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## Household car's Quantitative Research of Product Form Characteristic

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### Abstract

This paper, based on the method of Applied statistics and experimental psychology, use the principal component analysis method to Quantitative research the user's perceptual knowledge of household car shape design, and try to establish user's mental models of product form characteristics. Draw the image of automobile products distribution, so as to find the car of product form characteristics of the blank image area, for the user the value orientation of perceptual consciousness provides the possibility of numerical quantitative way.

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**Keywords:** Household cars, Morphological characteristics quantification, Principal component analysis, Perceptual knowledge model

### 1. Preface

The product modeling design is Effective expression of semantic to some extent, and Product form characteristics plays a key role in the product semantics communication. Products are perceived by users through its shape information and Produce short-term memory which matches the experience and knowledge of long time memory in the process of intuition, So as to form the individual perceptual intention of the product by users. User's perceptual intention of the product is usually with some fuzziness and can hardly be quantitative analysed, so we introduce language as a variable to its description based on fuzzy theory method, and make this fuzzy language information into numerical value which make the quantitative analysis of user's perceptual intention information possible.

This paper try to use statistics method to establish user model of automotive products form based on the fuzzy theory, and puts forward the possible quantitative research tools to household car product form. The research procedure as shown in figure 1.

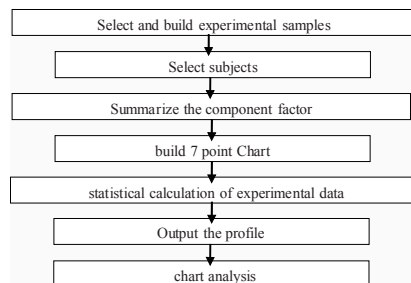


Figure 1.The research procedure





















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### 2.Establishment of experiment model

Experimental sample use the Sampling method. The first place is to build domestic automobile samples. We used the stratified random sampling method which Selected 25 household cars as a sample, as is shown in table 1; The second place is subjects sample. We use the Quota sampling method, and Try to make the distribution of average proportion In the professional, gender, age, etc into consideration. We select 20 males and 20 females as subjects In this experiment. Including 12 car appearance designers, 5 automotive engineers, 7 foreign trade managers, 7 civil servants, 3 accountings and 6 teachers.

This psychology experiment use questionnaire survey method、depth interview method to get composition factors that describe product, And further the semantic analysis scale method. Adding seven degree adjectives for composition factors respectively from weak to strong, On behalf of the "very approve of, is in favor of - a little for - neutral - just don't agree with -- inot in favor of - not in favor of a lot", and correspond score to - 3 points, - 2 points, 1 points, 0 points, 1 points, 2 points, 3 points. When Using the semantic analysis scale for experiment, the participants should choose the point Most conforms to his feeling to score in the seven scale accord to his impression of this evaluation object. We got the household cars' component factor after the depth interview for 10 designers and engineers: 1. (simple - complex), 2. (personality - mass), 3. (cold - kind), 4. (dynamic - calm), (delicate - straightforward), 6. (traditional, modern), 7. (small - atmospheric), (soft - hardened), 9. (luxury - plain), (human - machine) . Constructing seven scale of product component factor . With one model for example, all models by analogy.

Table 1. Car samples

			
VW New Lavida	New Fort for 3-boxes	Cadillac cts	Toyota V6 2.5L Royal
			
Toyota Camry	Mazda 6	VW Golf	VW Polo
			
VW Beetle	Kia K5	Mini cooper	Chevrolet Mindray
			
Modern Elentra	Faw WeiZhi	Fort iosis-x	Audi A6L
			
Citroen Picasso	Peugeot 408	Geely Panda	Honda City

### 3.Integration of data analysis

### 3.1 Weighted average

Collect all subjects' experimental data form and find out every household car sample 's weighted average in the form of various coordinate point, As shown in chart 2 .

