Exploration of Visual Appeal and Local Cultural Identity in Wooden Packaging Design

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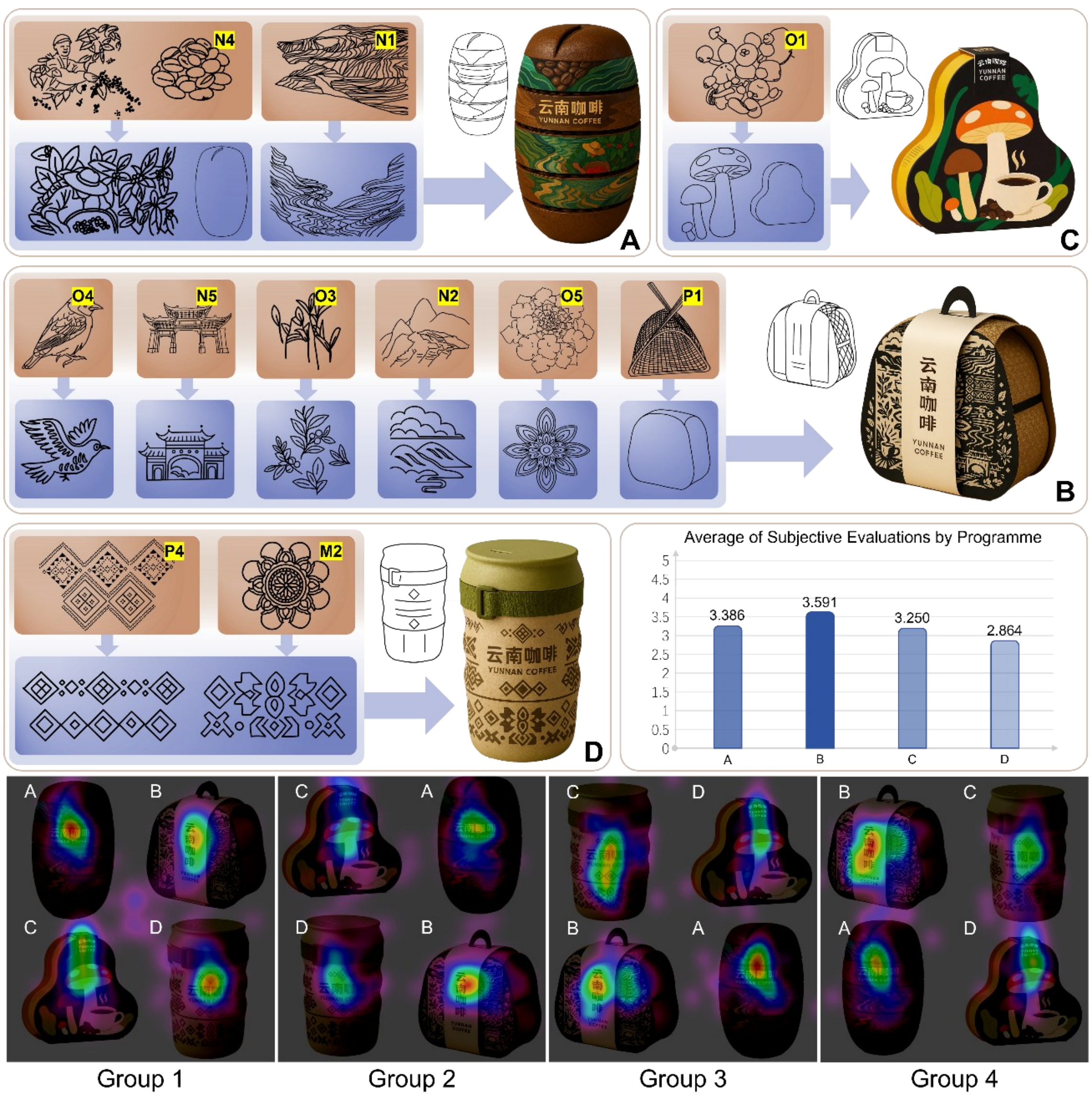
GRAPHICAL ABSTRACT



