

Research on the Sensibility Evaluation of Bamboo Woven Chandelier Shape Design Based on Quantitative Theory I

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To Link this Article: <http://dx.doi.org/10.6007/IJARBS/v14-i8/22259>

DOI:10.6007/IJARBS/v14-i8/22259

Published Date: 30 August 2024

Abstract

With the deterioration of the global environment and the advent of the era of emotional experience, the bamboo woven chandelier made of green, environmentally friendly and sustainable bamboo and in line with the emotional needs of consumers urgently needs to be developed. The emotional needs of consumers for bamboo chandelier have become an important design consideration, so it is very important to carry on the emotional evaluation of the design elements of bamboo chandelier. Based on the basic principles of kansei engineering, this paper focuses on the evaluation of the appearance design elements of bamboo woven chandelier, and establishes the relationship between the perceptual semantics of bamboo woven chandelier and the appearance design elements of bamboo woven chandelier through Quantitative Theory I, so as to obtain the basis for guiding the innovative design of bamboo woven chandelier and the evaluation of design effects.

Keywords: Kansei Engineering, Emotional Needs, Bamboo Woven Chandelier, Shape Design, Quantitative Theory I, Sensibility Evaluation.

Introduction

In the era of information society, the interaction between people in the real world has become less and less, resulting in the social phenomenon of "emotional vacuum", so people's needs for emotions are becoming more and more intense (Zhao,2014). In the field of consumption, it directly leads to the consumption trend of consumers' perceptual consumption, that is, consumers try to find emotional care and emotional experience in goods, which is the arrival of the era of emotional experience (Xiao,2016). How to design products to meet the emotional needs of consumers is particularly important.

Due to the increasingly severe global environment, green ecology and sustainable development have become one of the mainstream design concepts (Wang,2011; Xie ,2012). Bamboo is a green, environmentally friendly, fast growing and sustainable material that is more in line with the low-carbon concept of the modern economy (Mao,2006). The bamboo

woven chandelier products made directly from the original bamboo have the advantages of unique beauty, technology and environmental protection. Although there are many manufacturers, bamboo weaving practitioners, designers, etc., have designed and produced a lot of bamboo weaving chandeliers, and some scholars have studied some aspects of the perceptual cognition of bamboo weaving products (Zhang, 2021), but there is little research on the design elements of bamboo weaving chandelier products and their perceptual images in the minds of consumers. Therefore, this study takes bamboo woven chandelier as the research object, focusing on the perceptual evaluation of the appearance shape of bamboo woven chandelier based on the emotional needs of consumers.

At present, the theory used in the study of consumer emotional needs is mainly Kansei Engineering theory proposed by Japanese design master Kenichi Yamamoto. By adopting the theory of Kansei Engineering (Tian, 2019), consumers' subjective and difficult to quantify emotional needs can be evaluated and qualitatively and quantitatively based on the principle of engineering, and the objective quantitative results can be effectively correlated with the elements of product design, so that the designed products can meet the subjective emotional needs of consumers to the greatest extent (Yu et al., 2024). However, the principle of Kansei engineering cannot realize the objective verification of the perceptual design results of product styles by using mathematical principles, so it is difficult to verify whether the design results can truly meet the emotional needs of consumers. Quantitative Theory I, as an important theory to study the correlation and correlation between consumers' subjective emotions and product feature elements, creates a multiple linear regression mathematical model through specific quantitative assignment of the determined dependent variables to predict the characteristics and change rules of the dependent variables (Zhou & Zhu, 2018). And finally summed up the correlation weight between the dependent variable and the independent variable, so as to provide design reference for the detailed design and structural restructuring of the product. It can be seen that the subjective conclusions obtained from perceptual analysis can be verified objectively through mathematical modeling by applying Quantitative Theory I in the process of Kansei engineering analysis, so as to ensure that the designed products can meet the emotional needs of consumers to the greatest extent. This paper takes the appearance and shape of bamboo chandelier as the research object, uses the semantic difference method to conduct perceptual score on the selected bamboo chandelier style diagram, and summarizes and extracts its key style design elements. On this basis, Quantitative Theory I is combined with Kansei Engineering to deeply discuss the correlation degree between consumers' emotional needs and the style design elements of bamboo chandelier, and establishes the corresponding regression prediction Test the model, and finally verify the accuracy and scientificity of the prediction model through examples, and then provide references and suggestions for designers to design the appearance shape of bamboo woven chandelier.

