

Study on Design of Thrombotic Risk Hint Sign Based on Quantization Theory Class I

Sisi Liu^{1,*}, Yanping Zhao¹

¹School of Mechanical and Automotive Engineering, Qilu University of Technology (Shandong Academy of Sciences), Jinan 250353, China.

Abstract

Taking the thrombus risk warning sign as the design research object, the image modeling designer based on the quantitative theory class I is proposed. Through the SD method to obtain the user's perceptual image evaluation of the sample, at the same time to analyze the sign modeling, from the shape, structure, proportion, color and other aspects of the extraction of the perceptual image has a key impact on the modeling design elements, the application of quantitative theory class I to establish the relationship between perceptual vocabulary and modeling design elements, and to construct a corresponding mathematical analysis model, in the quantitative level to study the relationship between psychological sensibility and product design elements to assist product image modeling. Finally, the method is proved to be feasible by practical application.

Keywords

Product design, signage design, perceptual engineering, semantic difference method, quantitative theory class I.

1. Introduction

The central venous catheterization is a safe and effective infusion for patients with certain diseases, which can help the clinical medical work, but also brings a series of complications, in which catheter-related thrombosis accounts for a large proportion[1]. Therefore, in clinical treatment, medical workers and patients should always be reminded of the risk level of associated thrombosis in order to take appropriate measures. In response to this demand, many hospitals have chosen to hang thrombotic risk warning signs in specific locations such as wards, treatment rooms, and mark the patient's thrombotic risk, etc. In response to this need, in the design process of the thrombus risk warning sign, it is necessary to consider its special purpose and use environment to design its layout and color, etc., has reached the work that indicates the thrombus risk. This paper studies the design elements and perceptual images of the thrombus risk warning sign, constructs the mathematical model of the quantitative theory class i based on the cognitive characteristics of the specific user, and quantifies the subjective image information to guide the conceptual design of the sign.

2. Research Methods

2.1. Semantic Differences

Semantic Difference Method (SD) is the basis of perceptual image research[2]by the American scholar Osgood[3]Proposed in 1957, by reflecting the subject's perception on the Likert scale, the psychological perception was measured. A pair of perceptual words (e.g., loathed-like) that are antonyms are located at the left and right ends of the scale, and are divided into several categories. The evaluation grade is generally odd, using -3~+3 points to calculate. According to

the subjective score of the subjects, the quantitative data were constructed between the product modeling and the perceptual vocabulary[4].

2.2. Quantization Theory Class I

In order to establish the mapping relationship between the perceptual image and the design elements, the designer needs to get the weight of the design elements in the perceptual image space, and the corresponding relation can be obtained by means of linear or nonlinear analysis of the computer[5]. Quantification theory is a branch of multivariate statistical analysis, proposed by the Japanese scholar Lin Zhijifu in the 1950s, according to the purpose of its research, divided into quantitative theory I, II, III, IV, total 4. Quantization theory class I is to use multivariate regression analysis to establish mathematical models between independent variables as qualitative variables and dependent variables as quantitative variables, so as to solve the problem of prediction of dependent variables and reveal the internal relations and rules between things. Many scholars at home and abroad have applied the quantitative theory class I to the research of product image modeling design, and have achieved certain results[6-9].

In this study, within the theoretical framework of the perceptual engineering system, quantitative theory class i is applied to explore the corresponding relationship between the psychological perceptual image of the audience and the elements of modeling design, and it is used to support the product development process to achieve the goal of improving the quality of product design.

3. Research Process

The research process is to screen and design some new product samples on the basis of investigating the existing thrombus risk prompt signs, to conduct a questionnaire survey again, then decompose the product, extract the modeling design elements, and then apply the quantitative theory class I to analyze the corresponding relationship between the psychological perceptual image of the consumer and the modeling design elements according to the survey results.

