Research on Lipstick Modeling Based on Grey Relational Analysis

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Abstract. In order to define the product modeling elements that best meet the emotional needs of consumers, the priority evaluation mechanism of the modeling elements in the product perceptual design is established based on the grey correlation analysis method. Taking the lipstick modeling design as an example, firstly, using the Richter scale to investigate the consumer image value, based on the analysis software SPSS to confirm the product sample and the perceptual vocabulary, then using the morphological analysis method to confirm the characteristic distribution table of the product modeling elements, and to investigate the consumers' perceptual image recognition. Finally, the gray relational analysis method is used to evaluate the priority of product modeling elements.

1. Introduction

With the advancement of science and technology and the improvement of material level, consumers' demands for products are no longer limited to basic functions, but tend to become more perceptual[1]. The modeling of the product is the first feeling that the product gives the consumer, and has a heavy influence on the preference of the consumer product, so the designer should make clear the image feeling and preference of the consumer to the product when the product modeling is designed. If the modeling of the product is dissected and analyzed, meticulously to the various micro-features of the product modeling elements, by adjusting the characteristic relationship between the product elements, improve the accuracy of the product modeling, so as to help the designer to clarify the preference of consumers and the relationship between the product modeling.

2. Lipstick modelling analysis

In the Tang Dynasty, the imperial concubine liked to use sandalwood (ochre) on her lips to make makeup. Later, lipstick not only developed in color research and development, but also had strange shapes for lipstick to meet the expectations of different consumers [2]. Lipstick styling has also changed with a variety of external factors and different needs of consumers, and these changes are consistent with people's psychological image. Lipstick styling changes from canned to tubular, from mirror to matte, from foggy to transparent, and also according to different era counterpart infrared view to adjust, indicating that lipstick will change according to the aesthetic taste of consumers. Therefore, this study also aimed at this phenomenon in-depth exploration, lipstick as an example, from the grey correlation analysis method, through the study of lipstick modeling, through the questionnaire...
survey, leiket scale, cluster analysis and other statistical methods to sum up the relationship between export red modeling elements and perceptual vocabulary.

3. The basic principle of grey relational analysis

Grey Relational Analysis in Multi-criteria Decision-Making Theory is applied to establish multi-attribute decision-making model in product modeling perceptual design [3]. Grey correlation analysis is a kind of theory to determine the main influencing factors from N sub-factors. By analyzing the reference sequence and several comparison sequences to measure the degree of geometric shape proximity and determine the degree of correlation among the various factors, it can determine the advantages and disadvantages of each evaluation scheme [4-5]. The following are the steps of the Grey Associated Analysis:

1) Determination of reference and comparison sequences. Each reference sequence is the associated object of the m-group comparison sequence, let the reference sequence be \( x_i(k) \) then 1 reference sequence is \( x_0(k) = \{x_0(1), x_0(2), ..., x_0(n)\}; k=1,2,...,n \}, m comparison sequences are \( x_i = \{x_i(1), x_i(2), ..., x_i(m); i=1,2,...,n\} [6] \).

2) Normalization of sequence data. This study adopts the average value processing method, its formula is:

\[
x'_i = \frac{x_i(k)}{\frac{1}{n} \sum_{k=1}^{n} x_i(k)} [3]
\]

3) Calculate the difference sequence matrix. In this study, the distance method is used to subtract the reference sequence from each column in the comparison sequence and take the absolute value. The formula is:

\[
\alpha_{0i}(k) = |x_0(k) - x_i(k)| [6]
\]

4) Calculate the grey correlation coefficient. The formula is:

\[
\gamma(x_0(k), x_i(k)) = \frac{\Lambda_{0i}(k) + \xi \Lambda_{\text{max}}}{\Lambda_{0i}(k) + \xi \Lambda_{\text{max}}} [3]
\]

\( \xi \) For the resolution coefficient, the general resolution coefficient is 0.5, and \( \xi \in [0,1] [7] \).

5) Calculate the grey correlation. The formula is:

\[
\gamma(x_0, x_i) = \frac{1}{n} \sum_{k=1}^{n} \gamma(x_0(k), x_i(k)) [8]
\]

If \( \gamma(x_0, x_i) > \gamma(x_0, x_j) \), state \( x_i \) than \( x_j \) Closer to reference element \( x_0 \), can be sorted according to the size of the value.