Research Process and Methodology

This study takes the bamboo woven chandelier as the research object, aiming to build a prediction model of the relationship between the external shape design elements of the bamboo woven chandelier and the user's emotional perception image, so as to provide reliable perceptual evaluation and innovative design guidance for the shape design of bamboo pendant lamp. The research procedure is shown in Figure 1.

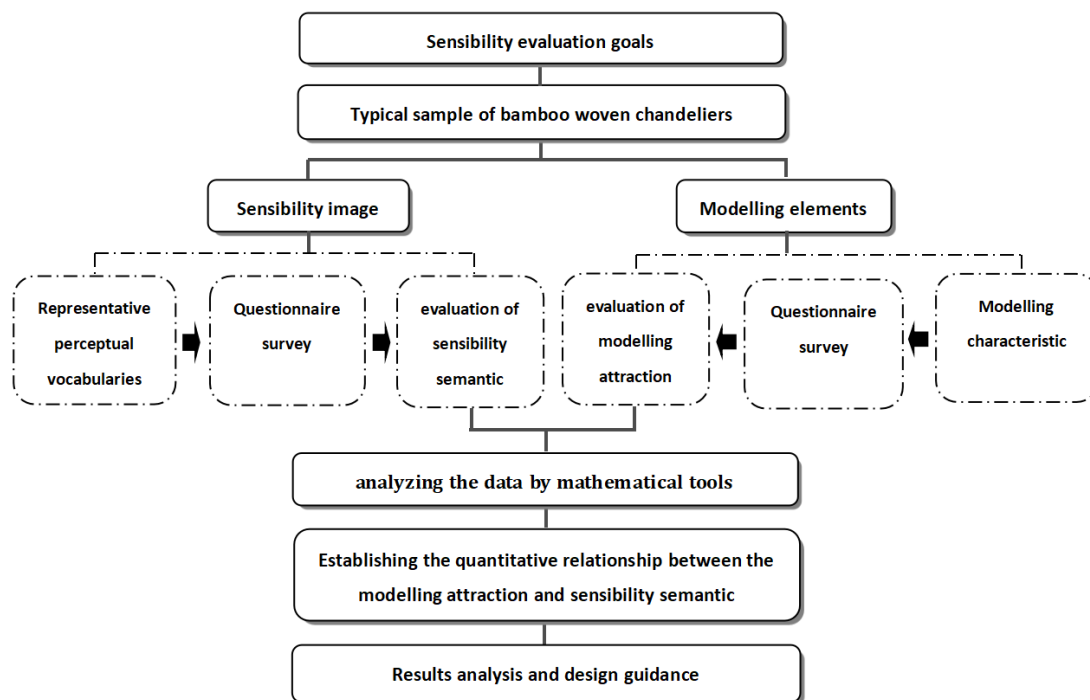


Figure 1








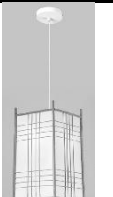





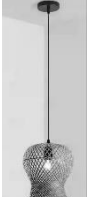












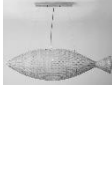





Flow chart of research on the sensibility evaluation of the shape design of bamboo woven chandelier

Selecting Typical Bamboo Woven Chandelier Samples

The selection of research samples plays a key role in the research results. The selection of research samples is based on the current market situation of bamboo woven chandelier in China, and its sources are mainly obtained from the following aspects. The first aspect comes from China's major e-commerce platforms, such as Jingdong, Taobao, Tmall, Pinduoduo, Tik Tok Mall, Kuaishou Mall, these online shopping platforms can collect the current available bamboo chandelier products, and can easily see which products are hot, and consumers' evaluation of the product. The second aspect comes from the offline sales of bamboo chandelier fairs, physical malls or stores, such as the lighting distribution center of Jiangmen Ancient Town in China. The third aspect comes from related websites, magazines, books, lighting product introduction manuals, etc. Through the keyword collection from the above three sources, a total of more than 35,800 samples of sellers, commodities and pictures related to bamboo chandeliers have been obtained. If these samples are collected and sorted according to methods such as traditional methods (ZHANG & Huang,2012) and web crawler technology (Liu & Liu, 2024), it will obviously bring huge workload, so this paper combines morphological analysis (Liu & Guo,2024). An expert group was formed to conduct morphological analysis of the samples initially searched, analyze the design elements of the bamboo woven chandelier, and then determine the specific sample pictures according to the screening principle of sample pictures. The selection of sample pictures follows the following basic principles: ① Sample pictures should have high clarity; ② The sample picture completely shows the shape of the bamboo woven chandelier; ③ The design elements in the sample picture are clearly visible; ④ The subject and background of the sample picture are clearly distinguished; ⑤ The shooting Angle of the sample should be front forward perspective shooting.

