



Semantic Innovation of Living Room Furniture in the Context of New Chinese Style

Qinglian Wang^{1,*}

¹ The Department of Art and Design, The Engineering & Technical College of Chengdu University of Technology, Leshan, Sichuan, 614000, China

SUMMARY: *In this paper, factor analysis is used to extract the main features of living room furniture-Ming style chair in the context of new Chinese style, and then combined with the AHP-QFD method to map the user perceptual imagery and design features to get the best design scheme. Finally, the styling features of the traditional and innovative design samples of the Nan Guan Hat Chair are taken as an example, combined with eye-tracking experiments. In this paper, nine most representative perceptual terms such as concise and simple are selected and named as sense of calmness, sense of tension and sense of simplicity according to the main factor characteristics. According to the QFD, several Ming chair components with the highest proportion of weight values are filtered out as follows: Profile 4, Hitch Brain 2, Tooth Head 1, Tooth Strip 1, Coupon Mouth 2, and Chair Leg 2, and their relative weights are, in order: 5.1%, 6.1%, 4.2%, 5.1%, 3.7% and 6.1%. The degree of decoration and stability of the Nan Guan Hat Chair are positively correlated with its preference; the modeling elements that have a guiding effect on the perception of the stylistic features are, in order of importance, the backrest, the base and the armrests.*

KEYWORDS: *Factor analysis; AHP analysis; QFD method; Nan Guan Hat Chair; Eye tracking*

1 Introduction

With the change of time, people's aesthetics from ancient times to the present has changed greatly, and with the emergence of new Chinese furniture, simple and generous design gradually attracted the attention of consumers, and then the furniture design began to shift from the cumbersome traditional Chinese to new Chinese furniture [1-3]. New Chinese furniture through the modern material, craft modeling, traditional cultural elements to highlight the classic beauty of traditional Chinese culture, not only absorbed the essence of traditional Chinese culture has a clear sense of modernity [4-6]. Among them, "Chinese style" is meant to express Chinese traditional culture, Chinese aesthetic ideas, Chinese humanistic feelings and Chinese philosophical history, so many changes and inheritance formed the modern characteristics of new Chinese furniture.

With the continuous deepening of the research on new Chinese furniture, designers and scholars gradually realize that the development of new Chinese furniture needs to inherit Chinese culture, rather than simply form imitation and improvement, the inheritance and understanding of culture is the core content of the development of new Chinese furniture [7-9]. However, in terms of the current development of new Chinese furniture, the design and

*2145241462@qq.com

<https://doi.org/10.65102/is2026063>

development of its design mostly stays in the inheritance of Ming and Qing Dynasty furniture forms, as well as the simple stacking of cultural elements and symbols [10]. This is mainly due to the majority of Chinese furniture designers are grown up in practice, the overall level of education is low, the inheritance and understanding of culture is insufficient, the cultural heritage is not also deep enough to convey the soul of Chinese culture. And the overall design ability is relatively weak, unable to transform the abstract culture into the concrete form of new Chinese furniture [11, 12]. In addition, at present, China's new Chinese furniture industry, from design to research and development, there is no perfect design theory system, and the cognition of the semantics of the form is also slightly insufficient, which hinders the development of the new Chinese style home.

In this paper, under the context of new Chinese style, taking 4 kinds of classic Ming seats in traditional and modern groups as examples, we first collect the Ming seat perceptual vocabulary, and use factor analysis to downsize the perceptual vocabulary to get 3 main factors. Then the AHP-QFD tool was used to establish the mapping model between user perceptual imagery and design features, and the single component with the highest weight in each series of components was screened out and designed as the final Ming chair design. Finally, the styling features of the design proposals were evaluated according to the users' needs in terms of "subjective imagery, eye tracking and cognitive strength of aesthetic features".

2 Research sample and methodology

2.1 Research sample

In this paper, we take the living room furniture in the context of new Chinese style--Ming style chair as an example to analyze the process of its morphosyntactic innovation expression. We collect samples of Ming style chairs through the online furniture platform and establish a sample gallery of Ming style chairs. According to the different shapes of Ming chairs, they are roughly divided into four categories: circle chairs, lamp-hanging chairs, official chairs, and cross chairs, etc. In order to avoid too many samples, it would be difficult for the samples to be analyzed. In order to avoid visual fatigue caused by too many samples, it is necessary to screen and refine the sample library of Ming-style chairs, removing blurred pixels and pictures with messy backgrounds, so as to minimize the impact on the visual senses of the test subjects. After the evaluation and screening by the expert group, each type of Ming chair was selected by using the four most frequent shapes on the market as representative samples to obtain the final sample database of Ming chairs.

2.2 Research methodology

2.2.1 Factor analysis

(1) Mathematical model of factor analysis

Assume that there are n samples, each of which contains x_1, x_2, \dots, x_p p indicators, each of which is standardized. Therefore the resulting factor model is:

$$\begin{cases} x_1 = a_{11}F_1 + a_{12}F_2 + \dots + a_{1m}F_m + \varepsilon_1 \\ x_2 = a_{21}F_1 + a_{22}F_2 + \dots + a_{2m}F_m + \varepsilon_2 \\ \dots \\ x_p = a_{p1}F_1 + a_{p2}F_2 + \dots + a_{pm}F_m + \varepsilon_p \end{cases} \quad (1)$$

where $F_j (j=1,2,\dots,p)$ are the common factors extracted from the variables after standardization and are independent of each other, with a mean of 0 and variance of 1. ε_i is a special factor for each variable x_i , and is also independent of the common factor $F_j (j=1,2,\dots,p)$ is also independent of each other, representing the part of x_i that is not included in the public factors, a_{ij} represents the weight of i variables on j public factors, called factor loadings. The above equation can be expressed as a matrix:

$$X = af + \varepsilon \tag{2}$$

Among them:

$$X = (x_1, x_2, \dots, x_p)^T, F = (F_1, F_2, \dots, F_m)^T, \varepsilon = (\varepsilon_1, \varepsilon_2, \dots, \varepsilon_p)^T \tag{3}$$

$$A = \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1m} \\ a_{21} & a_{22} & \dots & a_{2m} \\ \vdots & \vdots & \vdots & \vdots \\ a_{n1} & a_{n2} & \dots & a_{nm} \end{bmatrix} \tag{4}$$

(2) Statistical significance of the factor loading matrix A

1) a_{ij} denotes the correlation coefficients of i variables x_i on j common factors F_j , indicating the degree of linear correlation between x_i and F_j . The i -row element in A indicates the degree of dependence of the i variables x_i on each public factor, and the j -column element in A indicates the degree of correlation between the j public factors F_j and each variable.

