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Research on the model differentiation of baby carriage based on multidimensional Scaling method

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ABSTRACT. *As an important analysis method, the multidimensional Scaling method has a novel and positive significance for the application research in the field of industrial design. In this paper, the multidimensional Scaling method is applied to the research on the differences of stroller models which are common in the market at present. On the premise that the subjects do not get the perceptual vocabulary to express the characteristics of the stroller samples, the multi-scale method can use the subjective imagination of the subjects to discover the potential dimensions of the samples. Combining the research results with cluster analysis, we can easily select the representative baby carriage samples, which provides the basis for the next step of baby carriage modeling evaluation and design.*

KEYWORDS: *Kansei engineering, multidimensional Scaling method, spss, baby carriage*

1. Introduction

With the adjustment of national fertility policy and the development of society, more and more families pay attention to children's physical and mental health, and baby carriage is their intimate partner in the process of growth and development.At present, in China's baby carriage market, there are not only the quality problems that consumer concerns, but also many businesses in order to reduce costs, blindly copy the shape design of baby carriage, lack of self brand design innovation, greatly reducing the beauty and practicality of products, seriously affecting the brand image in society.Therefore, on the basis of ensuring the product quality, our baby carriage products need to improve the product design level to establish a good image of the enterprise and meet the needs of consumers.

In recent years, the integration of perceptual engineering in product design has gradually opened up a new field of design, creating a new way of experience and

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emotional interaction. To achieve good design results, designers need to change from a single consideration of product appearance to considering user feelings and needs, through the characteristics of different target groups, like, needs and other aspects of calculation, screening and analysis, from a perceptual point of view, we have created a "people-oriented" product design.

2. A Review of Multidimensional Scaling Method

2.1 Summary of Multidimensional Scaling Method

The design methods are all based on the conditions known to the experimental sample characteristics, but it is not easy to analyze the samples when these characteristics are unknown. In the product design method, the semantic difference method requires the subjects to locate in a series of perceptual vocabulary levels to determine the semantic level of the product to carry out the next experimental process. The experiment can not proceed without having prepared a list of the emotional statements that describe the product for the subjects to choose from. However, the multivariate analysis method does not need these adjectives, the subjects classify the samples according to their own subjective ideas, which has no effect on the progress and results of the experiment.

Multidimensional Scaling Method (MDS), is a natural extension of principal component analysis and factor analysis. The aim is to discover the underlying dimensions of "distance" between multiple things and explain the similarity between things with fewer variables [1]. In short, the multivariate scaling method is also a method of quantifying subjective assumptions to extract hidden attributes between things.

At present, there are also many applications of Multidimensional Scaling Method for modeling analysis of products in China, such as Jia-liang Lin [2] and others selected seven representative mobile phone samples by Multidimensional Scaling Method for semantic psychological evaluation of mobile phone modeling; Chunhe Li [3] got 8 pairs of representative and easy-to-perceived women's style sensibility, which provided the basis for the evaluation and design of women's wear. This paper studies the difference of stroller modeling by Multidimensional Scaling Method, in order to further understand the characteristics of stroller modeling and analyze the difference of stroller modeling.

2.2 Principle of Multidimensional Scaling Method

In the experiment, the subjects were asked to evaluate the difference degree of the sample by their own subjective idea under the condition of unknown sample attribute in advance. the evaluation value as input data represents the similarity (difference) relation between things in the low dimension space by the distance between points and points through proper dimensionality reduction. The main advantage of the multi-scale method is that it can directly simulate the performance

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of human psychological perception [2] Based on this advantage subjects did not need to know in advance what factors influenced the difference judgment and used their subjective difference or similarity to establish perceptual space. The subjects compared the sample pairs, and then got the different type matrix for the next analysis. In addition, this method is not as strict as other methods for data distribution and sample size, and is close to data between relatively simple things. Using multiple scale method can reduce the time cost and human resource cost of psychological evaluation of design effect.

