Affective Response Difference to the Viewing of Different Styles of Solid Wood Furniture Based on Kansei Engineering

Qiuli Lin,[a] Jun Cai,[b,*] and Yisi Xue [a]

Homogeneity of products is a serious problem in China's solid wood furniture market, especially reflected in the fact that the furniture form cannot meet the individualized demand of consumers. To explore the differences of consumers' affective response for different styles of solid wood furniture, this study used Kansei engineering to perform perceptual semantic experiments on Ming-style, Qing-style, and modern Chinese-style furniture. The perceptual images of three styles of solid wood chairs were compared by single factor variance. Additionally, it deconstructed the morphological elements of solid wood seats using morphological analysis and established a mapping model between morphological elements and affective response by quantification theory type-I and multivariable linear regression model. The results show that there are differences in affective response between Ming-style, Qing-style, and modern Chinese style solid wood furniture. Qing-style solid wood furniture tends to be "ornate" and "personalized". Modern Chinese-style solid wood furniture tends to be "modern" and "streamlined", Ming-style solid wood furniture is in between the two styles. This study can provide furniture designers with a way to compare the differences in affective responses of different products, and the resulting relationship between affective responses and morphological elements can assist in designing products.

DOI: 10.15376/biores.19.1.805-822

Keywords: Kansei engineering; Solid wood furniture; Affective response; Furniture style

*Contact information: a: College of Art and Design, Guangdong University of Technology, Guangzhou 510000, China; b: Academy of Arts and Design, Tsinghua University, Beijing100084, China; *Corresponding author: caijun@mail.tsinghua.edu.cn*

INTRODUCTION

Ever since man began to make utensils, wood seems to be the first choice because of its strong plasticity and long service life, and wood-based furniture occupies an important position in the history of human furniture. For example, Western furniture gradually increased the use of other materials in furniture soon after the first industrial revolution, while Chinese consumers still have a strong "solid wood complex" and special feelings for solid wood furniture. In China's solid wood furniture market, the main types of furniture are chair, sofa, tea table, bed, and cabinet furniture, which are all covered by the Ming-style, Qing-style, and modern Chinese style. Ming-style and Qing-style furniture have the characteristics of the time and culture of Ming Dynasty and Qing Dynasty respectively. The wood used to make them is precious and rare, so they face the problem of scarcity of wood resources. Modern Chinese style furniture combines traditional culture with modern consumer needs, which can choose a variety of materials for production.

However, its form faces problems such as severe product homogenization and difficulty in personalizing based on consumer demand. In this study, the differences in consumer affective response for the three styles of furniture are obtained with the help of Kansei engineering, and the mapping relationship between morphological elements and affective response is established to provide reference for the design of solid wood furniture.

Consumers cultivate affect, such as trust and reliance, through engaging with furniture in their daily lives, and accrue affective response to furniture as a result of frequent use. When a consumer purchases new furniture, past memories and experiences come into play in the purchasing decision. From the perspective of a furniture manufacturer, the added value of a product leads to more sales opportunities. Therefore, it is vital to learn about consumers' affective response when adding value to furniture, particularly those of Chinese heritage who hold specific preferences for solid wood furniture. According to the accounts of furniture makers interviewed, Guangzhou had exported pricey, solid wooden furniture to various countries and territories, including Singapore and Taiwan during the 1970s and 1980s. Today, the Chinese youth has gained an interest in merging traditional culture with the modern lifestyle, with the emergence of China-chic culture. Consequently, there is a strong emotional drive among youths towards the resurgence of traditional culture. The implementation of traditional cultures involves a thorough analysis of the emotional tendencies inherent in each element, rather than a mere replication of elements. This enables creators to select elements that evoke appropriate emotions in modern consumers. The process of cultural globalization, however, poses a threat to cultural diversity (Moalosi *et al*. 2010), making it more difficult for consumers to identify familiar national cultural traits in their purchases. The concept of national culture encompasses a unique set of emotions, including a sense of belonging among consumers, attachment to relatives, and even an affective bond within families (Ermias *et al.* 2023).

"Affect" can be viewed as an inclusive classification encompassing various mental states such as emotions, moods, and attitudes (Bagozzi *et al*. 1999). In the realm of psychological research, the fundamental emotion categories comprise happiness, sadness, fear, anger, disgust, and astonishment. These descriptions exhibit distinct categories, providing an intuitive reflection of human experience. Dimensional description presents another approach that effectively describes the spectrum of emotions that arise in natural communication settings. Dimensional description can gauge a person's sentiment on a scale ranging from positive to negative (Zeng *et al*. 2009). It is arduous for consumers to evaluate their emotions towards furniture based solely on basic emotions, which are also inconsequential to design. As a result, inferring consumers' emotional information from emotional vocabulary has become a prevalent research approach.

Emotions are viewed as a comprehensive process that includes stimulus event, action, and arousal (Bagozzi *et al*. 1999). Consequently, fulfilling consumers' affective response for furniture through an available medium is vital, and furniture form is the most intuitive method. The furniture form is a critical factor in the decision-making process when buying these products. Moreover, in the current climate of increasingly uniform product functionalities and technologies, furniture form design offers a crucial opportunity for manufacturers and merchants to distinguish themselves through product innovation. The questions the authors would like to explore are what differences in affective response exist between Ming-style, Qing-style, and modern Chinese style solid wood furniture, and the relationship between the affective response and the morphological elements. Kansei engineering, which involves the use of questionnaires and data analysis to map the

relationship between furniture design and emotive needs, is one method of achieving this goal.

The purpose of this article is to help designers find a quantitative method to study the differences in affective responses of different styles or series of products. The data can be compared to more accurately find the affective response conveyed by a product, allowing designers to target their designs.

LITERATURE REVIEW

Kansei Engineering

Kansei engineering is one of the emotional design methods that was invented by Dr. Mitsuo Nagamachi. Kansei engineering is defined as "translating user perception into a domain of product design", mainly aiming at seeking and expressing the relationship between design elements and consumer satisfaction. Common procedures of Kansei engineering include: (1) Choose a product field and gather perceptual words and sample images; (2) Analyze the words and images using techniques like factor analysis and cluster analysis; (3) Utilize a Likert scale to conduct perceptual experiments and surveys on the products; and (4) Utilize methods, such as multiple regression analysis and artificial neural networks, to plot the correlation between the space of perceptual words and design factors of the samples (Lin *et al*. 2021).