2) The common degree of the indicator x_i refers to the sum of squares of the i th row element in A , i.e:

$$h_i^2 = \sum_{j=1}^m a_{ij}^2 \tag{5}$$

From the orthogonal factor model, we get:

$$\text{var}(x_i) = \sum_{j=1}^m a_{ij}^2 \text{var}(F_j) + \text{var}(\varepsilon_i) \tag{6}$$

To wit:

$$1 = h_i^2 + \text{var}(\varepsilon_i) \tag{7}$$

It can be known that the common degree indicates the total variance contribution of m public factors to the indicator x_i , and the magnitude of h_i^2 represents how well the m public factors contain the original information of x_i .

3) The sum of squares of the j column elements in A is the total variance contribution

of the j public factors F_j to the original variable:

$$g_j = \sum_{i=1}^p a_{ij}^2 \quad (8)$$

The contribution of F_j to the same original variable is:

$$\varepsilon_j = \frac{g_j}{\sum_{i=1}^p \text{var}(x_j)} = \frac{g_j}{p} = \frac{1}{p} \sum_{i=1}^p a_{ij}^2 \quad (9)$$

The larger ε_j is, the more information the j male factors contain in the whole.

(3) Estimation of the factor loading matrix A

There are many methods to estimate the factor loading matrix, commonly used are: principal component method, great likelihood estimation method, least squares method, etc.

1) Principal component method

Let the eigenvalue of the sample X corresponding to the covariance matrix Σ be: $\lambda_1 \geq \lambda_2 \geq \dots \geq \lambda_p \geq 0$, and the value of the corresponding unit eigenvector is $\gamma_1 \geq \gamma_2 \geq \dots \geq \gamma_p \geq$, and the number of smaller factors is chosen to be k , and the cumulative contribution rate is calculated:

$$\frac{\sum_{i=1}^k \lambda_i}{\sum_{i=1}^p \lambda_i} \quad (10)$$

The percentage reaches a high level when Σ can be decomposed approximately:

$$\begin{aligned} \Sigma &= \lambda_1 \gamma_1 \gamma_1' + \lambda_2 \gamma_2 \gamma_2' + \dots + \lambda_k \gamma_k \gamma_k' + \lambda_{k+1} \gamma_{k+1} \gamma_{k+1}' + \dots + \lambda_p \gamma_p \gamma_p' \\ &\approx \lambda_1 \gamma_1 \gamma_1' + \dots + \lambda_k \gamma_k \gamma_k' + D = AA' + D \end{aligned} \quad (11)$$

Among them:

$$A = (\sqrt{\lambda_1} \gamma_1, \sqrt{\lambda_2} \gamma_2, \dots, \sqrt{\lambda_k} \gamma_k) = (a_{ij})_{p \times k} \quad (12)$$

$$D = \text{diag}(\sigma_1^2, \sigma_2^2, \dots, \sigma_p^2) \quad (13)$$

2) Great likelihood estimation method

Let the common factor $f \sim N_k(0, I)$, the special factor $\varepsilon \sim N_p(0, D)$, and the two are independent of each other, there are the original variables $X \sim N_p(\mu, \Sigma)$. The likelihood function calculated from the samples x_1, x_2, \dots, x_n is a function of μ and Σ , denoted as $L(\mu, \Sigma)$. Since $\Sigma = AA' + D$, the likelihood function can be expressed as $L(\mu, A, D)$, and let

(μ, A, D) be the maximum likelihood estimate, denoted as $(\hat{\mu}, \hat{A}, \hat{D})$, that is, $L = (\hat{\mu}, \hat{A}, \hat{D}) = \max L(\mu, A, D)$. It can be shown that $\mu = \bar{x}$ and that A and D satisfy the following equations:

$$\begin{cases} \Sigma D^{-1} A = A (I_k + A D^{-1} A) \\ D = \text{diag} (\Sigma - A A') \end{cases} \quad (14)$$

where $\Sigma = \frac{1}{n} \sum_{i=1}^n (x_i - \bar{x})(x_i - \bar{x})'$

3) Least Squares

Given a matrix $X_{n \times m}$, consider approximating it with a matrix of rank $k \leq \min(m, n)$, whereas the best approximation is the one that minimizes the distances between the vectors when the matrix is viewed as a vector. That is, given $X_{n \times m}$, a matrix $Y_{n \times m}$ of rank k is required such that $\text{tr}((X - Y)(X - Y)') = \min$. This requires a UDV decomposition of the matrix $X_{n \times m}$, which is:

$$X_{n \times m} = U_{n \times m} \begin{bmatrix} \lambda_1 & & & 0 \\ & \ddots & & \\ & & \lambda_r & \\ 0 & & & 0 \end{bmatrix} V_{n \times m}' \quad (15)$$

where $U = (\mu_1 + \mu_2, \dots, \mu_n)$, $V = (v_1 + v_2, \dots, v_n)$ is the orthogonal matrix, the positive $\lambda_1 \geq \lambda_2 \geq \dots \geq \lambda_r \geq 0$, and r is the rank of the matrix $X_{n \times m}$. After performing a singular value decomposition (i.e., UDV decomposition) on $X_{n \times m}$, there is then the equation $X = \sum_{i=1}^r \lambda_i u_i v_i'$.

Notice that $\lambda_1 \geq \lambda_2 \geq \dots \geq \lambda_r$:

$$\begin{aligned} \left\| X - \sum_{i=1}^k \lambda_i u_i v_i' \right\|^2 &= \text{tr} \left(\sum_{i=k+1}^r \lambda_i u_i v_i' \right) \left(\sum_{i=k+1}^r \lambda_i u_i v_i' \right)' \\ &= \text{tr} \left(\sum_{i,j=k+1}^r \lambda_i \lambda_j v_i u_i' u_j v_j' \right) = \sum_{i,j=k+1}^r \lambda_i \lambda_j v_i v_j' u_i' u_j \\ &= \sum_{i=k+1}^r \lambda_i^2 \end{aligned} \quad (16)$$

It can be shown that the right end of the above equation is indeed a minimum.

2.2.2 AHP analysis

Hierarchical analysis is a method of evaluation and decision making that combines qualitative and quantitative analysis. AHP advantages are:

Systematic: AHP systematizes the problems dealt with, no matter how complex they are, they can be analyzed and decided using decomposition, comparison, judgment and synthesis;

Comprehensive, AHP analyzes the problem, always synthesizes qualitative and quantitative analysis, and presents the results clearly with the method of ranking the advantages and disadvantages, which solves a lot of traditional problems that can only be analyzed quantitatively;

Simplicity: The basic steps of AHP are simple and clear, and the results can be obtained quickly after mastering the algorithms, which solves the problem of consuming human and material resources in traditional decision-making;

Accuracy: AHP relies on mathematical principles, experts and groups of companies with rich expertise to make the decision-making results more accurate.

