Research on User Perception Imagery-Based Experience Analysis and Associated Factors of Bamboo Chairs

Abstract: [Objective] This study aims to analyze the user experience of bamboo chairs from a perception imagery perspective and explore the relationships between various factors and the dimensions of chair experience. The goal is to provide a scientific basis for enhancing the aesthetics, comfort, and safety of bamboo chair designs. [Methods] From the perspective of affective engineering, a combination of Semantic Differential (SD) method, factor analysis, and psychological scale techniques was used in the study. [Results] Fifteen decomposed factors significantly influenced aesthetics, comfort, or safety, playing a key role in the user experience of bamboo chairs. [Conclusion] (1) The design of bamboo chairs should prioritize the unique characteristics of bamboo as the primary consideration. (2) The design should focus on the smoothness of the overall shape. (3) Strengthening ergonomic factors not only improves the comfort of bamboo chairs but also significantly enhances their aesthetic appeal.

Keywords: Bamboo chair, User perception, Correlation study, Affective engineering.

In his poem *On the Green Bamboo Pavilion of the Monk in Quanshan,* Su Dongpo once said: “I would rather go without meat than live without bamboo; lack of meat makes one thin, lack of bamboo makes one vulgar”. [1] In China, bamboo is one of the “Four Gentlemen of Flowers”, symbolizing the integrity and humility of a gentleman, and carries unique cultural connotations. Bamboo is a renewable resource, with low planting costs and easy harvesting, making it an important material in furniture design and manufacturing. China has abundant bamboo resources and a relatively high level of development and utilization, with the sales of bamboo furniture ranking among the top in the world. [2] Currently, due to the relative scarcity of wood resources in China, the design and manufacture of bamboo furniture have received increasing attention, and related research has become a hot topic in academia. For example, Jiang Lingfeng et al. proposed new insights into the design of bamboo chairs and their cultural transmission functions based on affective engineering theory, the SD semantic differential method, and Zen design concepts. [3] Pan Sheng et al. suggested that, from the perspectives of product design thinking, user service, and material characteristics, bamboo furniture will rapidly develop and become widely popular worldwide [4]. Hu Chengyi proposed that bamboo products not only meet functional needs but also provide dual emotional care through cultural and natural connections. [5] F. Yuan et al., through pressure distribution testing, demonstrated that bamboo chairs have a more effective pressure-relieving effect on the human body compared to office chairs. [6] V. Laemlaksaku et al., using satisfaction testing, found that modern bamboo chairs are more comfortable than traditional chairs. [7] LIU Ling-ling et al. summarized the combination of fine bamboo weaving techniques

and parametric modeling technology through the Rhino-based parametric plugin Grasshopper platform, which can expand the application of parametric design in the design and manufacturing of bamboo furniture.[8] N. Klaywises et al. proposed that bamboo can be developed into furniture products that effectively utilize the material, adapting to natural forms and enhancing both functionality and aesthetic appeal. [9]

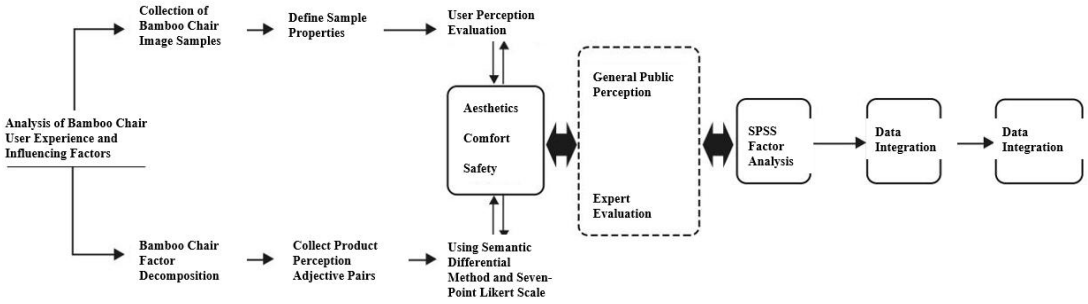
This paper, based on user perception imagery, analyzes the user experience of bamboo chairs in terms of three dimensions: aesthetics, comfort, and sense of security. It explores quantitative analysis approaches and methods for user perception in bamboo chair design and evaluation, and summarizes the key influencing factors of bamboo chair design. The findings of this study provide a basis for the application of bamboo materials in chair design and the enhancement of user experience, with methods and conclusions that can serve as a reference for related research.