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As the coffee market continues to expand and new consumption patterns emerge, a brand's cultural philosophy has become central to market differentiation. Consequently, innovative coffee packaging designs that integrate regional culture have drawn attention among designers and consumers. This study designed and evaluated wooden packaging prototypes. First, a repository was compiled of representative Yunnan cultural elements and four design schemes were developed. Next, 10 experts in the field of packaging design were invited. A multi-criteria evaluation framework was constructed, and the FAHP and CRITIC computed composite weights were determined for each index. Subsequently, TOPSIS was used to rank the scheme. An eye-tracking experiment was conducted with 44 test subjects to assess differences in visual attraction across schemes. Results showed that the FAHP–CRITIC–TOPSIS pipeline reliably identified the top-ranked scheme, and eye-tracking metrics corroborated its superior visual salience. The integrated approach combines subjective and objective evidence, rendering the weighting process more defensible and linking quantitative rankings with observed viewing behavior.

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Keywords: Wooden packaging design; Eye-tracking; FAHP; CRITIC; TOPSIS

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INTRODUCTION

With the sustained expansion of the global coffee market, the role of packaging design in brand communication and cultural expression has become increasingly prominent. As a crucial interface connecting products and consumers, packaging not only delivers information and signals aesthetics, but it also conveys cultural value. Wood serves simultaneously as a functional substrate and a carrier of cultural meaning, making its application in coffee packaging particularly well founded; furthermore, as a renewable and biodegradable material, wood aligns with the sectoral shift toward sustainable practice. However, despite these functions, designs across brands remain stylistically similar: persistent homogenization and insufficient use of regional cultural symbols reduce brand recognition. Recent studies have advanced packaging design and user-perception research. Carvalho *et al.* (2020) found that the tactile properties of packaging material influence experts' and consumers' judgments of the coffee's basic taste. Pinto *et al.* (2024) developed a novel eco-friendly capsule material for coffee. Liu *et al.* (2023) fabricated a biodegradable film derived from coffee by-products with natural pigments; it improved barrier performance and elicited color-driven affective responses toward the packaging. Current literature lacks systematic user-based validation of regional cultural expression and visual appeal, yielding homogenized packaging solutions. This study anchored design in local motifs and employed wood as the material substrate to produce multiple stylistic wooden packaging prototypes, and it established a multidimensional evaluation model integrating the FAHP-CRITIC- TOPSIS. Design performance was then validated through eye tracking experiments to provide reproducible empirical evidence and decision support for regionally informed packaging design.

Localized Packaging Design

"Locality" in packaging design refers to the articulation and integration of indigenous cultural elements and local values into packaging, primarily reflected in the localized adaptation of visual-cultural elements. Many coffee packages communicate their origins' culture through visuals, constructing distinctive brand narratives. For example, Latin American coffee packaging often employs warm palettes with ethnic motifs and uses Spanish or Portuguese text (Fig. 1A), whereas African-origin packaging frequently features bright indigenous patterns and local scripts to highlight traditions and terroir (Fig. 1B). Numerous studies have underscored the value of incorporating local cultural elements. Atmaja (2024) found that distilling salient local symbols for packaging can enhance brand recognition and market appeal. In a study on Pu'er coffee in China, Yin *et al.* (2025) reported that integrating symbols from ethnic apparel, architecture, and other artifacts can increase brand awareness and willingness to pay. Locality also relates to supporting place-based sustainability: many origin brands prominently display organic, fair-trade, and other certification marks to signal alignment with local ecosystem and community development. Swasty *et al.* (2023) designed a packaging scheme in an Indonesian coffee community emphasizing eco-friendly concepts, strengthening environmental positioning and improving product competitiveness while contributing to local sustainability. A survey by Mabalay (2024) showed that packaging made of eco-friendly materials and embedding local elements is preferred by consumers, elevating perceived quality and sustainable value and thereby raising purchase intention.