After multiple scale analysis and cluster analysis (ZHANG & Huang,2012), 32 representative samples were finally selected (see Table 1), including products of Star Light Art Lighting, Qianpu Lighting, Zhongshan Zhuyun Lighting Co., LTD. Because the objective of this paper is to make a sensibility evaluation of the shape of bamboo woven chandelier, in order to avoid the influence of color, background, material, texture mapping and other factors on the perceptual image of this study, the representative sample background is processed into a solid color, and the color processing is also done.

Tab.1
Selected Representative Samples

							
1	2	3	4	5	6	7	8
							
9	10	11	12	13	14	15	16
							
17	18	19	20	21	22	23	24
							
25	26	27	28	29	30	31	32

Establishing Sensibility Semantic Space

Collection and Screening of Representative Perceptual Terms

Through the collection of the real evaluation of buyers in the e-commerce platform, the brainstorming method of expert group members, the information provided by the bamboo chandelier shopping guide, the bamboo chandelier product brochure, the network, the magazine and other ways to obtain the perceptual image vocabulary of bamboo chandelier. And the expert method (the experts are composed of furniture design teachers and senior furniture designers) combined with the modeling characteristics of bamboo chandelier to

conduct preliminary screening, modification and classification of perceptual vocabulary, and finally select 6 pairs of compatible words with clear image tendency (see Table 2).


Table 2
Selected adjective couples

Fashionable—Classical	Regular—Rhythmically varied
Angular—Smooth	Transparent—Sealed
Conventional—Creative	Visible—Suggestive

Questionnaire Design

The SD method was used to establish a 7-level semantic difference scale (see Table 3) for 32 bamboo chandelier samples and 6 pairs of perceptual adjectives, and then combined them into a questionnaire.

Table 3
SD Scale of Sample 1

Fashionable	3	2	1	0	-1	-2	-3	Classical	
Regular	3	2	1	0	-1	-2	-3	Rhythmically varied	
Angular	3	2	1	0	-1	-2	-3	Smooth	
Transparent	3	2	1	0	-1	-2	-3	Sealed	
Conventional	3	2	1	0	-1	-2	-3	Creative	
Visible	3	2	1	0	-1	-2	-3	Suggestive	

Evaluation of Sensibility Semantic

This study adopts the method of network evaluation, the subjects are composed of buyers of bamboo chandeliers, those who like bamboo chandeliers, graduates of design majors, and those who need to buy lamps at home in decoration, among which the ratio of men and women is 1:1. With their active cooperation, all 300 questionnaires issued are recovered, of which 289 are valid questionnaires.

Establishing Modeling Elements Space

Determination of Modeling Features

Using the basic principle of morphological analysis, this paper analyzes the shape characteristic elements of bamboo woven chandelier. Firstly, the structure of bamboo woven chandelier is regarded as a collection of several design elements; Then, the shape is divided into several independent projects, such as the shape of the lampshade, the form of the composite space around the lampshade, the style of bamboo weaving, the number of lamp holders, and the shape of the lamp holder. Secondly, each project is subdivided into several feature elements, that is, categories. For example, the lampshade shape item can be divided into geometric form, organic form, associative form, creative structure form, etc. In this way, the bamboo woven chandelier is deconstructed, and the characteristic elements are preliminarily determined.

Questionnaire Design

Using the 5-order Ricker scale method, the decomposition table of the preliminary modeling feature elements was established according to the order of items and categories, taking the lampshade shape as an example (see Table 4), and combined into a questionnaire.

