Research on CMF Design of Tourist Train Carriages Based on KE

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Abstract. This study proposes a CMF design method based on Kansei engineering to address passengers' perceptual needs in tourist trains and to improve the alignment between design and cultural imagery. Taking Xinjiang–Central Asia regional cultural imagery as the analytical dimension, a methodological framework integrating design feature extraction and kansei evaluation is established through a systematic analysis of CMF design principles and perceptual imagery theory.Product imagery and corresponding CMF samples are then extracted and organized to construct a Kansei evaluation model tailored to train interior design. By mapping the relationships between perceptual imagery and design samples, the approach enables the translation from cognitive perception to design implementation, resulting in culturally adaptive and perceptually aligned CMF solutions.The results indicate that the proposed method effectively quantifies ambiguous perceptual demands and converts them into actionable CMF design parameters, thereby enhancing the user experience of train interiors.

Keywords: CMF Design, Semantic-Driven,Kansei Engineering.

1 Introduction

With the rapid development of cultural tourism, CMF design in tourist train interiors has increasingly become a key factor in enhancing passenger experience and shaping route brand identity[1]. Passenger expectations have evolved beyond basic functional requirements to encompass aesthetic quality, cultural identity, and emotional resonance[2]. Meanwhile, differences in routes and passenger groups create diverse demands for cultural expression and emotional experience. Therefore, tourist train interior design must balance regional culture, comfort, and manufacturability simultaneously, making it difficult to rely solely on designers' subjective judgment for systematic CMF decision-making. Kansei engineering provides an effective approach for translating users' perceptual needs into quantifiable CMF design elements.

Cultural imagery represents users' emotional perception and cognitive association with regional culture through environmental atmosphere, visual symbols, and cultural memory. In CMF design, such abstract imagery can be transformed into tangible

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design language through color, material, and finishing elements, which respectively convey emotional tone, regional texture, and tactile perception. Accordingly, the relationship between cultural imagery and CMF design can be regarded as a process of converting abstract cultural perception into operable CMF features.To address this issue, this study incorporates the cultural imagery of the Xinjiang–Central Asia region into the CMF design process and establishes a mapping relationship between cultural imagery, Kansei perception, and CMF elements for tourist train interiors.

2 Review of the Current Research Status

Existing studies on train interior design imagery in China primarily focus on color system construction, quantification of cultural imagery, and optimization of user experience. Regarding color systems, Xie Xuanhui[3] proposed a method integrating the NCS system with perceptual imagery theory, establishing a bidirectional mapping model between color feature extraction and imagery cognition through combined quantitative and qualitative approaches. In terms of perceptual imagery, Cui Zhonghui[4]investigated the application of regional culture in tourist train interiors by extracting representative cultural symbols and conducting imagery perception studies, thereby developing an evaluation system based on imagery factor indicators. For experience optimization, Hakim[5] applied QTT1 analysis to map local cultural elements into luxury train seat design, validating the role of regional imagery in user emotion and offering a transferable method for tourist train CMF design.

This paper addresses CMF design for tourist train interiors by translating passengers' kansei needs into design elements. Imagery–element relationships are quantified through analysis of color, materials, and finishes, and validated via design cases, establishing a CMF optimization framework to improve cultural adaptability and user experience.

3 Research Overview

Based on these CMF components, this study conducts a systematic investigation of perceptual imagery using methods such as focus group discussions, the semantic differential (SD) method, and imagery scale analysis[6]. These approaches are employed to establish correspondences between perceptual descriptors and specific CMF elements, and to quantify the relative importance of different imagery dimensions. The research framework proceeds as follows:1. Establish the experimental foundation through sample collection and selection of perceptual descriptors;2.Conduct perceptual evaluations using the SD method and Likert scales, and apply statistical analysis, factor analysis, and clustering to construct mappings between perceptual imagery and CMF elements;3.Extract key design features associated with tourist train interior imagery and, through sample-based analysis, clarify the relationships between perceptual descriptors and design attributes;4.Integrate weighted evaluation indicators for tourist train interior design to develop innovative CMF design solutions.

4 Analysis of CMF Design

This study proceeds as follows: tourism train interior samples are collected and their CMF features categorized; passengers' sensory imagery vocabulary is screened to construct a semantic lexicon; domain experts are consulted to refine CMF elements; user evaluations are conducted for statistical analysis of sensory imagery data; and finally, a CMF design experiment and scheme validation are performed to inform design practice.

4.1 Typical Sample Collection and Classification

A comparative analysis was conducted on representative tourist trains worldwide in recent years, including the Glacier Express , Peru's Titicaca train,, Japan's Shiki-Shima(see Fig. 1). From the three dimensions of color, materials, and finishing processes, the CMF schemes of tourist train interiors were systematically reviewed and synthesized.Color schemes are categorized as bright, dark, or neutral, and organized as monochromatic or multi-color palettes composed of dominant, secondary, and accent colors. Materials mainly include leather, wood, textiles, and metals, while finishing processes involve embossing, carving, and metal brushing. Their integration enables CMF expressions that balance functional performance with aesthetic value.

