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TO APPROACH THE FACTORS OF INFLUENCING CONSUMER PREFERENCES FOR CORRECTIVE EYEWEAR DESIGN

Hui-Ling, Chen[1], Yangli Xu[2], Jiann-Sheng, Jiang[3], Ta-Hsiung, Cho[4]

[1]*Graduate Institute of Cultural and Creative Design, Tung-Fang Design University, Kaohsiung, Taiwan*

[2]*Department of Art and Design, Shaoguan University, Guangdong, China*

[3]*Graduate Institute of Cultural and Creative Design, Tung-Fang Design University, Kaohsiung, Taiwan*

[4]*Department of Optometry, Chung Hwa University of Medical Technology, Tainan, Taiwan*

Abstract

Correctional eyeglasses used for myopia, hyperopia, astigmatism, and presbyopia require adaptation and prolonged wearing, similar to assistive devices. Unlike decorative glasses, which can be freely changed or not worn as desired and coordinated with overall attire, wearing eyeglasses alters facial appearance. The aesthetics, comfort, and functional quality of eyeglasses directly affect the wearer's willingness, thus impacting visual health and quality of life. Therefore, corrective eyeglass frames need to balance between aesthetic appearance and visual health.

This study employs methods such as the Kano Model, Important Performance Analysis (IPA), and Choquet integral to explore the key preference factors for the design of corrective eyeglass frames.

Differing from traditional 5-point equidistant semantic questionnaires, this study employs a non-equal interval semantic questionnaire with a golden ratio scale to differentiate adjacent semantic importance ratios, highlighting weighted emphasis on aesthetics. The results provide reference for eyeglass designers and related industries. It is expected to design eyewear that better meets the needs of the Taiwanese population, encouraging people to wear corrective eyewear willingly, thereby further maintaining visual health, improving quality of life, enhancing visual health, and quality of life.

Keywords

Continuous Kano Model, IPA (Important Performance Analysis), Choquet Integral, Golden Semantic Scale, Eyeglass Design

1. Preface

The most significant difference between corrective eyeglass frames and other fashion-oriented eyewear such as trendy sunglasses or sports glasses lies in the fact that corrective frames cannot be easily changed to match hairstyles, makeup, or overall attire for immediate and flexible adjustments. In addition to cost considerations, after undergoing optometry and fitting procedures, the eyes require a period of time to adjust to the new eyeglasses, which is a major factor. Furthermore, eyeglass frames are also currently the most economical, safe, and effective method for correcting vision. The proportion of myopia in Taiwan is very high, and with the aging population, the population requiring vision correction will continue to grow in the future.

This research survey is based on three additional principles added by Japanese professor Satoshi Nakagawa (Satoshi. 2006) to universal design: Economical for Long-term Use, Good Quality and Pretty, and Harmlessness to Human Body and Environment. The methods of Kano model and IPA are used in the study through a conduct by questionnaires among Taiwanese people to investigate their preferences for design factors of corrective eyeglass frames.

Instead of the traditional equidistant scale, the widely-used aesthetic golden ratio scale is applied to the questionnaires. Furthermore, the weights of each preference factor are measured using the Analytic Hierarchy Process (AHP), and then Choquet integral is employed as a comprehensive evaluation of the Important Performance Analysis (IPA). This serves as the reference origin for the two-dimensional matrix graph of the Important Performance Analysis (IPA). This further becomes the comparison basis for assessing satisfaction and importance across various preference factors. The research results are provided to designers and the optometry industry as a reference.

2. Literature Review

Some studies have shown that the average, symmetry, and characteristics of various parts of the face are significantly correlated with the attractiveness of facial features. (A. Cellerino,2003) However, wearing eyeglass frames changes a person's appearance. Thus, many eyewear designs focus on the suitability of facial shape, features, skin tone, as well as the shape, size, and material of the eyeglass frames. They hope to try and identify the optimal combination according to aesthetic standards.