Although current research on localized expressions in packaging has demonstrated the value of regional cultural symbols for visual communication and branding, particularly through empirical studies in regions such as Africa and Pu'er that showcase local totems, language, and environmental elements, important gaps remain. Existing work largely examines cultural elements in marketed cases, while giving limited attention to design translation pathways that operationalize locality in coffee packaging. Research on scheme optimization and selection remains limited. Furthermore, in coffee packaging design, the combined use of multi-criteria decision-making (MCDM) methods and eye-tracking for triangulated validation is seldom reported.

(A) Coffee packaging in Latin American (B) Coffee packaging in Africa

Fig. 1. Coffee packaging

Application of Eye-Tracking in Packaging Design

In packaging-design research, eye-tracking studies have primarily examined three areas: visual attention patterns, element-level effects, and key-information conveyance efficiency. Hang *et al.* (2025) combined Kansei engineering with eye-tracking to analyze tea-packaging elements, identifying between-design differences, salient features, and outliers in viewing behavior. Ko *et al.* (2024) reported that pink cosmetic packaging elicited the highest consumer attention, whereas black, white, blue, and orange were associated with greater attention to the surrounding context. Shahri *et al.* (2025) found that packaging shape influences attention and choice; greater surface area, convexity, and roundness were linked to a lower selection likelihood. Konoplianko (2024) observed that character-themed visuals, brand logos, and distinctive styles were associated with increased attention and purchase inclination. Guo *et al.* (2024) reported that reusable packaging and monochrome logos more readily captured attention. Overall, eye-tracking has become a key method for evaluating packaging effectiveness, yielding substantial insights into consumers' visual-attention patterns and informing design optimization.

Although research has demonstrated the utility of eye-tracking for revealing the effects of packaging on visual attention, most studies concentrate on baseline visual elements (*e.g.*, color palettes, size, structural form, label information). Analysis of cultural content conveyed by packaging remains limited. In current research, eye-tracking is primarily used to record objective metrics (such as fixation count, total dwell time, and average fixation duration) when consumers view packages, serving mainly to corroborate the reasonableness and effectiveness of earlier multi-criteria evaluations.

Decision Methods in Packaging Design Evaluation

The optimal selection of a packaging scheme typically requires multi-indicator assessment that balances professional criteria and user perceptions. Zhu *et al.* (2025) noted that integrating subjective judgments with objective data can reduce evaluation uncertainty. Xiao *et al.* (2024) developed a sustainability evaluation model for children's food packaging: 250 consumers scored design schemes, after which CRITIC-based normalization and information-content analysis objectively assigned weights to sustainability indicators. Zambujal-Oliveira and Fernandes (2024) argued that sustainable packaging must balance functionality, visual appeal, and environmental performance, and that hybrid weighting strategies (subjective plus objective) are preferable. Uzan (2025) reported that MCDM methods such as TOPSIS and VIKOR (VlseKriterijumska Optimizacija I Kompromisno Resenje) are widely applied in packaging and print-media contexts, improving decision efficiency and accuracy. Wang *et al.* (2024) used AHP to build a judgment matrix, compute indicator weights, and prioritize sustainable design requirements. Song and Bai (2025) applied TOPSIS to structure a systematic design process for packaging related to intangible cultural heritage.

Although a variety of subjective–objective weighting methods have been introduced into packaging design, deficiencies persist in indicator selection and decision validation. Existing indices tend to emphasize functionality, cost-effectiveness, and environmental factors, while real-world decisions are also shaped by aesthetic fit, brand cultural identity, and ethnic cultural identity. Accordingly, the present study incorporated cultural expressivity, aesthetics, and market attraction into the evaluation system. Most prior studies have relied on weighting-based selection without integrating eye-tracking for triangulated validation. In the present work, a library of local cultural motifs for wooden coffee packaging was compiled. By combining visual design with product functionality, multiple schemes were developed. FAHP and CRITIC were then used to integrate subjective and objective weights within a structured evaluation framework. Finally, TOPSIS was used to rank the schemes, and eye-tracking was used to capture consumers' visual responses for result validation. By linking cultural-symbol compilation, evaluation decision-making, and user-perception testing, this work addressed gaps in the localized design of wooden packaging and aimed to achieve an operable model to support regional-culture-guided sustainable packaging.

