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Study on Imagery Modeling of Solid Wood Chairs in Big Data

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Abstract: With the continuous improvement of people's quality of life and aesthetics, furniture products have higher requirements. Excellent solid wood chairs are the most representative products in furniture to enhance space and taste and whose design may significantly impact consumers' emotional experience and purchase decisions. This study aims to evaluate how the modeling imagery of solid wood chairs affects user preferences and emotional experiences. The development of the current era is inseparable from the analysis of big data. Firstly, a representative sample was obtained by multidimensional scaling (MDS), and the sample was analyzed and evaluated by factor analysis. Moreover, five groups of adjective vocabulary were selected to describe the modeling imagery of solid wood chairs, such as "balanced and coordinated", "unique and novel", "practical and simple", "quality and detailed" and "traditional and plain". Further, the triangular fuzzy theory was applied to analyze and discuss the 12 types of solid wood chairs in the five groups of adjective vocabulary. Then the study verified that the differences in the evaluations of the 12 samples in the "unique and novel" and "quality and detailed" groups were significant, but more minor differences in the groups of "traditional and plain", "balanced and coordinated" and "practical and simple". Through comprehensive comparison, five groups with similar modeling imagery were created, and solid wood chairs with different modeling imagery should be placed in suitable spaces. According to the results of this study, the evaluation of the modeling imagery of solid wood chairs can not only rely on subjective judgments but can be reasonably described through data analysis and mathematical algorithms. It can scientifically and effectively reflect the potential perception needs of consumers on the modeling imagery of solid wood chairs, as well as help to improve the design efficiency of the furniture product development stage.

Keywords: furniture design; solid wood chairs; multidimensional scaling; Kansei engineering; modeling imagery; factor analysis; triangular fuzzy theory

1. Introduction

With the rapid development of education and the economy, people's living standards have been improved, and the public's aesthetics have been dramatically enhanced. In this case, people begin to pay attention to the quality of life. When purchasing products, they pay more attention to the aesthetics of the products' shape [1]. Furniture is an essential living appliance for human life. Furniture is inseparable from people's clothing, food, housing, and transportation and contains positive aesthetic meaning and rich cultural connotations. Improving the human living environment and quality of life is also significant.

With the relaxation of COVID-19 restrictions worldwide, the furniture market will significantly grow in operating revenue. According to Statista data, the operating revenue of the furniture market is expected to reach $809 billion by 2024. The market is expected to grow at an annual rate of 5.31% (CAGR from 2023 to 2027) [2]. Due to the continuous advancement in processing technology, the materials used in furniture are becoming more and more abundant, which can be broadly classified into wood, metal, plastic, etc. [3]. In a survey of the global furniture market in 2021, wood furniture accounts for about 40% occupying the critical market share [4]. In addition, wood furniture is green and beneficial to people's health compared to materials that require the addition of various chemicals

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and processing [5], so consumers have a particular preference for wood furniture. With the rapid economic development in the past two decades, China has become the world's largest furniture producer. The output of China's furniture industry in 2020 was 912.21 million pieces, an increase of 1.7% year-on-year [6]. The market scale of wooden furniture has been expanding, and the furniture industry is also on the rise [7], which strongly represents China's furniture industry.

According to sociologists' analysis, most people spend more than two-thirds of their lives in contact with furniture. In addition to the bed, the chair has the longest contact time and the most closely related items with people, so the solid wood chair is the most market competitive and favored furniture by consumers. There are various kinds of chairs which can be divided into office chairs, dining chairs, bar chairs, leisure chairs, reclining chairs, and children's chairs, etc., according to different usage methods. Solid wood chairs are generally used as dining chairs, lounge chairs, and recliners due to the characteristics of the material, structure, and craftsmanship.

As a source of innovation, design has recently received much attention from researchers and practitioners. More and more furniture manufacturers regard furniture design as an essential strategic asset and core competitiveness [8]. Whether from ancient to modern times or from the East to the West, the chair has been an eternal theme in furniture design [9]. Chair design involves various factors such as shaping, function, material, structure, technology, aesthetics, and ergonomics, with a systematic theoretical basis and rich practical experience. However, it also is the best embodiment of the designer's concept and design level. The chair is a product that highly integrates practicality and art. In addition to meeting the user's functional needs to sit and rest, it is also necessary to consider its unique needs in the intellectual, emotional, aesthetic, and cultural aspects of spirituality [10]. The names of the various parts of the chair, such as the legs, back, surface, and armrests, are similar to human body parts, humane furniture, and even a good chair design with personality. The chair has a self-contained and complete sense of beauty, the beauty of its shape is no less than sculpture, but it also conveys the spirit of culture with the power to dominate the space. Hans J. Wegner, a Danish furniture designer, once said, "Imagine if you could design just one good chair in your lifetime – but that simply cannot be done." It means that chair design is a very challenging task for furniture designers.

Looking back at history, countless classic chair designs emerged. Finnish designer IImari Tapiovaara suggested that the chair's design was the beginning of any interior design. For example, architects should design chairs for their buildings; interior designers should consider chairs in combination with space, and product designers also explore new materials to design chairs. Now there are more and more furniture brands on the market, and the styles of solid wood chairs are also diverse. The styling characteristics of chairs are more easily perceived and distinguished by users than ergonomic features [11]. In addition, different styling attributes can cause different emotional experiences, which can influence the user's preference for styling [12]. In developing and designing solid wood chairs, designers usually work based on their experience and aesthetics. Because users and designers live in different environments and needs, their perception of the product shape is also different, directly affecting the user's preference for solid wood chairs.