Although traditional aesthetics often use facial symmetry and the golden ratio as standards of facial attractiveness, judging the sensual allure of a face is far more complex than people might imagine in reality. (K. Schmid,2008). Additionally, apart from the differences in facial features, various hairstyles, makeup, clothing, accessories, and styling can also influence an individual's overall impression. As time has passed, the demand for sunglasses has evolved from purely serving the function of shielding and protecting the eyes from sunlight to becoming a fashion accessory that reflects one's personal style. Nevertheless, the eyeglasses used for correcting vision are similar to other aids, which primary purpose is to maintain visual health. Due to needs taking time to adjust to new glasses after wearing them, unlike sunglasses and other decorative glasses which can be changed to alter one's style. However, the attractiveness of the eyewear when worn can directly impact the wearer's willingness to wear them.

Especially in recent years, Taiwan has passed legislation regarding optometrists. This indicates a significant advancement in Taiwanese public concern for visual health. The demands for corrective eyeglass frames have also increased in various aspects compared to before.

3. Research Design and Methodology

3.1 Golden Ratio Scale Semantics

The Golden Ratio Scale Semantics can be served as a proportional aesthetic scale. It is used to differentiate the preference level between adjacent semantics. It is highlighting the importance of aesthetic visual weighting, and the relevant description can be referred to (Kuo, Hsin-Lin and Li, Suh-Huey 2013).

Scale	Explanation
1	A1 and A2 equally important
1.618	A1 slightly more important than A2
2.618	A1 more important than A2
4.236	A1 much more important than A2
6.854	A1 extremely more important than A2

Table 1: Golden Ratio Scale

3.2 Continuous Kano Model with Golden Semantic Scale:

Kano Model is a two-dimensional model for measuring customer needs and performance indicators, which was introduced by Professor Noriaki Kano of Tokyo Institute of Technology in Japan in 1984 at the Japanese Society for Quality Control (JSQC), based on psychologist Herzberg's motivation-hygiene theory. The horizontal axis represents the degree of possession of quality elements, with further right indicating more abundant quality factors. The vertical axis represents the level of satisfaction, with higher positions indicating greater satisfaction, which form five different curves in the quadrants distributed in different areas. In this model, satisfaction varies depending on whether different quality factors are present in sufficient quantities. The relationship between satisfaction and quality is not solely represented by a single direct proportion curve.

The relationship will be represented by five different curves. In this model, the quality attributes between user satisfaction and product quality can be categorized into five types of elements. Namely, Must-be (M), One-dimensional (O), Attractive (A), Indifferent (I), Reverse (R), and Questionable(Q), as shown in Figure 1. By the model, one can investigate the relationship between quality factors and satisfaction in this study. The quality factors can affect user satisfaction from them. (Kano et al.,1984). By William DuMouchel in 1993, but using Golden Ratio Scale Semantics, we classify the functional quality attributes concerning the continuous variable analysis method to confirm the attributes of the functionality according to the quality attribute table. Finally, the two-dimensional chart of the Kano model is obtained, as depicted in Figure 2.