3.1. Design Survey

Through the network and on-site investigation of major hospitals related thrombotic risk sign, after expert interviews, questionnaires and cluster analysis, finally get 20 thrombotic risk sign sample. In order to avoid the influence of hospital name factors on the image of sign design, after redesign, the information related to the hospital is removed, and the corresponding design is carried out as a representative sample, as shown in figure 1.

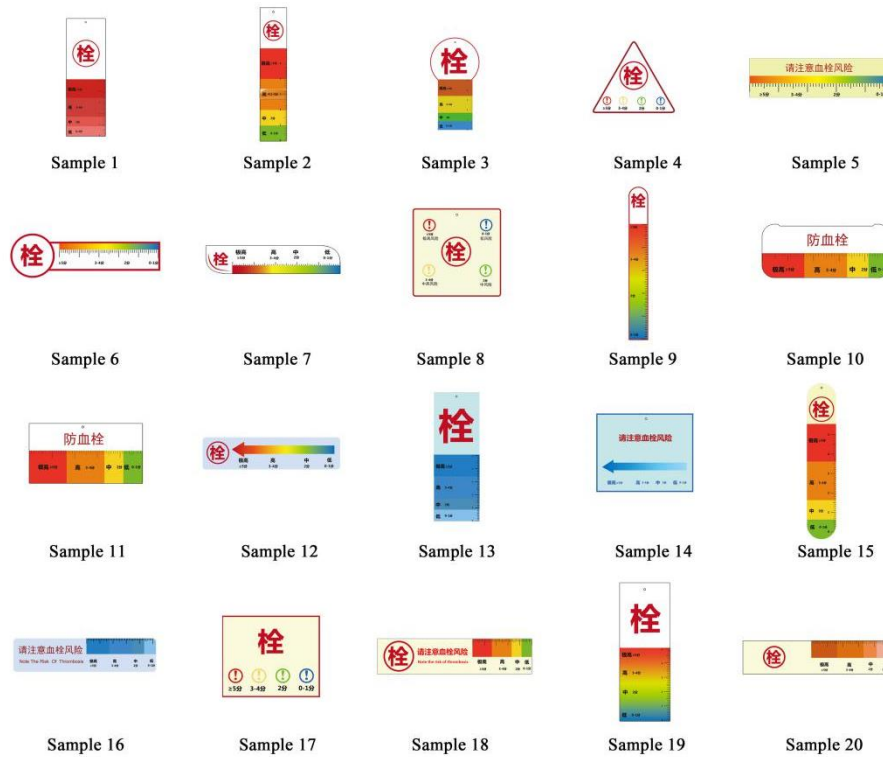


Figure 1. Representative Thrombosis Risk Prompt Sign Sample

Through consulting the hospital website, advertising and other ways to collect the appropriate description of the risk of thrombus sign design image of the perceptual vocabulary, a total of 50, after a questionnaire survey, similarity detection and cluster analysis, the final determination of two perceptual words.

professional, eye-catching, pairing these words with antonyms as a representative vocabulary pair (professional - popular, eye-catching - mediocre. Using SD method ,20 samples of thrombus risk prompt sign were selected to establish the 5th order semantic scale with 2 pairs of perceptual vocabulary respectively, and the scores from left to right were 1-5 to form the questionnaire, and the questionnaire design was shown in figure 2.

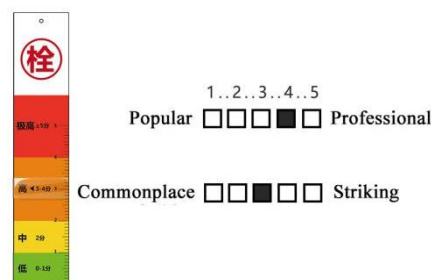


Figure 2. SD schematic diagram of the questionnaire on semantic differences

A total of 20 participants in the product design field (mean age 23,12 males and 13 females) completed the questionnaire. By statistics, the average value of perceptual evaluation of representative samples is shown in Table 1.

