include mean skin temperature; the indexes of ECG physiological characteristics include average heart rate, adjacent heartbeat interval difference and heart rate low frequency high frequency ratio; the pulse physiological characteristic indexes include average pulse rate, pulse interval difference and pulse low frequency and high frequency ratio Therefore, the above physiological indicators can be used as effective indicators of product preference evaluation to assist product design decisions.

In summary, using multiple physiological characteristic indexes to evaluate the preference of product appearance schemes can effectively judge the popularity of product appearance schemes, and then select the design scheme with higher user preference for product appearance.

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