This study focused on Yunnan coffee packaging, with three objectives: (i) build a motif library grounded in Yunnan's regional culture and generate four style-distinct schemes; (ii) construct a multi-criteria evaluation system for wooden coffee packaging and determine indicator weights; (iii) apply an integrated FAHP–CRITIC–TOPSIS procedure to select the top-ranked scheme, followed by eye-tracking to verify between-scheme differences in visual attention. The findings provide design implications for regional product branding and methodological references for packaging evaluation.

Cultural symbol translation theory was integrated with the Fuzzy Analytic Hierarchy Process (FAHP), Criteria Importance Through Inter-criteria Correlation (CRITIC), Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), and eye-tracking within a systematic investigation. First, representative Yunnan symbols were extracted and curated to form a motif library for wooden coffee packaging; four prototypes were created, each expressing distinct cultural connotations through wood materials and craft. Next, a structured evaluation system was established. FAHP was used to estimate subjective weights, CRITIC was used to estimate objective weights, and their fusion yielded composite weights for each dimension. Finally, TOPSIS was used to rank the four schemes, and eye-tracking data (*e.g.*, heat maps and fixation measures) were collected to validate the decision's robustness.

EXPERIMENTAL

Research Framework

This study adopted Yunnan cultural symbols as the design locus, developing a methodology that links localized expression with sustainable value. The workflow comprised five stages: regional symbol curation, packaging prototype design, consumer visual-behavior data collection, indicator-weight estimation, and scheme ranking and optimization (Fig. 2).

(1) Regional symbol extraction. The scope included ethnic totems, representative geological landscapes, characteristic flora and fauna, folk-costume motifs, and traditional crafts. Through systematic literature review and visual semantic analysis, representative symbols were translated into transferable motifs that convey Yunnan's regional characteristics. To avoid the ineffective application of cultural elements, symbols were categorized into ethnic totems, landmark landscapes, characteristic flora and fauna, and traditional handicrafts, ensuring that selected motifs for subsequent designs possess cultural value and aesthetic appeal.

(2) Packaging scheme design. Based on the extracted symbols, four Yunnan coffee packaging prototypes were created with differentiated styles and clear market positioning, emphasizing a balance between locality and contemporaneity. The distinctive cultural cues of Yunnan were retained, while prevailing coffee-market aesthetics and environmental requirements were addressed, yielding a diverse stimulus set for subsequent evaluation.

(3) Indicator weight determination. Given the multi-criteria nature of packaging design, an evaluation index system was constructed with six primary dimensions: aesthetics, cultural expressivity, practicality, sustainability, market appeal, and packaging cost. For weighting, FAHP was used to derive subjective weights from expert judgments, and CRITIC was applied to compute objective weights that reflect inter-scheme variability and inter-indicator contrast. The two were integrated *via* normalized aggregation to obtain a composite weight vector that balances subjective judgments and objective evidence, thereby mitigating single-method bias.

(4) Selecting the optimal scheme. The TOPSIS was employed to compute closeness coefficients, rank the four schemes, and identify a design path that balances locality and eco-friendliness, providing a reference for commercialization and iterative optimization of coffee packaging.

(5) Visual validation of scheme. To objectively assess visual performance, an eye-tracking experiment was designed. Forty-four young consumers participated. Using a remote eye-tracking system, each participant viewed the four schemes in sequence. Items recorded were the fixation count, total dwell time, mean fixation duration, and scanpath length for each scheme. These were used to generate heatmaps and scanpath diagrams. These data quantified attention to different visual elements and revealed preferences across design options.

