

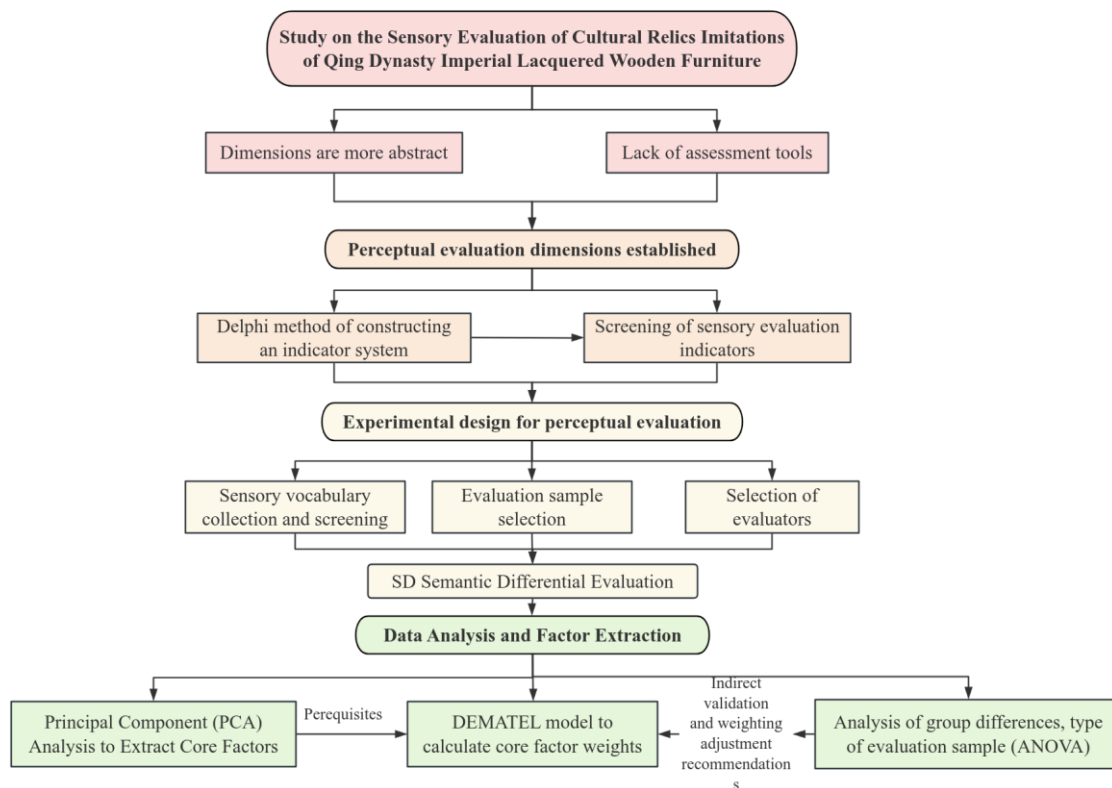
Sensory Evaluation of Cultural Relics Imitations of Qing Dynasty Imperial Lacquered Wooden Furniture

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DOI: 10.15376/biores.20.3.6853-6876

GRAPHICAL ABSTRACT



Sensory Evaluation of Cultural Relics Imitations of Qing Dynasty Imperial Lacquered Wooden Furniture

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To address the challenge that the perceptual evaluation dimensions of lacquer-wood furniture cultural relics imitations are inherently abstract and challenging to quantify, this study established a systematic perceptual evaluation framework to support the high-quality and large-scale development of lacquer-wood furniture cultural relics imitations. Based on 12 evaluation indicators derived through the Delphi method, six key perceptual evaluation indicators were identified. Using the semantic differential method (SD), evaluators assessed and scored 13 pairs of cultural relic imitation samples. Principal component analysis (PCA) was employed to extract the core evaluation factors. At the same time, one-way analysis of variance (ANOVA) was conducted to examine the impact of evaluator group type and sample type on the assessment results. Additionally, the Decision-Making Trial and Evaluation Laboratory model (DEMATEL) was utilized to determine the weight distribution of the core evaluation factors. The findings indicated that the perceptual evaluation system, constructed based on six core evaluation factors, exhibits strong scientific validity and practical applicability. This system is a standardized and objective tool for evaluating and certifying the quality of lacquer-wood furniture cultural relic imitations in museums.

DOI: 10.15376/biores.20.3.6853-6876

Keywords: *Qing Dynasty Imperial; Lacquered wooden furniture artifacts; Cultural relics imitations; Sensory evaluation*

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INTRODUCTION

In the context of global cultural heritage protection and preservation, Chinese traditional furniture culture has become an invaluable part of the world's cultural heritage, celebrated for its unique appeal and profound historical significance. Among the finest representations of Chinese traditional furniture, the Qing Dynasty Palace Lacquered Wooden Furniture Relics embody the exquisite craftsmanship of ancient China and carry rich historical and cultural meanings. The innovative ideas and distinctive designs embedded in their production process reflect the era's social, economic, and aesthetic ideals, leaving a lasting influence on the furniture manufacturing of subsequent generations (Jia 2021).

However, over time, the preservation state of many Qing Dynasty lacquered wooden furniture relics has deteriorated. Due to prolonged exposure to natural and human factors, these invaluable cultural relics face issues such as material aging, surface wear, and structural damage.

In the current museum exhibition context, these relics often cannot withstand the demands of frequent displays, making their adequate protection and presentation a pressing concern (Jia 2023). Since the early 21st century, to safeguard these treasures while also fulfilling public interest in cultural heritage, institutions, such as the Palace Museum, Shenyang Imperial Palace, and the Western Qing Tombs—key holders of Qing Dynasty palace lacquered wooden furniture relics—have started using replicas in exhibitions. These lacquered wooden furniture imitations not only replicate the appearance and craftsmanship of the original relics to a certain degree but also allow the audience to closely engage with and appreciate the relics, thus becoming an essential means of preserving cultural heritage and ensuring the continuity of traditional craftsmanship.

In research on lacquered wood furniture cultural relics imitations, although advancements in various tools and techniques have enabled quantitative assessments of intuitive, surface-level aspects, such as dimensions, material color characteristics, surface luster, and texture, various challenges remain. When it comes to more subtle and critical factors, such as the level of carving and inlay craftsmanship, the representation of stylistic features specific to a particular historical period, aesthetic value, and the degree to which the imitation aligns with the identity of potential users, these elements are deeply embedded in history, culture, aesthetic sensibilities, and humanistic contexts. As such, they possess a high degree of abstraction that cannot be measured purely through physical metrics. This creates significant obstacles in achieving quantitative analysis for evaluation. Consequently, conducting a scientific, comprehensive, and integrated assessment of lacquered wood furniture imitations remains challenging, hindering in-depth research and the precise display of these imitation products.

