Research on Harmonious Design of Chairs Based on the Kano Model and Analytic Hierarchy Process

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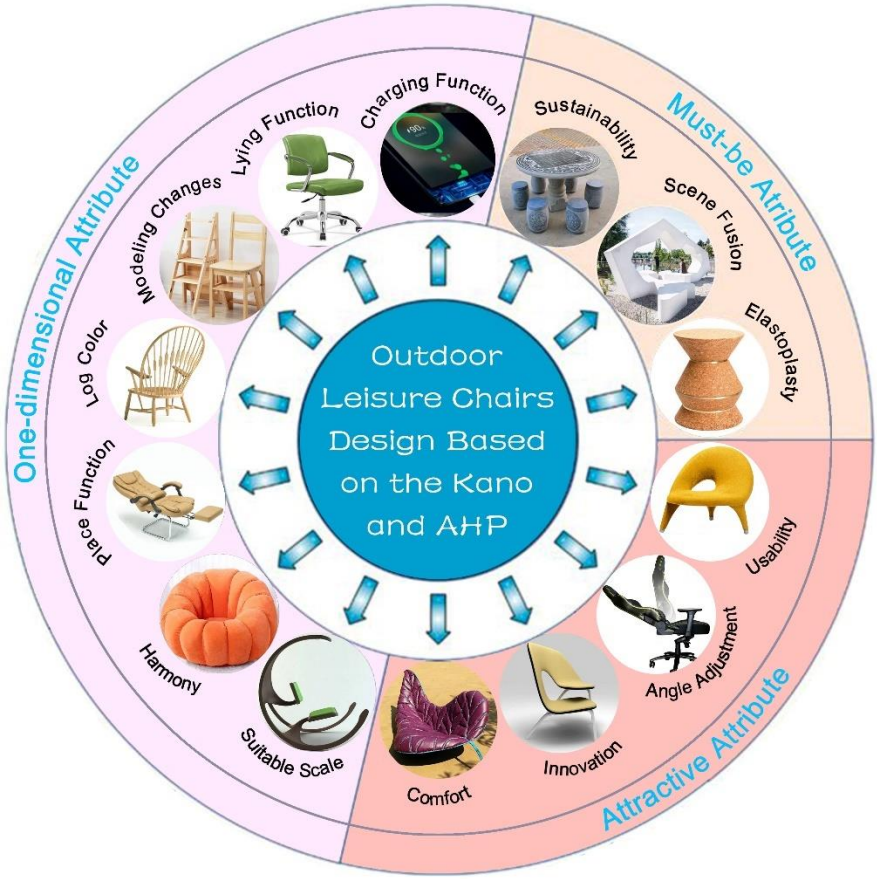
GRAPHICAL ABSTRACT



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To meet the functional and emotional needs of users for outdoor leisure chairs, the three-level theory of harmonious design was applied. A product design process was put together based on the Kano model and analytic hierarchy process (AHP). The Kano model obtained demand attributes and influence coefficients, while the AHP obtained total weights. The target products were designed and evaluated based on the three-level theory of harmonious design to improve the user experience and satisfaction of outdoor leisure chairs. The attribute categories of harmonious demand were obtained based on the Kano model, and the harmonious demands were ranked by importance. The design analysis and design practice were conducted with the goal of harmonious design. The AHP was used to analyze the comprehensive weights of the index factors, evaluate the user satisfaction of the three design schemes, and conduct consistency test and feasibility verification of the design schemes. The optimal design scheme was selected based on the total weight mean of three design schemes. The design and analysis method based on the Kano-AHP model can focus on user demand. It can objectively and efficiently analyze design pain spots, and effectively guide the harmonious design practice, which improves user satisfaction and market transformation efficiency of creative products.

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Keywords: Outdoor leisure chair; Harmonious design; User demand; Function; Emotion

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INTRODUCTION

Throughout history, the relationship between humans and nature has been complex. Humans have transformed their environment to meet their needs, but the concept and achievement of harmony with nature have varied across cultures and eras. Western countries have the idea of "harmonious aesthetics", while Eastern countries have the traditional aesthetic view of "beauty of neutralization and harmony". Aristotle explained beauty in terms of harmony. He believed that only harmonious things were beautiful, and that everything followed this law (Ma and Luan 1985). Therefore, the harmonious design concept has been particularly favored. During the Arts and Crafts movement, from Ashby's silverware, which blended slender, undulating lines with strong functionality, to Dresden's products, which encompassed various cultures, materials, styles, and techniques, most designers embodied a harmonious design concept of combining beauty with technology, learning from nature, and being faithful to materials and practicality. In the Tang Dynasty of China, harmonious beauty was applied by Luyu to evaluate the function and aesthetics of tea sets. In addition, the harmonious design concept was applied to Chinese Ming-style

furniture, which presented the characteristics of simplicity, elegance, delicacy and elegance. This is why the Ming-style furniture is famous in the world (Chen 2016).

A comprehensive review of the early product design and harmonious thought showed that harmonious design was not just a slogan, but its basic definition was established a long time ago in the design community (Zhao and Xu 2023). Over the years, many design masters have put forward related design concepts, design methods, and design principles in various fields, which promoted the development and innovation of design and played an important role in the sustainable development of the environment. At the same time, harmonious design has been gradually applied to product development and design processes in various fields, and it was used to reflect on whether these design objects truly embody the principles of harmonious design and sustainable development. Therefore, harmonized design has gradually been noticed by official authorities, forming suitable development paths and specific planning policies in various countries or regions, and applying them to various aspects of life (Sun *et al.* 2023). The living environment and production tools have changed, but the pursuit of harmonious beauty has never changed (Cai 2018). Instead, consumers are increasingly paying attention to harmonious design in order to ensure the survival of the environment and future generations (Bruno *et al.* 2022). When numerous natural and harmonious products are created, people first follow the principle of sustainable development and the concept of harmonious design.