In summary, it is meaningful to objectively analyze and study the relationship between different shapes of solid wood chairs and people's visual and psychological factors and explore users' evaluation of various solid wood chairs. On the one hand, it is beneficial to narrow the gap between designers and users on the perception of solid wood chair shapes; on the other hand, it is also conducive to improving the design value of solid wood chairs for furniture manufacturers, designers, and users. Existing solid wood chair size proportion, color, and material are common factors that affect the user's preference for solid wood chair modeling. Thus, solid wood chair modeling design in the whole design process is essential. The designers should aim to meet the potential emotional needs of users and carry out design development work to present a better user experience of solid wood chairs.

People's dining, office, reading, rest, and waiting lifestyles are inseparable from the chair, especially the solid wood chair. It plays a vital role in our home environment, and its modeling aesthetics is one of the critical factors affecting users' purchase and use [13]. Products with different

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shapes may bring different perceived values. Emotion is an essential factor that affects customers' purchasing behavior [14]. First of all, the chair should meet the function of sitting. Many researchers consider solving the problem of the best sitting posture. They deeply study ergonomics and integrate relevant human body data into chair design [15] to make it more comfortable. Then, some researchers tried to design chairs by opening a pneumatic seating system (PASS), a new human-computer interaction tool [16].

Besides, some researchers have used computer-aided and finite element multifunctional analysis to design chairs and analyze their structures to assess the strength of furniture [17,18] effectively. Other researchers applied shape syntax and parametric methods for chair design to enhance the efficiency of mass customization of chairs [19]. With the rapid development of artificial intelligence, researchers also learned to use convolutional neural networks and generative adversarial networks to assist chair design improving design efficiency [20,21]. However, most of the existing research on chair design has focused on the functional and technical aspects, and there needs to be more research on the connection between solid wood chair shape and user emotion. In summary, furniture is a sign of the level of social productivity development in a specific country or region in a particular historical period, and sitting furniture is one of the most sold categories, of which solid wood chairs, as essential to be a single item of furniture, have been less studied in terms of styling design, visual presentation, and visual imagery perception. The results of this study are more scientific and practical because a representative sample was selected through a scientific sample selection method, multidimensional scaling (MDS), and a two-dimensional image of the sample was redrawn to avoid the interference of other factors, such as angle, color, and material.

This study analyzed and explored consumers' visual and psychological perceptions of differently shaped solid wood chairs through objective methods such as perceptual engineering and fuzzy theory to understand consumers' purchase intentions and preferences. First, this study tried to transform consumers' feelings and intentions into design elements and provide a reference for modeling imagery and styles when designing solid wooden chairs. The designers can design products most suitable for consumers and market needs. Secondly, it could enable furniture manufacturers to position brands and furniture styles more accurately according to the characteristics of target users. Thirdly, the modeling imagery research helped analyze consumers' consumption intention on the brand and appearance of the solid wood chairs. Consumers can choose the right solid wood chair according to their home decoration style and personal preferences, which can provide practical style references for users and improve their quality of life. It could further promote the consumer to solid wood chair modeling imagery potential perceived demand research.

2. Materials and Methods

2.1. Research Framework and Process

Kansei Engineering was founded by M. Nagamachi at Hiroshima University about 30 years ago and has spread worldwide. Kansei Engineering aims to develop new products by transforming customers' psychological needs and feelings (Kansei) into design specifications [22]. The objectives of this study are as follows. (1) To use the MDS method to filter a representative sample of solid wood chairs and determine the range and number of adjectives that describe the modeling of solid wood chairs through an expert questionnaire. Factor analysis was used to determine the modeling imagery adjectives that could represent the styling of solid wood chairs. (2) The triangular fuzzy number calculation method was used to evaluate the adjectives describing the samples of solid wood chairs and to obtain the modeling imagery evaluation of the styling characteristics of the representative samples. (3) To integrate and summarize the research results, discuss the characteristics of consumers' styling imagery of these representative solid wood chairs, translate consumers' feelings and intentions into design elements, and provide designers with more detailed references to promote the sustainable development of the furniture industry. This research used solid wood chairs to investigate Chinese consumers' perceptions of modeling imagery. The framework of this research is shown in Figure 1.

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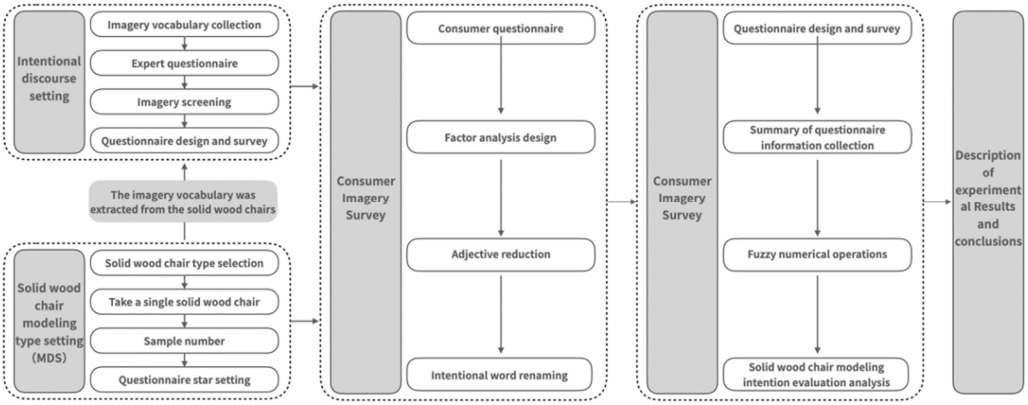

Figure 1. The research framework.