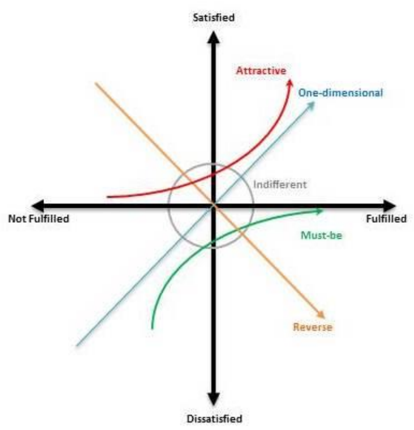

Figure 1: Kano Model

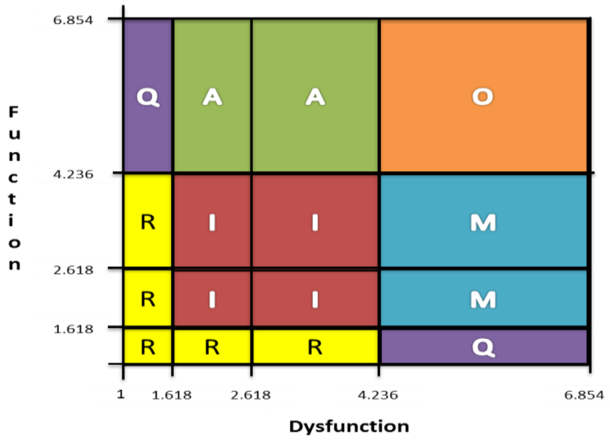

Figure 2: Continuous Kano Quality

3.3 Importance Performance Analysis (IPA)

Martilla and James first proposed the "Importance-Performance Analysis" model in 1977 (Martilla, 1977), applying it to quality measurement. In many satisfaction surveys, the Importance-Performance Analysis (IPA) method is often used with satisfaction and importance serving as evaluation criteria.

IPA two-dimensional quadrant diagrams are drawn to understand the priority order for product improvement. The two-dimensional matrix diagram can be divided into four quadrants: Factors falling in the first quadrant, with high importance and high satisfaction, belong to the " Keep Up the Good Work. Factors falling in the second quadrant, with high importance and low satisfaction, belong to the "Concentrate Here" category, indicating areas for improvement. Factors falling in the third quadrant, with low importance and low satisfaction, belong to the "Low Priority" category. Factors falling in the fourth quadrant, with low importance and high satisfaction, belong to the " Possible Overkill " category. The IPA two-dimensional matrix diagram is illustrated as depicted in Figure 3.

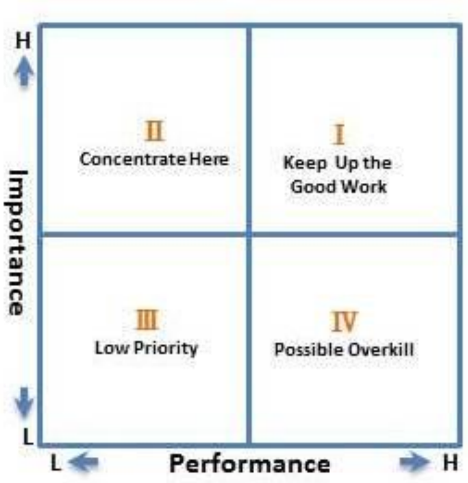

Figure 3 IPA two-dimensional matrix diagram

This study differs from traditional equidistant semantic questionnaires. It breaks away from the traditional discrete method of using the mode as the quality assessment standard. In the questionnaire survey, for Importance-Performance Analysis (IPA), a non-equidistant semantic questionnaire using the golden ratio scale (a proportional aesthetic scale) is employed, corresponding to the golden section ratio scale, as shown in Table 1.

3.4 Analytic Hierarchy Process (AHP)

The Analytic Hierarchy Process (AHP) is a multi-criteria decision-making method proposed by Professor Thomas L. Saaty of the University of Pittsburgh in 1971, which converts qualitative issues into quantitative analysis. In this study, a hierarchical structure is established using various factors. Based on the data collected from questionnaires, paired comparison matrices are constructed using evaluation scales. After consistency testing, relative weights and rankings of each factor are obtained. This study adopts the golden ratio scale with unequal intervals to differentiate the importance ratio of adjacent semantics using five scales.

3.5Choquet Integral Aggregation Evaluation Method

Choquet integral is one of weighted averages for comprehensive evaluation which helps determine the contribution rates of each evaluation criterion. It is defined as $\int hdg = \sum_{i=1}^{n}(h_i - h_{i-1})g(1,\cdots,i)$, where $h_0 = 0$, and the evaluations of each preference factor are $h_1,\cdots,h_n$ with $h_1 \geq h_2,\cdots,\geq h_n$. h can be regarded as the performance of the program to be evaluated on a specific attribute, i.e., the performance value, and g represents the subjective importance of each attribute. Therefore, the Choquet integral of h and g is the overall evaluation value of the scheme to be evaluated. For details, we refer to (Choquet G.,1953). As shown in Figure 4.