1. Research Approach

1.1 Research Approach

When choosing seating products, users often rely on their self-perception to define the product. The most immediate aspect that a product presents to people is its form characteristics, which serve as representations of the product's quality and value. In an era where consumer decisions are based on user perceptions, the form of the product has become an important medium for communication between consumers and designers.[10] When people see a product, they automatically form specific associations with it. Against this backdrop, this study constructs a bamboo chair user perception evaluation system, which includes three factors: aesthetics, comfort, and safety. A stratified sampling method is used to select typical samples from different types of bamboo chairs. With a focus on visual perception, a combination of quantitative analysis and expert evaluation is used to conduct research on the associated factors guided by user perception. The research framework is shown in Figure 1.

Figure 1 Research framework



2 Research Methods

2.1 Sample Selection

A total of 320 bamboo chairs were widely selected, categorized into different groups, and then subjected to stratified sampling. Ultimately, 32 representative bamboo chairs were chosen as the samples for factor analysis. Figure 2 shows some of the samples used in the experiment.

The images of the samples used in the experiment followed these principles:

(1) All images had the same basic perspective;

(2) Decorations and backgrounds that could interfere with the results were avoided;

(3) All images had the same resolution;

(4) The categories and styles were balanced.

Figure 2: Example of a research sample

2.2 Imagery Perception Evaluation Experiment

The study conducted an imagery perception evaluation based on a public questionnaire, targeting multiple user groups, and a correlation factor quantification centered around academic experts. By analyzing the correlation of statistical data, the study identified the key factors that significantly influence group perception imagery and performed a comparative and integrated analysis.

Evaluator Selection: A combination of online and offline methods was used for selecting evaluators. The selection process followed a stratified sampling method, covering different age groups and genders. Among the evaluators, 55.6% were male and 44.4% were female. Adults aged 18 to 60 made up 74.4%, while special age groups—children aged 5 to 18 (14.4%) and elderly individuals aged 61 and above (11.2%)—were also included for comparative study. Data collection was carried out based on affective engineering principles, using methods such as the Semantic Differential (SD) method.

2.3 Imagery Scale and Seven-Point Likert Scale

The imagery scale is a psychological concept developed based on the Semantic Differential (SD) method. It involves the measurement and analysis of the psychological quantity by evaluating how individuals perceive a particular object, thereby studying the imagery scale of that object . [11]In imagery evaluation, “adjective pairs” are used in conjunction with the Likert scale to assign values. The scale consists of a set of paired statements, with each statement having seven possible response levels ranging from “strongly agree” to “strongly disagree”. These levels are measured with values of -3, -2, -1, 0, 1, 2, and 3. Data is collected from a statistically significant number of respondents using the psychological scale, allowing for a quantitative analysis of the overall imagery scale evaluation and the categorical imagery scale evaluation for each sample image. In this study, the sample images are evaluated based on three criteria: aesthetics, comfort, and safety, using a seven-point Likert scale.

The calculation formula for the imagery evaluation value of a sample is as follows:

$$\mu_j = \sum_{i=1}^{n} j_i / n$$

When evaluating sample j, the imagery evaluation value μ_j is used as the core indicator. This evaluation is further refined into three dimensions: aesthetics, comfort, and safety. Each evaluator (a total of n evaluators) provides a score for sample j, denoted as j_i. During the statistical processing, not only is the overall imagery average of the sample calculated, but the differences in imagery evaluation between different groups are also analyzed in depth, leading to multi-dimensional, differentiated statistical results.

2.4 Design Factor Decomposition

To quantitatively analyze the relationship between user imagery scale and chair design, the study established a design factor decomposition system based on six categories—form, color, material, function, backrest, and armrest—comprising 29 descriptive factors. The values for each factor were assigned based on expert group decision-making, with a value range from -3 to 3, using the mean of expert evaluations. The design factor decomposition system established in this study is shown in Table 1.