2.2. Selecting Representative Samples

MDS is a technique for multivariate data analysis with reduced dimensionality. MDS transforms a set of points in a high-dimensional space into a low-dimensional space while maintaining the relative distance between pairs of points [23]. In other words, the purpose of MDS is to create a map of objects described only by a proximity matrix (similarity or dissimilarity). It is the representation of objects in a low-dimensional space (usually Euclidean) such that the distances between points reflect dissimilarity in some sense: similar objects are mapped as close to each other. In contrast, different objects are represented as points far from each other [24,25]. When choosing the optimal number of dimensions, reference may be made to the minimum stress index in each dimensional number scheme. The stress index takes values from 0 to 1. The lower the stress index, the more appropriate dimensionality [26]. Regarding Kruskal's interpretation, the degree of matching at different stress indices is shown in Table 1.

Table 1. Kruskal stress index interpretation.

Stress	Matching Degree
0.200	Poor
0.100	Fair
0.050	Good
0.250	Excellent
0.000	Perfect

First, the samples of this study were taken from the official websites and furniture-sharing platforms of domestic and international furniture brands. 300 clear and background interference-free images of three-quarters of solid wood chairs were collected as samples during this process. Due to many samples, the solid wood chairs with poor quality and high similarity were removed through focal discussion and pre-test by 4 design experts, and 123 samples of solid wood chair shapes were finally selected. The remaining samples were coded using Adobe Photoshop; grayscale processing was performed, and the logo was removed to eliminate the impact caused by color and branding. After that, 15 experts were invited to participate in the test (8 furniture design teachers working in a university, 4 furniture designers with over 10 years of work experience, and 3 Ph.D. students majoring in design, shown in Figure 2). Based on their subjective perceptions, the morphological features of the solid wood chairs in the sample were grouped according to the similarity (morphological features included back, armrests and legs, cross brace 1, cross brace 2, and chair surface, shown in Figure 3). A total of 5-15 groups were created, based on which a similarity matrix was formed, which was then converted into a similarity matrix for MDS analysis. Finally, the results

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of the MDS were used as categorical variables to cluster the samples using cluster analysis to provide the final most significant samples.

Figure 2. Participant was in test.

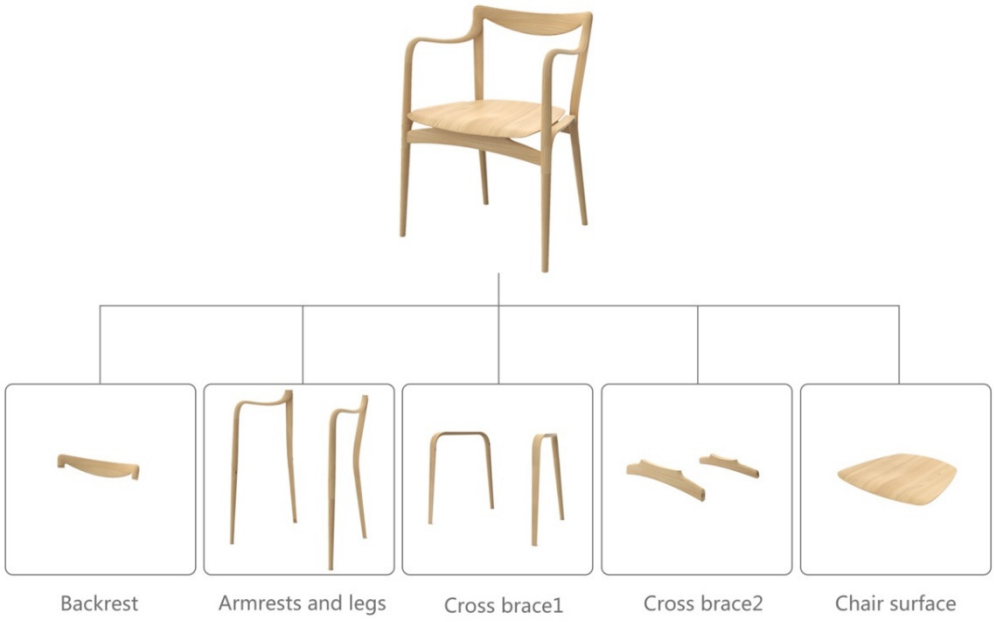

Figure 3. The formation of smartphone rear cameras.

2.3. Extraction and Factor Analysis of Modeling Imagery Adjectives

The adjectives related to the modeling of solid wood chairs were extracted from the official websites of furniture brands, shared platform websites, and related furniture books. After subjective sorting, 140 adjectives were selected, and other questionnaires were administered to experts. The adjectives were categorized using the questionnaire method. A total of 36 experts with experience in furniture design were invited to participate in the experiment, including 6 furniture company designers, 7 university teachers in design major, 15 postgraduate students, and 8 Ph.D. students in major of design. Participants were asked to select 40-50 adjectives from 140 adjectives that best matched the modeling imagery of the solid wood chair. At last, the first 40 most recognizable adjectives were selected for further analysis based on the corresponding scores from high to low.