Kansei Engineering is a well-established research methodology that has found applications in various fields. Xu *et al*. (2023) employed Kansei Engineering in their exploration of the impact of color and texture on leather shoes, while Shi *et al*. (2023) utilized Kansei Engineering to address the issue of inadequate emotional support in ship accommodation cabins. To comprehend consumers' perception of clothing style, Chen and Cheng (2023) created a predictive model of the perceptual image for women's professional attire utilizing Kansei engineering and BP neural networks. Kang and Nagasawa (2022) studied the extraction of cultural and creative elements for product design and its creative development through Kansei engineering and interactive genetic algorithms. Sousa *et al*. (2022) employed Kansei engineering to investigate consumers' perceived texture of automobile interiors; and Wu *et al*. (2022) examined the design of industrial robot modules using Kansei engineering.

With the advancement of computer technology and the growth of e-commerce platforms, online review mining has emerged as a significant area of interest in Kansei engineering. In particular, online review mining involves analyzing reviews posted on e-commerce platforms with the aid of computer technology, potentially reducing subjective error. Wu *et al*. (2023) collected online review data to identify service attributes that can enhance hotel innovation measures. Liu *et al*. (2023) utilized online reviews from e-commerce platforms for smart phones and proposed Kansei engineering improvements.

Chinese solid wood furniture mainly follows conventional sales method due to consumers' preference for experiencing and consuming products in brick-and-mortar stores. While there is a new approach in Kansei engineering, insufficient data collection renders it unsuitable for solid wood furniture in China.

Solid Wood Furniture

Solid wood furniture comprises furniture with solid wood as the primary material or frame. In existing research on solid wood furniture, most studies have concentrated on

materials and structure, ergonomics, design, and sales. For instance, Klingenberg *et al*. (2022) conducted research on the drying and shrinkage of wood in seven common tree species in urban afforestation to explore the possibility of using this type of wood for the production of small wooden objects and furniture; Yilmaz and Burdurlu (2023) examined the selection of joints for wooden furniture using a multi-criteria decision-making approach; Lipovac and Burnard (2023) assessed the role of wood materials in desk design through two experiments. Xu *et al*. (2023) optimized the three-dimensional corner joints of wooden furniture using parameterization. Yu *et al.* (2023) investigated the factors affecting users' online furniture purchase behavior with a hierarchical method. Reh *et al*. (2023) analyzed the strength of beech seat components. Sun *et al*. (2023) applied communication theory to the design of wooden furniture. Hitka *et al*. (2022) designed wooden seats for individuals with obesity utilizing data on the average weight of the Slovak population. Gudarzi *et al*. (2022) developed a structural equation model to analyze consumers' preferences for wooden furniture. Cai *et al*. (2022) investigated the connection between national risk and the export trade of wooden furniture, based on data from 1995 to 2020. Yang and Zhu (2021) examined the existing recycling techniques for waste wooden furniture and explored the possibilities for reusing and extracting hidden value from such waste. Chen (2022) utilized the situation theory to apply elements of Ming-style furniture to smart home environments designed for elderly users, and subsequently proposed the development of a user interface design for smart homes.

From the above studies, there is minimal research on emotional design of solid wood furniture, especially Chinese solid wood furniture that is considered with rich emotional connotation. In the era of serious homogenization of products, it is particularly important to integrate the affective response of consumers in furniture form differentiation design.

The Research Framework

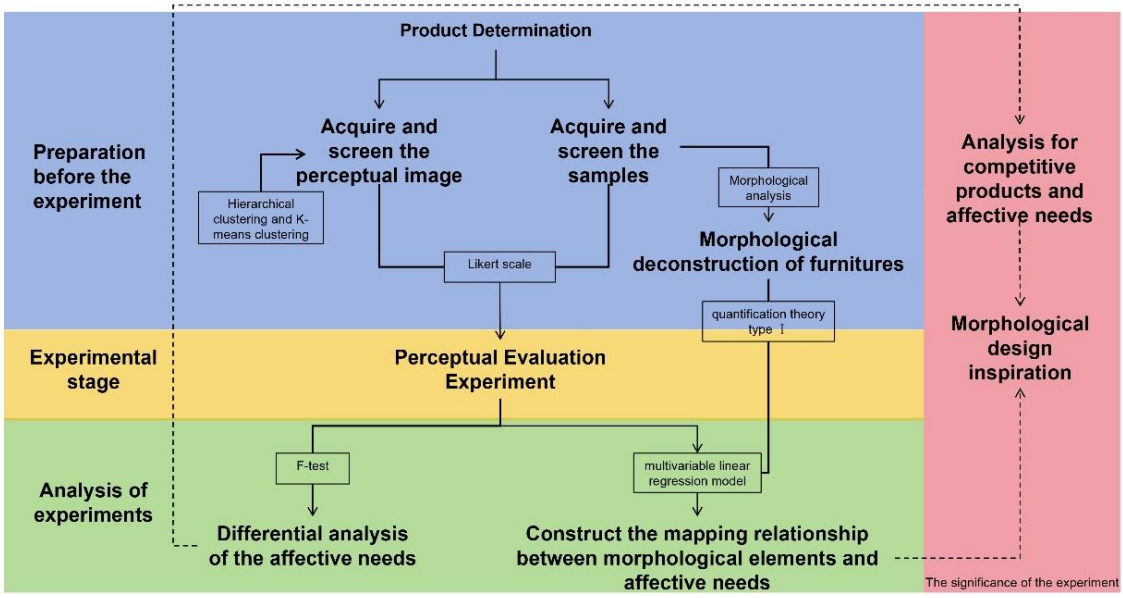


Fig. 1. The research framework

The purpose of this research is to explore the differences of Chinese solid wood furniture form in the three styles and the different affective response behind them. The research is segmented into three components, as displayed in Fig. 1. The initial step acquires the perceptual image words and experimental samples that can represent the affective response of consumers, followed by screening and deconstructing the sample morphology. In the second section, a perceptual semantic experiment is conducted to analyze consumers' affective response for furniture form using a 7-order Likert scale. The third section employed IBM SPSS Statistics 19 (IBM Corp., Armonk, NY, USA) to conduct one-way variance and multiple linear regression analyses on the questionnaire data. This developed a mapping relationship between the morphological elements of solid wood furniture and the affective response of consumers. For the experiment, the authors selected the Chinese solid wood chair as the research subject. The chairs were chosen because of their close relationship with people, competitiveness within the furniture market, and immense popularity among consumers (Xu and Pan 2023).