In this article, The measure of Choquet integral can be made up of the weights of AHP, and considered as follows.: If the contribution rate weights of two evaluation criteria are denoted as $g(1)$, $g(2)$ respectively, then the combined contribution rate weight can be represented as $g(1,2)$, in general $g(1)+g(2) \neq g(1,2)$. Therefore, in order to conduct a comprehensive evaluation, it is necessary to determine the contribution rates or weights for all combinations of evaluation criteria, referred to as fuzzy measures. The article uses AHP to determine the individual contribution rates of these evaluation criteria. The individual contribution rates $g(1),\cdots,g(n)$ lead to the joint contribution rate $g(1,2), g(1,2,3),\cdots,g(1,2,\cdots,n)$, where $g(i-1,i) = g(i-1) + g(i) + \lambda g(i-1)g(i)$. The measure g is called the Sugeno measure. Sugeno introduced λ-fuzzy measures (also known as Sugeno measures) in 1974.

It is generally applied to assess entities influenced by multiple objectives or criteria. Fuzzy measure λ can measure the degree of correlation (non-independence) between the subjective importance of various objectives or criteria by experts. It has a good effect on integrating information between the subjective importance and the objective satisfaction supported by evidence. The value of λ can be determined by the interaction of preference factors.

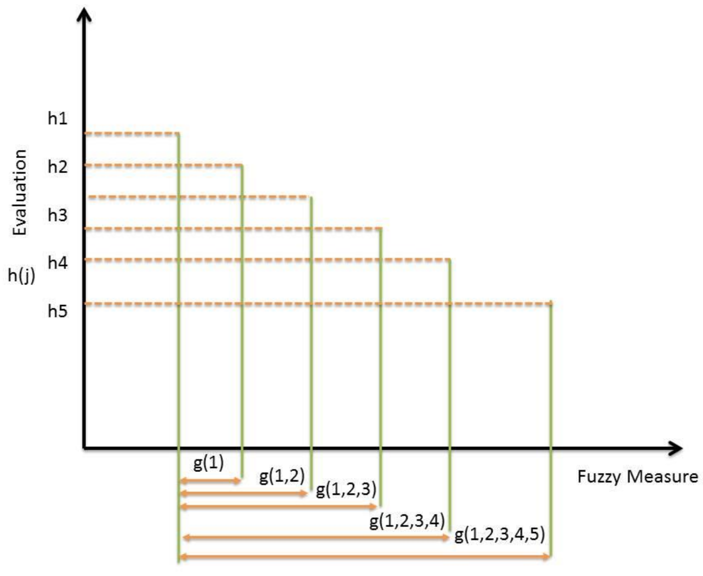

Figure 4: Comprehensive Evaluation Chart

The comprehensive evaluation $E = h_1(g(1) - g(0) + h_2(g(1,2) - g(1)) + h_3(g(1,2,3) - g(1,2))$
$+h_4(g(1,2,3,4) - g(1,2,3)) + h_5(g(1,2,3,4,5) - g(1,2,3,4))$.

By the Choquet integral comprehensive evaluation, it serves as the reference origin for the IPA two-dimensional quadrant chart, allowing for observation of the preference levels of each preference factor. (Dempster,1967).

4. Data Analysis and Conclusion

4.1 Analysis Results of the Kano Model

In the paper, the Kano questionnaires serves as a bidirectional questionnaire with positive and negative questions. It uses a five-point Likert Scale format, with the five scales in the questionnaire being "Strongly Like," "Neutral," "No Feeling," "Barely Accept," and "Strongly Dislike." The study utilized the statistical software SPSS 17 for reliability analysis. After collecting and organizing the questionnaires, a total of 329 questionnaires were analyzed. The Cronbach's Alpha value for the analyzed questionnaires was 0.823, indicating a reliable level of consistency. The summarized quality elements of preference factors for corrective eyeglass frame design using the Kano Model are summarized in Table 2.