Factor Analysis (FA) is a statistical method commonly used to simplify complex data [27]. Its main goal is to replace the original data structure with fewer dimensions while retaining most of the information contained in the original structure [28]. One factor combines multiple correlated variables and can measure the same characteristics. Factor analysis can use fewer dimensions to

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represent the original data structure and retain most of the information that the original data can provide [29,30]. According to Kaiser's research, the closer the KMO value is to 1 indicates the higher degree of variance correlation and is more suitable for factor analysis [31]. In short, this study used factor analysis to limit the number of modeling imagery adjectives. At this stage, 40 modeling imagery adjectives were obtained, and a consumer survey was completed using a 5-point Likert scale to obtain the lexical variance. The scale includes "very inappropriate", "inappropriate", "moderate", "appropriate", and "very appropriate". The questionnaires were collected from 112 participants. We conducted a factor analysis of the obtained results, and the corresponding factor elements were elicited in the modeling imagery adjectives. Finally, the factors were renamed according to the characteristics of the modeling imagery adjectives in the factor elements.

2.4. Modeling Imagery Opinions in Fuzzy Theory

Fuzzy theory is a scientific method used to study and process information and data. It was proposed by the control theorist L.A. Zadeh from the University of California, which mainly includes aspects of fuzzy set theory, fuzzy logic, fuzzy reasoning, and fuzzy control. This process is computed through rigorous mathematical methods and is used to deal with imprecise and fuzzy data to solve decision problems in fuzzy environments [32–34]. Zadeh argues that human ideas, reasoning, and perception of things are inherently highly fuzzy. Therefore, it is necessary to apply fuzzy and logical concepts to describe the degree of priority of the matrix. Through membership functions, it is possible to quantify the subject's internal feelings, translating them into values between 0 and 1, where the values indicate potential influences and their respective effects.

Fuzzy theory, in applying meaning measurement, is one of the best research methods. Nowadays, many design studies apply the fuzzy theory [35–37]. These studies usually use fuzzy numbers, of which the conventional types are triangular fuzzy numbers, trapezoidal fuzzy numbers, and ordinary fuzzy numbers, with triangular fuzzy numbers being the most common. The unique feature of the triangular fuzzy number is its membership function. The probability distribution is in the form of a triangle [38]. Suppose an int function $\boldsymbol{\mu_i(x)}$ of a triangular fuzzy number which is $\boldsymbol{t}$= ($\boldsymbol{t_1}$, $\boldsymbol{t_2}$, $\boldsymbol{t_3}$). When $\boldsymbol{t_1}$, $\boldsymbol{t_2}$, $\boldsymbol{t_3}$ are real numbers and $\boldsymbol{t_1 \le t_2 \le t_3}$. This membership function is shown in Figure 4 [39].

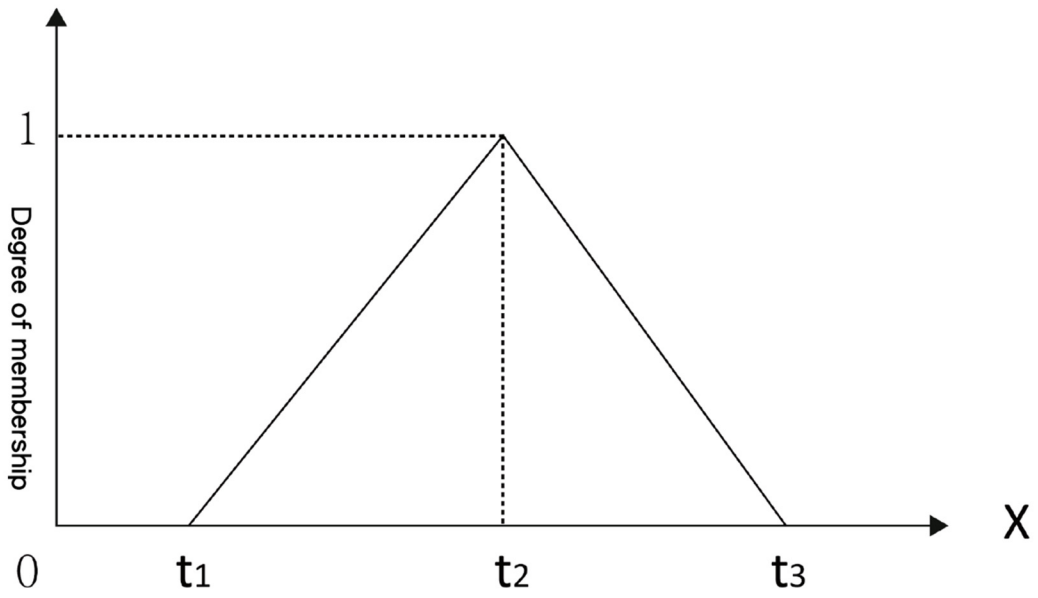

Figure 4. Membership function of a triangular fuzzy number.

This study used the fuzzy meaning of 7 ranks as a ranking method (see Table 2). Consumers were asked to rank a representative sample. The results of the fuzzy ranking were achieved by a 7-

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level triangular membership function, making the fuzzy meanings triangular fuzzy numbers after quantification. The triangular membership function is shown in Figure 5.