EXPERIMENTAL

Acquisition and Selection of Perceptual Images

A total of 114 perceptual words about Chinese solid wood chairs were collected using the Internet, books, brochures, *etc.*, and 28 perceptual words were selected through discussion and classification by a focus group. Subsequently, a 28 × 28 Similarity Matrix was built to score the similarity between perceptual words within a range from 1 to 5 points. A higher score indicates greater similarity between two words. Twenty-two professionals from the furniture industry were invited to score similarity, and 22 valid questionnaires were collected. After the results obtained were imported into IBM SPSS Statistics 19, a statistical analysis was conducted with the methods of hierarchical clustering and K-means clustering. A pedigree (Fig. 2) was drawn through hierarchical cluster analysis. In the principle of no single-word cluster or excessive numbers of words in a certain cluster, 5 clusters were more reasonable in combination with the pedigree.

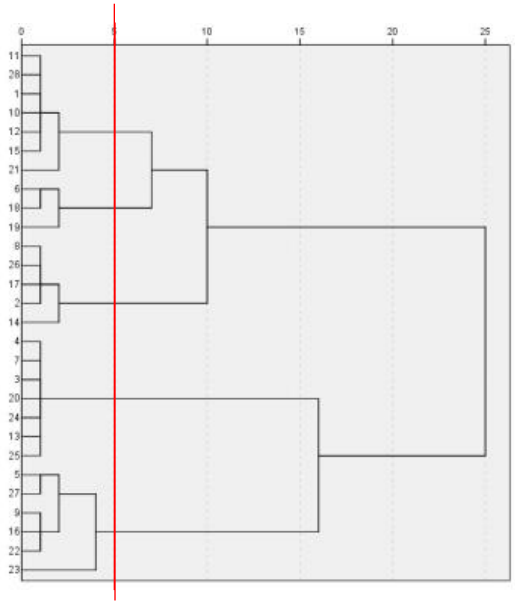


Fig. 2. Perceptual vocabulary clustering lineage map

K-means clustering can specify the number of target clusters and classifies samples into the nearest cluster by calculating the distance from each sample to the center of different clusters. After clustering, 5 clusters were obtained. Table 1 shows the final number of cases clustered and indicates the distance from words in each cluster to the center of clustering. The smaller the value is, the closer a word is to the center, so the word can be a representative of the cluster. Thus, the representative words of "retro (复古的)", "ornate (华丽的)", "personalized (个性的)", "sturdy (结实的)", and "streamlined (流畅的)" can be selected and used in the perceptual semantic evaluation experiment. In fact, the authors used Chinese words in the experiments. However, to be understood by readers from different cultural backgrounds, English words are used here and translated according to the Chinese meaning.

Table 1. Perceptual Lexical Groupings and Clustering Distances

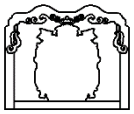
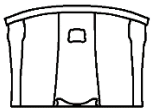
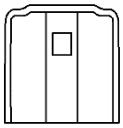
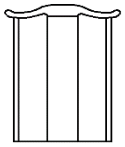
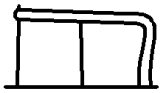
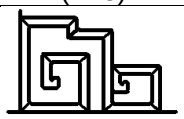
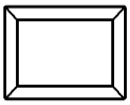
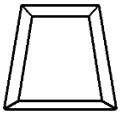
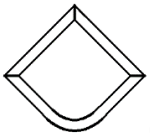
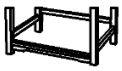
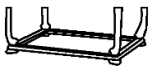
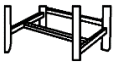
Group 1		Group 2		Group 3		Group 4		Group 5	
Words	Distance	Words	Distance	Words	Distance	Words	Distance	Words	Distance
Traditional	1.611	Delicate	2.152	Personalized	**1.354**	Firm	1.706	Streamlined	**1.678**
Orient-al	1.323	Ornate	**1.467**	Novel	1.399	Sturdy	**1.354**	Curvilinear	2
Retro	**1.254**	Elaborate	2.301	Innovative	1.487	Dull	2.577	Mellow	1.903
Elegant	1.759	Decorative	1.516	High-Profile	2.101			Smooth	2.188
Solemn	2.153	Luxurious	1.618	Unique	2.171			Light	3.77
Nation-al	2.405			Peculiar	1.457			Harmonious	2.498
Classi-cal	1.379			Fashionable	2.250				

Acquisition and Selection of Perceptual Images

Through field research, professional books, periodicals, magazines, brochures, *etc*., pictures of three chair styles were acquired. Through classification and the elimination of redundant samples, 12 pictures of Ming-style chairs (A1 to A12), 12 pictures of Qing-style chairs (B1 to B12), and 12 pictures of modern Chinese style chairs were obtained (including Chinese style chairs at home and abroad) (C1 to C12). With Adobe Photoshop (Adobe Inc., 13.0.1.3, San Jose, CA, USA), backgrounds and colors of above samples were removed, reducing the impact of background and color on consumer evaluations.

Morphological analysis is a method of problem-solving and invention approach introduced by Professor F. Zwicky. The technique revolves around breaking down intricate morphological structures into separate elements, exploring all conceivable morphological elements, and ultimately organizing and combining them to devise a new design scheme. The acquired samples were deconstructed morphologically using morphological analysis. The chair was then divided into six parts: backrest, armrest, seat surface, leg, connection between legs and carving, as detailed in Table 2.