Table 1. Statistical table for the perceptual evaluation of representative samples
Striking - Commonplace

	Questionnaire																				Average value
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Sample 1	3	3	3	3	4	4	4	1	3	5	1	3	2	2	2	3	4	3	3	4	3
Sample 2	3	5	3	5	2	3	4	2	3	4	5	5	5	5	4	4	4	5	5	5	4.05
Sample 3	4	2	2	2	2	4	5	2	4	1	5	3	2	4	2	3	4	4	4	4	3.15
Sample 4	2	2	2	4	3	5	4	4	2	4	4	2	2	3	5	2	3	3	3	4	3.15
Sample 5	3	4	4	5	2	1	1	1	2	2	2	1	3	3	2	1	1	4	1	3	2.3
Sample 6	4	3	4	5	2	2	4	1	1	1	4	2	4	5	5	3	3	4	3	4	3.2
Sample 7	2	4	3	3	3	2	5	3	4	5	5	1	1	3	4	3	3	3	3	2	3.1
																				
Sample 19	5	2	5	2	1	5	5	2	1	5	5	4	2	1	2	2	3	2	3	1	2.6
Sample 20	2	5	5	3	2	3	5	2	2	4	2	2	1	1	4	1	4	4	1	5	3.5

	Questionnaire																				Average value
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Sample 1	2	5	2	3	2	4	4	5	3	4	4	4	2	2	2	3	2	4	4	2	3.1
Sample 2	3	5	4	5	2	4	5	4	4	5	5	5	5	5	4	4	4	5	5	5	4.45
Sample 3	2	1	3	3	4	2	2	1	1	3	2	5	3	3	5	4	3	4	3	4	2.9
Sample 4	1	5	2	5	4	3	1	3	2	3	1	4	1	4	5	3	2	3	2	2	2.8
Sample 5	4	1	4	4	2	5	1	5	2	1	4	3	3	1	2	2	4	2	4	4	2.8
Sample 6	3	1	4	5	2	3	1	5	2	3	3	3	4	2	2	4	4	4	4	4	3.2
Sample 7	2	1	4	3	4	3	3	4	5	4	4	1	3	1	3	5	3	3	3	3	3.1
																				
Sample 19	4	5	2	3	1	5	2	3	3	3	3	4	5	2	3	1	4	2	1	5	3.05
Sample 20	5	4	1	3	1	3	3	2	1	1	2	2	4	1	2	1	1	1	3	3	3.55

3.2. Extraction of Product Modeling Design Elements

According to the system concept, a product can be realized by the combination of different design elements, and the design elements have different forms, thus forming the production of different shapes. In order to extract the key factors affecting the thrombotic risk sign, a new shape was created through the replacement and reorganization of the morphological elements, and on the basis of a large collection of product samples, a questionnaire survey and focus group method were used to investigate the users and potential users. A total of 30 subjects, including 15 men and 15 women, were selected to conclude the modeling design elements and their classification of the product, as shown in Table 2.

Table 2. Perceptual vocabulary and distribution of morphological elements

Sample No.	Morphological elements						Popular- Professional	Striking - Commonplace
	Proportion of title scale	White space	Shape	Layout	Number of main colors	Background colour		
Sample 1	4	3	1	1	1	3	3.1	3
Sample 2	5	1	1	1	2	3	4.45	4.05
Sample 3	3	3	2	1	2	3	2.9	3.15
Sample 4	4	1	3	1	2	3	2.8	3.15
Sample 5	4	3	1	1	3	2	2.8	2.3
Sample 6	4	3	3	2	3	3	3.2	3.2
Sample 7	5	3	3	2	3	3	3.1	3.1
Sample 8	4	3	1	3	2	2	2.15	2.4
Sample 9	5	1	3	1	3	3	3.35	3.4
Sample 10	5	2	3	1	2	3	2.95	3.25
Sample 11	5	2	1	1	2	3	2.85	2.8
Sample 12	5	1	1	2	3	1	2.4	3.05
Sample 13	4	2	1	1	2	1	3.15	2.4
Sample 14	4	3	1	1	2	1	3.2	2.9
Sample 15	5	1	3	1	2	2	2.9	3.15
Sample 16	1	2	1	2	1	1	3.2	2.9
Sample 17	2	3	1	1	2	2	3.15	2.65
Sample 18	1	1	1	2	2	2	2.6	2.25
Sample 19	3	2	1	1	3	3	3.05	2.6
Sample 20	3	3	1	2	1	2	3.55	3.5