After the data of the subjects were counted, the next concrete calculation method was made by Kruskal (1964) [4] It is proposed that the pressure (stress) function is used to describe the degree of fitting between the observed data and the MDS model, and the pressure value is gradually reduced by iterative method. The formula is as follows:

$$S = \sqrt{\frac{\sum\sum(d_{ij} - \hat{d}_{ij})^2}{\sum\sum(d_{ij})^2}} \tag{1}$$

Where S is the pressure coefficient, d_{ij} is the distance of a pair of things in the construction plane, and the estimate of $\hat{d}_{ij}$ is usually obtained by the method of simple regression. the smaller the pressure coefficient means that d_{ij} is not different from it, that is, the model fits well with the observed data.

3. Research Design

3.1 Classification Experiment

This paper applies the method of multi-analysis to the differential study of stroller modeling, collects pictures of 48 different brands of stroller modeling and decolors it, unifies it into black and white hue, and disposes the brand of stroller with mosaic to avoid the brand effect affecting the test results of the subjects. After all the baby carriage sample pictures have been processed and integrated into a rowdy questionnaire, as shown in Figure 1, the number of the sample is the rank number, e.g. A1, A2, B1.... Twenty graduate students in industrial design were invited for testing on a sample basis, with 10 men and women each. Subjects classified 48 carriage according to their individual subjective feelings. In order to understand the problems that may be encountered in the classification of baby carriage samples in advance, four subjects were first asked to classify the samples, and the classification results showed that the process of classifying these samples into five to six categories was easier. Therefore, the subjects classified the samples with 5 to 6 categories in the formal trial, please observe all the samples and divide the stroller samples they think are more similar into one category, the number of each class can be different.

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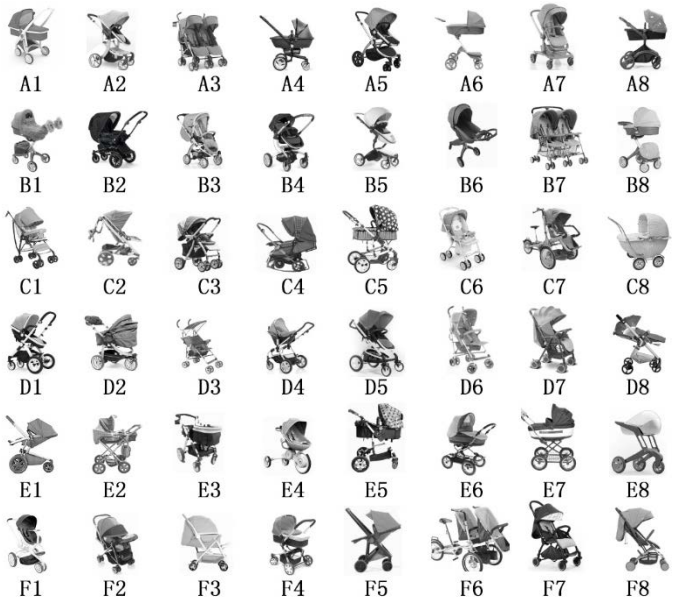

Figure. 1 Baby carriage questionnaire

Statistical data are recorded from the first category, first based on the sample of the smallest column (column A) in order of small to large, then on the prepared table when the two samples of the other columns are divided into the same category, and then on the sample of column B and C in order until the largest F. Repeat the above recording method until all the classification data of the 20 subjects have been counted, the scores of each table are summed, and the similarity values of the subjects are recorded as the similarity isometric matrix of the samples. Then subtract the values of each table in the matrix using the total value of the subjects 20, respectively, and get the dissimilarity isometric matrix of the 48 samples. The matrix data were input into the SPSS [5], analyzed with a multidimensional scale (ALSCAL), and sequentially extracted 2d to 6d data for analysis, as shown in the table.