Table 2. Solid Wood Chair Morphology Analysis

Form-Elements	Sub-Elements (Codes)				
Backrest	 (X11)	 (X12)	 (X13)	 (X14)	
Armrest	 (X21)	 (X22)	 (X23)	 (X24)	Lacking (X25)
Seat surface	 (X31)	 (X32)	 (X33)		
Leg	 (X41)	 (X42)	 (X43)		
Connection between legs	 (X51)	 (X52)	 (X53)	 (X54)	Lacking (X55)
Carving	Overfull (X61)	Suitable (X62)	Lacking (X63)		

Perceptual Evaluation Experiment

The semantic differential method, also known as SD method, was presented by Charles E. Osgood in 1957, which reflects users' perceptual cognition through the semantic meaning of a research object. The 5 adjectives selected above are matched with their antonyms respectively to form 5 pairs of words, which are combined with the 36 pictures of chairs collected to create a perceptual semantic evaluation scale. In the scale, positive and negative scores do not indicate quality but rather degrees. For example, in the word pair of "retro - modern", a larger negative value means the product is evaluated as more retro, and conversely, it is more modern. To reduce fatigue of users during evaluation and aesthetic appreciation, the 36 sample pictures were randomly divided into two separate questionnaires, each of which contains the same percentage of Ming-style, Qing-style, and modern Chinese style chairs. The questionnaires were distributed and completed on the Questionnaire Star website（https://www.wjx.cn/）.

Constructing Affective Response and Morphological Elements Mapping Relationships

Perceptual image refers to the emotions people associate with objects and reflects their deep-seated affective response. In the field of Kansei engineering, the consumer's perceptual image of a product is commonly understood as the affective response for the product. The primary objective of Kansei engineering research is to capture consumers' emotional requirements and associate them with design elements, typically morphological ones. Commonly implemented methods include neural networks, quantification theory type I, support vector machines, and genetic algorithms. Quantification theory type I investigates the correlation between a set of qualitative variables (independent variables)

and a set of quantitative variables (dependent variables). It can convert qualitative variables into quantitative data of two types, "0" and "1". In this paper, the qualitative data relates to the category of furniture forms, where "0" denotes that a particular morphology category is not part of a sample and "1" denotes that a sample includes a particular morphology category.

The multiple linear regression model examines how changes in the quantity of one phenomenon or thing relate to changes in the quantity of two or more independent variables. It reflects the relationship between a dependent variable and multiple independent variables. We consider the value of perceptual image evaluation as the dependent variable $\widehat{\boldsymbol{Y}}$, and each morphological element as the dependent variable $\boldsymbol{x}$, and use $\boldsymbol{x_m}$ as the code for each morphological element as shown in Eq. 1:

$$\hat{Y} = \alpha + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_m x_m \quad (1)$$

In Eq. 1, $\widehat{\boldsymbol{Y}}$ represents the independent variable, $\boldsymbol{\alpha}$ denotes the value of the constant term, $\boldsymbol{\beta_m}$ signifies the partial regression coefficient, and $\boldsymbol{x_m}$ stands for the dependent variable.

The coefficient of determination $\mathbf{R^2}$ is a crucial parameter that characterizes statistical results. In the multiple linear regression model analysis, a higher $\mathbf{R^2}$ value indicates greater precision and confidence in the data. Typically, a value of $\mathbf{R^2}$ greater than 0.7 is considered adequate to adopt the constraint confidence, see Eqs. 2, 3, and 4:

$$\mathbf{R^2} = \frac{\sum(\hat{y}-\bar{y})^2}{\sum(y-\bar{y})^2} = \mathbf{1} - \frac{\sum(y-\hat{y})^2}{\sum(y-\bar{y})^2} \quad (2)$$

$$\sum(\boldsymbol{y} - \hat{\boldsymbol{y}})^2 = \sum \boldsymbol{y^2} - (\boldsymbol{q_0}\sum \boldsymbol{y} + \boldsymbol{q_1}\sum \boldsymbol{x_1 y} + \cdots + \boldsymbol{q_k}\sum \boldsymbol{x_k y}) \quad (3)$$

$$\frac{\mathbf{1}}{\boldsymbol{n}}(\sum \boldsymbol{y})^2 \quad (4)$$

In Eqs. 2, 3, and 4, $\boldsymbol{q_k}$ denotes the regression coefficient, $\hat{\boldsymbol{y}}$ indicates the regression prediction value, and $\overline{\boldsymbol{y}}$ signifies the mean value of $\boldsymbol{y}$.

RESULTS AND DISCUSSION

In this survey, a total of 250 questionnaires were distributed, resulting in 247 valid responses. The respondents belonged to the Chinese generation aged between 18 and 35. There are 106 valid copies of Questionnaire 1 collected from male (= 53, 50%) and female (= 53, 50%) respondents, those with a junior college diploma or a degree (= 95, 89.6%), those with a background related to design (= 57, 53.8%), and those with a background irrelevant to design (= 49, 46.2%). As for Questionnaire 2, the authors collected 141 valid copies from male (= 66, 46.8%) and female (= 75, 53.2%) respondents, those with a junior college diploma or a degree (= 130, 92.2%), those with a background related to design (= 71, 50.4%), and those with a background irrelevant to design (= 70, 49.6%). The two questionnaires are independent from each other, with the same settings except for the different sample pictures. After the calculation of mean values, an initial table was obtained (see Table 3). The standard deviation values for each group of data are shown in the Appendix.

Table 3. Mean Value of Perceptual Evaluations

Samples Codes	Perceptual Scores				
	Retro-Modern	Ornate-Plain	Personalized-Common	Sturdy-Fragile	Streamlined-Blunt
A1	-1.02	1.13	0.46	-0.4	-0.16
A2	-0.64	0.79	0.17	-0.8	-0.21
A3	-0.6	-0.08	-0.6	-0.15	-0.32
A4	-0.88	-0.07	-0.08	-0.74	-0.52
A5	-0.79	0.75	0.27	-0.57	0.01
A6	-1.75	-1	-1.12	-1.42	0.11
A7	-0.77	0.55	0.06	-0.35	-0.35
A8	-1.26	-0.43	-0.32	-1.01	-0.53
A9	-1.31	-0.29	-1.06	-0.02	-0.44
A10	-1.93	0.4	-0.41	-0.88	0.43
A11	-1.06	0.21	-0.13	-0.63	-0.23
A12	-1.57	0.16	-0.11	-0.99	-0.58
B1	-1.39	-1.04	-0.65	-1.08	-0.65
B2	-1.74	-1.36	-0.9	-1.28	-0.35
B3	-2.15	-0.96	-0.5	-1.82	-0.56
B4	-0.43	-0.16	-1.39	-0.8	-0.24
B5	-1.77	-1.46	-0.65	-1.33	-0.4
B6	-0.92	-0.12	-0.7	-1.06	-0.08
B7	-2.11	-0.62	-0.82	-0.99	-0.44
B8	-2.28	-1.34	-1.04	-1.6	0.01
B9	-1.64	0.21	0.08	-0.36	0.44
B10	-1.3	-0.41	-0.62	-0.95	-0.24
B11	-2.04	-1.29	-1.13	-1.33	-0.28
B12	-1.93	-0.83	-0.77	-1.33	-0.16
C1	0.08	0.83	0.13	-0.08	-0.52
C2	0.8	0.97	-0.37	-0.37	-0.89
C3	1.52	1.65	0.24	-0.34	-1.24
C4	1.11	1.27	0.28	-0.16	-0.91
C5	-0.57	1.33	0.13	-0.27	-0.08
C6	-0.34	1.65	0.72	-0.73	-0.55
C7	0.88	1.04	-0.56	-0.13	-1.08
C8	1.74	1.06	-0.62	0.57	-0.72
C9	1.33	1.36	0.33	0.38	-0.32
C10	1.85	1.65	-0.38	0.91	-0.91
C11	-0.06	1.06	-0.26	0.22	-0.49
C12	1.52	1.47	0.58	0.34	-0.74