3.3. Establishment of Mathematical Models

According to the idea of the quantitative theory class I, the modeling design elements are regarded as the independent variable x (qualitative variable), the perceptual evaluation value as the dependent variable y (quantitative variable), There are r elements of styling design, and the number of categories of the j elements is represented by C_j . $C_j \delta_i(j,k)$ called the j styling design elements category k response in group i samples.

$$\delta_i(j,k) = \begin{cases} 1 & \text{The qualitative data for the j modelling design element} \\ & \text{in group i samples are in category k.} \\ 0 & \text{else} \end{cases} \tag{1}$$

Definition

$$x = \{\delta_i(j, k)\}$$

$$(i = 1, 2, \dots, n; j = 1, 2, \dots, r; k = 1, 2, \dots, c_j) \tag{2}$$

Assuming that there is a linear relationship between the value of perceptual evaluation and the various reactions of modeling design elements, a linear model can be obtained:

$$y_i = \sum_{j=1}^r \sum_{k=1}^{c_j} a_{jk} \delta_i(j, k) + \varepsilon_i \tag{3}$$

The a_{jk} is the k constant which only depends on the j modeling design element, while the ε_i represents the random error of the i sampling.

The least square estimate of the coefficient a_{jk} can be obtained by using n set of samples and using the least square principle $\overline{a_{jk}}$, so that it reaches the minimum, then the partial derivative is obtained $\overline{a_{jk}}$ the coefficient and it is equal to zero. After finishing:

$$Q = \sum_{i=1}^n \varepsilon_i^2 = \sum_{i=1}^n [y_i - \sum_{j=1}^r \sum_{k=1}^{c_j} \overline{a_{jk}} \delta_i(j, k)]^2 = \sum_{i=1}^n y_i - \bar{y}^2 \tag{4}$$

$$\sum_{j=1}^r \sum_{k=1}^{c_j} f(uv, jk) \overline{a_{jk}} = \sum_{i=1}^n y_i \delta_i(u, v)$$

$$(u = 1, 2, \dots, r; v = 1, 2, \dots, c_u) \tag{5}$$

The least square estimate of the a_{jk} can be obtained $f(uv, jk) = \sum_{i=1}^n \delta_i(u, v) \delta_i(j, k)$, solving the equations $\overline{a_{jk}}$, thus having

$$\bar{y}_1 = \sum_{j=1}^r \sum_{k=1}^{c_j} \overline{a_{jk}} \delta_i(j, k) \tag{6}$$

In order to explain the correspondence between perceptual image and modeling design elements more conveniently, the model can be further assumed as

$$\bar{y}_1 = \bar{y} + \sum_{j=1}^r \sum_{k=1}^{c_j} a_{jk}^* \delta_i(j, k) \tag{7}$$

\bar{y} is the average value of the perceptual evaluation, that is

$$\bar{y} = \frac{\sum_{i=1}^n y_i}{n} \tag{8}$$

a_{jk}^* , also known as the standard coefficient, is related to the coefficient

$$\overline{a_{jk}} a_{jk}^* = \overline{a_{jk}} - \frac{1}{n} \sum_{k=1}^{c_j} n_{jl} \overline{a_{jl}} \tag{9}$$

Where n_{jl} indicates the number of type l reactions in the j styling design elements in all groups of samples with

$$\sum_{l=1}^{c_j} n_{jl} = n$$

(j = 1,2, ..., r) (10)

For the purpose of measuring the accuracy of the model, the complex relation number r, its value can be solved by the following formula:

$$R = [\sum_{i=1}^n (\bar{y}_i - \bar{y})^2 / \sum_{i=1}^n (y_i - \bar{y})^2]^{\frac{1}{2}} \tag{11}$$

The square of the complex relation r, that is, the coefficient of determination R^2 , is generally used to represent the accuracy of the model.