Table 1 Multidimensional Scale Analysis Table

Dimensions	Stress	RSQ
2	0.1705	0.8681
3	0.1117	0.9185
4	0.0740	0.9520
5	0.0577	0.9652

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6	0.0487	0.9717

3.2 Results Analysis

In the multivariate scale method, the pressure index is an important index to evaluate the suitability of the model. different pressure index levels represent different suitability. when the stress value is less than 0.200, it indicates that the fit degree is not good, less than 0.100 indicates that it is ok, less than 0.050 indicates that it is very good, and less than 0.025 indicates that the fit degree is very good. As shown in the data in Table 1, the stress index gradually decreases with the increase of the dimension, 0.1705, 0.1117, 0.0740, 0.0577, 0.0487, respectively; the opposite RSQ value increases gradually with the increase of the dimension, 0.8681, 0.9185, 0.9520, 0.9652, 0.9717, respectively. The stress values illustrate that the six-dimensional model fits the observed data well, so the stress values of 0.0487 (rsq =0.9717) are analyzed. The coordinate values of 48 samples in the six-dimensional cognitive space can be obtained by MDS analysis (as shown in Table 2). and these six dimensions are actually latent features hidden in each sample.

Table 2 Coordinate values of samples in cognitive space

Sample	Dimensions						Sample	Dimensions					
	1	2	3	4	5	6		1	2	3	4	5	6
A1	1.5306	1.0789	0.0686	-0.1033	-0.3694	-0.0940	D1	-1.6153	0.3101	0.2235	-0.7346	0.1613	-1.1711
A2	-1.4832	0.7117	-0.1815	0.0725	-0.0532	-0.8198	D2	0.5502	-0.6329	1.3076	2.0701	0.1005	1.2909
A3	0.1025	-2.2306	-2.5528	-0.1803	-1.0181	0.3367	D3	-2.1218	0.2906	-0.9974	-0.2173	0.8473	0.1404
A4	1.9173	0.4447	-0.4876	-1.3956	0.3514	0.3723	D4	-0.4140	1.1609	0.5845	-0.5048	0.1825	-0.9065
A5	-1.0725	0.5081	-0.0935	-1.5553	-0.0520	0.0253	D5	-1.5978	0.9198	0.7154	-0.6430	0.3159	-0.7785
A6	1.9898	0.0470	-0.0928	-1.2782	0.7209	0.3538	D6	-2.1826	0.5716	-0.1713	0.6736	1.1874	0.4991
A7	-1.5707	0.8920	-0.3726	-0.5325	0.9598	0.1985	D7	-1.9433	0.3894	-0.5354	1.2462	-0.3881	0.6100
A8	2.0756	0.5016	-0.3132	-0.8026	0.3610	0.2328	D8	-1.1384	0.2147	1.4410	-0.2458	-1.0639	0.0397
B1	1.3465	0.7960	0.3979	-0.7905	-0.9414	-0.3300	E1	1.0516	-1.1462	-0.3674	-0.6684	0.4980	1.9571
B2	0.1086	0.9527	-0.6737	0.4953	-1.3298	0.3001	E2	1.1695	1.3827	-0.5560	0.5974	-0.1375	-0.4256
B3	-1.4342	1.3151	-0.1039	0.3191	0.7461	-0.0087	E3	1.8689	0.5276	-0.7955	0.3001	0.3336	-1.3056
B4	-1.4486	0.6579	-0.2149	0.1013	-0.2147	-0.7942	E4	0.2747	-1.9837	1.0476	-0.0918	0.6659	0.3423
B5	-0.8128	0.2397	0.1251	-1.7641	0.4153	0.3595	E5	1.8611	-1.3047	0.8735	0.9321	1.2901	-0.1879
B6	-0.7895	-1.7561	1.0598	-0.4227	-0.5519	-0.1260	E6	1.5810	1.0933	0.3175	0.7174	-0.7433	-0.4182
B7	0.2896	-1.9149	-2.6216	-0.8680	-0.7419	0.5385	E7	2.1653	0.4945	-0.2370	0.9814	0.0804	-0.2658
B8	2.1099	0.5067	0.3139	0.2498	-0.0672	0.1650	E8	1.0578	-1.6354	1.5380	-0.0406	1.2791	-1.0622
C1	-1.9954	0.1232	-0.6013	0.4257	1.2192	0.4773	F1	-0.8293	-1.4406	1.4981	-0.3578	-0.2303	0.7239
C2	-0.7399	-1.1878	1.9433	0.4539	-0.3845	-0.4583	F2	-1.5282	0.7045	-1.8299	-0.1508	0.2315	0.1164
C3	-0.9815	-0.1143	-0.1374	1.9425	-1.4211	0.2203	F3	0.5366	-0.0234	-0.0964	-1.5521	-1.0805	-0.2534
C4	1.1235	1.2719	-0.3016	1.2676	0.2685	-0.0272	F4	2.0707	0.4472	-0.1049	0.7342	0.4599	-0.0735
C5	2.0220	0.8814	0.4267	0.7237	0.5681	0.1704	F5	-0.0381	-0.2468	1.2098	-0.3574	-0.9589	1.7033
C6	-1.9112	0.0659	-0.5866	0.7105	1.3935	0.5620	F6	0.3244	-2.8348	-1.9403	0.5366	0.0808	-1.1512