Analysis of variance (ANOVA), also known as "F-test", is used to statistically compare the means of three or more groups to determine whether significant differences exist between them. In this paper, ANOVA was adopted to discuss differences in affective response of different chair groups (Ming-style, Qing-style, and modern Chinese style chairs).

Test of Normality

In the experiment of the paper, there are mainly two variables, namely the grouping variables of chair groups, including the groups of Ming-style (group A), Qing-style (group B), and modern Chinese style chairs (group C), and the continuous variables of scores given by consumers to these products in perceptual evaluation, so these scores need to be verified by a test of normality. Data verification is mainly based on the Kolmogorov-

Smirnova test in this paper (data size > 50). Data shows that the significant values are all above 0.05 ($p < 0.05$), so they conform to the requirement of all sample data in normal distribution.

One-Way Analysis of Variance

After the normality of data is verified, groups A, B, and C were analyzed statistically by a F-test, following the steps of a homogeneity of variance test (if $p < 0.05$, a Welch's t-test) – F-test – Least Significant Difference (LSD), to obtain results shown in Table 4. In the homogeneity of variance test, the p value of all word pairs is larger than 0.05, except the word pair of "retro - modern" with its p value less than 0.05, and the p value of this word pair also shows significant differences in the F-test and Welch's t-test of relevant data. In the F-test of the other four pairs, there are significant differences in their data, so the three groups of data can be compared in pairs.

Table 4. F-test Statistical Results

Adjective Words	Homogeneity of Variance Test	F-test		Welch's t-test	Least Significant Difference
	p-Value	Equality of Variances	Sig.	p-Value	
Retro-Modern	0.042	50.449	0.000	0.000	There is no significant difference between Group A and Group B (Sig. = 0.059)
					There is significant difference between Group A and Group C (Sig. = 0.000)
					There is significant difference between Group B and Group C (Sig. = 0.000)
Ornate-Plain	0.074	51.019	0.000	/	There is significant difference between Group A and Group B (Sig. = 0.000)
					There is significant difference between Group A and Group C (Sig. = 0.000)
					There is significant difference between Group B and Group C (Sig. = 0.000)
Personalized-Common	0.333	9.804	0.000	/	There is significant difference between Group A and Group B (Sig. = 0.020)
					There is no significant difference between Group A and Group C (Sig. = 0.476)

					There is significant difference between Group B and Group C (Sig. = 0.000)
Sturdy-Fragile	0.606	24.893	0.000	/	There is significant difference between Group A and Group B (Sig. = 0.018)
					There is significant difference between Group A and Group C (Sig. = 0.001)
					There is significant difference between Group B and Group C (Sig. = 0.000)
Streamlined-Blunt	0.742	9.292	0.001	/	There is no significant difference between Group A and Group B (Sig. = 1.000)
					There is significant difference between Group A and Group C (Sig. = 0.002)
					There is significant difference between Group B and Group C (Sig. = 0.002)
Note: Group A represents the Ming-style chair group; Group B represents the Qing-style chair group; Group C represents the modern Chinese style chair group					

Results of Multiple Linear Regression Analyses

The results of the morphological analysis were transformed into two kinds of data, "0" and "1", which were combined into Table 3, and jointly entered into the IBM SPSS Statistics 19 (IBM Corp., Armonk, NY, USA) to perform a multiple linear regression analysis between the elements of the solid wood furniture form and the scores of the affective responses, and the linear regression coefficients table in Table 5 was obtained.

Table 5. Linear Regression Coefficient

	Retro-Modern	Ornate-Plain	Personalized-Common	Sturdy-Fragile	Streamlined-Blunt
Constant term	-0.993	-0.427	-0.775	-1.058	-0.608
Coefficient of determination(R^2)	0.868	0.905	0.686	0.808	0.742

Consumers' affective responses are complex, and different forms can bring different sensory experiences to consumers. Therefore, it can be inferred that distinct aspects of the form exert varying degrees of impact on the sensory experience elicited. With the help of multiple linear regression model, the consumers' evaluation of furniture form as the dependent variable and the morphological elements of furniture as the independent variables were considered and the partial correlation coefficients between the morphological elements of furniture and the ratings in Table 6 were obtained.