Table 4

Decomposition of the Shape Features of Lamp-Chimney

Item (a ₁)	lamp-chimney form	o1	o2	o3	o4	o5
Category (c ₁₁)	Geometric form	o1	o2	o3	o4	o5
Category (c ₁₂)	Organic form	o1	o2	o3	o4	o5
Category (c ₁₃)	Suggestive form	o1	o2	o3	o4	o5
Category (c ₁₄)	Creative form	o1	o2	o3	o4	o5

Evaluation of Modeling Elements

Considering that the decomposition of the modeling features of bamboo chandelier requires certain professional knowledge, this study took 30 design graduate students, 10 design teachers and 10 product designers as subjects to evaluate the decomposition of the modeling features of 32 typical samples of bamboo chandelier, in which the ratio of men to women is 1:1. All 50 questionnaires issued are valid questionnaires.

Analyzing the Data by Mathematical Tools

The data obtained from the previous two questionnaires were processed by EXCEL software to obtain the subjects' average perceptual semantic evaluation of 32 bamboo chandelier samples (see Table 5) and the deconstruction items and categories of bamboo chandelier with high scores (see Table 6).

Table5

Average of Emotional Semantic Evaluation

Sample	1	2	...	32
Fashionable—Classical	-1.86	2.48	...	1.22
Regular—Rhythmically varied	2.62	-1.22	...	-2.67
Angular—Smooth	-1.43	-2.23	...	2.1
Transparent—Sealed	1.81	2.68	...	-1.68
Conventional—Creative	1.67	1.24	...	-1.21
Visible—Suggestive	2.46	2.29	...	-2.26

Tab.6

Main Shaping Elements

Item (a)	Category (c)					
lamp-chimney form (a ₁)	Geometric form C ₁₁	Organic form C ₁₂	Suggestive form C ₁₃	Creative form C ₁₄		
Lampshade space (a ₂)	Open space C ₂₁	Enclosed space C ₂₂	Mixed class C ₂₃			
Bamboo knitting pattern (a ₃)	Traditional type C ₃₁	Type of curves C ₃₂	of Type of lines C ₃₃	Curved straight combination type C ₃₄	Creative type C ₃₅	
Number of lampshade layers (a ₄)	Single-deck C ₄₁	Double-deck C ₄₂	Triple deck C ₄₃	Multilayer C ₄₄		
Lamp number (a ₅)	Single C ₅₁	Double C ₅₂	Triplet C ₅₃	Multiple C ₅₄		
Lamp holder configuration (a ₆)	Cylinder C ₆₁	Cuboid C ₆₂	Semicircular sphere C ₆₃			

Establishing the Relationship between Perceptual Semantics and Modeling Elements

In the process of converting perceptual evaluation scale into engineering scale, multiple linear regression analysis, Quantitative Theory I, neural network algorithm, genetic algorithm, rough set analysis and other methods can be adopted, among which Quantitative Theory I is the most commonly used method [7]. Quantitative Theory I is to study the relationship between a group of qualitative variables x (independent variable) and a group of quantitative variables y (dependent variable), and establish a mathematical model between them by using multiple linear regression, so as to realize the observation of dependent variable y(Xu et al.,2022). In this study, Quantitative Theory I is applied to establish the relationship between perceptual semantics and the modeling elements of bamboo chandelier. When the qualitative data of item a in sample s is category c, $\delta_s=1$; Otherwise $\delta_s=0$. Where: a is the item, c is the category, and $\delta_s(a, c)$ is called the reaction of Category c of item a in sample k. In this way, the modeling elements of 32 bamboo woven chandelier samples are quantified and converted into quantitative data represented by 1 and 0, that is, the response values of each sample modeling element. Taking the average value of perceptual semantic evaluation as the dependent variable and the response value of modeling elements as the independent variable, the following multivariate linear mathematical prediction model is established:

$$Y = \gamma_{11}C_{11} + \gamma_{12}C_{12} + \gamma_{13}C_{13} + \gamma_{14}C_{14} + \gamma_{21}C_{21} + \gamma_{22}C_{22} + \gamma_{23}C_{23} + \gamma_{31}C_{31} + \gamma_{32}C_{32} + \gamma_{33}C_{33} + \gamma_{34}C_{34} + \gamma_{35}C_{35} + \gamma_{41}C_{41} + \gamma_{42}C_{42} + \gamma_{43}C_{43} + \gamma_{44}C_{44} + \gamma_{51}C_{51} + \gamma_{52}C_{52} + \gamma_{53}C_{53} + \gamma_{54}C_{54} + \gamma_{61}C_{61} + \gamma_{62}C_{62} + \gamma_{63}C_{63} + m \quad (1)$$

Where, y is the average value of perceptual semantic evaluation; γ_{ij} is the weight coefficient of each independent variable, c_{ij} is the response value of modeling elements (i is the item, j is the category); m is the constant term value.