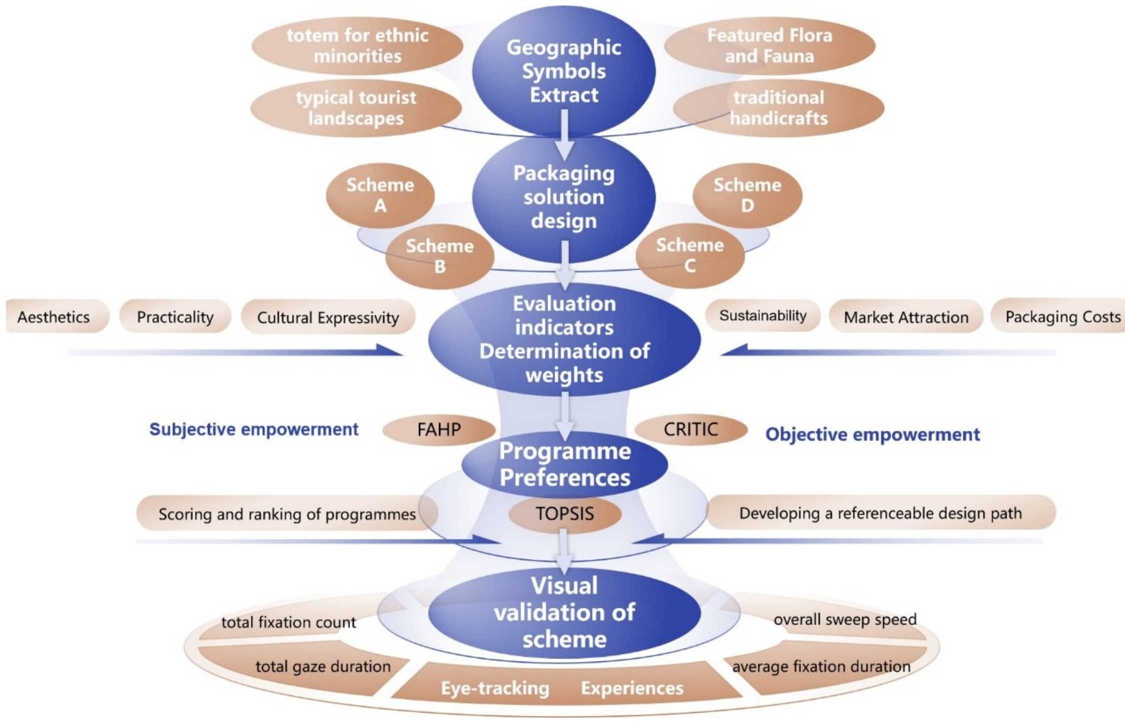

Fig. 2. Coffee packaging scheme research framework diagram

FAHP Method

FAHP is a MCDM approach that incorporates fuzzy logic into the AHP. Through structured pairwise comparisons, it derives criterion weights and alternative priorities while handling uncertainty and vagueness in design decisions (Liu *et al.* 2020). In this study, FAHP was used to construct a fuzzy complementary preference matrix for the evaluation index system and, *via* fuzzy arithmetic, to elicit experts' judgments on the relative importance of indicators to obtain subjective weights. This rendered the evaluation interpretable and feasible in culture and aesthetics, which are hard to quantify. The steps were as follows.

(1) The evaluation of Yunnan coffee packaging design was divided into three levels: the goal layer (Level A) for overall scheme evaluation, the criteria layer (Level B) for primary indicators, and the subcriteria layer (Level C) for secondary indicators.

(2) Using the 0.1 to 0.9 scale (Table 1), experts performed pairwise comparisons for each indicator pair. After averaging the judgments, the complementary preference matrix $R = [r_{ij}]$ was constructed with $r_{ij} \in [0,1]$, $r_{ij} + r_{ji} = 1$, $r_{ii} = 0.5$. Here, r_{ij} indicates the importance of indicator i relative to j.

$$R = \begin{bmatrix} 0.5 & r_{12} & \cdots & r_{1n} \\ 1 - r_{12} & 0.5 & \cdots & r_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ 1 - r_{1n} & 1 - r_{2n} & \cdots & 0.5 \end{bmatrix} \tag{1}$$

Table 1. Scale Method Clarification

Scale r	Define	Clarification
0.5	equal importance	Comparison of the two indicators is equally important
0.6	slightly important	Comparison of the two indicators, indicator i is slightly more important than indicator j
0.7	clearly important	Comparison of the two indicators, indicator i is significantly more important than indicator j
0.8	high priority	Comparison of the two indicators, with indicator i being more strongly important than indicator j
0.9	crucial	Comparison of the two indicators, with indicator i being extremely more important than indicator j
0.1,0.2,0.3,0.4	inverse comparison	If $r_{ij} = 0.6$, then $r_{ji} = 1.0 - 0.6 = 0.4$