Table 2.Data weighted average value

	Factor1	Factor2	Factor3	Factor4	Factor5	Factor6	Factor7	Factor8	Factor9	Factor10
Sample1	-1.4	-1.4	-1	-1.6	-1.8	-1.6	0.4	-0.6	-1.2	-1.6
Sample2	-1.2	0	-1.2	-1	-0.8	-0.4	1.2	1.6	-0.2	-1.6
Sample3	-1.6	-1.2	-1.4	0.4	-0.6	0.4	1.4	-0.2	-0.8	-0.2
Sample4	0	-1.4	-0.6	1	-0.2	0.8	0.8	-1	1.2	1.4
Sample5	-2	1.6	-1	-2.2	0.2	0.8	1.4	0.8	-1.2	-1.6
Sample6	-1.8	-0.2	-1.8	-0.6	-0.8	-0.4	0.8	1.2	-1.4	-2.2
Sample7	-1.2	-1.6	-1.8	-1.8	-1	0.2	1.4	1	-2	1
Sample8	-1.6	-2.2	-2.2	-1.2	0.4	1.2	1.2	-1.4	-2	1.4
Sample9	-0.8	1	-0.6	1	0.8	0.8	1.4	-0.4	-1	0
Sample10	-0.2	0.6	-0.4	1	0.6	0.2	-0.6	0.2	0	1.2
Sample11	-1.2	0	-1	-0.6	0	1.2	1.4	-0.2	0	1
Sample12	-0.8	2	1.4	0.4	-0.8	1.4	-1.2	-1.2	-0.4	-0.8
Sample13	-0.4	-2	-1.6	0.4	0.8	-0.2	1.2	1.6	-1.2	-0.6
Sample14	1.2	0.4	1.6	2.2	-1.4	-1.2	-0.6	0	1.2	-0.6
Sample15	0.8	-0.8	-1.2	1	-0.4	-1	0.4	0.8	-0.2	-1.6
Sample16	2	1.6	0.6	1.2	-1.2	-0.8	-0.4	1.4	1.2	0.8
Sample17	1	0	1.6	-0.2	-0.6	2	1.6	-0.8	-0.2	-2
Sample18	0.4	0.6	-0.8	-0.2	1.2	-1.2	-1.4	0.8	-1.8	-0.2
Sample19	1.4	0.4	-0.6	-2	0	-0.6	2	1.8	-0.4	-0.6
Sample20	1.2	0.4	0.8	0.8	0.2	-1.8	-0.2	-0.8	1.4	0.8
Sample21	2.2	0.4	0.6	-0.8	-2	-1.6	-0.4	-0.4	-1	0
Sample22	1	-0.4	-0.8	-1.2	-0.8	0	0.4	0.2	0.4	-0.8
Sample23	0.6	-0.2	1.4	-1.8	0	-2	-0.8	-1	-0.2	-1.8
Sample24	-0.8	-2	0.2	0	-1	-0.2	1.4	0.4	-0.8	0.2

### 3.2 necessity analysis based on the Applied statistics

#### •Data analysis

We take the principal component analysis method of applied statistics to work, the essence of the principal component analysis method is a multivariate statistical analysis method which converts multiple measured variables into several unrelated indicators, the composite indicators are not relevant, which refers to the information that each of the composite indicator representatives do not overlap. Such method is very suitable for experimental analyzing which contains multiple variables、 multiple samples and large quantity of experimental data.

Input the data of Table 2 into MICROSOFT EXCEL to made worksheet, and import SPSS program. Apply the Data Reduction under Analyze menu and choose Factor to analyze. In theFactor Analysis dialog box, first put these 10 pairs of component factors into Variables box, select Initial Solution in Discriptives tab, Indicate that the factor analysis are the commons, eigenvalues, percentage of variance and cumulative percentage, and select KMO and Bartlett's test of sphericity in correlation matrix option to display the KMO sampling appropriate parameters and sphericity test of Bartlett's. Then select "Principal components" method in factors-extraced tab,"Correlation matrix" in the "Analyze" option, "Eigenvalues over" in "Extract" option, and select eigenvalue that greater than 1 when setting factors-extracted. Finally select the "Save as

variable" in "Factor Scores" dialog box , so you can storage factor scores to the new data file and generate a new variable name. This experiment select "Regression" method and select "Exclude cases listwise" for the processing mode of missing values, which refers to analyze the observed values when there are no missing values in all the variables.

#### •Principal component extraction results

The experiment's common degrees form's Output results is shown in the Chart 2. "Initial" stands for Initial common degrees of each variable quantity, all this value are 1. "Extraction" is regeneration common degrees after Extraction of factors. It shows information ratio of each factor are extracted. It can be seen from this one , all variables 's information ratio been extracted is more than 0.5, and there are eight variables's extracted information ratio is above 0.7 or very close to 0.7. It shows that each variable's information had been extracted a lot, It is reasonable analysis.