Fig. 1. CMF Design Scheme Comparison Chart

4.2 Collection and Classification of Typical Tourism Trains

By extracting and structuring affective vocabulary from the user perspective, designers can more precisely identify passengers' emotional needs for tourist train interiors, thereby informing CMF design[7]. Based on a literature review, case analysis, and group discussions, an initial set of 132 affective descriptors (e.g., comfortable, warm, exquisite, elegant) was compiled. A mixed group of passengers and industrial/product design students (≈30 participants; 28 valid responses) then removed semantically redundant or CMF-irrelevant terms. A subsequent focus group further refined the list to 40 descriptors corresponding to 15 CMF features of tourist train interiors (see Table 1).

Table 1. Emotional Imagery Vocabulary

Number	Intent Vocabulary	Number	Intent Vocabulary	Number	Intent Vocabulary	Number	Intent Vocabulary
1	Warm	11	Exquisite	21	Steady	31	Full
2	Elegant	12	Luxurious	22	Practical	32	Orderly
3	Luxurious	13	Tranquil	23	High-end	33	Streamlined
4	Comfortable	14	Vibrant	24	Light	34	Bright
5	Friendly	15	Natural	25	Simple	35	Elegant
6	Rustic	16	Traditional	26	Durable	36	Youthful
7	Folk style	17	Romantic	27	Accessible	37	Artistic
8	Modern	18	Simple	28	Private	38	Cultural
9	Simple	19	Grand	29	Open	39	Retro
10	Fashionable	20	Innovative	30	Warm	40	Immersive

4.3 Sensory Intention Analysis Based on SD Method

For CMF emotional evaluation of tourism train interiors, a six-member expert panel (design postgraduates, academics, product designers, and industry practitioners) assessed 40 affective terms[8]. Using combined comparative scoring and dichotomous classification, the results were analyzed via Ward clustering. Based on the dendrogram, representative terms from each cluster were selected as the core vocabulary, and their antonyms were added to form 10 word pairs for subsequent SD analysis (see Table 2).

Table 2. Tourist Train CMF Design Sensory Vocabulary Correspondence

Number	Intent word pair	Number	Intent word pair
A1	Bright — Calm	A6	Friendly — Distant
A2	Warm — Stern	A7	Delicate — Rough
A3	Soft — Intense	A8	Smooth — Coarse
A4	Light — Heavy	A9	Concise — Complex
A5	Delicate — Coarse	A10	Neat — Messy

4.4 Sensory Intention Analysis Based on SD Method

To improve sensory evaluation validity, interior samples were pre-classified by style based on color, materials, and surface treatments (e.g., light luxury, new Chinese, European retro, modern minimalist, natural wood), and five representative samples were selected for SD analysis[9]. A questionnaire incorporating 10 affective word pairs was administered using a seven-point Likert scale. Of 35 distributed questionnaires, 30 valid responses were obtained from participants aged 20–50, including passengers, rail professionals, academics, designers, and students. Data were analyzed in SPSS: Cronbach's $\alpha = 0.974$; KMO = 0.915; Bartlett's test $p < 0.001$, indicating strong

internal consistency and suitability for factor analysis. The reliability and validity test results are presented in Table 3 and Table 4, respectively.

Table 3. Reliability Test of the Sensory Experiment Questionnaire

Variables	Cronbach's Alpha	Items
IntentionEvaluation	0.974	30

Table 4. KMO and Bartlett's Test

Variables	KMO	Bartlett's sphericity test		
Intention	0.915	Chi-square value	Df	Significane
Evaluation		799.111	45	0.000

Mean scores for the ten perceptual descriptor groups were calculated to identify high-frequency positive and negative terms. As shown in Table 5, user preferences cluster around three core imagery dimensions—simplicity, warmth, and refinement—which rank highest in both proportion and mean values. Specifically, simplicity (66.7%) and orderliness (57.3%) emphasize structural clarity and functionality; warmth (63.3%) and friendliness (54.7%) reflect emotional comfort; and refinement (62.0%), delicacy (61.3%), and smoothness (60.7%) indicate a preference for high-quality materials and finishes.

Table 5. Imagery Word Rating Statistics

Imagery Words	Positive Words	Positive Average	Positive Proportion	Negative Words	Negative Average	Negative Proportion
Bright—Calm	Bright	4.28	58.7%	Calm	-3.15	41.3%
Warm—Austere	Warm	4.52	63.3%	Austere	-2.98	36.7%
Gentle—Intense	Soft	3.95	49.3%	Intense	-3.22	50.7%
Light—Heavy	Light	4.11	56.0%	Heavy	-3.30	44.0%
Delicate—Coarse	Delicate	4.36	61.3%	Coarse	-3.02	38.7%
Friendly—Distant	Friendly	4.07	54.7%	Detached	-3.25	45.3%
Exquisite—Rough	Exquisite	4.43	62.0%	Rough	-3.09	38.0%
Smooth—Rugged	Smooth	4.31	60.7%	Rugged	-3.11	39.3%

As shown in Table 6, the light luxury style ranks highest, indicating the strongest user acceptance, with core imagery of simplicity, warmth, and refinement. Overall, styles combining warmth and approachability with minimalist aesthetics are preferred, and the alignment between materials and perceptual imagery is critical for design optimization.