Table 1: Decomposition of bamboo furniture design factors

Indicator Type	Refined Indicators	Evaluation Adjectives
Overall	Structural Complexity	Simple — Complex
	Structural Permeability	Hollow — Solid
	Modernity of Style	Modern — Traditional
	Lightness of Volume	Light — Heavy
	Curvature of Lines	Straight Line — Curved Line
	Individuality of Shape	Individual — Conventional
	Abstraction of Decoration	Abstract — Concrete
	Richness of Decoration	Rich — Simple
	Richness of Layers	Single — Rich
Color	Color Contrast	Contrast — Harmony
	Color Brightness	Bright — Dull
	Color Richness	Diverse — Single
	Hue	Subtle — Vibrant
	Color Temperature	Cool — Warm
Material	Material Hardness	Firm — Soft
	Texture Clarity	Clear — Faded
	Material Richness	Diverse — Single
Backrest	Backrest Enclosure	Open — Enclosed
	Backrest Size	Small (None) — Large
	Backrest Fit	Straight — Fitted
	Backrest Height	Low — High
Armrest	Armrest Volume Sense	Weakened — Highlighted
	Armrest Length	Short (None) — Long
	Armrest Height	Low — High
Function	Functional Diversity	Single — Diverse
	Flexibility and Variability	Flexible — Fixed
	Human-Machine Integration	Few — Many
	Functional Leisure	Leisure — Office
	Functional Practicality	Decorative — Practical

3 Results and Analysis

3.1 Overall Correlation

As shown in Table 2, overall, users' perception of the aesthetics of bamboo chairs is significantly correlated with 15 decomposed factors, perception of comfort is significantly correlated with 16 decomposed factors, and perception of safety is significantly correlated with 15

decomposed factors.

The 15 indicators—structural permeability, lightness of volume, curvature of lines, individuality of shape, color temperature, backrest enclosure, backrest size, backrest fit, backrest height, armrest volume sense, armrest length, armrest height, functional diversity, human-machine integration, and functional practicality—have significant effects on all three dimensions: aesthetics, comfort, and safety. These factors are of utmost importance for bamboo chair design.

In terms of the strength of influence, among all the related factors, the correlation coefficients between backrest height and backrest fit with comfort perception are the highest, both being 0.778. This indicates a very clear positive correlation between these two factors.

3.2 Correlated Factors of Aesthetic Perception

The correlated factors that significantly influence the aesthetic experience, ranked by correlation coefficient from high to low, are as follows: Backrest fit (0.729) > Human-machine integration (0.684) > Backrest height (0.681) > Armrest height (0.600) > Curvature of lines (0.590) > Functional diversity (0.549) > Armrest volume sense (0.526) > Lightness of volume (0.515) > Armrest length (0.514) > Backrest enclosure (0.494) > Structural permeability (0.489) > Backrest size (0.474) > Functional practicality (0.417) > Individuality of shape (0.365) > Color temperature (0.358).

Backrest fit has the most significant impact on the aesthetic experience of bamboo chairs and is an important approach for enhancing the aesthetic appeal of the chair. This characteristic is also evident in many chair designs that emphasize formal beauty, such as the Wassily chair, the Barcelona chair, and others.

Human-machine integration, backrest height, and armrest height have an impact that is second only to backrest fit. A reasonable level of human-machine integration, such as adjustability and supportive elements (e.g., lumbar and neck supports), aligns more closely with people's visual habits regarding chairs, thereby significantly enhancing the aesthetic experience of bamboo chairs. Backrest height and armrest height have important aesthetic and decorative value, directly influencing the perception of beauty.

Smooth lines, diverse functions, the lightness of volume, and the transparent, airy shape are also closely related to the aesthetic appeal of bamboo chairs. Bamboo material has excellent

elasticity and toughness, which provides advantages that other materials cannot easily match, especially in the processing of smooth curves in chair designs. How to leverage this advantage of bamboo material and balance these factors is a key issue that needs to be addressed in enhancing the aesthetic experience of bamboo chairs.

Moreover, innovative and unique shapes, along with the color temperature of the material, also play a significant role in enhancing the aesthetic experience.

The research results show that there are multiple possible ways to enhance the aesthetic experience of a chair. The combination and interaction of various factors create a wide variety of chair forms. This also helps to explain the rich diversity of bamboo chair design in both historical design processes and the contemporary consumer market.

3.3 Correlated Factors of Comfort

The correlated factors that significantly influence the comfort experience, ranked by correlation coefficient from high to low, are as follows: Backrest fit (0.778) = Backrest height (0.778) > Human-machine integration (0.767) > Armrest height (0.697) > Armrest volume sense (0.628) > Backrest size (0.612) > Lightness of volume (0.591) > Functional diversity (0.587) > Armrest length (0.577) > Backrest enclosure (0.554) > Curvature of lines (0.538) > Structural permeability (0.524) > Functional practicality (0.512) > Individuality of shape (0.465) > Color temperature (0.383) > Material hardness (0.365).

Overall, the factors that influence comfort are primarily related to the backrest, armrest, and human-machine integration. Among them, backrest fit and backrest height have the most significant impact on comfort. This suggests that in the evaluation of bamboo chairs, consumers tend to prefer high-backed chairs with greater enclosure and fit.