4. Case application

4.1. Research Steps

First of all, collect and screen the common lipstick pictures and adjectives in the market, get the representative sample of lipstick modeling and the emotional vocabulary; then use the questionnaire to make the representative sample and the perceptual language into the questionnaire to get the consumer perceptual evaluation scale; finally, combine the representative sample shape characteristic
distribution table with the perceptual evaluation matrix table, and use the grey correlation analysis method to establish the priority evaluation decision-making mechanism of modeling elements to meet the needs of consumers.

4.2. Identification of the representative sample
A focus group of five graduate students with six-year industrial design majors selected 270 lipstick images from official websites and related books from fashion magazines at home and abroad. Deconstruction of 50 samples by the above focus groups using morphological analysis results in 10 items, 28 categories, as shown in Tab.1.

| Projects                        | Category                                      |
|---------------------------------|-----------------------------------------------|
| Shell Model S1                  | 1) rectangle; 2) cylindrical; 3) arch; 4) organic |
| Shell Bottom Model S2           | (1) right angle; (2) internal form; (3) external arc |
| Shell Curve S3                  | 1) symmetric curve ;2) symmetric parallel line ;3) symmetric straight line |
| Shell grain S4                  | 1) stripes; 2) patterns; 3) geometry; 4) none |
| Shell transparency S5           | 1) transparency; 2) local transparency; 3) opacity |
| Shell transparency S6           | 1) transparency; 2) opacity |
| Shell body binding S7           | 1) Yes; 2) No |
| Connectivity S8                 | 1) Yes; 2) No |
| Open mode S9                    | 1) rotate; 2) pull out |
| aspect ratio S10                | 1):1 ;2):1:1~1:4; 3) above 1:4 |

Firstly, 50 lipstick samples are combined with the virtual values 1 or 0 in Table 1 to construct the morphological matrix. Then the software SPSS was used to cluster the 50 sample morphological elements matrix, and finally 12 representative samples were selected, as shown in Fig.1.

![Distribution table with the perceptual evaluation matrix table, and use the grey correlation analysis method to establish the priority evaluation decision-making mechanism of modeling elements to meet the needs of consumers.

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| Tab.1 Morphological deconstruction characteristics table |
|---------------------------------------------------------|
| Projects            | Category                                      |
|----------------------|-----------------------------------------------|
| Shell Model S1       | 1) rectangle; 2) cylindrical; 3) arch; 4) organic |
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| Shell transparency S6| 1) transparency; 2) opacity |
| Shell body binding S7| 1) Yes; 2) No |
| Connectivity S8      | 1) Yes; 2) No |
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![Fig.1 Represents the sample](image)

4.3. Determination of emotional vocabulary
A total of 150 words describing lipstick imagery were collected by consulting lipstick magazines and related literature. Delete the expression inaccurate, similar adjectives through the focus group, get the adjectives 51 and make the questionnaire, check out the 10 adjectives that they think are the most
suitable to describe the lipstick shape by 40 subjects, and get the most 10 adjectives after the questionnaire summary is integrated, shown in Tab.2.

**Tab.2 10 adjectives**

| Honororable | Ordinary | Delicate | Sweet | Elegant |
|-------------|----------|----------|-------|---------|
| Erotogenic  | Dreamy   | Classical| Vanguard| Distinctive |

The 12 selected samples were combined with 10 adjectives to form a fifth-order Likert scale, which was distributed to 20 subjects for perceptual image evaluation, and the perceptual image evaluation score table was obtained, as shown in Tab.3.

**Tab.3 Perceptual image evaluation score table**

| sample | Honororable | Ordinary | Delicate | Sweet | Elegant | Erotogenic | Dreamy | Classical | Vanguard | Distinctive |
|--------|-------------|----------|----------|-------|---------|------------|--------|-----------|----------|-------------|
| 1      | 3.58        | 3.08     | 3.5      | 2     | 2.92    | 2.92       | 1.75   | 3.75      | 3.17     | 2.25        |
| 2      | 2.17        | 2.33     | 3        | 2.58  | 3.42    | 2.42       | 2.58   | 3.42      | 2.67     | 2.42        |
| 3      | 3.17        | 2.08     | 3.42     | 2.83  | 2.42    | 3.09       | 3.33   | 2.5       | 3.58     | 3.92        |
| ...    | ...         | ...      | ...      | ...   | ...     | ...        | ...    | ...       | ...      | ...         |
| 12     | 4.25        | 2.5      | 4.17     | 3.17  | 2.5     | 3.92       | 3.42   | 2.83      | 4.08     | 4.17        |

The software SPSS was used to analyze the evaluation score in Table 3, and the three groups of component factors were obtained, as shown in Tab.4. The greater the factor load, the closer the relationship between the adjective and the factor. As can be seen from Tab.4, the contribution ratio of the three groups of factors is 43.489%:27.257%:16.27%, about 3:1:1:1 as a reference for selecting the final perceptual vocabulary.