In addition to its exquisite craftsmanship, the Qing Dynasty palace's lacquered wooden furniture embodies a potent cultural symbol of imperial power. Within the feudal hierarchy of the Qing Dynasty, palace furniture was an integral part of royal life and symbolized imperial authority (Wen 2016). The shape, size, and decorative patterns of the Qing court lacquered furniture adhered to strict regulations, often surpassing practical use (Chen and Gu 2025). For example, the dragon motif, a prevalent decorative element in Qing Dynasty court furniture, appeared in various forms—majestic and solemn, or robust and dynamic. The application of the dragon pattern, including its placement and frequency, was governed by precise rules to distinguish the user's status and to reinforce the visual representation of imperial power in daily life (Qu 2020). The restoration and evaluation of these cultural and symbolic elements are of greater significance than assessing purely aesthetic features such as appearance and size. This necessitates the development of a perceptual evaluation system designed explicitly to imitate Qing Dynasty palace lacquered wooden furniture artifacts.

To address the issues above, this paper sought to fill the research gap in the subjective evaluation of lacquered wood furniture artifact imitations. This study constructed a perceptual evaluation system for lacquered wood furniture artifact imitations by employing methods, such as Perceptual Engineering, Semantic difference method (SD), and the DEMATEL (decision-making experimental) model. The goal was to offer a fresh perspective and theoretical support for the research, production, and display of these imitations, while contributing to the scientific standardization of work within the cultural heritage and museum sectors.

EXPERIMENTAL

Methods

Semantic difference method

The Semantic Differential Method (SD) is a psychometric approach used to measure individuals' subjective feelings and perceptions of concepts, objects, or phenomena (Hu and Yan 2023). It is the primary experimental method employed in this study, where evaluators are invited to score the evaluation samples. The results are quantified using a 7-point Likert scale (-3, -2, -1, 0, 1, 2, 3).

Principal component analysis

Principal Component Analysis (PCA) is a multivariate statistical method that transforms multiple original variables into a smaller set of comprehensive, uncorrelated indicators (principal components) through linear combinations. This technique simplifies the data while retaining the maximum original information (Gewers *et al.* 2021).

This study employs PCA to perform dimensionality reduction on the evaluation data to identify the key factors in the perceptual evaluation of lacquered wooden furniture heritage imitations. PCA extracts the principal components with the strongest explanatory power, simplifying the perceptual review and highlighting the main evaluation dimensions.

Single-factor ANOVA

This study conducted a one-way analysis of variance (ANOVA) to examine the effects of different evaluation groups (experts, postgraduates, and the general public) and various types of evaluation samples on the evaluation results of lacquered wood furniture and cultural relics imitations. Using “group type” and “sample type” as independent variables and the evaluation values for the core evaluation factors extracted through PCA as dependent variables, the authors assessed the significance of differences in ratings between the different groups and sample types across each dimension (Patzelt *et al.* 2014). This study employed IBM SPSS Statistics (IBM Corp., version 27.0, Armonk, NY, USA) software to perform a one-way ANOVA.

Decision-Making Trial and Evaluation Laboratory model (DEMATEL)

After conducting PCA and analyzing the data's group differences (ANOVA), this study further applied the DEMATEL model to calculate the weight values of the core dimensions in the evaluation system for the similarity of lacquered wooden furniture cultural relics and their imitations. This approach ensures the final evaluation system is scientifically robust and practically applicable (Si *et al.* 2025).

In contrast to the traditional Analytic Hierarchy Process (AHP) method for calculating weights, the DEMATEL model highlights the causal relationships between dimensions. It mitigates the influence of subjective fluctuations in expert evaluations using the influence matrix and normalization process. Furthermore, it simplifies pairwise comparisons compared to AHP and reduces the risk of inconsistencies, which can compromise the accuracy of the results (Zheng *et al.* 2025).

For this study, DEMATEL was assigned weights to the indicators in the perceptual evaluation of lacquered wooden furniture heritage imitations. This method better accounts for the interrelationships between indicators, emphasizes key dimensions, and presents the influence relationships and rankings of importance in an intuitive, visual format.

Establishment of Perceptual Evaluation Dimensions and Perceptual Evaluation Vocabulary Screening

At the initial stage of the study, the Delphi method was employed after three rounds of expert consultation (with Kendall's coordination coefficients of 0.828, 0.839, and 0.651, $p < 0.01$) to construct an evaluation index system for lacquered wood furniture cultural relics replicas, consisting of 12 evaluation indices (Li *et al.* 2025). Six more abstract and challenging dimensions to assess through objective quantitative methods were extracted from these. The main dimensions and their interpretations are presented in Table 1.

Table 1. Lacquered Wood Furniture Heritage Imitations Perceptual Evaluation Dimensions

Evaluation Methods	Evaluation Dimension	Dimensional Interpretation
Perceptual evaluation	Line Morphology Fidelity	Continuity and articulation of lines, including transitions and inflections
	Carving Technique Fidelity	Liveliness and expressiveness of carving techniques
	Inlay Craftsmanship Fidelity	Fineness and rationality of inlay craftsmanship
	Period Style Fidelity	Qing imperial furniture is generally categorized into three periods: early (Shunzhi and Kangxi reigns), middle (Yongzheng and Qianlong reigns), and late (from Jiaqing to the late Qing dynasty). Each period exhibits distinct stylistic characteristics.
	Regional Style Fidelity	Furniture in different spaces of the Qing imperial court exhibited stylistic variations. For example, furnishings in major ceremonial halls, such as the Hall of Supreme Harmony (Taihe Dian) and the Palace of Heavenly Purity (Qianqing Gong), were predominantly in the Beijing style. In contrast, furniture in studies and private chambers favored the Suzhou style, while the Canton (Guang) style, influenced by Western aesthetics, was commonly used in palace halls and reception rooms.
	Identity-Aesthetic Compatibility	"Identity" underscores the symbolic representation of social status, "Aesthetics" encompasses stylistic preferences, and "Compatibility" reflects the degree of coherence and integration between the two.

To solicit vocabulary related to the dimensions of perceptual evaluation, questionnaires were distributed to 10 experts in lacquered wood furniture artifacts from the Palace Museum, the Jingzuo Mortise and Tenon Art Museum, and the Golden Lacquer Inlay Factory. Through literature collection, 145 vocabulary terms related to the perceptual evaluation of the degree of restoration of lacquered wood furniture artifact imitations were obtained.

Following the collection of vocabulary, focus group discussions were conducted to group similar terms, eliminate those with little relevance, and further clarify more abstract and ambiguous terms (Stalmeijer *et al.* 2025). As a result, 22 pairs of perceptual evaluation

vocabulary sets with positive and negative connotations were condensed, as shown in Table 2.