As an indispensable living appliance in people's lives, the design of furniture products is increasingly influenced by consumers' growing interest in green products, harmonious coexistence, and sustainable development value (Liu 2014, 2023). Although the demand for harmonious symbiosis furniture products is high, the realization and standardization of harmonious symbiosis concepts in furniture design have not been realized. Suandi *et al*. (2022) studied the common sustainability characteristics of the furniture industry. Ten sustainability characteristics were identified for the environment, 17 for the economy, and 16 for the social dimension as being common among manufacturers when designing their products, including design guidelines, design criteria, design optimization, design evaluation, design decision making, design strategies, and eco-design tools (Hu and Huang 2020). A further in-depth analysis was conducted, and the results showed that five environmental characteristics, social sustainability characteristics and two economic characteristics were the most important influencing factors, which determined the harmonious design strategy of furniture products, and establish a new evaluation and design standard for the furniture industries.

From the perspective of harmonious design of furniture color, Zhou (2007) and Hu (2010) studied the development trend and emotional semantics of modern furniture design. They proposed that the harmonious design of modern furniture color should meet people's psychological, emotional, and spiritual needs, so as to achieve the harmony between furniture and people and the environment. Yang and Liu (2009) and Liu (2015) studied the harmonious relationship between furniture design and scene, function, form, and color from the perspective of furniture design scenes. They believed that the harmonious degree between furniture and space scenes determined the style and artistic height of furniture design. With the gradual deepening of the combination of design evaluation systems and the furniture manufacturing industry (Niu 2022), the integration of various design evaluation systems has begun to transition from experimental small-scale applications to large-scale promotion, which will profoundly affect the design mode transformation of the future furniture manufacturing industry. Meanwhile, design evaluation systems and programs such as analytic hierarchy process (AHP), Kano, and Kansei Engineering can

provide practical references for the design and manufacturing of furniture products (Li *et al.* 2016; Papa *et al.* 2017; Liu *et al.* 2019; Li and Chen 2022; Yan *et al.* 2023; Zuo *et al.* 2023). The AHP-QFD-AD method can transform user requirements into clear functional requirements and specific design parameters.

Accurately reflecting user needs in furniture design can greatly improve the accuracy of design evaluation, reducing environmental impact throughout the furniture life cycle, achieving harmonious integration between furniture and the environment (Li *et al.* 2023). Zhong (2023), Wu (2023), and Zhou and Chen (2023) applied the theoretical model of product design to research furniture design. They explored a new research perspective and design evaluation method for furniture design innovation. Firstly, they used the Kano model to analyze the demand attributes of furniture and clarify the demand characteristics of furniture design. Then, they introduced the AHP to establish a multi-level hierarchical model, constructed a judgment matrix, and performed weight calculation and design factors weight sorting. Finally, the most important furniture design factors were determined based on the weight ranking, and furniture design was carried out based on the evaluation results. These theoretical models of product design can effectively improve consumer satisfaction and market share, so they are widely used in furniture design enterprises. Harmonious urban development is a decisive feature of the modern age, yet the current model of urban development has profoundly altered the natural environment, reducing the diversity of harmonious factors and ultimately threatening people's lives and behavior (Heymans *et al.* 2019; Yang and Zhu 2021). Numerous studies have shown the psychological and physiological benefits of proximity to nature and green space such as reducing stress and anxiety, decreasing aggressive behaviour and associated crime levels, faster healing rates for patients, increased physical function and greater social activity and community bonding (Beatley and Newman 2013; Ersen 2021).

This study aims to develop a design approach for outdoor leisure chairs that promotes sustainable development and environmental harmony. By analyzing the environmental, psychological, and functional factors throughout the entire lifecycle of outdoor leisure chairs (design, manufacturing, use, and disposal), a method is proposed here that considers the relationship between furniture design and environmental impact. This approach will enhance user satisfaction and economic benefits and contribute to the harmonious development of urban environments.

EXPERIMENTAL

Experimental Process

With the continuous progress of technology and the diversified development of user demand, the awareness of nature conservation is continually increasing. The design of outdoor leisure chairs has gradually shifted from the rest function to the integration of multiple functions, such as human-machine interaction, emotional communication, environmental integration, and humanistic care. In this way, people's diversified needs for personal value realization, quality of life improvement, city sense of belonging creation, and natural harmonious development are met. Therefore, the design of outdoor leisure chair needs to consider multiple design factors. The Kano model can qualitatively and quantitatively analyze the demand attributes of each design factor, determine the influence coefficient of user demand and the priority ranking of design factors, transform the key needs of users into harmonious design factors, provide clear design direction and strategy

for the development of outdoor leisure chairs, and maximize the satisfaction of users. The design schemes were completed based on the three-level theory of harmonious design and the priority of design factors, AHP was used to conduct design evaluation and quantitative analysis on a variety of design schemes to verify the coincidence degree and feasibility of the design schemes. The specific experimental process is shown in Fig. 1.