Table 6. Sample Comprehensive Score Statistics

Sample Style	Overall Average Score	PreferenceAverage Score	Core Imagery Word Score
Light Luxury Style	4.42	4.52	Concise (A4) = 4.65, Warm (A2) = 4.52, Exquisite (A7) = 4.43

NaturalWood Style	4.21	4.28	Warm (A2) = 4.52, Delicate (A5) = 4.36, Smooth (A8) = 4.31
Modern Minimalist	4.15	3.95	Concise (A4) = 4.65, Neat (A10) = 4.22, Bright (A1) = 4.28
Modern Minimalist	4.08	3.82	Light (A3) = 4.11, Friendly (A6) = 4.07, Soft (A4) = 3.95
European Retro	3.92	3.78	Bright (A1) = 4.28, Smooth (A8) = 4.31, Exquisite (A7) = 4.43

As shown in Fig.2 using two SD pairs (simple–complex, warm–cold), a 2D perceptual scale was constructed. Light luxury and modern minimalist cluster in high simplicity–high warmth; natural wood in high warmth–moderate simplicity; European retro in low simplicity–low warmth. This confirms a preference for concise, warm spaces, making high simplicity–high warmth the key design guideline.

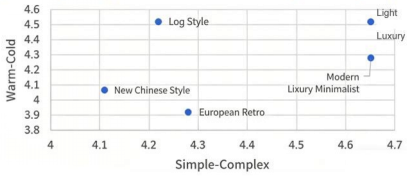

Fig. 2. Two-Dimensional Sensory Imagery Scale

5 Innovative CMF Design for Tourist Train Interiors

5.1 CMF Design Strategy for Interior of Central Asia Route Tourist Train

Based on perceptual analysis and regional context, high simplicity–high warmth is set as the design orientation. CMF design for dining and sleeping compartments balances function and experience.Dining areas emphasize openness with wood textures, warm tones, and metal accents; sleeping areas focus on privacy using low-contrast colors, soft materials, and matte finishes.

A CMF system ofsimplicity, warmth, nature, and refinement is applied: warm wood tones, off-white, and warm gray with subtle metal accents; wood, fabric, and matte metal in dining, and soft upholstery in sleeping areas. Matte, fingerprint-resistant finishes reduce visual complexity and enhance usability.The relevant design strategies are illustrated in Figure 3.

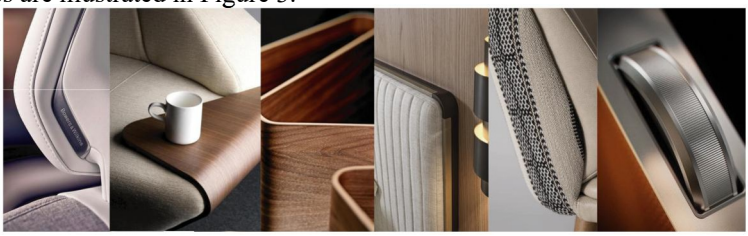

Fig. 3. Mood board

5.2 CMF Design Strategy for Interior of Central Asia Route Tourist Train

Guided by the above strategies, dining and sleeping compartments are designed under a unified CMF system with function-driven differentiation.The interior follows a simplicity–warmth tone, using warm wood, off-white, and warm gray with subtle metallic accents. Wood veneer, fabric, and soft upholstery emphasize natural texture and comfort, while matte, edge-refined, and fingerprint-resistant finishes enhance quality and usability.The dining area promotes openness through wood surfaces and continuous lighting with metallic detailing; the sleeping area prioritizes privacy with low-contrast colors and soft materials to create a calm, stable environment (see Figure 4).

Fig. 4. Blueprint

This design integrates regional culture with contemporary travel aesthetics, balancing overall coordination, functional adaptation, and cultural expression while reconciling standardization with personalization.

6 Conclusion

This paper takes the CMF design of tourist train interiors as its research object. Combining Kansei Engineering with user experience data, it analyzes passengers' functional and perceptual needs. Key perceptual dimensions are extracted via questionnaires and semantic differential methods, followed by the translation of perceptual insights into the relationships between color, material, and finish, clarifying the organizational logic of CMF elements. The findings are then applied to the design of dining and sleeping compartments for Central Asian route tourist trains, realizing the transformation from perceptual needs to concrete design expressions.

The results show that the method based on perceptual imagery analysis can improve the pertinence and rationality of design decisions, providing a reference for CMF design of tourist train interiors, as well as valuable insights for vehicle interior design within regional cultural contexts. The authors declare no competing interests.

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