Table 2. Sensory Evaluation Indicators and Sensory Evaluation Vocabulary Sets

Perceptual Evaluation Indicators	Number	Anti-Sense Evaluation Phrases and Interpretations
Line Morphology Fidelity	1	Fluent - Rigid: Evaluate whether the lines are continuous, smooth, and natural.
	2	Tense - Dull: Evaluate whether the lines are vivid, powerful, and expressive.
	3	Natural - Abrupt: Evaluate whether the transitions of lines are natural and coherent.
	4	Unrestrained - Constrained: Evaluate whether the lines are fluid and graceful.
	5	Forceful - Weak: Evaluate whether the lines are vigorous and full of strength.
Carving Technique Fidelity	1	Lifelike - Stiff: Evaluate whether the carving is vivid, dynamic, and expressive.
	2	Delicate - Coarse: Evaluate whether the carving is fine and exquisite.
	3	Proportional - Distorted: Evaluate whether the carving proportions are accurate and well-balanced.
Inlay Craftsmanship Fidelity	1	Natural - Abrupt: Evaluates whether the inlay craftsmanship appears natural and harmonious.
	2	Exquisite - Rough: Evaluates whether the inlay craftsmanship is delicate and refined.
	3	Ingenious - Chaotic: Evaluates whether the inlay craftsmanship is well-conceived and thoughtfully arranged.
	4	Integrated - Disjointed: Evaluates whether the inlay craftsmanship achieves seamless integration.
Period Style Fidelity	1	Consistent - Inconsistent: Evaluates whether the imitation aligns with the craftsmanship characteristics of its era.
	2	Distinct - Vague: Evaluates whether the imitation possesses distinct period-specific features.
	3	Congruent - Deviated: Evaluates whether the imitation style aligns with the stylistic characteristics of its era.
Regional Style Fidelity	1	Vivid - Rigid: Evaluates whether the imitation effectively captures the essence of the stylistic school.
	2	Consistent - Different: Evaluates whether the imitation aligns with the stylistic school's characteristics.
	3	Evocative - Spiritless: Evaluates whether the imitation successfully reproduces the artistic essence of the stylistic school.
Identity-	1	Harmonized - Deviated: Evaluates whether the imitation aligns

Aesthetic Compatibility		with identity aesthetics.
	2	Symbolic - Non-symbolic: Evaluates whether the imitation effectively conveys social status symbolism.
	3	Classic - Ordinary: Evaluates whether the imitation embodies classic aesthetic characteristics.
	4	Consistent - Incongruent: Evaluates whether the imitation aligns with identity aesthetics.

Selection of Evaluators

To ensure that the perceptual evaluation of lacquered wood furniture cultural relics imitations aligns with public perception, enriches the cultural communication value of these imitations, and overcomes the limitations of an evaluation system based solely on experts and researchers, the study aimed to provide a more comprehensive, socially valuable, and universally applicable evaluation system. Sixty-five participants were selected for the experimental perceptual evaluation of lacquered wood furniture. These participants were drawn from lacquer and wood furniture heritage experts, furniture graduate students, and the general public. To obtain more extensive and representative public evaluation results, this study did not impose restrictions on the age, occupation, or educational background of participants from the general public. This group included a diverse range of individuals, such as museum visitors, community residents, and non-specialized university students. The selection criteria for the evaluators are presented in Table 3.

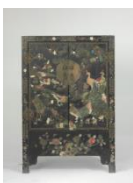
Table 3. Criteria for Selection of Evaluators

Type of Personnel	Request
Qing Dynasty lacquered wood furniture experts	For over twenty years, professionals with senior professional titles or recognized as National Masters or Arts and Crafts Masters have been engaged in theoretical research or practical work on Qing Dynasty lacquered wood furniture.
Young faculty members and postgraduate students	Young faculty members or postgraduate students in furniture design and manufacturing disciplines, specializing in traditional furniture research, or having received systematic training in traditional furniture knowledge.
General public	/

Experimental Sample

To ensure the universality of the perceptual evaluation system, the study selected 13 representative samples of lacquered wood furniture artifacts from the Palace Museum. Additionally, eight pairs of their corresponding imitations and five pairs of craft imitations of the same type as the original artifacts were included (Table 4). Most imitation samples were produced by local cultural relics imitation enterprises, such as Yuan Sheng Long Bo and the Beijing Gold Lacquer Inlay Factory, commissioned by the Palace Museum. The production process followed a standardized workflow: the production units first conducted surveys at the original storage sites to collect information on the original structure, techniques, and other relevant details.

Table 4. Evaluation Sample

Artifact Type	Artifacts and Names				
Original artifact					
	Fengxian Hall plaque	Gilded lacquered wooden folding chair 1	Gilded lacquered wooden folding chair 2	Altar	
Imitation					
Original artifact					
	Carved dragon round table	Fragrant table	The footrest of the throne in Yuqing Palace	Carved Kang table	
Imitation					
Original artifact					
	Cabinet with a hundred-treasure inlay	Antique motif hanging screen	Multicolored stone inlaid cabinet	Mother-of-pearl inlaid cabinet	Jade inlaid hanging screen
Imitation					

CAD drawings were then created and confirmed with the Palace Museum. Based on the approved drawings, prototypes were produced and subjected to mid-term inspection. Finally, the completed imitation products were manufactured.

Evaluation Using SD

The experiment utilized the SD for evaluation. Since the original artifacts are primarily stored in the Palace Museum's treasury as essential collection items, assembling the originals and their imitations in the exact location for centralized display and evaluation is challenging. Therefore, this study employed an online questionnaire format, in which photographs of the original artifacts and their corresponding imitations—captured from the same angle and in orthogonal perspective—were presented to respondents for visual observation and evaluation. A questionnaire was distributed to 65 evaluators, who were asked to score and assess 13 groups of artifact and replica samples using perceptual terms collected and refined during the pre-study phase. Each set of opposing perceptual phrases was quantified using Likert's 7-point scale (-3, -2, -1, 0, 1, 2, 3) (Wang *et al.* 2025a). Based on the focus of different evaluation dimensions, specific parts of the cultural relics and their imitations were selected as evaluation objects for each dimension (Table 5).

Table 5. Example of the Semantic Differential Method Perceptual Evaluation Questionnaire

Sample Evaluation	Evaluation Dimension	Sensory Evaluation Vocabulary	Quantitative Scores						
	Carving Technique Fidelity	Lifelike - Stiff	-3	-2	-1	0	1	2	3
		Delicate - Coarse	-3	-2	-1	0	1	2	3
		Proportional - Distorted	-3	-2	-1	0	1	2	3

RESULTS AND DISCUSSION

PCA of Perceptual Evaluation Vocabulary and Evaluation Dimensions

After the 65 evaluators conducted the SD evaluation of the experimental samples, the data were imported into SPSS, Version 27.0 (IBM Corp., Armonk, NY, USA) to calculate the mean scores for each sample across different perceptual evaluation phrases under each dimension. The results are presented in Table 6.

Table 6. Example of Part of the Calculation of the Mean Value of the Evaluation Results

Dimension	Sensory Vocabulary and Scores				
Line Morphology Fidelity	Fluent - Rigid	Tense - Dull	Natural - Abrupt	Unrestrained - Constrained	Forceful - Weak
Sample1	0.34	-0.22	-0.14	0.31	0.17
Sample2	-0.28	-0.15	-0.28	-0.14	-0.4
Sample3	-0.22	-0.25	-0.11	-0.05	-0.37
Sample4	-0.26	-0.35	-0.37	-0.11	-0.03
Sample5	1.03	0.88	0.82	1.03	1.09
Sample6	0.86	0.75	0.85	1.02	1.09
Sample7	0.06	-0.42	-0.15	0.11	-0.2
...	...	...	...	...	...
Identity-Aesthetic Compatibility	Harmonized - Deviated	Symbolic - Non-symbolic	Classic - Ordinary	Consistent - Incongruent	/
Sample1	0.35	0.49	0.54	0.49	/
Sample2	-0.46	0.22	0	-0.31	/
Sample3	0.05	0.12	-0.14	-0.02	/
Sample4	-0.22	-0.32	-0.18	-0.15	/
Sample5	1.06	0.83	1	1	/
Sample6	0	0.15	-0.15	-0.03	/
Sample7	-0.17	-0.55	-0.49	-0.48	/

Note: The symbol '...' represents an ellipsis, indicating that some data has been omitted for brevity due to the large amount of information; As all participants in this study were Chinese, the questionnaire presented Chinese equivalent terms instead of English.