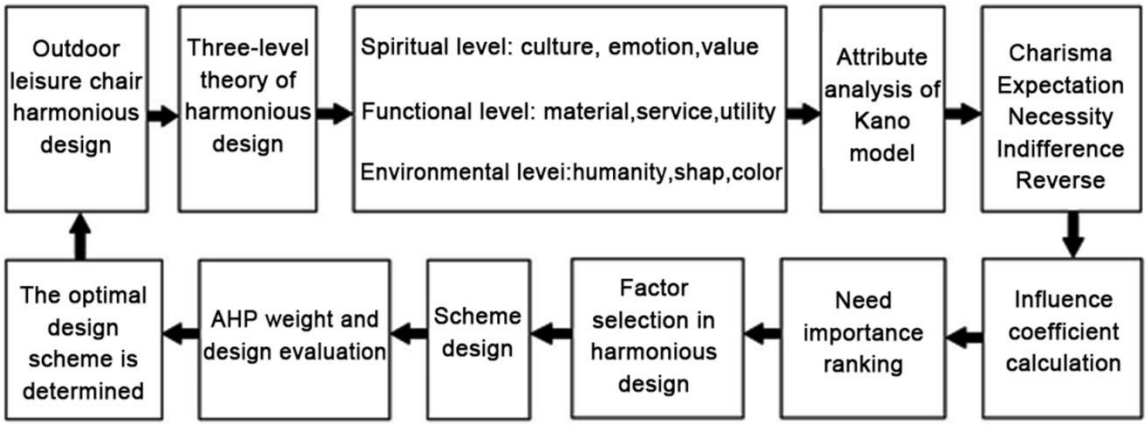

Fig. 1. Experimental process

Table 1. The Design Requirements of Outdoor Leisure Chairs

Demand Types	Number	Harmonious Demands	Matching Level
Humanistic care	A_1	Harmonious experience	Environmental level
	A_2	Comfortable and pleasant	
Modeling criteria	B_1	Modeling transformation	
	B_2	Appearance affinity	
	B3	Suitable scale	
Color specification	C_1	Bright color	
	C_2	Low color saturation	
	C_3	Log color	
Emotional expression	D_1	National culture	spiritual level
	D_2	Scene fusion	
Cultural idea	E_1	Innovative concept	
	E_2	Saving concept	
	E_3	Benevolence thought	
Property of value	F_1	Use value	
	F_2	Aesthetic value	
	F_3	Sustainable value	
Material properties	G_1	Hard materials	Functional level
	G_2	Flexible materials	
	G_3	Elastoplastic material	
Service function	H_1	Usability	
	H_2	Angle adjustment	
	H_3	Lying flat function	
	H_4	Placement function	
	H_5	Charging function	

Constructing Kano Model

As a tool for user research and data analysis aiming at the classification and prioritization of user demand attributes, the Kano model can construct a nonlinear relationship between the influence coefficient of user demand and satisfaction based on qualitative and quantitative survey data of the impact of user demand. From the perspective of user psychological cognition, the Kano model investigates and analyzes a psychological reaction of users when using a product, so as to analyze the attributes of functional requirements. The relationship between user satisfaction and product quality is obtained through the influence coefficient of various product factors, and the priority ranking of functional requirements and key design factors are determined to guide product design.

Questionnaire Survey and Data Analysis

A questionnaire survey targeted frequent users of outdoor leisure chairs, specifically park leisure users, outdoor fitness enthusiasts, and families engaged in outdoor sports with children. According to the user interviews and user demand of the three groups of people, it was found that different users had a low satisfaction with the shape, material, function, interaction, culture, color, service, and other aspects of the existing outdoor leisure chairs, and there were pain points in harmonious demand design in many aspects. According to the three-level theory of harmonious design and the occurrence frequency of functional demand words, 24 core demands among 8 types of demand were screened out, and the scale of user demand evaluation was established according to these demands. The scale is described in Table 1.

Methods

The Kano model survey questionnaire was developed according to the 24 core demand indicators in Table 1. Each functional attribute included two research questions: forward and reverse. It indicated the satisfaction degree of outdoor leisure chair with or without a certain functional attribute. Then, 100 respondents were invited, including park leisure crowd (30%), outdoor fitness crowd (30%), and outdoor parent-child sports crowd (40%), and 95 valid questionnaires were obtained. According to the classification and comparison table of the evaluation results, the survey questionnaire data of target users were classified and summarized. In addition, 24 user demand indexes were classified based on demand attributes. Better-Worse coefficients were calculated by Eqs. 1 and 2, and the influence coefficients of each user demand were calculated by Eq. 3. The results are shown in Table 2.

According to whether a certain function of the outdoor leisure chair is available, the user satisfaction coefficient can be divided into satisfaction coefficient (referred to as SI) and dissatisfaction coefficient (referred to as DSI). The formula is as follows:

$$\mathrm{SI} = \frac{A+O}{A+O+M+I} \tag{1}$$

$$\mathrm{DSI} = \frac{O+M}{A+O+M+I} \times (-1) \tag{2}$$

The EI calculation formula about each user demand influence coefficient of outdoor leisure chair is as follows:

$$\mathrm{EI} = \sqrt{\mathrm{SI}^2 + \mathrm{DSI}^2} \tag{3}$$

According to the results of user satisfaction of outdoor leisure chair in Table 2, a four-quadrant model of user demand factors was established. The mean of the absolute value of Worse coefficient and the value of Better coefficient (0.493,0525) was taken as the quadrant boundary to draw a four-quadrant diagram of the harmonious design factors, which is shown in Fig. 2.