The basic process of AHP is shown in Figure 1. In today's society, where technology and economy have made great leaps, there is an endless variety of furniture on the market, which tends to be diversified in terms of appearance, function and technology, with more and more furniture to choose from, and users are more inclined to buy goods that meet their needs. For furniture companies, the ultimate goal of designing furniture is to achieve great economic benefits, whether the furniture can be recognized by customers is an important part of the furniture competition, so it is particularly important to obtain the degree of importance of user needs before designing furniture. Using AHP to decide on the importance of user requirements for living room furniture can more conveniently help to understand the real furniture preferences of users and guide the direction for the next furniture design.

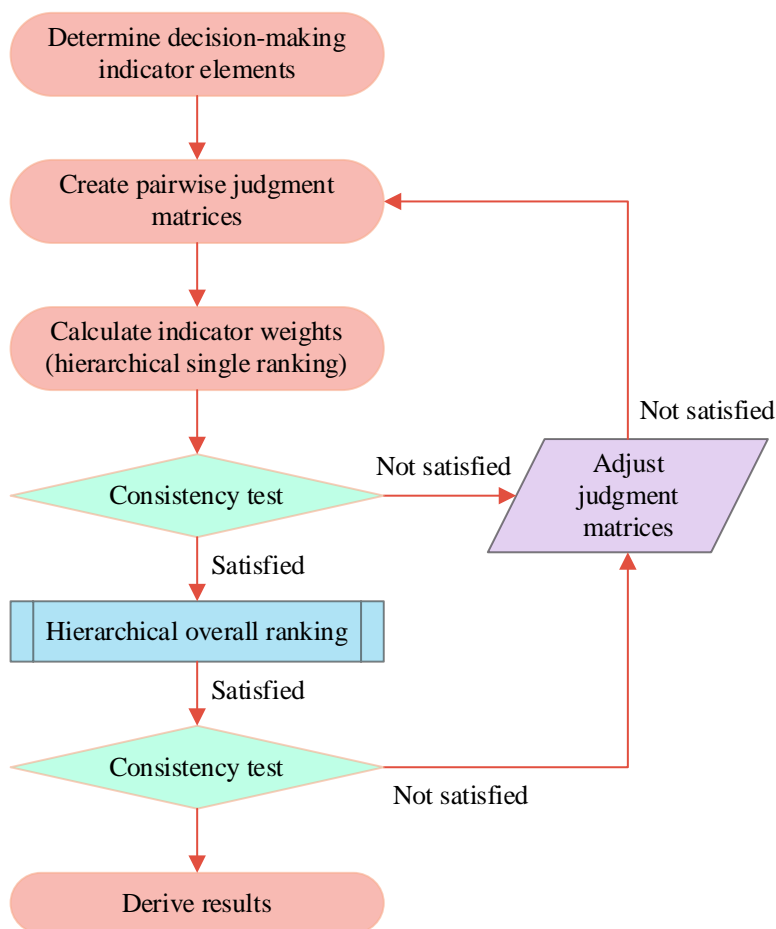


Figure 1: AHP basic process

2.2.3 QFD method

(1) Basic concept of QFD

QFD, or Quality Function Deployment, is a customer demand-driven product development method based on quality assurance. QFD has the advantages of cost reduction, reduction of R&D time, reduction of post-design changes, and improvement of customer satisfaction, and has been widely used worldwide with great success. The ASI model evolved from the simplification of the 64 steps of the integrated QFD analysis model, and this process has four stages, corresponding to product planning, parts planning, process planning and production planning in the product development process.

(2) Quality House Basic Concepts and Component Structures

The process of expanding the quality function requires the participation of matrix charts, and the quality house is the most central and widely used tool to realize this process, which can help complete the mapping of customer demand to product quality requirements.

1) Customer demand and customer demand weight: The “left wall” of the quality house input is the customer demand and the importance of customer demand, in this stage, first of all, after market research, user research and other access to customer demand, and then summarize the information obtained, summarize, sort out and fill in the chart, and finally score the customer demand to determine the importance of the demand.

2) Technical features/engineering measures: The “ceiling” part of the quality house is the technical features or engineering measures of the product. At this stage, customer demands should be analyzed, and the designers should convert the demand information into the technical

features of the product in professional language, which is used to express what kind of technological means can be used to solve the problems of the demands raised by the customers.

3) correlation matrix: the “room” of the quality house is the correlation matrix that expresses the relationship between customer demand and technical features, in this part, you can use numbers, symbols and other ways to show the degree of correlation between the customer's demand and technical features, so that the designers can make sense of the degree of contribution of a certain technical feature to the extent of the customer's demand.

4) Interrelationship matrix: the “roof” of the quality house is used to express the degree of correlation between each technical feature.

5) Evaluation Matrix: The “right wall” of the quality house is the evaluation matrix, which is used to evaluate the customer's satisfaction with the product, the competitiveness of the product in the market and the level of improvement.

6) Weight of technical characteristics: the bottom “basement” part of the quality house is the importance of the product's technical characteristics, which is obtained by calculating the importance of customer demand, and customer demand and technical characteristics of the correlation matrix. After determining the final technical characteristics, designers need to determine the direction of product design and improvement based on the technical difficulty, design cost, production capacity and other factors.

After completing the construction of the above quality house, the quality house of the product planning part of the ASI model is obtained, and the designers can complete the quality house of the corresponding part design, process requirements and production standards in the same way according to the needs, so as to complete the whole QFD workflow, and to carry out the user's needs throughout the whole process, which helps to realize the product development and design.

2.2.4 User Requirements Weighting and Transformation Algorithm

(1) Calculation of user demand weights

For the results of the user demand hierarchy, the weight of each demand indicator is calculated using the AHP hierarchical analysis method, which can be divided into the following three core steps.

1) Construct a comparison judgment matrix. Compare the indicators in the guideline layer and indicator layer, and score them using the nine-level scale method, and construct a comparison judgment matrix according to the results.

2) Calculation of user demand weights. The above judgment matrices use geometric mean method, arithmetic mean method and other calculation methods to find out the user demand weight W_i , the formula is as follows:

$$M_i = \prod_{j=1}^n a_{ij} \quad (i=1, 2, 3, \dots, n) \quad (17)$$

where: a_{ij} is the element in the i th row and j th column of the matrix; n is the number of evaluation elements. Yes:

$$\bar{W}_i = \sqrt[n]{M_i} \quad (18)$$

where: M_i is the product of each row of the matrix; \bar{W}_i is the geometric mean of each row of the matrix. i.e:

$$W_i = \frac{\bar{W}_i}{\sum_{i=0}^n \bar{W}_i} \quad (19)$$

3) Consistency test. By solving the maximum eigenvalue λ_{\max} of the judgment matrix, the consistency test is performed on each judgment matrix, and only when $R < 0.1$, the judgment matrix is considered to meet the consistency requirements, otherwise the judgment matrix should be adjusted until it meets the consistency test. Consistency test in the calculation of the relevant data for:

$$E = \frac{\lambda_{\max} - n}{n - 1} \quad (20)$$

where: λ_{\max} is the maximum eigenvalue of the judgment matrix; n is the judgment matrix order. That is:

$$R = \frac{E}{I} \quad (21)$$

where: R is the consistency ratio coefficient; E is the judgment matrix inconsistency index; I is the average random consistency index.