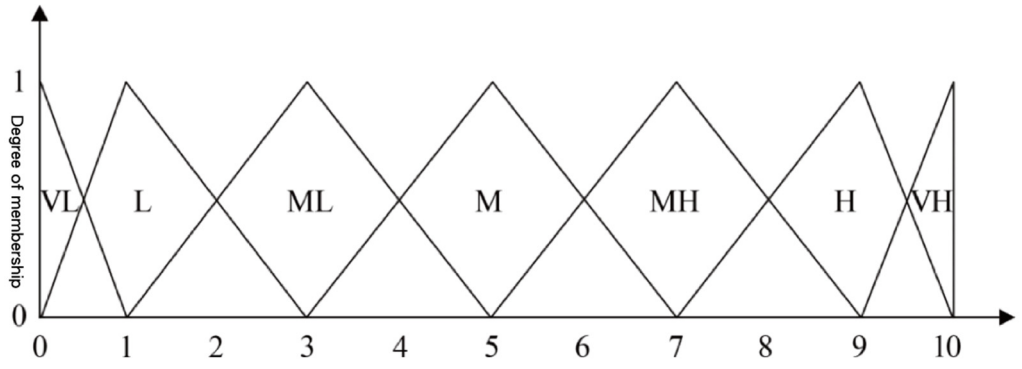

Figure 5. Membership function of a triangular fuzzy number.

Table 2. Linguistic variables for the importance and the ratings.

Linguistic Variables
Very Low (VL)
Low (L)
Medium Low (L)
Medium (M)
Medium high (MH)
High (H)
Very High (VH)

Demulsifying the triangular fuzzy numbers in the membership function for further analysis and comparison results in crisp values. The maximizing set and minimizing set method proposed by Chen in 1985 [40] is the most commonly used defuzzification method adopted in this study. The principle is to use the weights of two triangular fuzzy numbers and reduce them to the total utility value.

The questionnaire used in this study was designed according to the principle of fuzzy meaning. The questionnaire adopted a 7-point Likert scale with 12 samples paired with five adjective groups. For example, how do you rate the balance of coordination of sample S1? How do you rate the uniqueness and novelty of sample S1? How do you rate the practical simplicity of sample S1? How do you rate the quality details of sample S1? How do you rate the traditional simplicity of sample S1? That helps determine consumers' opinions on the 12 solid wood chair samples. After fuzzing the results, the total utility values for each form of the modeling imagery were obtained, charted, and further analyzed for the 12 samples. These results can inspire furniture brands, designers, and consumers.

3. Results and Discussion

3.1. Results of Representative Sample Selection

The study achieved the best results by MDS analysis with 4 dimensions (pressure = 0.08952), as shown in Table 3.

Table 3. The stress and of different dimensions of MDS analysis.

Dimensions	Stress
2	0.15254
3	0.11235

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4	0.08952

The results of the MDS were used as a categorical variable to classify the samples into 12 categories by cluster analysis. In contrast, the distance of each sample from the center of the category was obtained (see Table 4). The sample with the smallest distance from the center is the representative sample of its category. In addition, to reduce the interference of other factors and copyright issues, we applied Adobe Illustrator to convert these 12 representative samples into two-dimensional images of uniform style and angle (see Figure 6). The final converted 12 representative samples are shown in Figure 7.

Table 4. The results of cluster analysis.

Sample	Category	Distance	Sample	Category	Distance
S7	1	4.84651	S26	7	2.90934
S118	2	3.10012	S36	8	3.51596
S102	3	4.92846	S43	9	2.47886
S50	4	2.28655	S12	10	2.76357
S88	5	4.84236	S76	11	4.80691
S23	6	2.64236	S63	12	4.18767

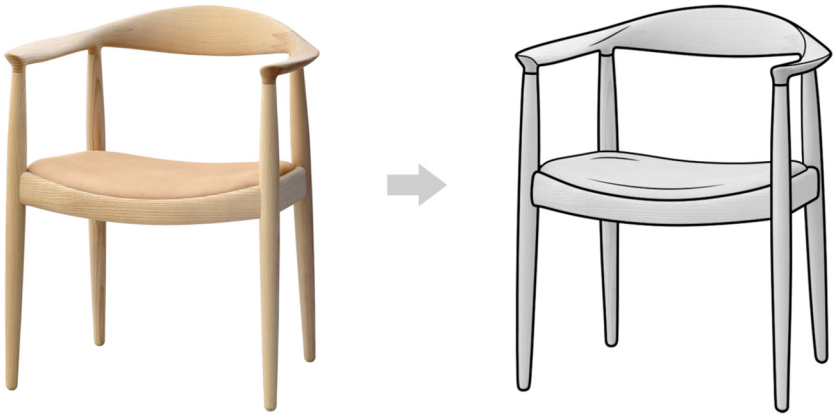

Figure 6. Representative samples converted into 2D images.

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Figure 7. Twelve representative samples.

3.2. Results of the Modeling Imagery Adjectives Extraction and Factor Analysis

A questionnaire method with the participation of experts was used to classify modeling imagery adjectives. A total of 32 experts were invited to participate in the experiment, including 6 teachers of literature majors, 20 postgraduate students, and 6 Ph.D. students who majored in design. These participants were asked to select 40-50 adjectives from 140 adjectives that best matched the modeling imagery adjectives of the solid wood chair concerning a two-dimensional diagram of a representative sample (selected by a multiscale approach). Finally, the 40 most recognized adjectives were selected for further analysis based on the average number of selections (see Table 5).

Table 5. The 40 adjectives that were most recognized.