KMO and Bartlett test

The KMO and Bartlett's tests were performed on the perceptual vocabulary data under the six evaluation dimensions. When the KMO value was greater than 0.5 and the P-value was less than 0.05, it indicated that principal component analysis could be conducted. The test results for the evaluation data of perceptual vocabulary under the six dimensions are shown in Table 7 (Wang *et al.* 2025b).

After testing, all six evaluation dimensions met the requirements for principal component analysis ($KMO > 0.5$), with the C, D, and E indicators showing powerful results ($KMO > 0.7$). The p-value was less than 0.05, indicating statistical significance and confirming a correlation between the perceptual evaluation phrases under each dimension, making dimensionality reduction analysis feasible.

Although the KMO value for the E indicator was relatively low (0.533), it exceeded the minimum acceptable threshold of 0.5, indicating that the data were suitable for factor analysis. Moreover, Bartlett's test of sphericity was significant ($P = 0.009 < 0.05$), further confirming the appropriateness of applying factor analysis. Given the number of perceptual

evaluation terms associated with this dimension and their conceptual dispersion, the relatively low KMO value is considered reasonable.

Table 7. Results of KMO and Bartlett's Test

KMO and Bartlett's Test		
KMO value	A. Line Morphology Fidelity	0.598
	B. Carving Technique Fidelity	0.580
	C. Inlay Craftsmanship Fidelity	0.713
	D. Period Style Fidelity	0.781
	E. Regional Style Fidelity	0.533
	F. Identity-Aesthetic Compatibility	0.742
p-value	A. Line Morphology Fidelity	0.000
	B. Carving Technique Fidelity	0.047
	C. Inlay Craftsmanship Fidelity	0.019
	D. Period Style Fidelity	0.000
	E. Regional Style Fidelity	0.009
	F. Identity-Aesthetic Compatibility	0.000

Principal component dimensionality reduction analysis

When extracting the perceptual evaluation words for each dimension in principal component analysis, the primary criterion is the variance explained by each principal component.

Table 8. Example of Partial Explanation of Variance for Each Dimension of Perceptual Vocabulary

Dimension	No.	Characteristic Root	Variance Explained Rate	Accrue	Principal Component Extraction		
					Characteristic Root	Variance Explained	Accrue
A. Line Morphology Fidelity	1	4.797	95.938	95.938	4.797	95.938	95.938
	2	0.131	2.612	98.550			
	3	0.051	1.024	99.574			
	4	0.021	0.412	99.986			
	5	0.001	0.014	100.000			
B. Carving Technique Fidelity	1	2.516	83.867	83.867	2.516	83.867	83.867
	2	0.404	13.468	97.335			
	3	0.080	2.665	100.000			
...	...	...	...	...	...	...	...

Note: The symbol '...' represents an ellipsis, indicating that some data has been omitted for brevity due to the large amount of information

Typically, components with an eigenvalue greater than one are considered significant. Additionally, the cumulative contribution rate serves as an essential reference.

Suppose the cumulative contribution rate exceeds 80%. In that case, it indicates that the extracted principal components effectively capture the core features of the data and adequately represent the evaluators' main tendencies across different dimensions of perceptual evaluation (Table 8) (Tanner-Smith and Tipton 2025). After calculating the maximum eigenvalue and variance explained ratio for each perceptual vocabulary group in the respective dimensions, the scree plot method was employed. The scree plot (Figs. 1 through 6) visually illustrates the changes in the eigenvalues of each component.

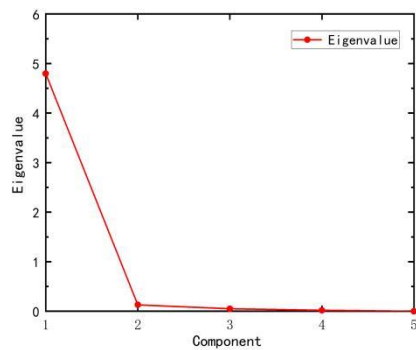


Fig. 1. Line morphology fidelity, perceptual vocabulary, gravel map

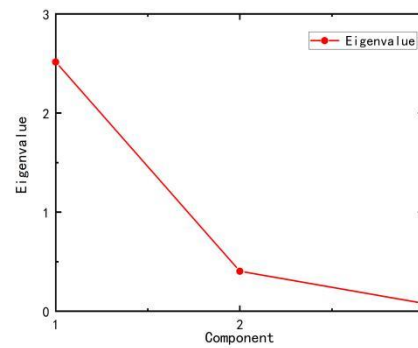


Fig. 2. Carving technique fidelity, perceptual vocabulary, gravel figure

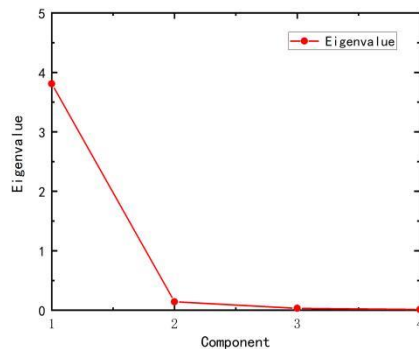


Fig. 3. Inlay craftsmanship fidelity, perceptual vocabulary, gravel map

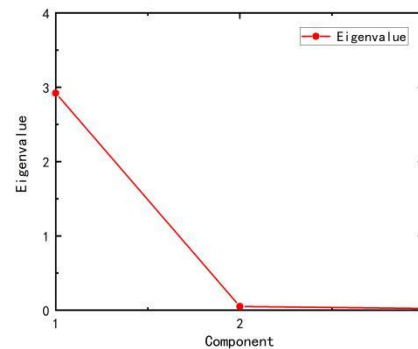


Fig. 4. Period style fidelity, perceptual vocabulary, gravel map

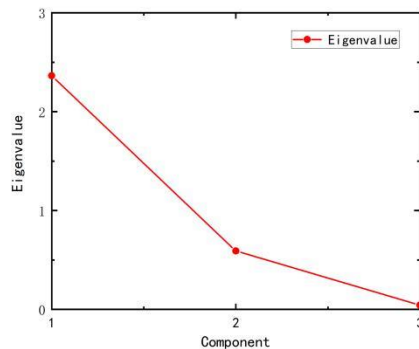


Fig. 5. Regional style fidelity, perceptual vocabulary, gravel map

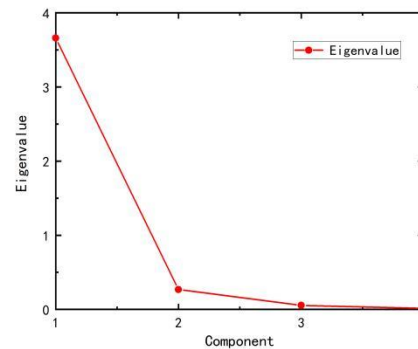


Fig. 6. Identity-aesthetic compatibility, perceptual vocabulary, rubble map

According to professional judgment criteria, the principal components are identified at the points where the curvature of the scree plot curve shows a sharp decline, indicating a significant change in slope. These points correspond to the main components that effectively summarize the key information from the original data. As a result, six principal components were ultimately extracted (Hayes and Preacher 2025).