Table 2. Results of User Satisfaction Analysis of Outdoor Leisure Chairs

Types	Number	A	O	M	I	R	SI	DSI	EI	Attri-butes	Importance Ranking
Concern	A_1	29	38	11	16	1	0.713	-0.521	0.883	O	6
	A_2	38	32	5	18	2	0.753	-0.398	0.851	A	7
Mould	B_1	31	40	13	9	2	0.763	-0.570	0.953	O	3
	B_2	23	26	12	33	1	0.521	-0.404	0.660	I	16
	B_3	22	36	15	22	0	0.611	-0.537	0.813	O	9
Color	C_1	11	4	46	33	1	0.16	-0.532	0.555	M	22
	C_2	26	5	28	36	0	0.326	-0.347	0.477	I	24
	C_3	25	44	7	16	3	0.750	-0.554	0.933	O	4
Emotion	D_1	30	18	14	32	1	0.511	-0.340	0.614	I	19
	D_2	5	21	45	21	3	0.283	-0.717	0.771	M	10
Culture	E_1	48	20	2	25	0	0.716	-0.232	0.752	A	11
	E_2	11	27	18	37	2	0.409	-0.484	0.633	I	18
	E_3	10	13	44	28	0	0.242	-0.600	0.647	M	17
Value	F_1	16	30	4	44	1	0.489	-0.362	0.609	I	20
	F_2	19	10	49	15	2	0.312	-0.634	0.707	M	14
	F_3	9	13	51	20	2	0.237	-0.688	0.728	M	13
Material	G_1	18	22	8	44	3	0.435	-0.326	0.543	I	23
	G_2	23	22	5	41	4	0.495	-0.297	0.577	I	21
	G_3	9	22	46	13	5	0.344	-0.756	0.830	M	8
Function	H_1	38	18	9	27	3	0.609	-0.293	0.676	A	15
	H_2	34	27	6	27	1	0.649	-0.351	0.738	A	12
	H_3	22	49	14	9	1	0.755	-0.670	1.010	O	2
	H_4	29	34	20	9	3	0.685	-0.587	0.902	O	5
	H_5	22	56	4	13	0	0.821	-0.632	1.036	O	1

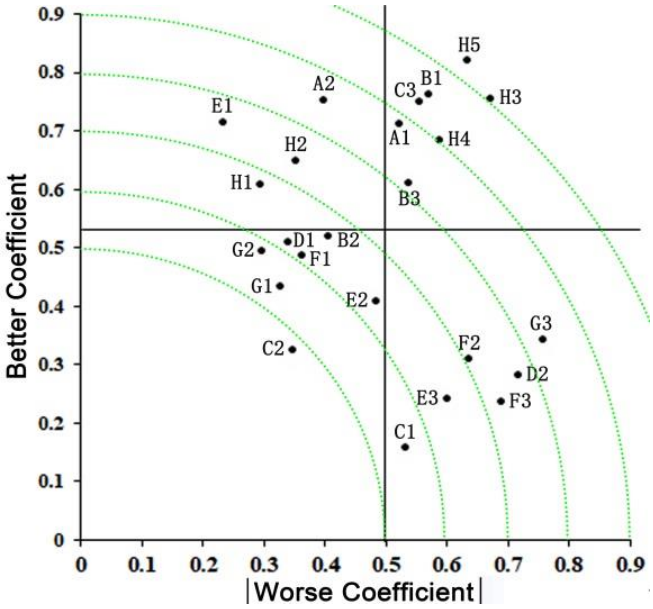

Fig. 2. Four-quadrant diagram of the harmonious design factors

RESULTS AND DISCUSSION

The User Demand Influence Coefficient

The user demand influence coefficient of outdoor leisure chair was calculated using Eq. 3. When |DSI| > 0.493 and SI > 0.525, it indicates that the attribute of current demand is one-dimensional attribute. Harmonious experience (A_1), suitable scale (B_3), modeling transformation (B_1), log color (C_3), lying flat function (H_3), placement function (H_4), and charging function (H_5) are located in the first quadrant. The EI order of the user demand influence coefficient is: $H_5 > H_3 > B_1 > C_3 > H_4 > A_1 > B_3$. If the outdoor leisure chair design can have this quadrant function that meets user demand, the satisfaction of users can be greatly improved. When |DSI| < 0.493 and SI > 0.525, it indicates that the attribute of current demand is attractive attribute. Comfortable and pleasant (A_2), innovative concept (E_1), usability (H_1), and angle adjustment (H_2) are located in the second quadrant. The EI order of their user demand influence coefficients is $A_2 > E_1 > H_2 > H_1$. This shows that users have a great demand for the comfort and pleasure of outdoor leisure chairs. Thus, innovative ideas, angle adjustment, and usability functions should be vigorously met. When |DSI| < 0.493 and SI < 0.525, it indicates that the attribute of the current demand is indifference attribute. It is shown as the third quadrant includes appearance affinity (B_2), low color saturation (C_2), national culture (D_1), saving concept (E_2), use value (F_1), hard materials (G_1), and flexible materials (G_2). Users do not care about these design factors. When |DSI| > 0.493 and SI < 0.525, it indicates that the attribute of the current demand is must-be attribute. It is shown in the fourth quadrant that includes some necessary demand, such as bright color (C_1), scene fusion (D_2), benevolence thought (E_3), aesthetic value (F_2), sustainable value (F_3), and elastoplastic material (G_3). This shows that users have certain requirements for these six demands, which can reflect the high-quality user experience of outdoor leisure chairs. Inverse attribute is negligible because it rarely appears in statistical analysis.