Table 6. Partial Correlation Coefficient

Form Elements	Codes	Partial Correlation Coefficient				
		Retro-Modern	Ornate-Plain	Personalized-Common	Sturdy-Fragile	Streamlined-Blunt
Backrest	x_{11}	-0.606	-0.18	-0.21	0.143	0.495
	x_{12}	0	0	0	0	0
	x_{13}	-0.373	0.087	0.026	0.414	0.634
	x_{14}	0.152	-0.081	-0.501	0.112	0.495
Armrest	x_{21}	-1.009	-0.084	0.272	0.141	0.094
	x_{22}	-0.188	0.429	0.22	-0.154	0.077
	x_{23}	0	0	0	0	0
	x_{24}	0.152	0.407	0.303	0.322	0.154
	x_{25}	0.18	0.395	0.102	0.496	0.099
Seat surface	x_{31}	-0.098	0.483	0.55	0.253	0.15
	x_{32}	0	0	0	0	0
	x_{33}	-0.63	-0.155	-1.029	0.153	0.677
Leg	x_{41}	0	0	0	0	0
	x_{42}	-1.031	-0.691	0.244	-0.942	0.156
	x_{43}	-0.545	-0.26	0.167	-0.782	0.162
Connection between legs	x_{51}	0	0	0	0	0
	x_{52}	0.543	-0.301	-0.706	0.528	-0.326
	x_{53}	1.587	0.275	-0.056	0.565	-0.625
	x_{54}	1.454	-0.026	-0.508	0.425	-0.393
	x_{55}	1.079	0.336	-0.329	0.466	-0.213
Carving	x_{61}	-1.026	-0.929	-0.145	-0.595	-0.071
	x_{62}	0	0	0	0	0
	x_{63}	1.165	0.574	0.246	0.052	-0.379

A Model for Mapping Furniture Form Elements to Affective Responses

As shown in Table 5, the coefficient of determination $\mathbf{R^2}$ values of five groups of perceptual imagery vocabulary are very high, ranging from 0.686 to 0.905, except for the "personalized - common" group, which is a little lower, the other four groups are all greater than 0.7, which indicates that the overall regression analysis has better statistical results and higher credibility. The results in Table 6 show no correlation between $\boldsymbol{x_{12}}$, $\boldsymbol{x_{23}}$, $\boldsymbol{x_{32}}$, $\boldsymbol{x_{41}}$, $\boldsymbol{x_{51}}$, and $\boldsymbol{x_{62}}$ and perceptual image scores. Combined with Eq. 1, the mapping relationship between the furniture form elements and the evaluation of perceptual image is constructed, see Eqs. 5, 6, 7, 8, and 9:

$$\begin{aligned}\hat{Y}_{\text{retro-modern}} = &-0.993 - 0.606x_{11} - 0.373x_{13} + 0.152x_{14} - 1.009x_{21} - 0.188x_{22} \\ &+ 0.152x_{24} + 0.18x_{25} - 0.098x_{31} - 0.63x_{33} - 1.031x_{42} - 0.545x_{43} \\ &+ 0.543x_{52} + 1.587x_{53} + 1.454x_{54} + 1.079x_{55} - 1.026x_{61} + 1.165x_{63}\end{aligned} \quad (5)$$

$$\begin{aligned}\hat{Y}_{ornate-plain} = &-0.427 - 0.18x_{11} + 0.087x_{13} - 0.081x_{14} - 0.084x_{21} + 0.429x_{22} \\ &+ 0.407x_{24} + 0.395x_{25} + 0.483x_{31} - 0.155x_{33} - 0.691x_{42} - 0.26x_{43} \\ &- 0.301x_{52} + 0.275x_{53} - 0.026x_{54} + 0.336x_{55} - 0.929x_{61} + 0.574x_{63}\end{aligned} \quad (6)$$

$$\begin{aligned}\hat{Y}_{personalized-common} = &-0.775 - 0.21x_{11} + 0.026x_{13} - 0.501x_{14} + 0.272x_{21} + 0.22x_{22} \\ &+ 0.303x_{24} + 0.102x_{25} + 0.55x_{31} - 1.029x_{33} + 0.244x_{42} + 0.167x_{43} \\ &- 0.706x_{52} - 0.056x_{53} - 0.508x_{54} - 0.329x_{55} - 0.145x_{61} + 0.246x_{63}\end{aligned}$$

(7)

$$\hat{Y}_{sturdy-fragile} = -1.058 + 0.143x_{11} + 0.414x_{13} + 0.112x_{14} + 0.141x_{21} - 0.154x_{22} + 0.322x_{24} + 0.496x_{25} + 0.253x_{31} + 0.153x_{33} - 0.942x_{42} - 0.782x_{43} + 0.528x_{52} + 0.565x_{53} + 0.425x_{54} + 0.466x_{55} - 0.595x_{61} + 0.052x_{63}$$

(8)

$$\hat{Y}_{streamlined-blunt} = -0.608 + 0.495x_{11} + 0.634x_{13} + 0.495x_{14} + 0.094x_{21} + 0.077x_{22} + 0.154x_{24} + 0.099x_{25} + 0.15x_{31} + 0.677x_{33} + 0.156x_{42} + 0.162x_{43} - 0.326x_{52} - 0.625x_{53} - 0.393x_{54} - 0.213x_{55} - 0.071x_{61}$$

(9)

DISCUSSION

When analyzing solid wood furniture forms, it was found that the elements of different forms of solid wood chairs constitute a rich gene pool that can be used for furniture design. Even though they are different styles of solid wood chairs, we can always find similar parts in them. In the development of Chinese solid wood furniture, Ming furniture is widely regarded as the key influence on the design of Qing and modern Chinese furniture styles. Therefore, there are always ways to find the shadow of the Ming-style furniture forms in Qing-style or modern Chinese style furniture, such as $\boldsymbol{x_{12}}$, $\boldsymbol{x_{13}}$, $\boldsymbol{x_{22}}$, $\boldsymbol{x_{24}}$, $\boldsymbol{x_{25}}$, $\boldsymbol{x_{31}}$, $\boldsymbol{x_{41}}$, $\boldsymbol{x_{55}}$, $\boldsymbol{x_{62}}$, and $\boldsymbol{x_{63}}$,which are prevalent among them. Qing-style furniture forms are in the Ming-style furniture form based on the addition of carvings; in contrast, modern Chinese style furniture forms are more simplified than that in Ming-style and Qing-style.

Fig. 3. Radar chart of the average values

In a one-way ANOVA, comparative results for the affective response of the three styles of solid wood furniture under the evaluation of the five dimensions were obtained. A radar chart of the average ratings of the three styles of solid wood furniture based on the data in Table 3 is shown in Fig. 3. In the "retro-modern" dimension, there is little difference in consumer evaluations of groups A and B, while there is a significant difference between group C and groups A and B, which means that consumers' affective response for groups

A and B are "retro" and group C is "modern". In the "ornate-plain" dimension, there were significant differences between groups A, B, and C, with group B favoring "ornate" and groups A and C favoring "plain", with group C being more plain than group A. In the "personalized-common" evaluation, group B has a more prominent performance, they are “personalized", while groups A and C are more common. In the fourth dimension, there were significant differences between groups A, B, and C. Group B appeared to be sturdier, group A was sturdy, and group C appeared to be "fragile". In the final evaluation dimension, there is a significant difference between group C furniture and the other two groups. Group C is more streamlined than groups A and B, but all three groups are streamlined.