(2) User demand transformation

By using AHP to analyze and calculate, the user demand indicator weights of the intelligent janitorial robot are obtained, and then the user demand needs to be transformed into the technical characteristics of the product by using QFD, and the core of the process is the construction of HOQ. The construction process of HOQ is as follows:

1) The left wall of HOQ. The calculation results of each user demand index and its comprehensive weight are imported into the quality house to construct the left wall of HOQ.

2) Ceiling of HOQ. According to the product technical attributes required to satisfy different user needs, the product technical characteristics corresponding to each demand indicator are analyzed and expanded respectively. The summarized results are imported into the quality house to construct the ceiling of HOQ.

3) Room of HOQ. Analyze and determine the correlation between user requirements and product technical characteristics, and use 5, 3, 1, 0 to correspond to the strong, medium, weak and irrelevant relationship between the two, and import the determination results into the quality house to construct the room of HOQ.

4) Basement of HOQ. Calculate to get the absolute weight as well as the relative weight of the product's technical characteristics, and import the calculation results into the quality house to construct the basement of HOQ.

HOQ weight calculation:

$$W_j = \sum_{i=1}^q W_i P_{ij} \quad (22)$$

$$W_k = \frac{W_j}{\sum_{i=1}^q W_j} \quad (23)$$

where: W_j is the absolute weight of quality characteristics; W_i is the user demand weight; P_{ij} is the correlation coefficient; q is the total number of user demands; and W_k is the relative weight of technical characteristics.

5) Roof of HOQ. The roof of HOQ is used to determine the autocorrelation relationship between the technical characteristics, this relationship includes the possible existence of the technical characteristics of mutual obstruction, mutual promotion or irrelevant relationship, that is, when a technical characteristic changes may have three kinds of impact on the other technical characteristics of the effect of the change, with “+” and “-” signs are used to indicate the mutually reinforcing and mutually hindering relationships between technical characteristics, and the results are imported into the quality house to construct the roof of HOQ.

3 Findings and analysis

3.1 Sensory vocabulary collection for bright seats

The first selection of the sensual imagery of Ming style seats was made, and 32 sensual words of Ming style seats were obtained through the user research of Ming style seats. 5 furniture designers were invited to re-select the 32 sensual words of Ming style seats, and 9 most representative sensual words were selected, which were concise, simple, thick and clumsy, heavy, rounded, strong and upright, ethereal, elegant, and refreshing.

A questionnaire survey was conducted in XX school with 100 design students randomly selected from freshmen and sophomores. A total of 100 valid questionnaires were collected, and the reliability of the questionnaires were all greater than 0.85, which is suitable for the next step of analysis. The data of perceptual vocabulary matrix is shown in Table 1, in which A, B, C, D, E, F, G, H, I represent “simple, concise, thick, heavy, rounded, strong, ethereal, elegant and fresh” respectively. Overall, most of the scores for the Ming style seat's sensibility vocabulary were around 3, with a rating of Conformity.

Table 1: Sensory Vocabulary Matrix Data

Sample	A	B	C	D	E	F	G	H	I
1	3.843	3.741	4.745	4.124	3.673	3.19	3.381	4.839	3.435
2	3.365	4.406	4.933	4.833	4.036	3.047	2.872	4.859	3.470
3	4.552	3.743	4.397	3.566	3.902	3.554	3.566	4.062	3.728
4	4.031	4.244	4.03	3.685	3.836	3.492	3.413	4.005	3.571
5	4.332	3.638	2.489	2.929	2.281	4.548	4.159	3.593	3.742
6	4.264	4.252	2.863	3.116	2.599	4.249	3.823	3.670	3.523
7	4.130	4.472	4.411	3.727	2.696	4.042	2.997	3.910	3.327
8	4.677	2.784	3.094	2.575	2.291	3.642	3.722	3.243	3.976
9	4.863	4.856	2.238	2.316	2.272	4.038	4.429	4.892	4.891
10	3.755	4.455	2.624	2.535	2.331	2.471	3.862	4.539	4.103
11	4.387	4.843	3.175	2.853	2.372	2.946	3.744	4.139	3.743
12	4.244	4.035	3.440	2.708	2.315	3.019	4.519	3.374	3.510
13	3.411	3.024	2.466	2.379	4.848	2.417	4.571	3.358	3.092
14	3.448	3.189	2.642	2.433	4.902	2.521	4.597	3.451	3.341
15	3.190	2.615	2.607	2.423	4.494	2.552	4.702	3.114	3.368
16	3.007	2.451	2.350	2.314	4.893	2.780	4.794	3.016	2.685

3.2 Analysis of the perceptual vocabulary of the Ming chair

The factor analysis method was used to reduce the dimensionality of perceptual vocabulary, and the KMO and Bartlett sphericity tests of the factor analysis were needed to verify the structural validity and interrelationships of the factor analysis. The experimental results show that the KMO value is $0.7938 > 0.7$, and the Bartlett sphericity test value is $0.0134 < 0.05$, which is a significant difference. The KMO and Bartlett sphericity test proves that the data can be used for factor analysis method.

Extracting the factor gravel plot operation on the user perceptual imagery measurement table, it can be clearly seen that there are three indicators greater than 1, which can downgrade the perceptual vocabulary to three strata. The total variance interpretation results obtained after stratification are shown in Table 2. The results show that the cumulative contribution rate in the first 3 indicators is 89.94%, which is greater than 85%, proving that the 9 perceptual words can be downgraded into 3 main factors.

Table 2: Total variance explained

Initial eigenvalue component	Extract load sum of squares						Sum of squares of rotational loads		
	Total	Variance percentage (%)	Accumulative perception (%)	Total	Variance percentage (%)	Accumulative perception (%)	Total	Variance percentage (%)	Accumulative perception (%)
1	4.2837	47.60	47.60	4.2837	47.60	47.60	3.1042	34.49	34.49
2	2.6534	29.48	77.08	2.6534	29.48	77.08	2.6454	29.39	63.88
3	1.1576	12.86	89.94	1.1576	12.86	89.94	2.3451	26.06	89.94
4	0.3348	3.72	93.66						
5	0.2274	2.53	96.19						
6	0.1759	1.95	98.14						
7	0.0932	1.04	99.18						
8	0.0533	0.59	99.77						
9	0.0207	0.23	100.00						

The rotated component matrix is shown in Table 3, where only factors with absolute values > 0.5 are labeled. The results show that only the mellow and ethereal emotional imagery indicators are negatively correlated with the components, while the rest of the indicators show positive correlation with the components.