(3) The next step was to apply the row-sum normalization method. Let *n* be the number of indicators and R_{ij} the element in row i, column j. First compute the row sums:

$$M_i = \sum_{j=1}^{n} R_{ij} (i = 1,2, \dots, n) \tag{2}$$

Then normalize to obtain the weight of indicator *i*:

$$W_i = \frac{M_i - \frac{n-1}{2}}{\frac{n(n-1)}{2}} \tag{3}$$

The resulting weight vector is $W = (W_1, W_2, \dots, W_n)^T$, representing the subjective importance ranking judged by experts.

(4) From W, construct the consistent preference matrix $\hat{R} = \left[w_{ij}\right]$ by

$$w_{ij} = \frac{n-1}{2}\left(w_i - w_j\right) + 0.5 \tag{4}$$

Compute the consistency index (*CI*):

$$CI(A, W) = \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} |w_{ij} - r_{ij}|}{n^2} \tag{5}$$

A smaller *CI* indicates better consistency. *CI*<0.1 is typically acceptable; otherwise, revise R or reconsult experts to improve consistency.

CRITIC Method

The CRITIC method is an objective weighting technique that considers both intra-indicator variation and inter-indicator redundancy when computing weights. By combining each indicator's standard deviation with Pearson correlation among indicators, CRITIC derives objective weights for the evaluation dimensions (Diakoulaki *et al.* 1995). In this study, CRITIC complemented the subjective FAHP weights by processing scheme-evaluation data to obtain an objective importance ranking, providing a basis for multi-source integration. The steps were as follows.

(1) Scores for each design scheme on each dimension were collected from 10 experts. The ten experts included professors specializing in product design at universities and design directors from coffee brand companies. Let x_{ij} denote the score of scheme i on dimension j ,where m is the number of schemes and n is the number of evaluation dimensions. Form the matrix:

$$X = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \tag{6}$$

(2) Apply range normalization to remove unit and scale effects, obtaining $Z = [Z_{ij}]$.

$$z_{ij} = \frac{x_{ij} - \min(x_j)}{\max(x_j) - \min(x_j)} \tag{7}$$

(3) For each dimension j, compute the column mean $\bar{z}_j = \frac{1}{m}\sum_{i=1}^{m} z_{ij}$ and the standard deviation:

$$\sigma_j = \sqrt{\frac{1}{m}\sum_{i=1}^{m}(z_{ij} - \bar{z}_j)^2} \tag{8}$$

(4) For dimensions j and k , compute the Pearson correlation coefficient:

$$r_{jk} = \frac{\sum_{i=1}^{m}(z_{ij} - \bar{z}_j)(z_{ik} - \bar{z}_k)}{\sqrt{\sum_{i=1}^{m}(z_{ij} - \bar{z}_j)^2}\ \sqrt{\sum_{i=1}^{m}(z_{ik} - \bar{z}_k)^2}} \tag{9}$$

(5) Combine dispersion and conflict information to obtain the CRITIC value for each dimension:

$$C_j = \boldsymbol{\sigma}_j \cdot \sum_{k=1, k \neq j}^{n}(1 - r_{jk}) \tag{10}$$

A larger C_j indicates greater contrast intensity and thus higher objective importance.

(6) Normalize CRITIC values to obtain objective weights V_j:

$$V_j = \frac{C_j}{\sum_{j=1}^{n} C_j} \tag{11}$$

TOPSIS Method

TOPSIS is a multi-criteria evaluation technique that ranks alternatives by their distance to a positive ideal solution and distance to a negative ideal solution, enabling comparative assessment across multiple indicators (Behzadian *et al.* 2012). To remove unit and scale differences, indicators are first normalized. Then they are weighted using the combined weights obtained from FAHP and CRITIC, yielding a weighted normalized decision matrix. The ideal solutions are identified from this matrix, and schemes are ranked by closeness to the positive ideal.