The study further examined the intrinsic relationships between the perceptual vocabulary groups and the principal components within each dimension to achieve a more streamlined set of perceptual evaluation dimensions. By introducing the key indicator of the loading coefficient, a detailed analysis was conducted, and the results are presented in Table 9.

Table 9. Loading Coefficients Between Each Perceptual Word and Principal Components

Dimension	Perceptual Vocabulary Group	Loading Factor	Commonality (Common Factor Variance)
		Principal Component 1	
A. Line Morphology Fidelity	Fluent - Rigid	0.976	0.952
	Tense - Dull	0.965	0.931
	Natural - Abrupt	0.982	0.965
	Unrestrained - Constrained	0.979	0.959
	Forceful - Weak	0.995	0.989
B. Carving Technique Fidelity	Lifelike - Stiff	0.877	0.769
	Delicate - Coarse	0.893	0.797
	Proportional - Distorted	0.975	0.950
C. Inlay Craftsmanship Fidelity	Natural - Abrupt	0.969	0.940
	Exquisite - Rough	0.990	0.981
	Ingenious - Chaotic	0.989	0.978
	Integrated - Disjointed	0.955	0.912
D. Period Style Fidelity	Consistent - Inconsistent	0.990	0.980
	Distinct - Vague	0.983	0.965
	Congruent - Deviated	0.988	0.977
E. Regional Style Fidelity	Vivid - Rigid	0.747	0.559
	Consistent - Different	0.971	0.943
	Evocative - Spiritless	0.929	0.863
F. Identity-Aesthetic Compatibility	Harmonized - Deviated	0.932	0.868
	Symbolic - Non-symbolic	0.925	0.856
	Classic - Ordinary	0.979	0.958
	Consistent - Incongruent	0.990	0.979

As shown in Table 9, all perceptual vocabulary groups corresponded to commonality values greater than 0.4, indicating a strong correlation between the study items and the principal components. This suggests that the principal components can effectively extract the relevant information (Singh *et al.* 2025). Based on this, the study further condensed and integrated the existing perceptual evaluation phrases for each dimension. As a result, six core factors were successfully identified: Line Liveliness and Natural Flow; Carving Fineness and Expressiveness; Inlay Integration and Exquisite Craftsmanship; Period Style Accuracy and Consistency; Stylistic School Essence and Form Fidelity; Gracefulness and Elegance. The detailed interpretation of these core factors is shown in Table 10.

Table 10. Core Factors and Their Interpretation

Factor Name	Explanation
Line Liveliness and Natural Flow	Encompasses various characteristics, such as line smoothness, natural flow, and dynamic tension, to assess whether the imitation of lacquered wood furniture exhibits the same fluidity and seamless beauty as the original artifact in its line formation.
Carving Fineness and Expressiveness	Evaluates the fineness of carving, texture quality, vividness of form, and expressive details to determine whether the imitation accurately replicates the exquisite craftsmanship of the original artifact, achieving a delicate, lifelike artistic effect.
Inlay Integration and Exquisite Craftsmanship	Assesses whether the imitation faithfully restores the seamless integration, harmonious color coordination, and well-balanced layout of inlays in Qing Dynasty palace lacquered wood furniture, ensuring a cohesive, refined, and elegant visual presentation.
Period Style Accuracy and Consistency	Examines whether the imitation accurately reconstructs the historical characteristics of Qing Dynasty palace lacquered wood furniture by adhering to the specific period's design, ornamentation, and material selection, verifying its ability to convey an intense historical atmosphere and temporal authenticity.
Stylistic School Essence and Form Fidelity	It focuses on the inheritance and representation of the unique stylistic traditions of lacquered wood furniture, emphasizing both the adherence to craftsmanship standards, structural proportions, and external forms and the continuation of aesthetic spirit and innovation, ensuring that the imitation achieves a high standard of authenticity in both form and essence.
Gracefulness and Elegance	Evaluates whether the imitation successfully restores the dignified elegance, courtly aesthetic, and regal lifestyle associated with Qing Dynasty palace lacquered wood furniture, determining whether it meets the highest standards of aesthetic adaptation.

After condensing the core factors, the study conducted a quadratic principal component analysis further to assess the downscaling of the perceptual evaluation dimensions. This analysis used the composite score data of the six core factors. The mean scores of the different samples on each core factor are presented in Table 11.

Table 11. Mean Scores of Each Sample on Core Factors

Sample No.	Line Liveliness and Natural Flow	Carving Fineness and Expressiveness	Inlay Integration and Exquisite Craftsmanship	Period Style Accuracy and Consistency	Stylistic School Essence and Form Fidelity	Gracefulness and Elegance
1	0.46	0.45	2.49	2.343	1.53	1.87
2	-1.25	0.22	0.21	-1.69	-0.84	-0.55
3	-1	2.49	2.15	-0.514	0.15	0.01
4	-1.12	1.32	2.85	-2.89	-1.25	-0.87
5	4.85	1.24	2.44	-0.05	2	3.89
6	4.57	2.62		-1.57	0.13	-0.03
7	-0.6			-2.63	-0.55	-1.69

After conducting the KMO and Bartlett's test, the result showed that the KMO value was 0.000, below the standard threshold of 0.5. This indicates that the six core factors were independent of each other and there was no significant correlation. As a result, the PCA process was terminated. The six core factors were directly used as the final simplified evaluation dimensions. The detailed test results are presented in Table 12.

Table 12. KMO and Bartlett's Test for the Six Core Factors

KMO and Bartlett's Test		
KMO value		0.000
Bartlett's test	Approximate chi-square	87.593
	df	15
	p	0.000

Analysis of group cognitive bias and the effect of evaluation samples on evaluation results

The raw data corresponding to the evaluation results of the six core factors were input into the SPSS statistical analysis software. The group type and sample number were set as independent variables, while the scoring results for each of the six core factors were treated as dependent variables. A one-way ANOVA was then conducted. The detailed results of the ANOVA are presented in Tables 13 and 14.

As shown in Table 13, group type had a significant effect on the dimensions of Inlay Integration and Exquisite Craftsmanship, Period Style Accuracy and Consistency, Stylistic School Essence and Form Fidelity, and Gracefulness and Elegance, with significance levels at 0.01 ($F = 5.438$, $p = 0.005$), 0.01 ($F = 12.261$, $p = 0.000$), 0.05 ($F = 3.702$, $p = 0.025$), and 0.01 ($F = 5.225$, $p = 0.006$), respectively. This suggests that perceptions of these four core factor dimensions varied across evaluation groups, indicating that these four dimensions may be more crucial than the remaining two in the evaluation process.