Chart 3.Extraction Method

	Initial	Extraction
Simple & complex	1.000	.586
Personality & mass	1.000	.684
Cold & kind	1.000	.500
Move & calm	1.000	.761
Delicate & straightforward	1.000	.677
Traditional & modernc	1.000	.634
Small & spectacular	1.000	.529
Soft & hard	1.000	.746
Luxury & plain	1.000	.727
Human & mechanical	1.000	.756

The total variance explained table results shown in the Chart 3. "Total "represents the eigenvalue, the size of the characteristic value reflects the common factor of variance contribution, and bigger Eigenvalue represents the bigger variance contribution. "% of Variance" on behalf the percentage of the characteristic value in Variance. "Cumulative %"represents the additive value of percentage. The eigenvalue bigger than 1 is listed in right column. "Extraction Sums of Squared Loadings" draws two factors meet the requirements, and variance that these two factors explained accounted for 65.414% of the whole variance which reflect most of the information of all variables. They are principal component extracted in the experiment which can be Used for further analysis.

Chart 4. The total variance explained Chart

Component	Initial			Extraction Sums of Squared Loadings		
	Total	%of Variance	Cumulative %	Total	%of Variance	Cumulative %
1	4.802	36.942	36.942	4.802	36.942	36.942
2	2.956	28.472	65.414	2.956	28.472	65.414
3	.923	8.782	74.196			
4	.855	7.163	81.359			
5	.767	6.366	87.725			
6	.603	5.838	93.563			
7	.489	2.205	95.768			
8	.421	1.768	97.536			
9	.371	1.412	98.948			
10	.251	1.052	100			

Sample factor loading matrix can be shown in Chart 4 .This table shows the related coefficient between each variable and main factor 1&2. The comprehensive index(main factor 1&2) can be respectively represents with y1, y2, and 10 variable can be respectively represents with x1,x2,x3, x4 x5, x6, x7, x8, x9 and x10. We can get the relevant model of the main factor:

$$y_1 = 0.719x_1 + 0.349x_2 + 0.612x_3 + 0.635x_4 - 0.729x_5 + 0.527x_6 - 0.349x_7 + 0.663x_8 + 0.108x_9 + 0.762x_{10} \quad (3-1)$$

$$y_2 = 0.561x_1 + 0.543x_2 + 0.526x_3 + 0.529x_4 + 0.439x_5 - 0.592x_6 - 0.543x_7 - 0.524x_8 + 0.285x_9 + 0.766x_{10} \quad (3-2)$$

Table 5.Component Matrix(a)

c.Extraction Method:Principal Component Analysis.

	Component	
	1	2
Simple & complex	.719	.561
Personality & mass	.349	.543
Cold & kind	.612	.526
Move & calm	.635	.529
Delicate & straightforward	-.729	.439
Traditional & modernc	.527	-.592
Small & spectacular	-.349	-.543
Soft & hard	.663	-.524
Luxury & plain	.108	.285
Human & mechanical	.762	.766

### 3.3 Household car products image profile

On the basis of the analysis of the above data, we can apply the extracted main component to draw two points which determined by two variables in two-dimensional space, and then analyze the distribution characteristics of the data through the distribution characteristics of these points, including density degree and distribution direction. Then using the Scatterplot functions of SPSS software to set the X-axis for "REGR Fator Scoer 1 for anlysis 1 [fac1\_1]", the Y-axis for "REGR provided Fator Scoer for analysis 1 [fac2\_1]" in the left rectangular box, then output samples two-dimensional imagery maps, as shown in the figure, the horizontal axis represents the aggregative indicator 1 of principal component analysis, the vertical axis represents the aggregative indicator 2 of the principal component analysis and the red dots represent samples.

The load value of the principal component is called correlation coefficient in factor component matrix, if they are greater than 0.5, it means the relevance is higher and what original variables the composite indicator better represents. We can know what variables the aggregative indicator 1 and 2 respectively better represent according to this principle. Using the principle that the variables which two axes representatives could not repeat, we can label the horizontal axis in negative direction for fine, soft, simple, user-friendly, the horizontal axis in the positive direction for the rough, rigid, complex, mechanical; label longitudinal axis in the positive direction for the public, friendly, quiet, traditional, rustic, longitudinal axis in the negative direction of the personality, apathy, dynamic, modern and luxurious.