The results show that there are indeed differences in consumers' affective response of the three styles of Chinese solid wood furniture. The reasons for the differences are not only influenced by the different backgrounds of the times and regional cultures, but the materials used are also not to be ignored. During the Ming and Qing dynasties, Zheng He travelled to the Southeast Asian region and countries and brought back many tropical hardwoods. These woods are mainly red sanders (*P. santalinus* L.f.), Andaman padauk (*P. dalbergioides* DC), Scented rosewood (*D. odorifera* TC Chen), and Neang nuon (*D. bariensis* Pierre), which offers superior carving performance. Therefore, even in the present Ming-style and Qing-style furniture, we can still see carvings used as decoration or structure, especially in Qing-style furniture. Perhaps it is the presence of carvings that makes the furniture seem more ornate and sturdier. In addition, Qing-style furniture was mainly produced in Guangzhou, where many tropical hardwoods were gathered after the middle of the Qing Dynasty. Carpenters in Guangzhou made sturdier furniture when there was plenty of raw material. With global environmental awareness, many of the woods used to make solid wood furniture are under control, which is an important reason for restricting the development of Ming-style and Qing-style furniture. In modern Chinese style furniture, we find a combination of materials, such as wood with leather or wood with metal. The use of a variety of materials changes the emotional experience of the furniture for the consumer, such as a tendency towards "fragile", "modern", and "plain", and also triggers new affective response.

In previous research on furniture emotional design, more attention has been paid to the study of a certain type or style of furniture form, reflecting the affective response of consumers for the furniture. For example, Xu and Pan (2023) studied the impact of morphological image on consumer preference and emotional experience on twelve solid wood chairs, and Kang *et al*. (2022) used Deep Convolutional Neural Networks (DCNN) and Deep Convolutional Generative Adversarial Networks (DCGAN) to generate creative pictures of bamboo furniture that satisfy customers' needs as a way of creating inspirations for bamboo furniture design. The authors studied the differences between the affective response of multi-style furniture, and the results can help designers to clearly compare the affective response of consumers for different styles of furniture and can provide new ideas for design by combining the mapping model of morphological elements and affective response. Furthermore, the research framework and methodology detailed in this paper are suitable for pre-design studies of product iterations and competitive analysis. This enables designers to identify disparities in the affective responses among various products, allowing for targeted design towards specific consumer groups.

The disadvantage is that the authors’ questionnaire survey was targeted at the younger Chinese generation aged 18 to 35 and did not cover other age groups, so the results of the survey are only suitable for explaining the affective response and preferences of this

age group for three styles of solid wood furniture. In addition to consumers' affective response, product form is also influenced by function, culture, economic, history, and technology that have not been addressed in this study. In future research, the authors hope to continue to explore the influence of the above factors on furniture form, and will further explore what the relationship might exist between consumer affective response and form elements in the context of time.

CONCLUSIONS

1. This study examined the differences in affective response of Ming-style, Qing-style, and modern Chinese style furniture in the Chinese solid wood furniture market. With the help of Kansei engineering, five evaluation dimensions were obtained: "retro-modern", "ornate-plain", "personalized-common", "sturdy-fragile", and "streamlined-blunt". An ANOVA on the data from the perceptual semantic experiment showed that there were differences in consumers' affective response for three styles of furniture. Consumers considered Qing-style furniture to be more ornate and personalized, modern Chinese style furniture to be more modern and streamlined, and Ming-style furniture to have balanced scores across the five evaluation dimensions.
2. The mapping model of furniture form elements and affective response was constructed by multiple linear regression model. There is no correlation between x_{12}, x_{23}, x_{32}, x_{41}, x_{51}, and x_{62} with the scores of perceptual images, and the other elements can be mapped with the scores of the five dimensions of affective responses. x_{42} is the most representative of retro and sturdy; x_{53} embodies modernity, characterized by fragile and streamlined forms, while x_{33} showcases a personalized and blunt attribute. x_{61} is applied to make the furniture more ornate, whereas x_{63} provides a plainer appearance to the furniture. Lastly, x_{31} makes the furniture appear more common.

REFERENCES CITED

Bagozzi, R. P., Gopinath, M., and Nyer, P. U. (1999). "The role of emotions in marketing," *Journal of the Academy of Marketing Science* 27, 184–206. DOI: 10.1177/0092070399272005

Cai, Y. L., Zhu, H., Chen, Z. H., and Geng, Y. (2022). "Country risk and wooden furniture export trade: Evidence from China," *Forest Products Journal* 72(3), 180–189. DOI: 10.13073/FPJ-D-22-00019

Chen, D., and Cheng, P. A. (2023). "Perceptual image prediction model of professional dress style based on PSO-BP neural network," *Journal of Engineered Fibers and Fabrics* 18, 1-10. DOI: 10.1177/15589250231189816

Chen, W. (2022). "Research on furniture design integrating Ming-Style furniture modeling elements and image sensor data: Taking suitable old furniture as an example," *Journal of Sensors* 2022, Article ID 5306491. DOI: 10.1155/2022/5306491

Ermias, K. G., Bee, L. C., Seongseop K., Bona, K., and Heesup, H. (2023). "Hawker culture ethnocentrism: Building an integrative framework for consumer intention

toward hawker centers," *Journal of Hospitality and Tourism Management* 56, 336-346. DOI: 10.1016/j.jhtm.2023.07.011

Gudarzi, E., Tajdini, A., Pourmousa, S., Jahan Latibari, A., and Roohnia, M. (2022). "Structural equation modeling (SEM) of consumer preferences for wooden furniture (home and office)," *BioResources* 17(1), 1551-1565. DOI: 10.15376/biores.17.1.1551-1565

Hitka, M., Štarchoň, P., Simanová, Ľ., Čuta, M., and Sydor, M. (2022). "Dimensional solution of wooden chairs for the adult bariatric population of Slovakia: Observational study," *Forests* 13(12), Article Number 2025. DOI: 10.3390/f13122025