The Priority of Design Factors

According to the distance of each demand point from the coordinate origin in the scatter diagram of the four-quadrant model of user demand, the priority of the design factors of outdoor leisure chair is determined. The greater the distance from the demand point to the coordinate origin, the higher the priority of the design factor. It can be seen from Fig. 2 and EI value that the priority of the design factors of outdoor leisure chair from high to low (top 12) is as follows: charging function (H_5) > lying down function (H_3) > modeling transformation (B_1) > log color (C_3) > placement function (H_4) > harmonious experience (A_1) > comfortable and pleasant (A_2) > elastoplastic material (G_3) > suitable scale (B_3) > scene fusion (D_2) > innovative concept (E_1) > angle adjustment (H_2). Among them, the elastoplastic material (G_3) and scene fusion (D_2) are must-be attribute, and it is sufficient to satisfy the two demands in the design. Therefore, designers should focus on 10 aspects including charging function, lying flat function, log color, modeling transformation, placing function, harmonious experience, comfort and pleasure, appropriate scale, innovative concept, and angle adjustment in the design process of outdoor leisure chairs. The better these 10 user demand indexes are designed, the better they can bring users a superior user experience and quality. The user demand influence coefficient of charging function, lying flat function, modeling transformation, log color and placing function is the largest among the 10 aspects indexes, which is not only the core needs of users, but also the focus of design of outdoor leisure chair. According to the above analysis, the design of outdoor leisure chair based on the Kano model should take charging function, lying flat function, modeling transformation, log color, and placing function as the main appeal points and design highlights, and user demand indexes with slightly lower sensitivity are served as design supplements and the ways to improve satisfaction, such as harmonious experience, comfort and pleasure, appropriate scale, innovative concept, and angle adjustment.

Discussion

According to the research on the harmonious design demand of outdoor leisure chairs, the corresponding relationship and importance ranking between user demand and each design factor are summarized. The design factors must meet the user's mandatory attribute criteria, including elastoplastic material (G_3), scene fusion (D_2). The design factors should try to meet one-dimensional attribute including charging function (H_5), lying flat function (H_3), modeling transformation (B_1), log color (C_3), placement function (H_4), harmonious experience (A_1), and suitable scale (B_3). The design factors should strive to meet attractive attribute that include comfortable and pleasant (A_2), innovative concept (E_1), angle adjustment (H_2). At the functional level, it is necessary to set up the charging function for the outdoor leisure chair, achieve the lying flat function, placement function and angle adjustment and select elastoplastic log material to create a harmonious user experience. At the spiritual level, the innovative design concepts are adopted, and the image of "harmony" is taken as the design creative point to achieve the situational integration of outdoor leisure chair and natural environment. At the environmental level, through the innovative design concepts of modeling transformation and structural rotation, the outdoor leisure chair can achieve modeling transformation and suitable scale demand, enhance its comfort and pleasure with the natural color of logs, and improve the harmonious experience of man-machine-environment. Based on the above design analysis, three design schemes of outdoor leisure chairs were designed. They are shown in Fig. 3.

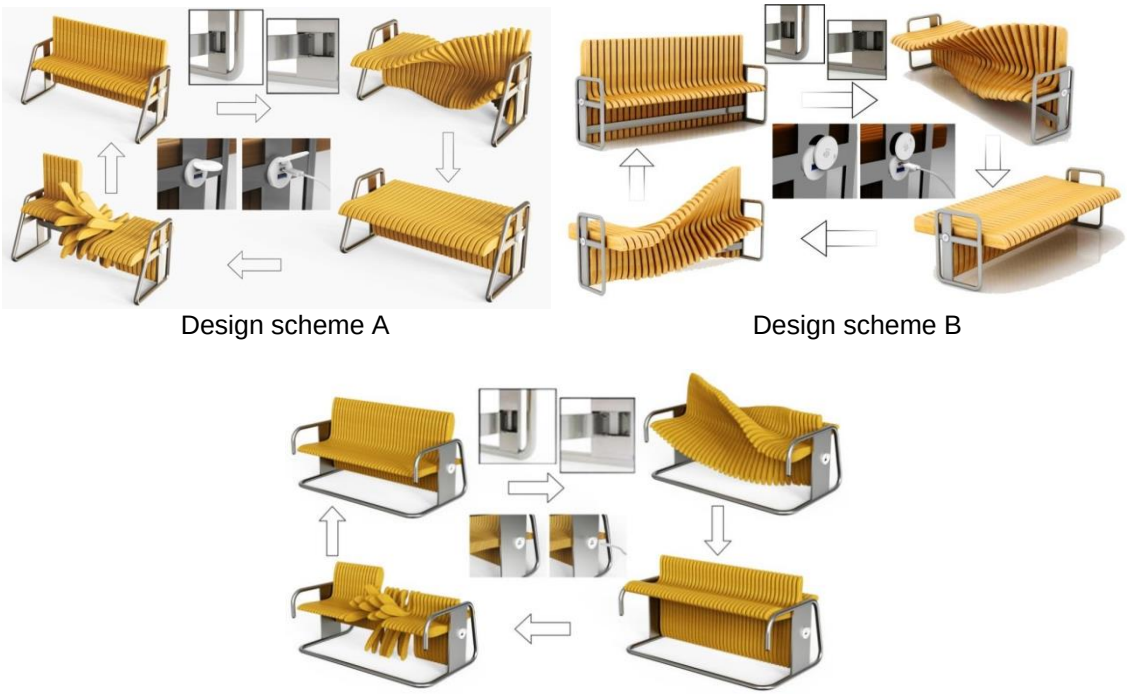

Fig. 3. The three design schemes of outdoor leisure chair

Constructing AHP Model and Judgment Matrix

The hierarchical structure of the AHP model was defined with the following hierarchy: target hierarchy, criterion hierarchy, and solution hierarchy. Data analysis of priority determination and consistency confirmation were completed after construction of the hierarchy. According to the Kano model importance ranking results (top 12) and attribute categories, the component factors of the criterion hierarchy (environmental level, spiritual level, functional level) and the solution hierarchy (attractive attribute, one-dimensional attribute, must-be attribute) of the outdoor leisure chair was obtained, as shown in Fig. 4.