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C7	-0.4526	-2.4692	-0.3604	0.5281	-0.3711	-1.7650	F7	-1.4681	0.7982	0.4054	0.3906	-0.8218	1.0638
C8	2.0791	0.3930	0.4367	-0.8318	-0.5167	-0.0440	F8	-1.6379	0.2288	1.3929	-0.3805	0.2311	-0.3327

Taking the coordinate values of the six dimensions in Table 2 as the classification variables and combining with the cluster analysis, the 48 samples can be divided into 5 categories and judged according to the distance of the sample from the center of the category, and the least distance is the representative sample of the class. The results of the cluster analysis are shown in Table 3.

Table 3 Results of Cluster Analysis

NO.	Category	Distance	NO.	Category	Distance	NO.	Category	Distance
A2	1	0.92512	F8	1	1.61711	C5	4	1.34117
A5	1	1.54632	B2	2	1.11061	C8	4	1.03090
A7	1	0.83888	C3	2	2.26028	E1	4	2.56319
B3	1	0.95394	C4	2	1.16517	E3	4	1.70414
B4	1	0.99662	E2	2	1.09566	E5	4	2.45799
B5	1	1.86770	E6	2	1.24365	E7	4	1.37648
C1	1	1.39725	A3	3	1.22208	F3	4	2.19407
C6	1	1.65978	B7	3	1.65227	F4	4	1.11473
D1	1	1.36439	C7	3	2.10345	B6	5	1.24521
D3	1	1.19628	F6	3	1.15825	C2	5	1.16746
D4	1	1.74067	A1	4	1.00450	D2	5	2.36403
D5	1	1.27300	A4	4	1.32962	D8	5	1.90133
D6	1	1.43001	A6	4	1.27182	E4	5	1.36227
D7	1	1.82145	A8	4	0.80881	E8	5	2.41907
F2	1	1.71610	B1	4	1.47588	F1	5	0.97200
F7	1	1.81441	B8	4	0.76147	F5	5	1.89937

According to the results of Table 3, there are 17 in the first category, 5 in the second category ,4 in the third category, 14 in the fourth category and 8 in the fifth category. In the first category, the distance of A7 from the sample center is 0.83888, compared with the other numbers in the same class, the sample with the smallest distance from the sample center, so A7 is selected as the representative sample of the first category. In the same way, the distance between E2 and the center of the sample is 1.09566, which is the smallest sample in the second category, so it is selected as the representative sample of the second category.The distance between F6, B8, and F1 and the sample center is 1.15825, 0.76147, 0.97200, respectively, and the distance from the sample center is the smallest in the third, fourth, and fifth categories, so it is the representative sample in the class in which it is located. Among the 48 samples, the 5 samples, A7, E2, F6, B8 and F1, were the most different in shape and shape, which best reflected the differences of various kinds of carriage, and therefore could cover the widest range of styling semantics of stroller products in the market, thus laying a good foundation for the next step to use them as test samples for the selection of representative adjectives.

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Figure. 2 Finally selected 5 representative samples and their models

4. Conclusion

In this paper, the diversity of stroller modeling is studied by multi-scale method, and five representative stroller modeling samples are selected with cluster analysis. It is shown that the multi-scale method can use the subjective difference or similarity of the sample without describing the perceptual vocabulary of the sample in advance to judge the sample and establish the perceptual space so as to dig out the potential attributes of the sample for the next research. In the course of the experiment, the number of subjects and samples is not strictly required, so we can use SPSS to process the data under the premise of lower time cost and human resource cost, and efficiently complete the analysis of the difference relationship between simple things.

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