We can get the following conclusions after analyzing the image schema of the 25 family car models: Firstly, the area where red dots are intensive, means integrating each variable indicators the product imagery is very close in the area; the area where red dots are parse, means the product imagery is decentralized in this area. In this way we quantify the aesthetic perception people to the Tablet PC, which is not easy to be intuitive reaction perceptual. The area where product imagery is intensive, is called products imagery coincidence area, means that it is not suitable for re-development of new products, such as in the figure, we can see the imagery of Volkswagen Golf and Polo, Mazda 6 and Ford iosis, Wei Zhi and Picasso are coincidence, then we should avoid the image focal point and select the area where product imagery is decentralized if we want to develop new models.

Secondly, analyzing from the distribution direction of the dot, the endpoint in the negative direction of the horizontal axis is the Volkswagen Beetle, this period represented by variables are delicate, soft, simple, user-friendly. Prototype of Beetle is designed by German designer Porsche in 1930s, We can see it from the location of the imagery maps that the car is one of the personalized models recognized of public. The endpoint in the positive direction of the horizontal axis is the General Motors Cadillac cts, this endpoint represented by the variables are the rough, cold, complex, mechanical. This body waist is

very tall and strong, and headlamps, fog lamps of the car are using angular, rectangular elements. imagery figure of each car samples can be analyzed in the same way to find the positioning of the models in the branding process.

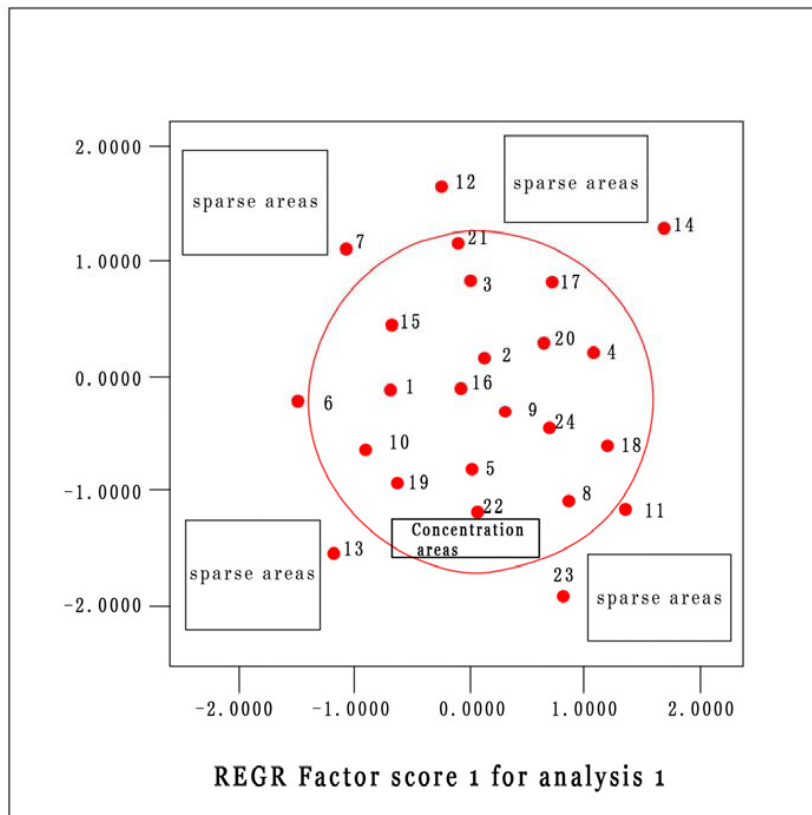


Figure 2. product image profile

## Conclusion

Automobile product appearance modelling had attracted more and more attention in our country, but there still exist some problems in design process when designers work on the appearance of automobile. They don't form the scientific and systematic analysis to users' demand but depends on their feelings, which calls for hidden trouble of the elimination. This paper gets perceptual image profile based on the morphology of the car through statistics, psychology, social studies of science research theory and research methods, and Builds user's mental models. With Putting forward scientific and effective product value data analysis method, provides a basis for future automobile appearance design.

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