Table 13. ANOVA of Group Type on Core Factor Score Results

Core Element	Population Type (Mean $\pm$ Standard Deviation)			F	p
	1.0 (n = 105)	2.0 (n = 140)	3.0 (n = 210)		
Line Liveliness and Natural Flow	-0.44 $\pm$ 8.54	1.01 $\pm$ 8.37	1.38 $\pm$ 7.65	1.805	0.166
Carving Fineness and Expressiveness	0.64 $\pm$ 6.30	2.18 $\pm$ 7.03	1.22 $\pm$ 5.81	1.639	0.195
Inlay Integration and Exquisite Craftsmanship	1.21 $\pm$ 6.70	3.73 $\pm$ 6.17	1.30 $\pm$ 5.97	5.438	0.005
Period Style Accuracy and Consistency	-1.19 $\pm$ 4.95	-0.86 $\pm$ 5.33	1.27 $\pm$ 4.58	12.261	0.000
Stylistic School Essence and Form Fidelity	-0.89 $\pm$ 5.29	0.14 $\pm$ 5.35	0.74 $\pm$ 4.62	3.702	0.025
Gracefulness and Elegance	-1.23 $\pm$ 7.04	0.19 $\pm$ 7.18	1.30 $\pm$ 5.96	5.225	0.006

Table 14. ANOVA of Sample Number on Core Factor Score Results

Core Element	Sample Number (Mean $\pm$ Standard Deviation)				F	p
	1.0	2.0	3.0	...		
Line Liveliness and Natural Flow	0.46 $\pm$ 8.30	-1.25 $\pm$ 7.48	-0.98 $\pm$ 7.62	...	7.869	0.000**
Carving Fineness and Expressiveness	0.45 $\pm$ 5.91	0.22 $\pm$ 5.75	2.49 $\pm$ 5.95	...	1.645	0.147
Inlay Integration and Exquisite Craftsmanship	2.49 $\pm$ 6.54	0.22 $\pm$ 5.85	2.15 $\pm$ 6.28	...	1.803	0.128
Period Style Accuracy and Consistency	1.92 $\pm$ 4.75	-0.45 $\pm$ 5.07	0.49 $\pm$ 5.05	...	2.719	0.013*
Stylistic School Essence and Form Fidelity	1.17 $\pm$ 4.77	-0.75 $\pm$ 4.78	-0.18 $\pm$ 5.17	...	5.969	0.000**
Gracefulness and Elegance	1.88 $\pm$ 6.19	-0.55 $\pm$ 6.29	0.02 $\pm$ 6.48	...	5.583	0.000**

Note: The symbol ‘...’ represents an ellipsis, indicating that some data has been omitted for brevity due to the large amount of information

According to Table 14, sample numbering had significant effects on Line Liveliness and Natural Flow, Period Style Accuracy and Consistency, Stylistic School Essence, Form Fidelity, and Gracefulness and Elegance, showing significance levels at 0.01 ($F=7.869, P=0.000$), 0.05 ($F=2.719, P=0.013$), 0.01 ($F=5.969, P=0.000$), and 0.01 ($F=5.583, P=0.000$), respectively. This implies significant differences in scores across different samples in the corresponding dimensions.

The ANOVA graphs (Figs. 7 and 8) further reveal that samples 5 and 6 under Line Liveliness and Natural Flow, one under Period Style Accuracy and Consistency, one under Stylistic School Essence and Form Fidelity, and five under Gracefulness and Elegance showed significant differences compared to other samples.

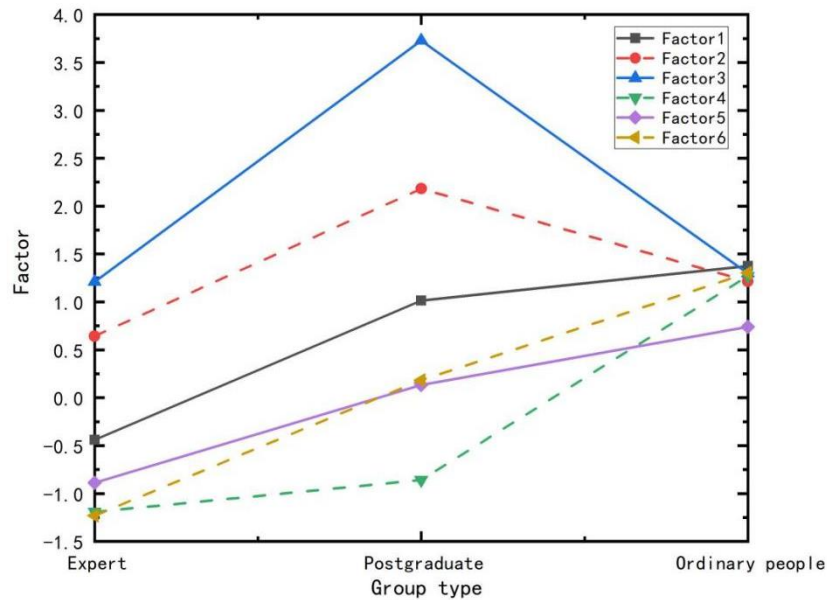


Fig. 7. Comparative analysis of variance of group types

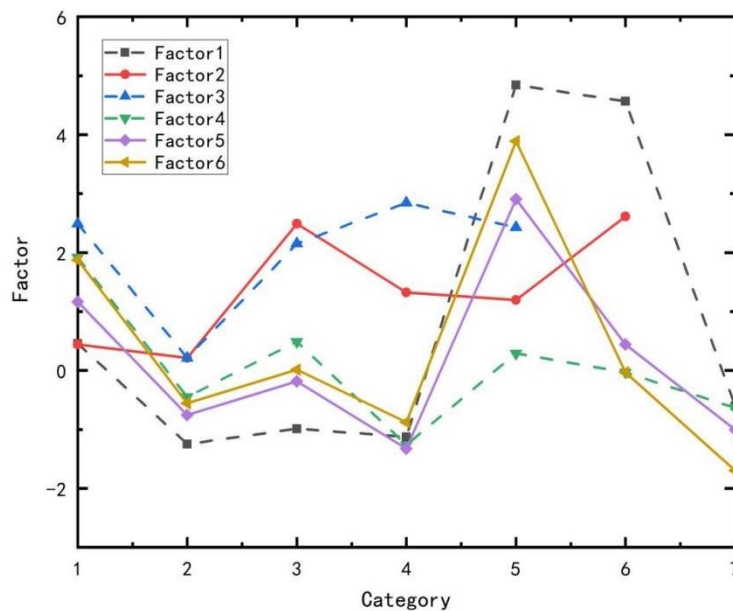


Fig. 8. Comparative analysis of variance of sample numbers

Reviewing the questionnaire data, it appears that the samples with substantial differences under these three core factor dimensions are the Qing Dynasty Palace Round Table (Line Liveliness and Natural Flow), Qing Dynasty Court Round Table, and Qing Dynasty Court Kang Table replicas (Stylistic School Essence and Form Fidelity, Gracefulness and Elegance), and the Qing Sage Emperor Kangxi's Divine Plaque Replica in the Hall of Bongxian (Period Style Accuracy and Consistency) (Fig. 9).



Fig. 9. Samples with significant differences in evaluation results

DEMATEL model to calculate core factor weights

Building on the final core factors derived from PCA, this study employed the DEMATEL model to calculate the weights of these core factors quantitatively. The research team selected 10 senior experts in lacquered wood furniture and cultural relics imitations, all with extensive theoretical knowledge and practical experience in the area. Using their professional expertise, these experts rigorously scored the six core factors based on their relative importance, using a 0 to 4 scale. This scoring provides a solid data foundation for further in-depth analysis. The relationship matrix for the scoring data is presented in Table 15, with the core factors numbered ordinally from 1 to 6.