Quality Elements	Functional (Positive)	Not Functional (Negative)	Classification
1. Consider Using Durability	5.338	4.211	A
2.Appropriate Pricing	4.221	5.539	M
3.Economic in Continuous Use	5.485	4.128	A
4.Easy to Maintain and Repair	5.823	5.850	O
5.Comfortable and Beautiful to Use	6.084	6.063	O
6.Satisfying Quality	5.936	6.124	O
7.Make Good Use of Materials	4.212	4.222	I
8.Harmless to Human Body	5.649	6.204	O
9. Harmless to the Natural Environment	5.531	5.476	O
10.Promote Recycling and Reuse	5.344	4.072	A
(A) Attractive, (I): Indifferent, (M): Must-be (O), One-dimensional			

Table 2: Classification of Quality Attributes in Kano Model Using Golden Ratio Scale Semantic

Following Table 2, we can observe the quality classifications of each factor in the Kano Model. "Appropriate pricing" belongs to the Must-be type, "Material versatility" belongs to the indifferent type, "Consider Using Durability," " Economic in Continuous Use," and " Promote Recycling and Reuse " belong to the attractive type, while "Easy to Maintain and Repair," "Comfortable and Beautiful to Use," "Satisfying Quality," "Harmless to Human Body," and "Harmless to the Natural Environment " belong to the One-dimensional type.

4.2 Analysis Results of AHP

The AHP hierarchy structure in this study is based on the three principles introduced by Professor Satoshi Nakagawa in universal design. The first level consists of three principles: "Economical for Long-Ter Use," "Good Quality and Pretty," and "Harmlessness to Human Body and Environment." The second level comprises ten criteria: "Consider Using Durability," "Appropriate Pricing," "Economic in Continuous Use," "Easy to Maintain and Repair," "Comfortable and Beautiful to Use," "Satisfying Quality," "Make Good Use of Materials," "Harmless to Human Body," "Harmless to the Natural Environment," and "Promote Recycling and Reuse." An AHP hierarchical assessment index was established accordingly, as depicted in Figure 5.