Table 3: Rotated component matrix

Sensuous image	Ingredient		
	1	2	3
Unsophisticated		0.8901	
Succinct			0.7693
Clumsy	0.9625		
Serious	0.9833		
Fruity		-0.7986	
Sturdy		0.9027	
Vacant	-0.8974		
Graceful			0.8505
Fresh		0.5728	0.7613

The principal component analysis was used to obtain the component score coefficient matrix, which is shown in Table 4. In the user sensibility vocabulary of Ming chair, 3 factors

are extracted. The first factor consists of three indicators, namely, thick, heavy, and ethereal, which is named as the composure factor; the second factor consists of simple, rounded, and strong, which is named as the tension factor; and the third factor consists of concise, elegant, and fresh, which is named as the simplicity factor. They correspond to the sense of calmness, tension and simplicity that the Ming chair brings to people.

Table 4: Component score factorization matrix

Sensuous image	Ingredient		
	1	2	3
Unsophisticated	-0.0229	0.3633	-0.0497
Succinct	0.0181	-0.0522	0.3898
Clumsy	0.3275	-0.0058	-0.0818
Serious	0.3354	-0.0134	-0.0726
Fruity	0.0633	-0.2785	-0.0523
Sturdy	0.1188	0.4931	-0.3617
Vacant	-0.2899	-0.0651	0.0415
Graceful	0.0367	-0.2389	0.5108
Fresh	-0.1796	0.0317	0.3849

3.3 Constructing the explicit seat AHP judgment matrix

Five furniture design experts were invited to score the criterion layer in the AHP hierarchical model of Ming chair, and constructed a criterion layer matrix judgment. According to the matrix calculation, $CI=0$, $CR=0<0.1$, which satisfies the consistency test.

In order to make the weighting results more objective, after taking out the weights of experts on the criterion layer, it is necessary to summarize the weights of 5 experts and calculate their average values, and the average weights of experts' scores are shown in Table 5. The average weights of 5 experts' scores for the 3 representative sensual semantics "sense of calmness, tension and simplicity" are respectively 0.1711, 0.2781 and 0.5508 respectively.

Table 5: The average weight of expert ratings

Specialist	A sense of calmness	Tension	Minimalism
1	0.1242	0.3473	0.5697
2	0.2835	0.2635	0.4925
3	0.1183	0.3051	0.593
4	0.2486	0.2598	0.5048
5	0.081	0.2148	0.5939
Mean	0.1711	0.2781	0.5508

3.4 QFD modeling of user perceptual mapping

The QFD tool was used to model the mapping between user perceptual imagery and design features. In this section, five furniture designers were invited to use \triangle , \circ , and \bullet to make a matrix judgment between the user perceptual imagery weights on the left side of the quality house and the morphological features of the ceiling components. Where \triangle is 3 points, representing weak correlation; \circ is 5 points, representing moderate correlation; and \bullet is 7 points, representing strong correlation. The results of the morphological feature weights of the corresponding parts are shown in Table 6. According to the QFD construction of the user perceptual mapping model can be derived from the weight value of each component index, according to the weight value of the individual components, screening out each series of

components with the highest weight of individual components, which will be designed as the final seat design program. Among them, the weight value of the highest proportion of several Ming-style seat components are: door post 4, hitch brain 2, head 1, tooth 1, strip 1, coupon mouth 2, chair legs 2, the relative weight of the following order: 5.1%, 6.1%, 4.2%, 5.1%, 3.7% and 6.1%.

Table 6: Morphometric weight of corresponding components

Feature of part	Number	A sense of calmness	Tension	Minimalism	Relative weight (%)
Pomelo	1	●	○	△	3.7
	2	●	○	○	3.7
	3	○	○	△	3.4
	4	●	●	○	5.1
	5	○	○	○	4.4
Brain	1	●	●	○	5.1
	2	●	●	●	6.1
	3	●	△	○	3.7
	4	●	○	○	3.7
	5	●	○	△	3.7
	6	●	○	○	3.7
Tooth root	1	●	●	△	4.2
	2	●	○	○	3.7
	3	○	○	△	3.4
Tubercle	1	●	●	○	5.1
	2	○	○	△	3.4
Crown	1	○	△	○	3.4
	2	●	○	○	3.7
	3	△	○	○	3.4
Leg of chair	1	●	○	△	3.7
	2	●	●	●	6.1
	3	●	○	○	3.7
	4	●	△	○	3.7

4 Design Practice and Verification

4.1 Experimental design program

4.1.1 Research materials

When the SD method was used to conduct a cognitive study on the stylized imagery of Ming-style chair furniture, in order to improve the scientific and rigorous nature of the study, this paper takes the picture of a single visual angle of the chair furniture as the research object. The study first conducted eye-tracking experiments on the observation angles of Ming-style chair furniture to find out more attractive observation angles, which in turn improved the credibility and accuracy of the following SD questionnaire method.

In this paper, four traditional classic shapes and four modern chair furniture of the Southern Official's Hat Chair are selected as samples, and the traditional groups are: high armrests, plain high backrests, three-section backrests, and fan-shaped seats, respectively, named Traditional 1 to Traditional 4. The modern groups are: raised central part of the hitching brain, short old door post, high backrests, and fan-shaped seats, respectively, named Modern 1 to Modern 4.

Two subjective evaluation forms were used for each group to evaluate the styling

characteristics of the Nan Guan Hat chair in the form of a 5-level scale with semantic differentiation for stability, fashionability, degree of ornamentation and sense of proportions. Afterwards, the subjects were asked to sort the chairs according to the degree of favoritism and make a 5-level rating of the beauty of each styling element and the whole, and after the experiment, the data were counted according to the scores of -2, -1, 0, 1, and 2, which were divided according to the grades from the lowest to the highest. After completing the data collection of objective and subjective evaluation, statistics and comparative analysis were conducted.

4.1.2 Methodological steps of the experiment

(1) Likert scale method questionnaire analysis

Likert scale is designed to be simple and easy to operate, and the characteristics of high survey efficiency, more accurate results, and easy to implement make it widely used in research in the field of social sciences. The scale consists of a set of questions or statements to express the subject's assessment or opinion of things. The scale form is usually used in surveys with five or seven levels, and the answers are scored in the analysis, and the total score is obtained by accumulating the individual branches of the questions in each questionnaire, and the result reflects the comprehensive attitudes of the survey group towards the things.