Kang, X. H., Nagasawa, S. Y., Wu, Y. X., and Xiong, X. F. (2022). "Emotional design of bamboo chair based on deep convolution neural network and deep convolution generative adversarial network," *Journal of Intelligent and Fuzzy Systems* 44(2), 1977-1989. DOI: 10.3233/JIFS-221754

Kang, X. H., and Nagasawa, S. Y. (2022). "Integrating Kansei engineering and interactive genetic algorithm in Jiangxi red cultural and creative product design," *Journal of Intelligent and Fuzzy Systems* 44(1), 641-660. DOI: 10.3233/JIFS-221737

Klingenberg, D., Nolasco, A. M., Candaten, L., Cavalcante, A. K. L., Aguiar, D. L., Souza, E. C., Bispo, L. F. P., and Dias, J. A. F. (2022). "Drying wastes from urban forestry as an option for their recovery and use in furniture and small wooden objects," *Environment, Development and Sustainability* 24, 11615–11625. DOI: 10.1007/s10668-021-01913-z

Lin, S., Chen, H. Q., and Wang, Z. C. (2023). "Research on design system of offshore platform accommodation cabin based on Kansei engineering," *Journal of Ship Production and Design* 39(2), 89-98. DOI: 10.5957/JSPD.06220018

Lin, S., Shen, T., and Guo, W. (2021). "Evolution and emerging trends of Kansei Engineering: A visual analysis based on CiteSpace," *IEEE Access* 9, 111181-111202. DOI: 10.1109/ACCESS.2021.3102606

Liu, Z. H., Wu, J. F., Chen, Q. P., and Hu, T. (2023). "An improved Kansei engineering method based on the mining of online product reviews," *Alexandria Engineering Journal* 65, 797-808. DOI: 10.1016/j.aej.2022.09.044

Liu, X., and Yang, S. X. (2022). "Study on product form design *via* Kansei engineering and virtual reality," *Journal of Engineering Design* 33(6), 412-440. DOI: 10.1080/09544828.2022.2078660

Lipovac, D., and Burnard, M. D. (2023). "Human preferences for the visual appearance of desks: Examining the role of wooden materials and desk designs," *Buildings* 13(7), Article Number 1680. DOI:10.3390/buildings13071680

Moalosi, R., Popovic, V., and Hickling-Hudson, A. (2010). "Culture-orientated product design," *International Journal of Technology and Design Education* 20, 175–190. DOI: 10.1007/s10798-008-9069-1

Réh, R., Hitka, M., Naď, M., Langová, N., Rolník, L., Lee, S. H., and Sydor, M. (2023). "Influence of the number of layers on the strength of beech laminated elements in the three-point flexural test," *BioResources* 18(2), 2913-2927. DOI: 10.15376/biores.18.2.2913-2927

Sousa, E., Sampaio, R., Sotgiu, E., Ribeiro, G., Silva, C., and Vieira, J. (2022). "Tactile and visual perception of plastic textures for car interiors: Psychophysical and affective dimensions," *International Journal of Industrial Ergonomics* 92, Article ID 103369. DOI: 10.1016/j.ergon.2022.103369

Sun, Y., Yen, C. C., and Chen, T. L. (2023). "Designing 'forest' into daily lives for sustainability: A case study of Taiwanese wooden furniture design," *Sustainability* 15(9), Article Number 7311. DOI:10.3390/su15097311

Wu, Y., Zhou, D., Cheng, H., and Yuan, X. (2022). "A new configuration method for glass substrate transfer robot modules based on Kansei engineering," *Applied Sciences* 12(19), Article Number 10091. DOI:10.3390/app121910091

Wu, J., Yang, T., Zhou, Z. W., and Zhao, N. (2023). "Consumers' affective needs matter: Open innovation through mining luxury hotels' online reviews," *International Journal of Hospitality Management* 114, Article ID 103556. DOI: 10.1016/j.ijhm.2023.103556

Xu, D. D., Wu, C. F., and Wang, C. S. (2023). "A study on perception of visual–tactile and color–texture features of footwear leather for symmetric shoes," *Symmetry* 15(7), Article Number 1462. DOI: 10.3390/sym15071462

Xu, L., and Pan, Y. (2023). "Study on imagery modeling of solid wood chairs in big data," *Electronics* 12(8), Article Number 1949. DOI: 10.3390/electronics12081949

Xu, X. T., Xiong, X. Q., Yue, X. Y., and Zhang, M. (2023). "A parametric optimized method for three-dimensional corner joints in wooden furniture," *Forests* 14, Article Number 1063. DOI: 10.3390/f14051063

Yang, D., and Zhu, J. (2021). "Recycling and value-added design of discarded wooden furniture," *BioResources* 16(4), 6954-6964. DOI: 10.15376/biores.16.4.6954-6964

Yılmaz, K., and Burdurlu, E. (2023). "Selection of wooden furniture joints with multi-criteria decision-making techniques," *Wood Material Science and Engineering* Available Online, 1-16. DOI: 10.1080/17480272.2023.2242329

Yu, C., Liu, W., Fei, Y., Chen, J., and Hu, Z. (2023). "Influencing factors of online furniture purchase behavior based on analytic hierarchy process," *BioResources* 18(2), 2857-2873. DOI: 10.15376/biores.18.2.2857-2873

Zeng, Z., Pantic, M., Roisman, G. I., and Huang, T. S. (2009). "A survey of affect recognition methods: Audio, visual, and spontaneous expressions," *IEEE Transactions on Pattern Analysis and Machine Intelligence* 31(1), 39-58. DOI: 10.1109/TPAMI.2008.52

Article submitted: September 19, 2023; Peer review completed: November 26, 2023; Revisions received: December 6, 2023; Revisions accepted: December 11, 2023.
DOI: 10.15376/biores.19.1.805-822

APPENDIX

Standard Deviation Values for Each Group of Data Related to Perceptual Evaluations

	Standard Deviation				
	Retro-Modern	Ornate-Plain	Personalized-Common	Sturdy-Fragile	Streamlined-Blunt
Group A	0.42	0.57	0.47	0.38	0.29
Group B	0.53	0.54	0.35	0.36	0.27
Group C	0.81	0.28	0.43	0.44	0.31
All Groups	1.22	0.97	0.53	0.63	0.37