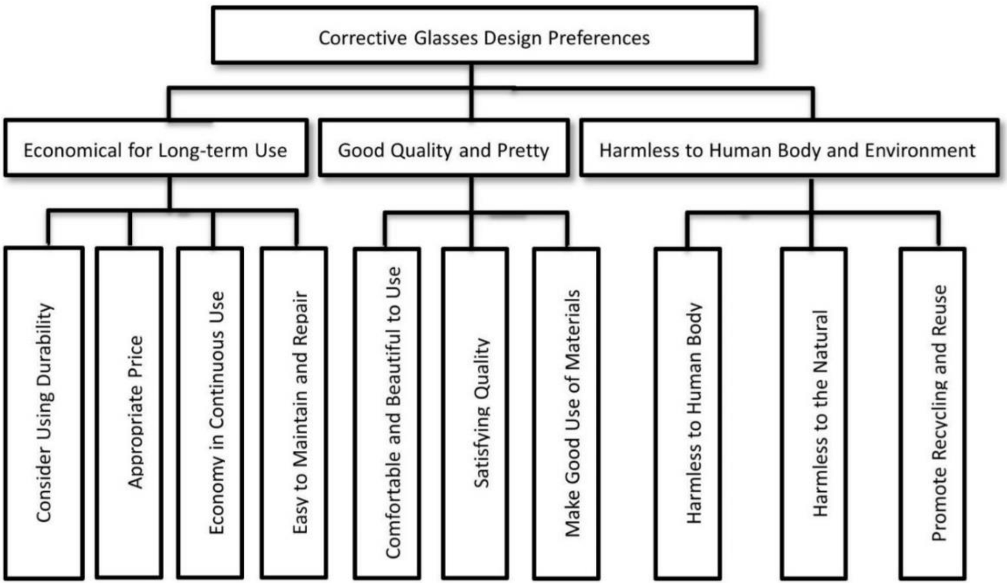

Figure 5: AHP Hierarchy Analysis Diagram for Corrective Frame Glasses

On the Table 3, The weight and ranking are obtained after AHP analysis

Aspect	Weight	Ranking	Key Attractive Factor Index	Overall Weight	Overall Ranking
Economical for Long-term Use	0.508	1	Consider Using Durability	0.206	1
			Appropriate Pricing	0.153	3
			Economic in Continuous Use	0.087	5
			Easy to Maintain and Repair	0.061	7
Good Quality and Pretty	0.325	2	Comfortable and Beautiful to Use	0.177	2
			Satisfying Quality	0.095	4
			Make Good Use of Materials	0.053	9
Harmlessness to Human Body and Environment	0.167	3	Harmless to Human Body	0.083	6
			Harmless to the Natural Environment	0.056	8
			Promote Recycling and Reuse	0.029	10

Table 3: Summary of Overall Weights for Design Preference Factors of Corrective Frame Glasses

4.3Analysis Results of IPA

In the IPA questionnaire, the options for importance level are "Very Important," "Important," "Neutral," "Unimportant," and "Very Unimportant," these five options. The number of valid questionnaires after collection and organization is 396. The overall Cronbach's Alpha value for the entire questionnaire after collection was 0.913 by the statistical software SPSS 17, which indicating a high level of reliability. The IPA evaluation matrix is as shown in Table 4.

Factor	Importance	Satisfaction
1.Consider Using Durability	5.364	4.529
2.Appropriate Pricing	5.415	4.314
3.Economic in Continuous Use	5.213	4.476
4.Easy to Maintain and Repair	5.517	4.807
5.Comfortable and Beautiful to Use	5.586	4.894
6.Satisfying Quality	5.747	4.790
7.Make Good Use of Materials	4.709	4.236
8.Harmless to Human Body	6.034	5.039
9. Harmless to the Natural Environment	5.258	4.445
10.Promote Recycling and Reuse	4.655	3.957

Table 4. IPA Evaluation Matrix (r_{ij})

The highest importance rating is for "Harmless to Human Body" (6.034), while the lowest is for "Promote Recycling and Reuse" (4.655). The highest satisfaction rating is for "Harmless to Human Body" (5.039), while the lowest is for "Promote Recycling and Reuse" (3.957).

4.4 The Choquet integral comprehensive evaluation of IPA importance and satisfaction

In this paper, since the factors in the AHP process are assumed to be independent, their weight measurements can be assumed to be additive measures, i.e., $\lambda = 0$. As derived from Section 3.4, the results are shown in Table 5. Therefore, the comprehensive evaluation of importance is

$$E_{important} = 0.338+0.546+0.989+0.337+0.828+1.105+0.294+0.454+0.250+0.135=5.276$$

Similarly, from Table 5, we can obtain the comprehensive evaluation of satisfaction

	Factor 8	Factor 6	Factor 5	Factor 4	Factor 2	Factor 1	Factor 9	Factor 3	Factor 7	Factor 10
Importance	6.034	5.747	5.586	5.517	5.415	5.364	5.258	5.213	4.709	4.655
g(j)	0.083	0.095	0.177	0.061	0.153	0.206	0.056	0.087	0.053	0.029
$h_i(g(i)-g(i-1))$	0.338	0.546	0.989	0.337	0.828	1.105	0.294	0.454	0.250	0.135

Table 6: Choquet Integral Comprehensive Evaluation of Satisfaction

	Factor 8	Factor 5	Factor 4	Factor 6	Factor 1	Factor 3	Factor 9	Factor 2	Factor 7	Factor 10
Satisfaction	5.039	4.894	4.807	4.790	4.529	4.476	4.445	4.314	4.236	3.957
g(j)	0.083	0.177	0.061	0.095	0.206	0.087	0.056	0.153	0.053	0.029
$h_i(g(i)-g(i-1))$	0.282	0.866	0.293	0.455	0.933	0.389	0.249	0.660	0.225	0.115

Table 5: Choquet Integral Comprehensive Evaluation of Importance

We will use the evaluation (Satisfaction, Importance) = (4.467, 5.275) as the reference coordinate origin for the IPA two-dimensional quadrant diagram, as shown in Figure 6. This will serve as the reference basis for comparing each preference factor.