In this study, the structured Likert questionnaire was used to conduct the survey, the questions are simple and easy to understand, the recovery rate and the quality of the recovery is high, and the data collected is convenient for statistical analysis and research. In order to avoid the influence of color on the test results, the pictures were first processed as colorless images. The questionnaire of preference was conducted using Likert scale. The total number of subjects was 100, including 50 men and 50 women.

(2) Image feature extraction of hotspot map

The study selects the hotspot map of the eye-tracking experiment as the basis, and obtains the index data of the Ming-style chair furniture modeling evaluation system through the image feature extraction and analysis of the hotspot map. There were 10 subjects in this eye-tracking experiment, including 5 men and 5 women. The subjects had normal naked eye vision or corrected vision and normal color vision. The experimental procedure was as follows:

1) Instruct the subjects to enter the laboratory and sit down at a position 100 cm from the display. Calibration was performed and the experiment was started after successful calibration.

2) Present the experimental instruction to the subject: "Please watch the experimental picture carefully below, and keep quiet during the experiment.

3) Conducting the practice experiment: Prompted that the practice experiment was about to begin. The monitor presents the practice picture and asks the subjects to watch it, after watching it, press any key to end it and present the second picture.

4) Conducting a formal experiment: Prompts that the formal experiment is about to begin. The subjects were provided with two types of pictures for the test. The first was a single picture with a white background, and each picture was viewed for 5 seconds to eliminate the effect of visual tentative phenomenon on the results of the study. The second was a picture of chair furniture with a 20-second viewing time for the picture. The pictures were played automatically and ended by pressing any key when finished. The experiments of Sample A and Sample B were conducted separately.

5) End of experiment: record and save the data.

4.2 Examination of results

4.2.1 Evaluation of subjective intention of modeling features

The subjective evaluation table corresponds to the subjects' "styling features cognition" and "preference". The subjective evaluation of the styling feature cognition of the traditional group is shown in Figure 2; the subjective evaluation of the styling feature cognition of the modern group is shown in Figure 3; the mean value of the subjective evaluation of the styling feature cognition of the traditional and modern groups of the Nan Guan Hat Chair is shown in Figure 4; and the mean value of the feature cognition preference of the traditional and modern Nan Guan Hat Chair is shown in Figure 5.

It can be seen that there is a certain commonality in the subjects' perception of the shape of the four traditional southern official chairs, which are generally considered to be well stabilized, with a strong sense of tradition and coordinated proportions, while there is a large difference in the degree of decoration; and their preferences are in the following order: traditional No. 3 > No. 1 > No. 4 > No. 2. Compared to the traditional group, the modern group generally had a lower degree of preference, and their degree of preference was in the following order: modern No. 2 > No. 1 > No. 3 > No. 4.

The binary variable correlation analysis of the "styling features cognition" and "preference" of the traditional and modern groups shows that the Pearson correlation coefficients of the degree of decoration and preference are 0.9934 and 0.9874 respectively, with $P < 0.01$. Therefore, it can be considered that there is a strong positive correlation between the degree of decoration and the degree of preference in the traditional group and the modern group of Nan Guan Hat Chair.