The judgment matrix was constructed to measure the importance of each index in each level relative to the previous level. The weight value of each index in the same level was obtained by comparing the two indexes, and the consistency was tested according to the comparison results. The questionnaire was designed according to the outdoor leisure chair evaluation index. The scoring form of the questionnaire was determined by the 1 to 9 point scale assignment method. The pairwise comparison judgment matrix was constructed to calculate the eigenvectors and maximum eigenvalues of the matrix.

To improve the universality and accuracy of the evaluation results of user demand, a questionnaire was distributed to 10 experts composed of furniture designers, furniture marketers and park leisure people. According to the above judgment rules, each index was compared in pairs. Each index was calculated based on the weight values of the previous level, and then the weight was calculated by geometric average method. Each hierarchy weight vector was obtained according to the normalized processing results. The comprehensive weight was obtained by multiplying the weight of the criterion hierarchy index with the weight of the solution hierarchy index. The calculation results of the index weight and comprehensive weight are shown in Table 3.

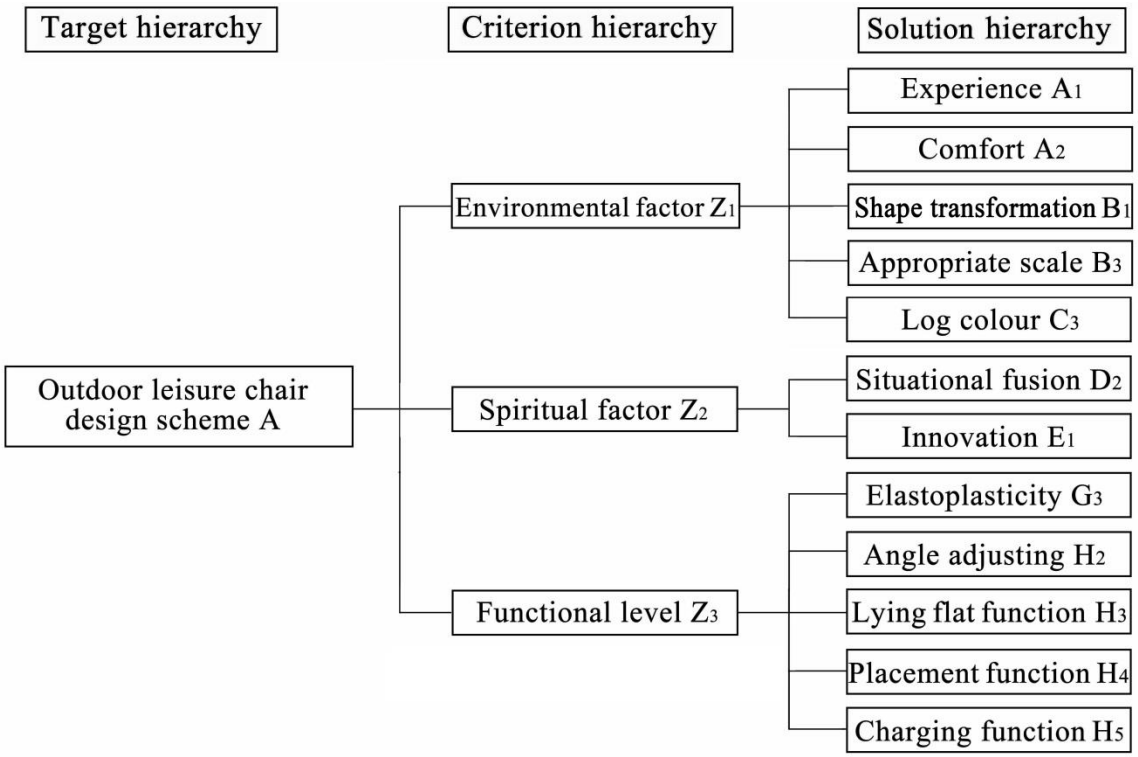

Fig. 4. A hierarchical model for evaluating outdoor leisure chairs

Table 3. Comprehensive Weight of Criterion Layer and Scheme Layer

Criterion Hierarchy	Criterion Hierarchy Index Weight	Solution Hierarchy	Solution Hierarchy Index Weight	Comprehensive Weight
Z_1	0.363	A_1	0.165	0.060
		A_2	0.109	0.040
		B_1	0.383	0.139
		B_3	0.054	0.020
		C_3	0.289	0.105
Z_2	0.066	D_2	0.571	0.038
		E_1	0.429	0.028
Z_3	0.571	G_3	0.091	0.052
		H_2	0.047	0.027
		H_3	0.264	0.151
		H_4	0.138	0.079
		H_5	0.460	0.263

Consistency Test Results

The weight vectors W_1, W_2, W_3, and W_4 were obtained by sum-product method, and the consistency of the judgment matrix was tested. To ensure the consistency of evaluation criteria and rubric of evaluation experts, and ensure the compatibility of judgment matrix, the result consistency test of the judgment matrix based on the approximate eigenvectors of weight vectors W_1, W_2, W_3, and W_4 was carried out. It was confirmed that the judgment matrix has compatibility and satisfactory consistency when the CR values of the test coefficients are all smaller than 0.1. The judgment matrix passes the consistency test and the data is valid. The calculation formulas are as follows:

$$\mathrm{CI} = \frac{\lambda_{max} - n}{n-1} \quad (4)$$

$$\mathrm{CR} = \frac{CI}{RI} \quad (5)$$

where λ_{max} is the largest eigenvalue of the judgment matrix. CI is the consistency index of the judging matrix. CR is the consistency ratio. RI is the random index. A consistency test was performed on the target hierarchy and criterion hierarchy, and the results of the consistency test for each matrix were all smaller than 0.1.