Table 15. Matrix of Expert Scoring Relationships

Core Factor Serial Number/Core Factor Serial Number	1	2	3	4	5	6
1	0	0.9	1	1.1	1	1
2	1	0	1	1	1	1
3	2.8	2.6	0	3	2.9	2.9
4	2.3	1.6	3.1	0	3	2.9
5	1.9	1.6	2.5	2.9	0	3
6	1.9	1.6	3	2.9	3	0

On this basis, the scoring data are used to calculate the degree of influence for each element, including the D value (the degree of influence of an aspect on others), the C value

(the degree of influence that other elements have on the component), the center value ($D + C$), and the cause value ($D - C$). Specifically:

The D value represents the degree of influence an element has on others. A larger D value indicates that the component has a more substantial impact.

The C value reflects the degree of influence that other elements have on a particular element. A larger C value indicates that different elements have a more substantial impact on the given element.

The center value ($D + C$) signifies the element's importance. A larger center value means the element plays a more significant role.

The cause value ($D - C$) shows the influence of an element on others. If the value is greater than 0, the aspect is more of a cause (influencing others), while a value less than 0 suggests that the component is more of an effect (influenced by others).

Table 16 (Altuntas and Gok 2025) shows the results of these calculations for the influence degree values.

Table 16. DEMATEL Calculation of Impact Degree Values

Core Factor Number	Impact D-value	Influenced C-value	Centrality D+C Value	Degree of Cause D-C Value (R)
1	1.436	2.682	4.118	-1.247
2	1.422	2.271	3.693	-0.849
3	3.636	2.870	6.506	0.765
4	3.476	2.938	6.413	0.538
5	3.257	2.939	6.196	0.317
6	3.391	2.917	6.308	0.475

Through the analysis of the results from the DEMATEL model, the following conclusions can be drawn:

Centrality: The centrality, represented by the $D + C$ value, is highest for Core Factor 3 (6.506), indicating that this factor is strongly connected with other factors and plays a crucial role in the research system of lacquered wood furniture cultural relic imitations. Core Factors 4, 5, and 6 also have relatively high centrality, while Core Factors 1 and 2 have weaker centrality, suggesting that they are less central to the system.

Degree of Cause: The $D - C$ values, which indicate the degree of causality, are positive for Core Factors 3, 4, 5, and 6, with Core Factor 3 having the highest value (0.765). This suggests that these factors have an active influence and serve as key drivers of changes within the system. Conversely, Core Factors 1 and 2 have negative DC values, indicating that they are more influenced by other factors rather than driving change themselves (Fig. 10).

According to the centrality-causality diagram, it is more intuitive to observe that Core Factors 3, 4, 5, and 6 are clustered in the first quadrant. This indicates that these factors have high centrality and causality, meaning they are essential and serve as causal drivers. In contrast, Core Factors 1 and 2 are clustered in the fourth quadrant, which reflects high centrality but low causality. This suggests these factors are essential but mainly act as consequential factors (Figs. 11 to 12).

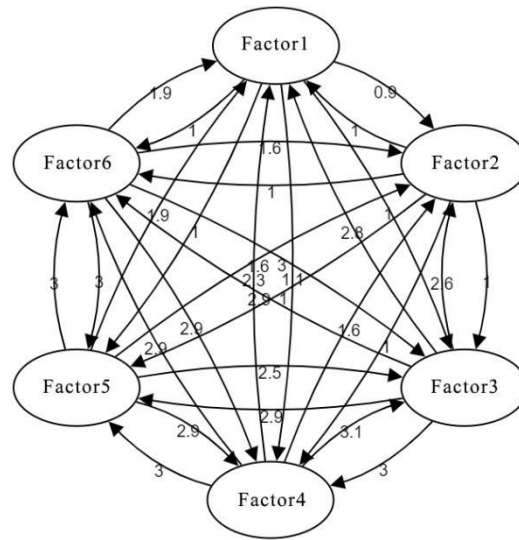


Fig. 10. Core factor impact relationships

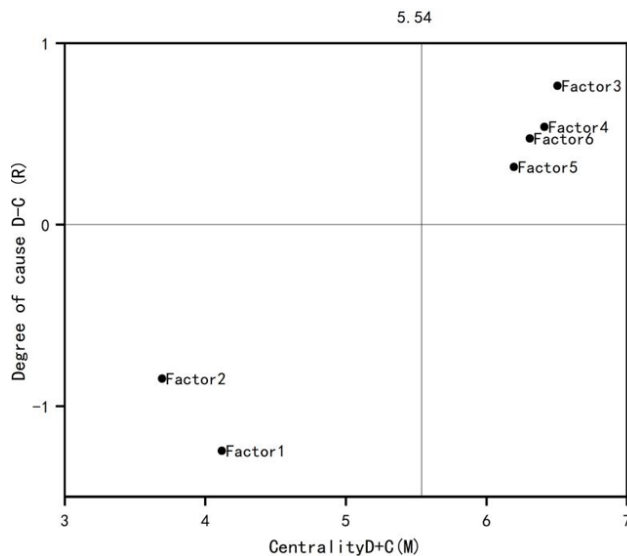


Fig. 11. Core factor centrality-causality chart

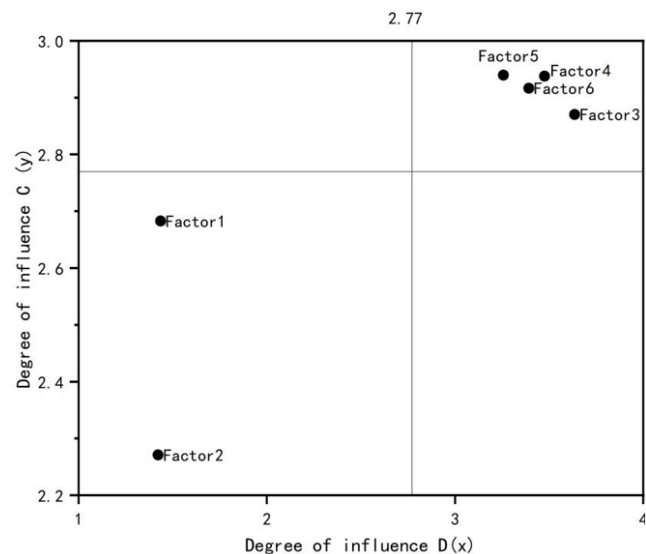


Fig. 12. Core factor influence-influenced chart

The weight values of the core factors were calculated based on the influence and being influenced values between the factors. The results of these calculations are presented in Table 17.

Table 17. Calculation of the Weight Values of the Core Factors

Core Factor Number	Impact D-value	Influenced C-value	Centrality D+C Value	Weight
1	1.436	2.682	4.118	0.124
2	1.422	2.271	3.693	0.111
3	3.636	2.870	6.506	0.196
4	3.476	2.938	6.413	0.193
5	3.257	2.939	6.196	0.186
6	3.391	2.917	6.308	0.190

Collection and Refinement of Perceptual Vocabulary

This study relied on the 12 indicators from the previous Delphi study to ensure the directional and targeted collection of perceptual vocabulary. Six perceptual evaluation indicators were selected to extract relevant vocabulary, enhancing the accuracy of perceptual vocabulary. The SD method was used for user evaluation of the experimental samples. Dimensionality reduction was performed on the perceptual vocabulary under each index, addressing potential synonymous redundancy.