**Tab.4 Results of factor analysis**

| Adjectives | Component 1 | Component 2 | Component 3 |
|------------|-------------|-------------|-------------|
| Classical  | -.945       | .058        | .156        |
| Dreamy     | .918        | .176        | .084        |
| Elegant    | -.857       | .160        | -.173       |
| Distinctive| .775        | .409        | -.178       |
| Sweet      | .586        | .321        | .513        |
| Erotogenic | -.120       | .973        | -.154       |
| Vanguard   | .308        | .884        | -.188       |
| Honorable  | .043        | .880        | .381        |
| Delicate   | .138        | .741        | .626        |
| Ordinary   | -.086       | -.109       | .896        |
| Contribution| 43.489%     | 27.257%     | 16.274%     |

In order to objectively select the perceptual vocabulary, using SPSS to cluster the three groups of component factor load values in Table 4, referring to the contribution ratio of the above three groups of factors 3:1:1, the final selection of the five perceptual vocabulary is: Classical, Dreamy, Sweet, Vanguard, Elegant.

**4.4. Grey relational analysis**

Using a focus group to deconstruct the shapes of 12 samples with reference to Table 1, this study compiled a scale of 5th-order Richter scale using 1-5 values for 12 representative samples. Finally, the distribution of modeling elements of 12 samples and the "classical" scale were obtained, as shown in Tab.5.
In order to effectively evaluate the influence of various modeling elements on the perceptual vocabulary "classical", the grey correlation analysis method was used to analyze the evaluation results of the subjects, and the priority evaluation mechanism of lipstick modeling elements was established to meet the demands of consumers. First, the sequence matrix $D$ is constructed based on the styling elements of the 12 samples in Tab.5, where column 1 is set as a reference sequence and column 2 to 11 as a comparison matrix, then the matrix $D$ is:

$$
D = \begin{bmatrix}
0 & 0.317 & 0.233 & 0.217 & \cdots & 0.278 \\
1 & 2 & 2 & \cdots & 1 \\
1 & 1 & 1 & \cdots & 1 \\
\vdots & \vdots & \vdots & \ddots & \vdots \\
2 & 2 & 2 & \cdots & 2
\end{bmatrix}
$$

Using the formula of average value (1), the data in the sequence matrix are normalized to obtain the normalized sequence matrix $S$:

$$
S = \begin{bmatrix}
1.157 & 0.850 & 0.792 & \cdots & 1.015 \\
0.462 & 0.923 & 0.923 & \cdots & 0.462 \\
0.169 & 0.632 & 0.632 & \cdots & 0.632 \\
\vdots & \vdots & \vdots & \ddots & \vdots \\
0.923 & 0.923 & 0.923 & \cdots & 0.923
\end{bmatrix}
$$

According to the difference sequence matrix formula (2), the difference sequence matrix $E$:

$$
E = \begin{bmatrix}
0.695 & 0.073 & 0.131 & \cdots & 0.553 \\
0.988 & 0.219 & 0.160 & \cdots & 0.383 \\
0.113 & 0.193 & 0.252 & \cdots & 0.029 \\
\vdots & \vdots & \vdots & \ddots & \vdots \\
0.234 & 0.073 & 0.131 & \cdots & 0.092
\end{bmatrix}
$$

From the difference sequence matrix $E$ can be known: $\Delta_{\text{max}} = 1.136; \Delta_{\text{min}} = 0.015 \ \xi = 0.5$, Under the condition of the resolution coefficient, the grey correlation coefficient matrix $R$ of each comparison sequence is calculated by using formula (3):
By calculating the degree of gray correlation of each comparison sequence, the importance of each shape element of lipstick is evaluated. If the comparison sequence of the shape elements is closer to the reference sequence, the degree of gray correlation is closer to 1, and the relationship is closer.[3]. The smaller the resolution coefficient is, the stronger the correlation is.[9]. In order to establish the priority evaluation mechanism of the styling elements in lipstick sensory design more objectively, this study analyzed the relationship of the grey correlation degree of the various elements of lipstick modeling under the condition of resolution coefficient of 0.5, 0.4, 0.3 and 0.2 (when the resolution coefficient is 0.1, the difference of the research results is large, so the research results are not included in the consideration), and obtained the grey correlation degree of the various elements of the "classical" lipstick modeling design under the different resolution coefficients, shown in Tab.6.