From the perspective of human-machine integration, although its impact is slightly weaker than that of the backrest, its influence on the comfort of bamboo chairs cannot be ignored. Human-machine integration varies across different consumer groups, which requires thorough user research in the design of bamboo chairs. It is essential to address both physiological and psychological needs in the design process, ensuring that the chair meets a wide range of comfort preferences.

Additionally, the color temperature that conveys a sense of warmth has a significant positive

impact on comfort. This places clear demands on the processing techniques of bamboo materials, as appropriate surface treatments can create tones that enhance the feeling of comfort.

3.4 Correlated Factors of Safety Perception

The correlated factors that significantly influence the safety experience, ranked by correlation coefficient from high to low, are as follows: Backrest height (0.787) > Backrest fit (0.741) > Human-machine integration (0.736) > Armrest height (0.698) > Armrest volume sense (0.667) > Backrest size (0.623) > Lightness of volume (0.617) > Armrest length (0.595) > Functional practicality (0.579) > Backrest enclosure (0.553) > Individuality of shape (0.544) > Functional diversity (0.543) > Structural permeability (0.485) > Curvature of lines (0.415) > Color temperature (0.363).

The backrest has the most significant impact on the safety experience, with all four detailed indicators of the backrest showing a significant correlation with safety. A reasonable backrest height and a backrest fit that better matches the user's hips, waist, shoulders, neck, and head, along with a large backrest and high enclosure, contribute to a higher sense of safety. Similarly, the substantial, stable, and appropriately sized armrest volume, with reasonable height and length, also significantly enhances the feeling of safety.

A structurally permeable backrest design may lead to a higher sense of safety. However, this result might be influenced by the relatively consistent shape processing techniques used for bamboo chairs. High-backed bamboo chairs typically take full advantage of bamboo's flexibility, creating strong line characteristics and high permeability in the design.

Table 2: Correlation analysis between perceived imagery and decomposition factors for bamboo seats

Indicator Type	Refined Indicator	Description	Aesthetics	Comfort	Safety
Overall	Structural Complexity	Simple — Complex	0.271	0.316	0.284
	Structural Permeability	Hollow — Solid	0.489**	0.524**	0.485**
	Modernity of Style	Modern — Traditional	0.077	0.111	0.191
	Lightness of Volume	Light — Heavy	0.515**	0.591**	0.617**
	Curvature of Lines	Straight Line — Curved Line	0.590**	0.538**	0.415*

Indicator Type	Refined Indicator	Description	Aesthetics	Comfort	Safety
Color	Individuality of Shape	Individual — Conventional	0.365*	0.465**	0.544**
	Abstraction of Decoration	Abstract — Concrete	0.137	0.185	0.235
	Richness of Decoration	Rich — Simple	-0.037	0.041	0.098
	Richness of Layers	Single — Rich	0.139	0.097	0.050
	Color Contrast	Contrast — Harmony	0.091	0.145	0.120
	Color Brightness	Bright — Dull	0.331	0.216	0.243
	Color Richness	Diverse — Single	0.069	0.143	0.183
	Hue	Subtle — Vibrant	0.157	0.098	0.076
	Color Temperature	Cool — Warm	0.358*	0.383*	0.363*
Material	Material Hardness	Firm — Soft	0.317	0.365*	0.277
	Texture Clarity	Clear — Faded	0.109	0.086	0.028
	Material Richness	Diverse — Single	-0.037	0.012	0.115
Backrest Detail	Backrest Enclosure	Open — Enclosed	0.494**	0.554**	0.553**
	Backrest Size	Small (None) — Large	0.474**	0.612**	0.623**
	Backrest Fit	Straight — Fitted	0.729**	0.778**	0.741**
	Backrest Height	Low — High	0.681**	0.778**	0.787**
Armrest Detail	Armrest Volume Sense	Weakened — Highlighted	0.526**	0.628**	0.667**
	Armrest Length	Short (None) — Long	0.514**	0.577**	0.595**
	Armrest Height	Low — High	0.600**	0.697**	0.698**
Overall Details	Functional Diversity	Single — Diverse	0.549**	0.587**	0.543**
	Flexibility and Variability	Flexible — Fixed	-0.020	0.033	0.079
	Human-Machine Integration	Few — Many	0.684**	0.767**	0.736**
	Functional Leisure	Leisure — Office	0.064	-0.051	0.022
	Functional Practicality	Decorative — Practical	0.417*	0.512**	0.579**