Quality	Artisanal	Detailed	Harmonious	Stylish
Crafted	Elegant	High-quality	Coordinated	Aligned
Simple	Durable	Overall	Eco-friendly	Lightweight
Practical	Safe	Sturdy	Novel	Balanced
Natural	Stable	Modern	Precise	Concordant
Refined	Superior	Demure	Orderly	Austere
Smooth	Unique	Traditional	Quaint	Delicate
Exquisite	Innovative	Serviceable	Plain	Comfortable

The questionnaire survey combined the 40 most recognized adjectives with 12 representative samples. A total of 122 questionnaires were collected by convenience sampling, of which 112 were valid (52 by male and 60 by female). The data were subjected to a first-factor analysis using SPSS. Then after component analysis, factors with the absolute value of factor loadings higher than 0.6 (23 factors in total) were selected for the second-factor analysis, as shown in Table 6.

Table 6. The 23 adjective factors with absolute load capacity value higher than 0.6.

Adjectives	Initial	Extraction	Adjectives	Initial	Extraction
Harmonious	1.000	0.782	Safe	1.000	0.761

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Coordinated	1.000	0.765	Serviceable	1.000	0.671
Orderly	1.000	0.719	Practical	1.000	0.627
Aligned	1.000	0.703	Crafted	1.000	0.745
Balanced	1.000	0.686	Quality	1.000	0.718
Concordant	1.000	0.638	Detailed	1.000	0.717
Unique	1.000	0.774	Exquisite	1.000	0.601
Novel	1.000	0.768	Traditional	1.000	0.786
Innovative	1.000	0.745	Plain	1.000	0.637
Stylish	1.000	0.694	Simple	1.000	0.742
Modern	1.000	0.656	Elegant	1.000	0.718
Stable	1.000	0.805			

The KMO value was 0.866, obtained by factor analysis, and Bartlett's test result was 3402.315 (df=780, p=0.000), reaching statistical significance. This result indicates that the correlation matrix in the original cluster has common factors and is suitable for factor analysis.

The transformed matrix showed significant differences in the five components derived from the second-factor analysis. After component analysis, factors with absolute values of factor loadings higher than 0.6 (16 factors in total) were selected, as shown in Table 7. Therefore, all 16 adjectives and 5 component factors from this factor analysis can be used in the following analysis.

Table 7. The component matrices following the transformation.

Adjectives	Component				
	1	2	3	4	5
Aligned					
Balanced					
Concordant					
Coordinated					
Orderly	0.838	0.867			
Unique	0.812	0.806			
Novel	0.807	0.800			
Innovative	0.750	0.669			
Modern	0.727				
Practical					
Simple			0.741	0.786	
Quality			0.608	0.751	
Crafted				0.632	
Detailed					
Traditional					0.860
Plain					0.638

By the second factor analysis, five groups consisting of 16 adjectives were established and named "balanced and coordinated", "unique and novel", "practical and simple", "quality and detailed" and "traditional and plain" for further study, as shown in Table 8.

Table 8. Naming of each factor (groups of adjectives).

Factor	Adjective Groups	Factor Naming	Code
1	Aligned, Balanced, Concordant, Coordinated, Orderly	Balanced and Coordinated	B&C
2	Unique, Novel, Innovative, Modern, Elegant	Unique and Novel	U&N

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3	Practical, Simple, Serviceable	Practical and Simple	P&S
4	Quality, Crafted, Detailed	Quality and Detailed	Q&D
5	Traditional, Plain	Traditional and Plain	T&P

3.3. Results of Fuzzy Manipulation

Based on the 12 representative samples (two-dimensional images) shown in Figure 5, combined with the five renamed sets of adjective vocabularies in Table 8, a modeling imagery evaluation questionnaire could be derived, which was designed according to the 7-point Likert scale corresponding to the 7-level fuzzy meaning, as shown in Table 2. 120 participants were invited using a convenience sampling method, and 117 valid questionnaires were received, including 51 males and 66 females. Their ages ranged from 18 to 40 years old. The questionnaire results were quantified as triangular fuzzy numbers using a triangular membership function to quantify the fuzzy meaning. After summing and averaging, their mean values are shown in Table 9. Finally, the triangular blur maps were drawn based on the participants' modeling imagery evaluation of the 12 representative samples, as shown in Figure 7.

Table 9. Ranking and mean of modeling imagery evaluation of 12 representative samples of solid wood chairs.

Balanced and Coordinated	Unique and Novel	Practical and Simple	Quality and Detailed	Traditional and Plain
S7（5.4,7.1,8.5）	S9（5.2,7.1,8.5）	S1（5.3,7.1,8.6）	S7（5.1,6.9,8.4）	S7（4.4,6.2,7.9）
S1（4.7,6.6,8.2）	S10（5.0,6.8,8.4）	S2（5.0,6.8,8.4）	S1（4.8,6.5,8.1）	S2（4.1,5.9,7.6）
S11（4.5,6.4,8.1）	S6（4.4,6.2,7.9）	S7（4.9,6.7,8.3）	S9（4.3,6.1,7.8）	S1（4.0,5.8,7.5）
S12（4.5,6.4,8.1）	S7（4.4,6.2,7.9）	S9（4.6,6.5,8.1）	S11（4.1,6.0,7.8）	S12（3.9,5.8,7.6）
S9（4.5,6.3,8.0）	S8（4.3,6.2,7.9）	S8（4.3,6.2,7.8）	S6（4.1,5.9,7.6）	S11（3.9,5.7,7.6）
S2（4.4,6.3,8.0）	S1（4.0,5.8,7.5）	S3（4.2,6.1,7.8）	S8（3.9,5.8,7.5）	S4（4.0,5.7,7.2）
S8（4.4,6.2,7.8）	S11（3.7,5.5,7.3）	S11（4.1,6.0,7.7）	S10（3.9,5.6,7.3）	S3（3.7,5.6,7.3）
S5（4.4,6.2,7.7）	S3（3.4,5.2,6.9）	S5（3.9,5.8,7.5）	S3（3.8,5.6,7.4）	S5（3.9,5.6,7.4）
S10（4.0,5.7,7.4）	S12（3.4,5.2,6.9）	S6（3.9,5.8,7.5）	S12（3.8,5.6,7.4）	S9（3.7,5.5,7.3）
S6（3.9,5.7,7.4）	S2（2.9,4.6,6.5）	S12（3.8,5.7,7.5）	S2（3.7,5.6,7.3）	S8（3.6,5.5,7.2）
S3（3.8,5.6,7.4）	S5（2.8,4.4,6.2）	S10（3.5,5.2,7.0）	S5（3.3,5.1,6.8）	S6（3.6,5.4,7.2）
S4（3.8,5.5,7.1）	S4（1.5,2.8,4.4）	S4（3.3,5.0,6.7）	S4（1.9,3.5,5.3）	S10（3.4,5.1,6.8）