To solve the model, SPSS statistical software can be applied. The response values of modeling elements of 32 bamboo woven chandelier samples are taken as independent variables, and the average value of perceptual semantic evaluation is taken as dependent variable. The results obtained by multiple linear regression analysis and partial correlation analysis include the data of determination coefficient, partial correlation coefficient, constant term, category score, etc., and the data table of relevant information can be obtained after sorting. A portion of the table is listed in Table 7, using the "Fashionable—Classical" example.

Table 7

Association analysis of between shaping elements and adjective couple "Fashionable—Classical"

Item	Category	Partial correlation coefficient	Category score	
			Fashionable	Classical
a ₁	C ₁₁	0.78	0.38	
	C ₁₂		2.21	
	C ₁₃		1.89	
	C ₁₄			-0.26
a ₂	C ₂₁	0.94	0.66	
	C ₂₂			-0.27
	C ₂₃		Ruled out	
a ₃	C ₃₁	0.89		-2.24
	C ₃₂			-1.03
	C ₃₃		2.02	
	C ₃₄		0.46	
	C ₃₅		2.23	
a ₄	C ₄₁	0.72		-0.21
	C ₄₂		Ruled out	
	C ₄₃		0.12	
	C ₄₄		0.34	
a ₅	C ₅₁	0.54	Ruled out	
	C ₅₂		0.20	
	C ₅₃			-0.24
	C ₅₄			-0.26
a ₆	C ₆₁	0.67	0.86	
	C ₆₂		1.96	
	C ₆₃			-1.64
Coefficient of determination	0.89		Constant value	-0.45

Result Analysis and Innovative Design Guidance

(1) Category scores represent the degree and direction of each category's influence on perceptual semantics, positive values represent positive perceptual semantics, negative values represent negative perceptual semantics, and excluded categories indicate that there is no obvious correlation with perceptual semantics. As can be seen from Table 7, the score of the traditional bamboo woven chandelier is -2.24, which is biased toward "Classical", which also verifies that in order to make the bamboo woven chandelier more retro characteristics

in the market, the choice of bamboo woven style still retains or draws on the traditional bamboo woven style with obvious "traditional feature symbols" to a certain extent, such as samples 1 and 11.

(2) According to Table 7, the prediction function of perceptual image vocabulary on the relationship between "Fashionable -- Classical" and the various modeling elements of bamboo woven chandelier can be obtained: $y_{\text{Fashionable}} = 0.38c_{11} + 2.21c_{12} + 1.89c_{13} - 0.26c_{14} + 0.66c_{21} - 0.27c_{22} - 2.24c_{31} - 1.03c_{32} + 2.02c_{33} + 0.46c_{34} + 2.12c_{35} - 0.21c_{41} + 0.12c_{43} + 0.34c_{44} + 0.20c_{52} - 0.24c_{53} - 0.26c_{54} + 0.86c_{61} + 1.96c_{62} - 1.64c_{63} - 0.39$ (coefficient of determination is 0.89); In order to test the validity of the above function, samples can be selected again, and the above process can be carried out again. The re-obtained data and the data calculated by the prediction function are analyzed by T test. The test shows that the significance level is greater than 0.05, and there is no significant difference, indicating that the result is reasonable.

Similarly, the prediction function of the relationship between other perceptual image terms and the various modeling elements of the bamboo woven chandelier can be calculated, and the function results can be used to judge whether the perceptual image expressed by the designer's innovative design scheme is consistent with the user's feeling needs, which provides a rational and intuitive basis for the modification of the design scheme.

Conclusion

Products based on consumers' emotional needs are the real needs of human beings in modern society. Designers need to study the elements of product design that cause emotional fluctuations and the corresponding quantified perceptual evaluation images. Based on kansei engineering theory and related methods, this paper captures consumers' perceptual evaluation of bamboo chandelier and establishes the relationship between the perceptual semantics of bamboo chandelier and the appearance design elements of bamboo chandelier by using Quantitative Theory I, so as to provide guidance and evaluation for the innovative design of bamboo chandelier. Such a design method is a design method that meets the real needs of consumers, and the products designed are also humanized products, rather than simply catering to consumers. This method can also be applied to other furniture modeling innovation design and other furniture design research fields.

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