Tab.6 The distribution of classical modeling elements

| Modelling Elements | ξ=0.5 Sorting | ξ=0.4 Sorting | ξ=0.3 Sorting | ξ=0.2 Sorting |
|--------------------|---------------|---------------|---------------|---------------|
| S 1                | 0.61          | 9             | 0.51          | 9             |
| S 2                | 0.55          | 10            | 0.445         | 10            |
| S 3                | 0.806         | 4             | 0.729         | 4             |
| S 4                | 0.645         | 8             | 0.537         | 8             |
| S 5                | 0.806         | 3             | 0.730         | 3             |
| S 6                | 0.847         | 1             | 0.779         | 1             |
| S 7                | 0.840         | 2             | 0.770         | 2             |
| S 8                | 0.656         | 7             | 0.548         | 7             |
| S 9                | 0.753         | 6             | 0.662         | 6             |
| S10               | 0.791         | 5             | 0.707         | 5             |

According to the ranking of each modeling element in Table 6, the modeling element S6 is the most important to the "classical" lipstick modeling design, followed by S7, S5, S3, S10, S9, S8, S4, S1, and S2 is the most unimportant modeling element in the "classical" lipstick modeling design.

Tab.7 General ranking of grey correlations of modeling elements for each perceptual word

| Modelling Elements | Classical | Vanguard | Sweet | Dreamy | Elegant |
|--------------------|-----------|----------|-------|--------|---------|
| S 1                | 9         | 9        | 8     | 9      | 10      |
| S 2                | 10        | 10       | 10    | 10     | 9       |
| S 3                | 4         | 5        | 3     | 2      | 3       |
| S 4                | 8         | 7        | 9     | 8      | 7       |
| S 5                | 3         | 4        | 5     | 4      | 6       |
| S 6                | 1         | 1        | 1     | 1      | 2       |
| S 7                | 2         | 2        | 2     | 3      | 1       |
| S 8                | 7         | 8        | 7     | 5      | 8       |
| S 9                | 6         | 6        | 6     | 7      | 5       |
| S10               | 5         | 4        | 4     | 6      | 4       |
According to the above grey correlation calculation method and so on to the perceptual vocabulary Dreamy, Sweet, Vanguard, Elegant lipstick modeling design, and then sort out the perceptual vocabulary modeling elements gray correlation degree total ranking, shown in Tab.7.

According to the general order of grey correlation of the various perceptual words in Table 7, we can see that:

1. According to the results of grey correlation analysis, S6(shell transparency) is the most important, S2(shell bottom modeling) is the least important, S6(shell transparency) is the most important, S2(shell bottom modeling) is the most important, S6(shell transparency) is the most important, S7(shell shape) is the most important, S6(shell transparency) is the most important, and S2(shell modeling) is the most important.

2. It is concluded that S7 and S6 are very important to the overall design of lipstick modeling, while S1 and S2 are not important to the overall design of lipstick modeling. The results of the grey correlation of the modeling elements can help designers master the key lipstick modeling elements and reasonably combine the design resources.

5. Conclusion
Using the questionnaire and Li Kete scale to quantify the perceptual image value of the consumer's counterpart red modeling, this study evaluated the priority of the export red modeling elements to the consumer's perceptual demand by using the grey correlation analysis method. Taking the "classical" perceptual vocabulary lipstick modeling element design as an example, the results show that S6(shell transparency) is the most important in the "classical" lipstick modeling design, and S2(shell bottom modeling) is not important in the "classical" lipstick modeling design. This study takes the product sensibility design as the direction, uses the grey correlation analysis method to evaluate the product modeling element, its analysis result can help the designer to understand which of the modelling design elements is the design appeal which can influence the consumer preference most, and closes the gap between the designer and the consumer in the product sensibility image cognition, enables the designer to grasp the consumer's specific psychological appeal in the lipstick modelling design more precisely, and transforms into the lipstick design key modelling factor, thus enhances the consumer satisfaction and product quality.

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