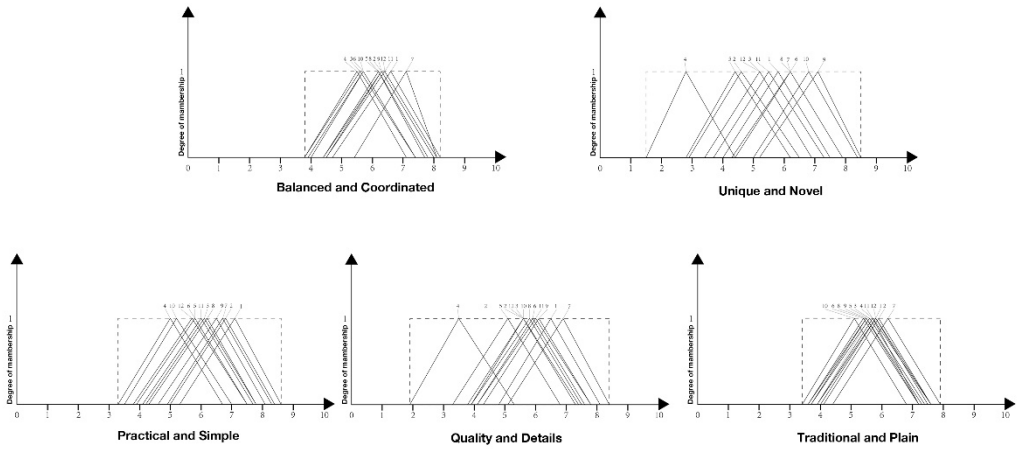

Figure 8. The triangular fuzzy numbers of the 12 representative samples in each modeling imagery evaluation.

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Based on Table 9, the absolute utility values of the modeling imagery evaluation for 12 representative samples (see Table 10) were obtained by deblurring the triangular fuzzy numbers of each sample. The detailed calculation is as follows:

Presume n numbers of triangular fuzzy number in a membership function, which was defined as $\tilde{t}_i = (\tilde{t}_{i1}, \tilde{t}_{i2}, \tilde{t}_{i3})$, i=1, 2,...,n; then the minimum $\mu_G(x)$ and maximum $\mu_M(x)$ are G and M respectively as shown in equation (1).

$$UT(\tilde{t}_i) = \frac{\left[\frac{(\tilde{t}_{i3} - X_{min})}{((X_{max} - X_{min}) + (\tilde{t}_{i3} - \tilde{t}_{i2}))} + 1 - \frac{(X_{max} - \tilde{t}_{i1})}{((X_{max} - X_{min}) + (\tilde{t}_{i2} - \tilde{t}_{i1}))}\right]}{2}, \quad i = 1, 2, \ldots \ldots n \tag{1}$$

Table 10. Absolute utility values of 12 representative samples of solid wood chairs.

Samples	Balanced and Coordinated	Unique and Novel	Practical and Simple	Quality and Detailed	Traditional and Plain
S1	0.5868	0.4754	0.6621	0.5787	0.4754
S2	0.5454	0.3097	0.6195	0.4439	0.4900
S3	0.4493	0.3878	0.5164	0.4493	0.4439
S4	0.4305	0.0278	0.3603	0.1451	0.4570
S5	0.5287	0.2775	0.4729	0.3732	0.4516
S6	0.4608	0.5338	0.4729	0.4900	0.4203
S7	0.6644	0.5232	0.6048	0.6324	0.5338
S8	0.5313	0.5309	0.5284	0.4729	0.4294
S9	0.5484	0.6566	0.5722	0.5192	0.4348
S10	0.4724	0.6195	0.3932	0.4485	0.3750
S11	0.5599	0.4348	0.5019	0.5046	0.4667
S12	0.5599	0.3878	0.4614	0.4493	0.4758

The above results illustrate that, as Figure 7 shows, the different kinds of solid wood chairs differ less in the visual evaluation of “balanced and coordinated”, “practical and simple” and “traditional and plain”, but are more differentiated in terms of “unique and novel” and “quality and detailed”.

As shown in Table 9, S7 generally ranked high in all evaluations. It is particularly outstanding in the three aspects of “balanced and coordinated”, “quality and detailed,” and “traditional and plain”, and better in the other two aspects. S1 scores the highest in “practical and simple” and is more average in “quality and detailed”. S9 and S10 score high in “unique and novel” and “balanced and coordinated”.