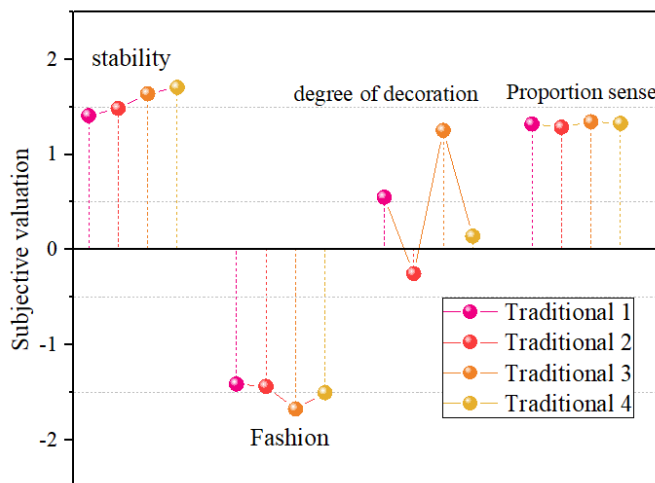


Figure 2: Subjective Evaluation of the Traditional Guan Guan Hat Chair

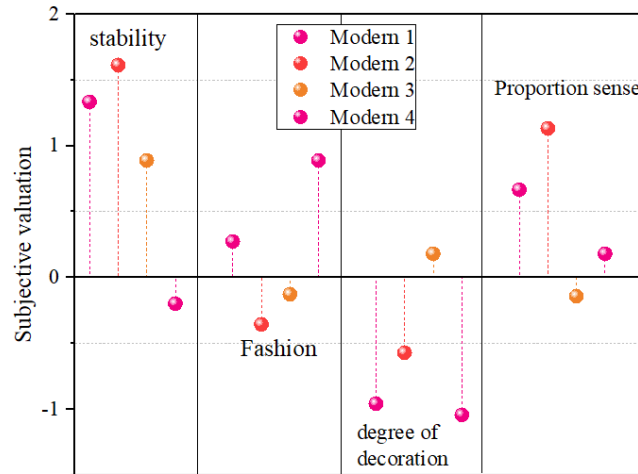


Figure 3: Subjective Evaluation of the Modern Guan Guan Hat Chair

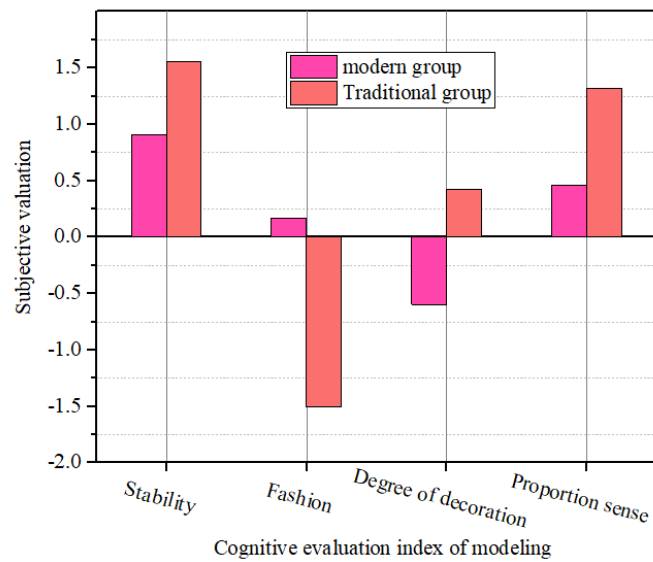


Figure 4: Cognitive Subjective Evaluation of Two Groups of Nanguan Hat Chairs

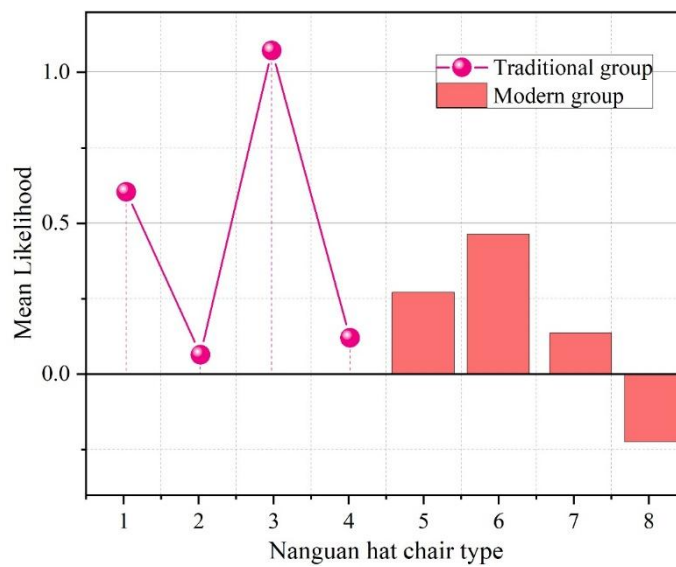


Figure 5: Cognitive preference for two groups of Nanguan hats

4.2.2 Eye tracking analysis of modeling features

(1) Eye-tracking hotspot maps of the styling features of traditional southern official chair

Among the 8 single-sample hotspot maps, traditional 3 and modern 2 were extracted and analyzed with the lowest hotspot maps of traditional 2 and modern 4. The hotspot maps of the 4 groups of single-sample are shown in Fig. 6, where (a) ~ (d) represent traditional 3, traditional 2, modern 2 and modern 4, respectively.

1) In the traditional group, the gaze point tended to focus on the backrest area, and in the modern group, although the backrests were no longer decorated with carvings, subjects still habitually made several attempts to obtain aesthetic information from the backrests.

2) Through the comparative analysis of the hotspot maps of “Traditional 3” and “Traditional 2”, it can be seen that the subjects' attention to both of them is concentrated in the area of the backrest carvings and decorations, followed by the coupon mouths of the base, the foot post and the structural joints, and the surface of the seat, but the overall distribution of attention to “Traditional 3” is more concentrated and obvious, while the attention to “Traditional 2” is more scattered, indicating that the subjects need to go through more sight lines. However, the overall distribution of attention to “Traditional 3” is more concentrated and obvious, while the overall elegance of “Traditional 2” is more dispersed, indicating that subjects need to look for the target of interest through more points of view.

(3) From the perspective of visual search, the higher density of attention points on “Modern 4” indicates that the more direct and efficient target search is focused on the curvature of the backrest and the protruding soft bag on the fan-shaped seat surface, and there are traces of habitual search on the legs, whereas the attention points on “Modern 2” are focused on the natural texture of the backrest, the step-by-step door post and the upper cross post, indicating that the door post and the soft bag on the fan-shaped seat surface are controversial issues affecting the subjects' favoritism. The focus of attention on the natural texture of the backrest, the door post and the upper door post suggests that the door post and the soft bag on the scalloped seat surface are controversial issues affecting the subjects' favoritism.



(a)Traditional 3



(b)Traditional 2

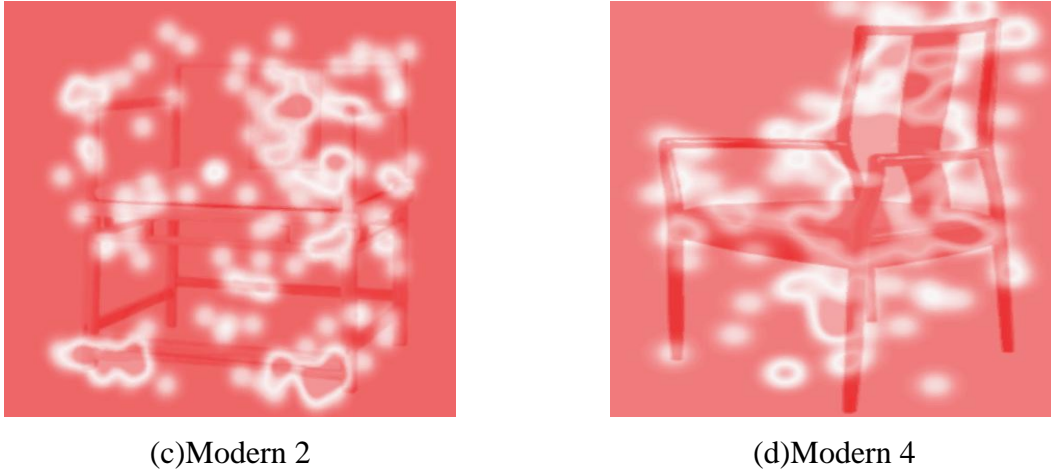


Figure 6: Heat maps of the four monomer samples

(2) Eye tracking and data analysis

Based on the above analysis, the sample “Traditional 3”, which ranked first in terms of styling recognition and preference and was not controversial, was selected to divide the interest area and further analyze its eye movement data.

1) Visual attention analysis

The visual attention data of each modeling feature is shown in Table 7. It can be seen that the total gaze time and the number of gaze points of each modeling feature are arranged in ascending order, which are the backrest, the base, the armrest, the seat surface and the hitching brain in that order. According to the average gaze time, in descending order, they are the backrest, base, armrest, seat surface, and armrest. Longer gaze times and a greater number of gaze points indicate that this area is particularly attractive for “stylistic feature recognition” because of its more distinctive shape or prominent location and size.

Table 7: Visual attention data of various modeling features

Region of interest	Total fixation time(ms)	Number of fixation points	Average fixation time(ms)	Time weight of fixation (%)
Backrest	14965	76	193.81	43.39
Base	13105	72	183.77	36.3
Armrest	4644	33	124.51	17.72
Seat	3137	17	172.21	12.52
Brainstorming	886	5	176.29	2.36

2) Visual search analysis

The visual search data for each modeling feature is shown in Table 8, which shows that: the average number of conversions in descending order is backrest, base, seat surface, armrest, and hitch brain. The higher number of transitions in the region of interest indicates constant reciprocal gaze to the region. The highest frequency of gaze was for the armrests, indicating that subjects processed a large amount of information when “profiling” this area. Subjects in the scanning, the focus of their attention will be a longer stay in a particular area of interest that is “selective attention”, the longest continuous attention to the area of interest that is the object of selective attention to the subjects, the statistics of the area of interest of the time of attention in the following order: the backrest>base>armrest>seat>hitching brain.