(1) Assume m design schemes and n indicators. Let x_{ij} be the score of scheme i on indicator j , and form:

$$\mathbf{X} = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \tag{12}$$

(2) Apply vector normalization columnwise to obtain r_{ij}:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \tag{13}$$

Let W_j and V_j denote the subjective and objective weights from FAHP and CRITIC. Compute the combined weight:

$$w_j = \frac{W_j \times V_j}{\sum_{j=1}^{n} W_j \times V_j} \tag{14}$$

Construct the weighted normalized decision matrix $v_{ij} = \omega_j r_{ij}$.

(3) For each indicator j, define the positive ideal and negative ideal as:

$$A^+ = \{\max(v_{1j}, v_{2j}, \dots, v_{ij})\}$$
$$A^- = \{\min(v_{1j}, v_{2j}, \dots, v_{ij})\}$$

(4) Calculate the Euclidean distances from each scheme to the positive and negative ideals:

$$D_i^+ = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^+\right)^2} \tag{15}$$

$$D_i^- = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^-\right)^2} \tag{16}$$

(5) Compute the closeness coefficient C_i and rank schemes in descending order:

$$C_i = \frac{D_i^-}{D_i^+ + D_i^-},\ 0 \le C_i \le 1 \tag{17}$$

A larger C_i indicates that the scheme is closer to the positive ideal.

RESULTS AND DISCUSSION

Construction of Yunnan Regional Symbol Library

Focusing on Yunnan's regional culture, this study systematically extracted and categorized representative visual-cultural elements of Yunnan. The motif library comprised 20 coded symbols across four categories, which served as the core material repository and coding scheme for subsequent design experiments (Fig. 3).