In order to measure the contribution of various modeling design elements to the prediction of perceptual evaluation value, the demand bias correlation coefficient. Firstly, the correlation matrix between the y of perceptual evaluation and the elements of modeling design is B:

$$B = \begin{bmatrix} 1 & b_{y1} & b_{y2} & \dots & b_{yr} \\ b_{1y} & 1 & b_{12} & \dots & b_{1r} \\ b_{2y} & b_{21} & 1 & \dots & b_{2r} \\ \dots & \dots & \dots & \dots & \dots \\ b_{ry} & b_{r1} & b_{r2} & \dots & 1 \end{bmatrix}$$

And the inverse matrix is B^{-1} :

$$B^{-1} = \begin{bmatrix} b_{yy} & b_{y1} & b_{y2} & \dots & b_{yr} \\ b_{1y} & 1 & b_{12} & \dots & b_{1r} \\ b_{2y} & b_{21} & 1 & \dots & b_{2r} \\ \dots & \dots & \dots & \dots & \dots \\ b_{ry} & b_{r1} & b_{r2} & \dots & b_{rr} \end{bmatrix}$$

Then the number of the relationship between the perceptual evaluation value y and the j modeling design element is

$$R_{yj} = \frac{-b_{yj}}{\sqrt{b_{jj}b_{yy}}} \tag{12}$$

That is, the contribution of the j modeling design elements to the y of perceptual evaluation value is R_{yj}

Excel software is used to solve the mathematical model to obtain the value of category score, constant term, complex relation number, determination coefficient and partial relation number. The results are shown in Table 3.

Table 3. Quantitative Theory Class I Analysis Results

Project	Category	Professional - Popular		Striking - Commonplace	
		Category Score	Partial correlation coefficient	Category Score	Partial correlation coefficient
Title Scale	Greater than 3:1	0.17	0.51	-0.40	0.79
	3:1-1:1	-0.10		-0.05	
	1:01	0.39		0.30	
	1:1-1:3	-0.28		-0.23	
	Less than 1:3	0.07		0.23	
Reserved amount	0-20%	-0.04	0.51	0.18	0.73
	20-40%	-0.40		-0.38	
	40-60%	0.25		0.09	
Form	rectangle	0.09	0.54	-0.04	0.52
	triangle	-1.17		-0.40	
	Irregular	0.00		0.15	
Layout	Up and down	0.12	0.50	-0.02	0.18
	Left and right	-0.15		0.05	
	mix	-0.70		-0.08	
Number of main colors	Less than four colours	0.11	0.38	0.39	0.72
	Four to seven	0.09		0.05	
	More than seven	-0.22		-0.29	
Background Color	Cold colour system	0.07	0.49	0.11	0.73
	Warm Color System	-0.35		-0.35	
	Medium colour	0.18		0.17	
Constant term		3.04		2.96	
Multiple correlation coefficient		0.71		0.90	
Complex coefficient of determination		0.50		0.80	

By using the theory of quantitative theory class I, we get the partial relation number of each perceptual image and modeling design elements, the standard coefficient and the decision system of each modeling design elements classification. The partial relation number indicates the contribution of the modeling design elements to each perceptual image, the standard coefficient of the classification of the modeling design elements further indicates the contribution of the modeling design elements to each perceptual image, and the determining coefficient indicates the accuracy of the model.

When carrying on the product design, if we want to get some kind of product with high perceptual image evaluation, we should give priority to the modeling design elements with high correlation, and then we should give priority to the category of modeling design elements with high standard coefficient.

3.4. Analysis of Results

1. Of the six morphological items ,(title scale ratio),(retention amount),(main color quantity),(background color) were more relevant to the "striking - mediocre" perceptual vocabulary than (layout). (retention),(shape) are more relevant to the "professional-popular" emotional vocabulary, and are less relevant to (the number of main colors) and (background colors).