Total Weight Analysis and Design Evaluation of Design Schemes

The 12 indexes of three design schemes were substituted into the judgment matrix passed by the consistency test. Pairwise comparative analysis were carried out on the questionnaire results of 10 experts, and the geometric average method was used to calculate the solution hierarchy index weights of the three design schemes. The index weights and consistency test results of the three design schemes are shown in Table 4.

There are 12 evaluation indexes in the solution hierarchy of the design schemes. According to the index weights of the criterion hierarchy and solution hierarchy, the average weight of the three design schemes can be obtained as follows: design scheme A is 0.148, design scheme B is 0.180, and design scheme C is 0.072. By comparing the average weight of the three design schemes, design scheme B is determined to be the optimal design scheme. In addition, the maximum value of the judgment matrix consistency ratio for the three design schemes is 0.028 (CR<0.1), which indicates that each judgment matrix has satisfactory consistency. Therefore, the weight data and the evaluation results of the optimal design scheme are valid.

Table 4. The Index Weights and Consistency Test Results of Design Schemes

Indexes	Scheme A	Scheme B	Scheme C	λ_{max}	CI	RI	CR	Consistency Test Results
A_1	0.311	0.451	0.238	3.018	0.009	0.520	0.018	Pass
A_2	0.249	0.426	0.325	3.018	0.009	0.520	0.018	Pass
B_1	0.388	0.469	0.143	3.009	0.005	0.520	0.009	Pass
B_3	0.335	0.432	0.233	3.006	0.003	0.520	0.005	Pass
C_3	0.345	0.473	0.182	3.018	0.009	0.520	0.018	Pass
D_2	0.363	0.514	0.123	3.029	0.015	0.520	0.028	Pass
E_1	0.399	0.418	0.183	3.018	0.009	0.520	0.018	Pass
G_3	0.365	0.404	0.231	3.003	0.001	0.520	0.003	Pass
H_2	0.444	0.472	0.084	3.004	0.002	0.520	0.004	Pass
H_3	0.452	0.476	0.072	3.003	0.001	0.520	0.003	Pass
H_4	0.443	0.490	0.067	3.003	0.001	0.520	0.003	Pass
H_5	0.273	0.411	0.316	3.006	0.003	0.520	0.005	Pass

The subjective evaluation system has been proven to be applicable for analyzing similar competitive products and user demand, clarifying design strategies and design focus for enterprises, providing theoretical basis and quantitative indexes for the design of marketable products, and effectively improving the market conversion efficiency of products. In the future, the authors will add eye trackers in the experiment to further improve the accuracy of this subjective evaluation system, and develop corresponding evaluation procedures for design strategies and design schemes.

CONCLUSIONS

1. This study combined Kano and analytic hierarchy process (AHP) models to determine user needs and design pain points for outdoor leisure chairs. The Kano model identified key user attributes, while AHP helped select the optimal design scheme based on weighted evaluation criteria. This approach offers a valuable method and evaluation system for iterative product design, especially without objective product data.
2. The Kano model analysis showed that charging function and lying flat function were the top user priorities for outdoor leisure chairs. These findings provided clear design focus areas to meet user needs.
3. The optimal design scheme of outdoor leisure chairs was identified by AHP, which can provide qualitative and quantitative design decisions for decision-makers or designers. The consistency test results verified the effectiveness and reliability of the evaluation model constructed by AHP in optimizing the design scheme. This evaluation and analysis method achieved the symmetry between subjective and objective evaluation of product design.

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REFERENCES CITED

Beatley, T., and Newman, P. (2013). "Biophilic cities are sustainable, resilient cities," *Sustainability* 5(8), 3328-3345. DOI: 10.3390/su5083328

Bruno, D., Ferrara, M., D'Alessandro, F., and Mandelli, A. (2022). "The role of design in the CE transition of the furniture industry—the case of the Italian company cassina," *Sustainability* 14(15), 9168-9187. DOI: 10.3390/su14159168

Cai, Z. Q. (2018). "Discussion on the construction of exterior environment landscape of buildings from the perspective of harmonious coexistence between human and nature," *Shanxi Architecture* 44(1), 38-40. DOI: 10.13719/j.cnki.cn14-1279/tu.2018.01.020

Chen, J. L. (2016). "Exploration of aesthetic characteristics and creative concepts of Ming-style furniture of hardwood," *Sculpture* 3(1), 46-47. DOI: 10.3969/j.issn.1007-2144.2016.03.015

Ersen, N. (2021). "Analysis of furniture products' contribution to turkey's economy with a hybrid multi-criteria decision making method," *BioResources* 16(1), 339-353. DOI: 10.15376/biores.16.1.339-353

Heymans, A., Breadsell, J., Morrison, G. M., Byrne, J. J., and Eon, C. (2019). "Ecological urban planning and design: a systematic literature review," *Sustainability* 11(13), 3723-2742. DOI: 10.3390/su11133723