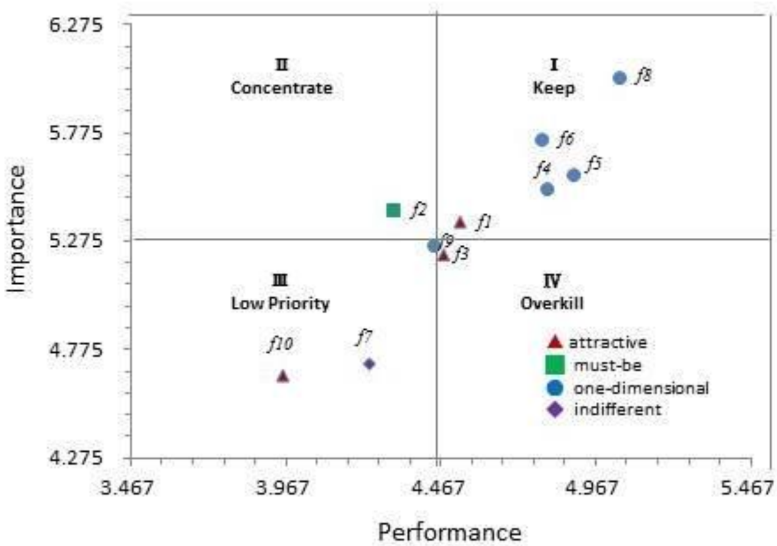

Figure 6: IPA Two-Dimensional Quadrant Diagram

After combining the results of IPA and Kano model analysis in this study, we obtained the IPA two-dimensional quadrant diagram shown in Figure 6. Factors falling in the first quadrant, indicating "Keep Up the Good Work," include: "Consider Using Durability"(Attractive),"Ease of Maintenance and Repair"(One-dimensional), "Comfortable and Beautiful to Use "(One-dimensional),"Satisfactory Quality"(One-dimensional), and "Harmless to Human Body"(One-dimensional). Factors falling in the second quadrant, indicating "Concentrate Here," include, Appropriate Pricing" (Must-be). Factors falling in the third quadrant, indicating "Low Priority," include, "Harmless to the Natural Environment" (One-dimensional), "Make Good Use of Materials " (Indifferent), and "Promote Recycling and Reuse" (Attractive). Lastly, factors falling in the fourth quadrant, indicating "Possible Overkill," include: "Economic in Continuous Use" (Attractive).

5. Conclusion and Recommendations

In this study on preferences for corrective eyeglass frame design, the combination of results from IPA and the Kano Model led to the creation of the IPA quadrant map (Figure 6). From this chart, we can draw the following conclusions: The factor that needs to be prioritized for improvement in this study is Factor 2, "Appropriate Pricing." In the classification of the Kano model, it falls under the category of "must-be" attributes. This attribute signifies that the product must have this basic functionality. Adding this feature to the design of corrective eyeglass frames may not necessarily increase user satisfaction, but its absence would definitely have a negative impact on the product. The factor that falls into the quadrant of secondary improvement priority is Factor 7, "Make Good Use of Materials", this factor belongs to the category of "indifferent quality." This indicates that users do not have particular feelings about this type. Whether this factor is present or absent, it will not lead to positive or negative evaluations. In the same quadrant, there is also the attractiveness factor F10, "Promote Recycling and Reuse." Improvement in this factor contributes to enhancing user satisfaction. Attributes like these represent the needs of potential customers. Factor F9, "Harmless to the Natural Environment," also belongs to this quadrant and is classified as an expected type, which is best to be consistently maintained. The factor that falls into the quadrant of overachievement is F3, " Economic in Continuous Use." This factor is classified as "attractive" in the Kano model attribute classification. The remaining "attractive" factor F1, " Consider Using Durability," along with the "expected" factors F4, F5, F6, and F8, fall into the quadrant of "keep up the good work." In future research, investigations can be conducted regarding public awareness of material-related health issues and promotion of recycling and reuse in eyeglass frame design. This would help clarify whether the issues lie in perception or lack of available choices.

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