Table 8: Visual search data of various modeling features

Region of interest	Average video rate (second·s ⁻¹)	Average conversion count	First-person view count
Backrest	0.5209	2.1971	7
Base	0.5386	1.729	5
Armrest	0.7418	0.8717	3
Seat surface	0.5675	1.4008	1
Brainstorming	0.5502	0.3118	0

4.2.3 Perceived intensity of modeling aesthetic features

The results of the cognitive strength of the aesthetic elements of traditional 3D styling are shown in Figure 7. As can be seen from the figure, the backrest, base and armrest scores are above the x-axis, which can be regarded as the features that can most influence the cognitive strength of the subjects' modeling, and this result is consistent with the eye-tracking data. The overall shape score is higher than that of the armrests, seat surface and the hitchback, which indicates that there is a mechanism of “feature integration” in the process of shape cognition.

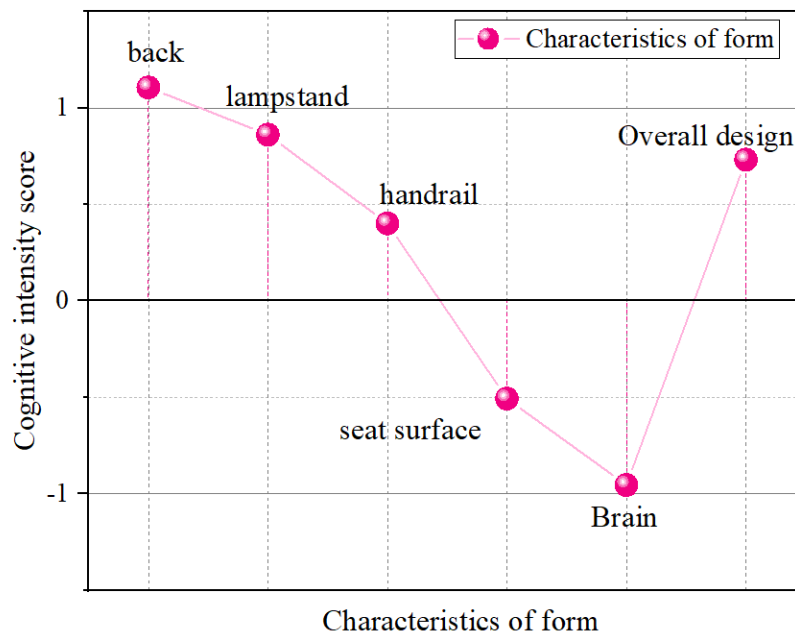


Figure 7: The Cognitive Intensity of Traditional 3D Modeling Aesthetic Elements

5 Conclusion

Taking the Ming-style seat as an example, this paper explores the innovative expression effect of its morphosyntax in the context of the new Chinese style.

In this paper, we obtained the three factors most relevant to the user's perceptual imagery, naming them composure, tension, and simplicity. The user's demand for Ming style seat modeling is: simplicity > tension > composure, and the seat parts that best meet the user's perceptual image are obtained by constructing a QFD quality house. By practicing the design of Ming style seat of Nan Guan Hat Chair, it is obtained that the attention time of each area of interest is in the following order: backrest>base>armrests>seat surface>brain, and the importance of modeling elements is in the following order: backrest>base>armrests>seat surface>brain. In addition, the overall shape scores were higher than some of the seat features,

suggesting that feature integration occurs during shape cognition.

References

- [1] Cui, X., Xu, J., & Dong, H. (2025). Design Preferences for Contemporary Chinese-Style Wooden Furniture: Insights from Conjoint Analysis. *BioResources*, 20(1).
- [2] Mao, Y. (2024). Influence of material and decoration on design style, aesthetic performance, and visual attention in Chinese-style chairs. *Forest Products Journal*, 74(3), 220-232.
- [3] Shuang, G., Mohamad, D., Hapiz, H. Y., & Naser, M. Y. M. (2025). Chinese Traditional Cultural Elements in Modern Furniture: A Quantitative Analysis of Consumer Satisfaction. *International Journal of Creative Future and Heritage (TENIAT)*, 13(2), 169-187.
- [4] Chao, L., & Suhaily, S. S. (2024). Application of Traditional Cultural Elements in the Design of New Chinese-Style Furniture. *Pakistan Journal of Life & Social Sciences*, 22(2).
- [5] Li, C., Suhaily, S. S., & Zhou, Y. (2025). The influence of traditional regional architectural culture on Neo-Chinese style furniture design: a case study of the lingnan region in China. *Scientific Reports*, 15(1), 38002.
- [6] Cai-ping, L. I. A. N., Pei-yao, W. E. I., Xiao-ren, P. A. N. G., & Zhi-hui, W. U. (2023). The Design of Bamboo in the New Chinese Style Furniture. *China Forest Products Industry*, 60(3).
- [7] Ye, J., Zhang, J., Gao, L., Zhou, Y., Liu, Z., & Han, J. (2022). Neo-Chinese style furniture design based on semantic analysis and connection. *KSII Transactions on Internet and Information Systems (TIIS)*, 16(8), 2704-2719.
- [8] Wang, L., Gong, Y. H., Niu, S. F., & Ren, Z. X. (2025). Cultural Symbols Migration and User Perception: Innovation in Chinese-Style Furniture Design. *BioResources*, 20(2).
- [9] Zeng, J., & Gu, C. (2017, June). The application of decorative Jinsha gold decoration on the new Chinese style furniture. In *2017 2nd International Conference on Education, Sports, Arts and Management Engineering (ICESAME 2017)* (pp. 1007-1011). Atlantis Press.
- [10] Zeng, J., & Deng, S. (2017, May). The Development Direction of The New Chinese-style Mahogany Furniture Design-Based on Market Trend Concerning the Generation of 1980s/1990s. In *2017 4th International Conference on Education, Management and Computing Technology (ICEMCT 2017)* (pp. 320-324). Atlantis Press.
- [11] Jing, Y., Cheng, Y., Yu, S., & Lin, J. (2024). An Innovative Application of Diagonal Ridge Elements of Classical Suzhou-style Buildings to Furniture Design Based on Kansei Engineering and Shape Grammar. *BioResources*, 19(3).
- [12] Hong, C., Mahdzir, A., Azwan, H., & Sayuti, A. (2025). Inheritance and Innovation of Chinese Traditional Furniture Culture from the Contemporary Furniture Design Styles--

Focus on Ming Dynasty Chair Furniture. Pakistan Journal of Life & Social Sciences, 23(1).