Table 11. Five groups of solid wood chairs modeling images, with a similar comprehensive visual evaluation.

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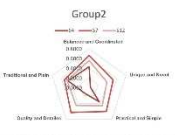
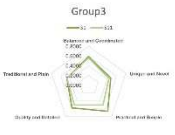
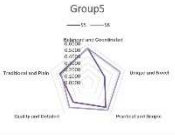
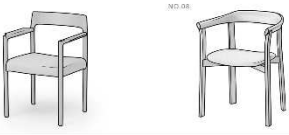
Group	Radar chart for visual images	Grouping of modeling features and images of solid wood chairs
1		
2		
3		
4		
5		

As Table 11 shows, the shape of Group 1 solid wood chairs generally conforms to the "balanced and coordinated" and "practical and simple". Group 1 in solid wood chairs have a strong sense of the overall armrest backrest, smooth and beautiful lines of appearance; the connection of the chair surface and legs is relatively simple and practical, with no extra parts, making people feel that these are two chairs with excellent comfort.

In Group 2, solid wood chairs are generally "balanced and coordinated", "traditional and plain" and "practical and simple". Group 2's solid wood chairs have the taste of account furniture and classical furniture. Group 3's solid wood chair, the components are concealed connection, and the transition details are exceptionally delicate and full of quality. Group 4 solid wood chair styling is unique and novel in visual recognition to a certain degree. Group 5 in the solid wood chair shape, the proportional relationship between the components is more balanced and coordinated, soft cushion design can increase the comfort of the user sitting.

As can be seen from Table 11, S2 and S3 are very close to the modeling imagery evaluation value, scoring high in "practical and simple" and "traditional and plain". However, they do not perform as well in terms of "unique and novel" and "quality and detailed".

S4, S7, and S12 have similarities in terms of "traditional and plain" and "practical and simple". s7 ranks first in terms of "balanced and coordinated", "quality and detailed", and "traditional and plain", and tops in terms of "unique and novel" and "practical and simple". S1 and S11 are very close to each other in modeling imagery evaluation and score high in terms of "practical and simple" and "quality and detailed". S6, S9, and S10 are rich in styling variations, especially S10 has elegant curves and visual aesthetics. S5 and S8 have some similarities in terms of "balanced and coordinated", "traditional and plain" and "practical and simple". According to the questionnaire, these two types of solid wood chairs are in the middle position in all aspects. Respondents generally believe the chair surface is a soft package design and should be comfortable for sitting.

3.4. Experimental Validation

To study the user groups' modeling imagery evaluation of each solid wood chair, this experiment was conducted using semi-structured interviews through convenience sampling with 20 participants (10 furniture designers and 10 people with furniture purchasing experiences), shown in

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Figure 9. Among them, 12 males and 8 females. The interviews took 20 minutes for each participant, who was given USD 7 as payment. The interview results showed that the "traditional and plain" and "balanced and coordinated" solid wood chairs were suitable for placing in the tea space, with an antique and calm atmosphere that would show the cultural sophistication of the user. The "practical and simple" and "quality and detailed" solid wood chairs with a better sense of comfort and taste due to their simple shape and exquisite craftsmanship, suitable for modern minimalist spaces, simple and elegant, giving users a naturally warm and pleasant feeling. The "unique and novel" solid wood chairs are more suitable for aesthetic spaces, cafes, and restaurants due to their rich colors and stylish shapes, and contemporary young people love their distinctive forms. A complete understanding of the preferences of different ethnic groups for furniture styles provides a reference for consumers in purchasing furniture and for designers in the furniture styling phase.

Figure 9. The participant was in a semi-structured interview.

4. Conclusion

This study used MDS, cluster analysis, expert questionnaire, factor analysis, fuzzy theory, and semi-structured interviews to study the modeling imagery of solid wood chairs. Since the accuracy of the evaluation samples and modeling imagery adjectives further affects the objectivity and accuracy of the study results, we first used MDS and cluster analysis to sort out the representative samples; then, the expert questionnaire and factor analysis were used to select the modeling imagery adjectives effectively. Finally, the modeling imagery evaluation of solid wood chairs was further analyzed using the triangular fuzzy number operation in fuzzy theory. The sample selection method of this study is a scientific technique that differs from previous ones because the samples were converted to two-dimensional images to avoid the interference factors such as angle, color, texture, and brand preference. The study revealed the composition of solid wood chairs (shown in Figure 3) and provided structural and detailed references for designers to use when designing chairs. Moreover, 123 images of solid wood chairs (shown in Figure 2) were collected to form a database of solid wood chairs so that companies and designers could better utilize the results of this study.

The results show that different shapes of solid wood chairs present unique visual effects. A total of 12 representative samples differed less in the modeling imagery evaluation of "balanced and

coordinated", "practical and simple" and "traditional and plain". However, it was more differentiated in terms of "unique and novel" and "quality and detailed". There were overall similarities in some samples; for example, for S1 and S11, some assessments were similar. Therefore, furniture manufacturers and designers may consider alternatives to both.

The results of this study can be applied to the design development of chairs. For further research directions, combining materials and processes may be considered. The method shown in this paper aims to obtain the evaluation values of modeling imagery for solid wood chairs, which requires creating a chair design system. It is worth considering that there are differences in consumers' lives in different countries, which may lead to different emotional needs and aesthetic preferences. The participants were from mainland China and had similar cultural backgrounds. Further research could also include the cultural background as a variable if the consumers' tendencies towards modeling imagery are handled correctly.

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