2. Among the six morphological items, the correlation coefficients for all two groups of perceptual vocabulary were high in terms of (title scale ratio),(retention scale) and (shape), showing that the modeling categories of the two items had the greatest impact on the

perceptual cognition of the sign; whereas (main color),(background color) only affected a pair of perceptual vocabulary.

3. For the "professional - public" vocabulary, it is affected by (1:1),(40-60%),(rectangular),(upper and lower layouts),(less than four main colors), and (cold background colors). For "striking - mediocre" emotional vocabulary, (title scale ratio 1:1), (white 0-20%), (shape rectangle), (layout up and down), (main color less than four colors), (background color neutral color system) have a greater impact on it.

Table 4. Perceptual imagery and correspondence of modeling elements

	Professional - public	striking - commonplace
Proportion of title scale	1:01	1:01
White space	40-60%	0-20% 40-60%
Shape	Rectangle Irregular shape	Irregular shape
Layout	Up and down	Left and right
Number of main colors	Less than four colors Four to seven colors	Less than four colors Four to seven colors
background colour	Cold Color System Neutral colors	Cold Color System Neutral colors

In this study, according to the results of quantitative theory, the corresponding tables of perceptual images and modeling elements are sorted out (Table 4).it can be seen from table 4 that of the 20 samples, sample ii is most consistent with the perceptual image of "professional", "Striking".

4. Conclusions

The perceptual image of the product fully conveys the psychological feelings of the user, builds a bridge for the two-way communication between the designer and the consumer, does not understand the effective way of the user's emotional needs, and can also be customized for the appropriate product according to the perceptual image evaluation of the special crowd.

Taking the design of thrombus risk warning sign as an example, the design of product image modeling based on quantitative theory class I was studied. Using the SD method to obtain the user's perceptual image evaluation of the sign, the key design elements of the sign are extracted from the six aspects of title scale proportion, white color quantity and main color quantity, and the mathematical model between the perceptual vocabulary and the design elements of the sign is established by using the quantitative theory class I. Using this method, we can extract the design items which have a key influence on the perceptual image, help the designer to better understand the needs of special users, and choose more suitable product modeling. For the content of this study, the follow-up study will further improve the unexpected modeling design scheme.

References

[1] Gao Liu ,Dan Li , Yan Ma, Yan Xu, Xin Xie , Beibei Wang , Jihong Yang ,XiaHuo , Shijun Li, comparison of thrombotic complications with different central venous catheterization in elderly patients; Journal of PLA Medical College ,2016,37(1).

- [2] Shijian Luo, Yunhe Pan, Research Progress of Perceptual Image Theory, Technology and Application in Product Design [J]. Journal of Mechanical Engineering ,2007,43(3):8-13.
- [3] Osgood CE, Suci GJ, Tannenbaum PH.The measurement of cleaning [M]. Urbana: University of Illinois Press ,1957.
- [4] Mingzhu Li , Canqun He , Zhangping Lu , Lian Yang . Research on Automotive Image Modeling Design Based on Quantification Theory Class I. Mechanical Design, Vol .33, No .4, April 2016.
- [5] Mei-yu Zhou ,Qian LI. The Application of Neural Networks in Product Design Sensibility [J]. Journal of Donghua University (Natural Science),2011,37(4):509-513.
- [6] Hsiao SW, Chiu FY, Lu SH. Product- form design model based on genetical gorithms [J]. International Journal of Industrial Ergonomics ,2010,40(3):237-246.
- [7] Schutte S, Eklund J. Design of rocker switches for work -vehi-cles - an application of kansei engineering [J]. Applied Er-gonomics ,2005,36(5):557-567.
- [8] Yong Li. Research on Product Image Modeling Design Based on Quantification Theory I [J]. Mechanical Design ,2010,27(4):40-43.
- [9] Xue Zhang. Comparison of effects of modeling elements on cognitive differences in perceptual imagery [J]. Mechanical Design ,2013,30(8):110-112.