The logic of this process is as follows:

- (1) Refine perceptual indicators based on Delphi method results.
- (2) Collect perceptual vocabulary based on the indicators.
- (3) Use PCA to reduce the dimensionality of perceptual vocabulary based on SD evaluations, ensuring that the six core factors reflect the multidimensional nature of lacquered wood furniture heritage replica evaluations.

Secondary Data Mining and Group-Type Differences

After obtaining the six core factors, a secondary data mining process was conducted, focusing on differences in ratings between group types and sample types. The goal was to gain insights into the cognitive patterns and understanding of the evaluation dimensions of lacquered wood furniture among groups with different cultural backgrounds.

Core Factors with Insignificant Differences: The core factors “Line Liveliness and Natural Flow” and “Carving Fineness and Expressiveness” showed no significant differences in ratings, indicating that users could intuitively perceive these factors by observing the appearance and details of the craftsmanship.

Core Factors with Significant Differences: Significant differences were found in the remaining four core factors: “Inlay Integration and Exquisite Craftsmanship”, “Period Style Accuracy and Consistency”, “Stylistic School Essence and Form Fidelity”, and “Gracefulness and Elegance”. These factors exhibit significant differences between the general public and the other two groups—graduate students and industry experts, likely due to their abstract nature, making them harder for non-experts to grasp. This also reflects the limited public awareness of these evaluation indicators from the cultural heritage perspective, highlighting the need for further improvement in future dissemination and educational efforts within relevant fields.

“Period Style and Genre Style Reduction Accuracy” was vital for determining the historical and artistic value of lacquered wood furniture replicas.

“Gracefulness and Elegance” highlighted the Qing dynasty palace aesthetic, linking the furniture replicas to imperial reverence and elegance.

Sample-Type Differences

Significant differences were found in evaluations of the Qing dynasty palace round table and carved kang table replicas, particularly in the core dimensions “Line Liveliness and Natural Flow”, “Stylistic School Essence and Form Fidelity”, and “Gracefulness and Elegance”. These differences can be attributed to:

The complexity and artistic nature of the line composition in these palace living space furniture types.

The distinctive genre style characteristics might be complex for ordinary evaluators to capture.

The lower-key, more restrained style of living furniture compared to ritual or temple furniture makes it harder to associate it with the imperial status of the Qing dynasty.

Results of the DEMATEL Model Calculations

The DEMATEL model revealed that four core factors, “Inlay Integration and Exquisite Craftsmanship,” “Period Style Accuracy and Consistency,” “Stylistic School Essence and Form Fidelity,” and “Gracefulness and Elegance,” had the highest centrality and causality values. These factors were identified as causal, meaning they play a more significant role in determining the quality of lacquered wood furniture replicas.

For example, the “precise fit of period style” not only reflects the replica’s historical accuracy but also converges with the evaluation of “Line Liveliness and Natural Flow,” influencing the overall quality assessment.

Conversely, the two factors “Line Liveliness and Natural Flow” and “Carving Fineness and Expressiveness” were considered outcome factors, with lower centrality and causality values. These factors focus more on the visible, intuitive aspects of the furniture's appearance.

Final Weights of Core Factors

The final calculated weights for the core factors are as follows: “Line Liveliness and Natural Flow” – 0.124 ; “Carving Fineness and Expressiveness” – 0.111 ; “Inlay Integration and Exquisite Craftsmanship” – 0.196 ; “Period Style Accuracy and Consistency” – 0.193 ; “Stylistic School Essence and Form Fidelity” – 0.186 ; “Gracefulness and Elegance” – 0.190.

The top four core factors align with the factors showing significant differences in group analysis. This consistency proves that the factors with differences are objectively more important, not just based on group preferences, further validating the DEMATEL model’s calculations.

Implications for the Evaluation System

This study highlights the importance of the core factors with significant group differences, demonstrating the evaluation system's high universality across various application scenarios. The results show that the evaluation system is an effective tool for evaluating the quality of lacquered wood furniture replicas, as specific group preferences do not limit it.

Additionally, the evaluation of specific sample types, such as the Fengxian Hall God Plaque and Qing Dynasty Palace Carved Dragon Round Table, may benefit from adjusting the weights of core factors in future evaluations, particularly in sensitivity and perceptual assessments of lacquered wood furniture.

Limitations and Future Research

This study is constrained by the early-stage development of lacquered wood furniture relic imitation in China. Only a limited number of high-quality imitation samples have been produced, primarily by the Palace Museum, which holds the most extensive Qing dynasty palace furniture collection. The complexity of the imitation process, mainly due to the partial loss of traditional craftsmanship, further limits the availability and diversity of samples. As a result, the evaluation sample set used in this study, while carefully selected, may not fully capture the broader spectrum of existing or future imitations.

In future research, as more imitations of lacquered wood furniture relics are developed and made accessible, efforts should be made to expand the range and diversity of evaluation samples. Additionally, repeated evaluation designs involving the same

participants will be considered further to test the stability and reliability of the evaluation system. These improvements will contribute to the ongoing refinement of a scientific, standardized, and socially grounded evaluation framework, ultimately supporting more rigorous cultural relic imitation, conservation, and exhibition practices.

CONCLUSIONS

In this study, a comprehensive approach was adopted to construct the perceptual evaluation system for lacquered wooden furniture cultural relics imitations:

1. Six subjective evaluation indices were extracted based on the index system developed through the Delphi method. Perceptual vocabulary was collected, and the semantic differential (SD) method was applied, with evaluators rating the samples according to the vocabulary. The principal component analysis (PCA) was then used to reduce the dimensionality of the perceptual evaluation system, resulting in the identification of six core evaluation factors.
2. A secondary PCA verified the mutual independence of these factors, confirming them as the core evaluation elements for perceptual assessment. In exploring the influence of group and sample type differences on evaluation outcomes, significant variations were observed in the evaluation of four core factors: “Inlay Integration and Subtlety,” “Period Style Accuracy and Consistency,” “Stylistic School Essence and Form Fidelity,” and “Gracefulness and Elegance.” These factors proved critical in the sensibility evaluation of lacquered wooden furniture relics.
3. Subsequent application of the DEMATEL model to calculate the influence and weight of each factor showed that the weight distribution and the observed group differences were consistent, thus validating both the group difference analysis and the scientific robustness of the DEMATEL model. The final core factors and associated weights exhibit firm scientific grounding and practical relevance. They are suitable for the quality assessment and acceptance procedures for lacquered wooden furniture cultural relics in museums.

ACKNOWLEDGMENTS

The authors are very grateful to the Palace Museum for providing the evaluation sample materials, to the supervisor, Prof. Fan Zhang, for providing the thesis guidance, and to the volunteers who participated in this current trial.

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Article submitted: April 3, 2025; Peer review completed: May 10, 2025; Revised version received: May 12, 2025; Accepted: June 16, 2025; Published: June 26, 2025.
DOI: 10.15376/biores.20.3.6853-6876