Hu, M. F. (2010). "The thought of green design of modern furniture," *Journal of*

Packaging 2(3), 90-92. DOI: CNKI:SUN:BZXB.0.2010-03-028

Hu, Y., and Huang, K. M. (2020). "Evaluation of street furniture design based on analytic hierarchy process," *Packaging Engineering* 41(22), 330-334. DOI: 10.19554/j.cnki.1001-3563.2020.22.053

Li, Q., Guo, H. D., and Fan, S. J. (2016). "ISM-AHP analysis of safety control elements for the recycling and utilization of old industrial buildings," *Industrial Safety and Environmental Protection* 42(2), 73-78. DOI: 10.3969/j.issn.1001-425X.2016.02.020

Li, Z., and Chen, Y. S. (2022). "Application of Kano model in the furniture demand analysis of primary and secondary school," *Furniture* 43(3), 38-41. DOI: 10.16610/j.cnki.jiaju.2022.03.009

Li, Y. J., Xiong, X. F., and Qu, M. (2023). "Research on the whole life cycle of a furniture design and development system based on sustainable design theory," *Sustainability* 15(18), 3928-3949. DOI: 10.3390/su151813928

Liu, M. B. (2014). "Inspiration and practice of Ming and Qing furniture design language in modern furniture design," *Journal of Huaihua University* 33(10), 103-107. DOI: 10.16074/j.cnki.cn43-1394/z.2014.10.024

Liu, M. B. (2015). "Analysis and setting of furniture design scenarios," *Shandong Industrial Technology* 21(1), 299. DOI: 10.16640/j.cnki.37-1222/t.2015.21.261

Liu, N., Guan, Y. H., and Bai, X. P. (2019). "Research on the design of 3D parking spaces in commercial complexes based on AHP," *New Building Materials* 46(8), 145-149. DOI: 10.3969/j.issn.1001-702X.2019.08.037

Liu, M. B., Zhu, X. R., Chen, Y. M., and Kong, Q. (2023). "Evaluation and design of dining room chair based on analytic hierarchy process (AHP) and fuzzy AHP," *BioResources* 18(2), 2574-2588. DOI: 10.15376/biores.18.2.2574-2588

Ma, L. Q., and Luan, Y. X. (1985). "The common ideal of beauty between Confucius and Aristotle," *Jianghan Forum* 6(8), 40-45. DOI: CNKI:SUN:JHLT.0.1985-06-008

Niu, N. (2022). "The application of 3D printing technology in furniture design," *Beauty and Era* 7(2), 29-31. DOI:10.16129/j.cnki.mysds.2023.07.025

Papa, E., Coppola, P., Angiello, G., and Carpentieri, G. (2017). "The Learning process of accessibility instrument developers: testing the tools in planning practice," *Transp. Res. Part A Policy Pract* 108-120. DOI: 10.1016/j.tra.2017.03.010

Suandi, M. E. M., Amlus, M. H., Hemdi, A. R., Rahim, S. Z. A., Ghazali, M. F., and Rahim, N. L. (2022). "A review on sustainability characteristics development for wooden furniture design," *Sustainability* 14(14), 8748-8803. DOI: 10.3390/su14148748

Sun, Y. k., Yen, C. C., and Chen, T. L. (2023). "Designing 'forest' into daily lives for sustainability: A case study of Taiwanese wooden furniture design," *Sustainability* 15(9), 7311-7332. DOI: 10.3390/su15097311

Wu, Z. Z., Zhao, J. X., and Sun, P. J. (2023). "Research on innovative design of office furniture based on Kano/AHP/QFD," *China Forest Products Industry* 60(11), 52-57. DOI: 10.19531/j.issn1001-5299.202311008

Yang, D. R., and Zhu, J. G. (2021). "Recycling and value-added design of discarded wooden furniture," *BioResources* 16(4), 6953-6963. DOI: 10.15376/biores.16.4.6954-6964

Yang, N. B., and Liu, W. T. (2009). "Outdoor furniture design for construction of harmonious community," *Packaging* 30(4), 99-101. DOI: 10.19554/j.cnki.1001-3563.2009.04.035

Yan, W. Z., Zhao, D. W., and Mehta, A. (2023). "Fabrication-aware design for furniture with planar pieces," *Robotica* 41(1), 48-73. DOI: 10.1017/S0263574722000443

Zhao, Y., and Xu, Y. (2023). "Evaluation model for modular children's wooden storage cabinet design," *BioResources* 18(4), 7818-7838. DOI: 10.15376/biores.18.4.7818-7838

Zhong, G. M. (2023). "Design of growth-oriented children's seats based on KANO–AHP method," *Packaging Engineering* 14(44), 118-126. DOI: 10.19554/j.cnki.1001-3563.2023.14.012

Zhou, J. (2007). "Harmonious design of furnitures' colors," *Journal of Zhengzhou Light Industry University* 5(1), 71-73. DOI: 10.3969/j.issn.1009-3729.2007.02.021

Zhou, Y. D., and Chen, C. (2023). "Design of educational furniture service system for 'future learning center' based on KANO model," *Packaging Engineering* 18(44), 418-425. DOI: 10.19554/j.cnki.1001-3563.2023.18.050

Zuo, W., Wang, N. Y., and Zhang, Z. D. (2023). "Study on the design of imagery of Ming-style chair shape based on KE," *Journal of Forestry Engineering* 8(3), 190-197. DOI: 10.13360/j.issn.2096-1359.202209042

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