Note: *P<0.05,**P<0.01

1 Discussion

Some of the conclusions of this study are consistent with related research, such as: Wei

Feng, Dong Shiyu, and others' research proposed that the smoothness of the chair's lines, the backrest's enclosure, and fit have a significant impact on the comfort of the seat [12]； Wu Shuangshuang and others suggested that the multifunctionality and adjustability of the chair are important factors influencing its comfort [13]； Lu Jianxiong and others, based on ergonomics principles and methods, explored the impact of sitting posture changes and chair design on human comfort [14]； Gong Jialan and others verified the influence of seat color on both the aesthetics of the seat and users' psychological experience, and suggested that warm-colored seats better highlight the elegance and brightness of the chair, further confirming the viewpoints discussed in this paper [15].

From the perspective of specific bamboo chair design strategies, the research results provide the following key insights:

(1) Fully leverage the characteristics of bamboo material to enhance the user experience of bamboo chairs.

Bamboo is lightweight, durable, and easy to process. With high hardness and strong toughness, it is often referred to as "green steel" [16]. Compared to other materials, bamboo is more easily manipulated to improve the fit and enclosure of the backrest, as well as to achieve a balance between lightweight, fluid shapes and durable, stable functionality. Significant factors affecting the user experience, such as backrest fit, backrest enclosure, volume lightness, and functional diversity, all show excellent adaptability to bamboo material, allowing for an enhanced aesthetic, comfort, and safety experience at a relatively low cost.

Furthermore, bamboo's natural grain, fresh color, fine texture, and variety bring a unique aesthetic to the chair [17]. Research shows that bamboo's pale yellow hue and smooth texture evoke associations of nature, health, and environmental friendliness, which have a clear positive impact on the user experience.

Bamboo carries unique cultural connotations and symbolizes resilience, integrity, humility, and nobility [18]. Excellent chair design can fully convey this cultural meaning, achieving emotional resonance in the user experience.

(2) Bamboo chair design should prioritize "curves" and focus on the overall fluidity of the shape.

Research results show that higher degrees of line curvature and fluidity, along with transparent structures and lightweight, ethereal form characteristics, better align with user

perception and enhance the user experience.

The earliest curved backrest chairs in China can be traced back to the Eastern Han Dynasty, where they were known as “Hu Chuang” (a type of low seat). During the Tang Dynasty, people began designing chairs with round backrests, and the armrests and backrests were integrated into a single curved form [18]； By the Ming and Qing Dynasties, the design of chairs became more diverse, with the incorporation of various curves into chair designs [19]. The findings of this study’s quantitative analysis demonstrate the significant impact of line curvature and fluidity on aesthetic experience, comfort, and safety in bamboo chair designs. Bamboo, as a fast-growing, renewable, and eco-friendly natural material, inherently carries the vitality and dynamism of curves. By focusing on “curves” in design, bamboo’s flexibility can be maximized, using techniques such as bending, weaving, and layering to create chair forms that are both mechanically sound and rich in natural beauty.

(3) Enhance the functionality of bamboo chairs and improve human-machine integration, which has a positive impact on comfort, aesthetics, and safety experiences.

Research results indicate that focusing on ergonomics and functionality not only benefits the improvement of comfort and safety but also plays a crucial role in enhancing aesthetics. The British aesthetician A. R. Liddell argued that “people experience pleasure from the proportional arrangement of objects’ appearance and form in front of them, while objects lacking such arrangement cause discomfort, indifference, or even aversion”. Factor analysis in this study reveals that chairs designed in accordance with ergonomic principles exhibit more aesthetically pleasing forms, leading to an enhanced aesthetic experience. Moreover, enhanced functionality and human-machine integration ensure that the chair remains stable and reliable in various usage scenarios, significantly improving the sense of safety for the user.

2 Conclusions and Outlook

Users’ overall experience with bamboo chairs is influenced by a variety of factors, including form design, color coordination, material texture, and attention to detail. This study systematically analyzed 30 sub-elements and quantitatively evaluated them across the three dimensions of aesthetics, comfort, and safety, accurately identifying the core influencing factors. The approach

demonstrates clear innovation in the field of chair design, and the evaluation system constructed provides solid data support for improving the quality of bamboo chair design and optimizing user experience.

This study used image samples as a medium for information transmission. Future work could involve further validation using actual products. Additionally, while this research focuses on "bamboo chairs", considering the diverse materials used in chair design, exploring the commonalities and differences in user experience factors across wooden, rattan, and hybrid material chairs is an important direction for future studies.

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