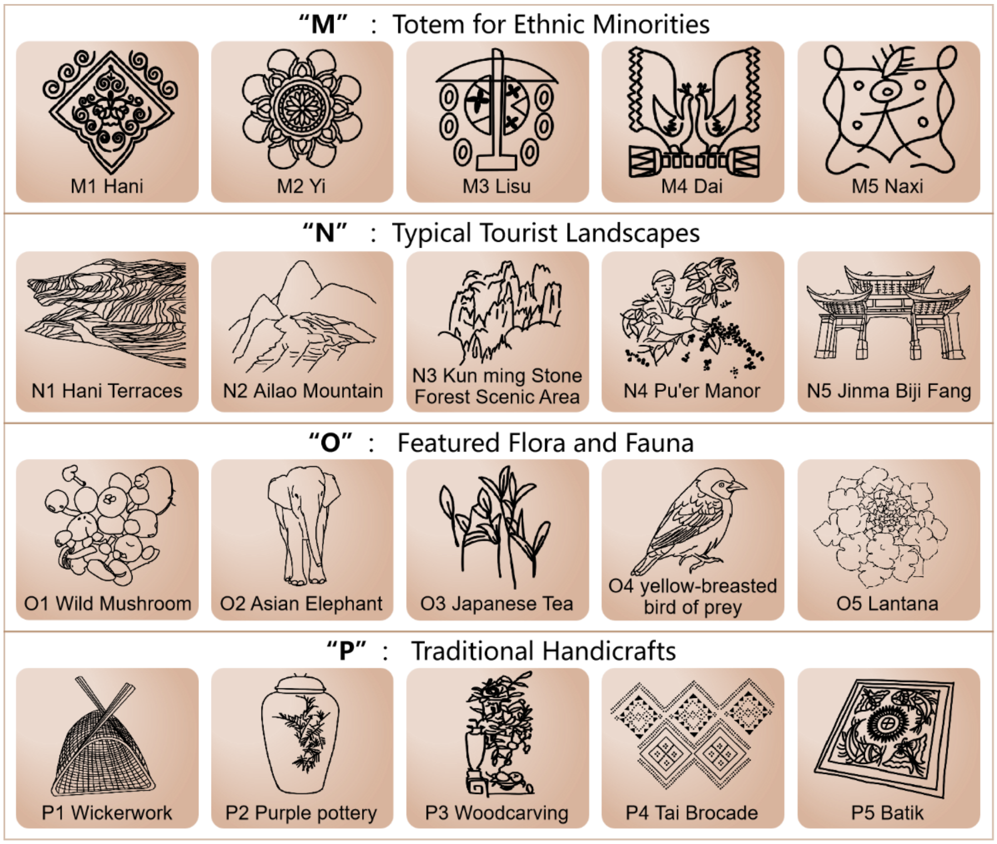

Fig. 3. Yunnan regional symbol classification

The symbol types were defined as follows. Category M includes ethnic minority totems, which exhibit high symbolic recognizability and a sense of cultural belonging. Category N covers landmark tourist landscapes, providing strong visual narrativity and potential for design translation. Category O encompasses characteristic flora and fauna, which highlight biodiversity and evoke ecological associations for consumers through packaging. Category P comprises traditional handicrafts, emphasizing artisanal craftsmanship and the heritage of Chinese traditional handwork.

Packaging Scheme Design

Based on the above motif library, four coffee-packaging prototypes were developed with differentiated styles and clear market positioning, each blending symbol codes with design aesthetics to realize effective cultural-symbol translation (Fig. 4).

Scheme A (N4 + N1). This scheme integrates the terraced landform of the Hani terraces into the packaging structure. In addition, it incorporates a coffee-harvesting scene from a Pu'er estate into the illustration, forming a coherent tableau that signals agricultural wisdom and natural abundance. Walnut or maple was selected for the wooden components; the fine growth-ring grain and warm tactile quality enhance the organic character of the gift box. After drying treatment, both materials exhibit stable moisture content and a fine, distinctly directional grain pattern, delivering a warm, tactile feel and premium texture consistent with design specifications. A mortise-and-tenon assembly was applied to create a layered structure, ensuring tight joints while maintaining detachability. The surface was sanded to 120-grit and finished with food-grade wood wax oil, creating a thin moisture-resistant film. Decorative motifs may be applied directly to wood surfaces that have been sealed and primed appropriately or alternatively bonded onto a sealed substrate using thin wood veneer or a film adhered by low temperature hot pressing. To ensure adhesion and long term durability, wood moisture content should be stabilized prior to fabrication, a compatible primer or adhesive must be selected, and the surface layer's stability should be validated through wet heat cycling and abrasion resistance testing. The tiered structure allows beans to be stored in separate compartments, improving practicality. The tactile quality and wood grain reinforce the natural, eco-friendly appeal, suiting the high-end gift market.

Scheme B (O4 + N5 + O3 + N2 + O5 + P1). The graphics merge featured flora and fauna, landmark landscapes, and traditional crafts, adopting a black-and-gold silhouette woodcut style that embodies cultural–ecological symbiosis and aligns with contemporary craft aesthetics. The structure is a three-dimensional arched paper box; the inner materials are eco-friendly kraft paper and biodegradable ink. Basswood was chosen as the woodcut substrate inspired by wickerwork; its uniform grain supports precise rendering of intricate silhouettes. Fabrication combined laser engraving with hand trimming and sanding to remove burrs; shallow grooves were carved along edges to evoke bamboo-weave textures. Wooden elements were bonded to the paper box with a corn starch-based eco-adhesive, ensuring sufficient strength while avoiding chemical pollution. The low mass of basswood prevents excessive weight. This scheme's high graphical density facilitates rich brand associations, suiting the cultural–creative gift and souvenir market.

Scheme C (O1). This scheme features wild mushrooms in a cartoon style to convey ecological diversity. The structure is a flat, mushroom-shaped paper box with a lightweight wooden inlay at the base. Paulownia or cedar was used due to low density and adequate bending strength. The wood was cut into thin boards to match the base, then sanded with 80-grit for a matte finish to avoid scratching the inner surface. The inlay improves overall sturdiness; the natural porosity of these woods can slightly regulate humidity inside the box to protect coffee beans. Prior to fabrication, timber is kiln dried to a stable moisture content and subjected to dimensional stability testing; subsequent measures to mitigate warping include cross lamination or thin veneer bonding combined with mortise and tenon joinery and adhesive bonding. Surface treatment requires a compatible primer followed by a food grade finish. Before mass production, the packaging's long term performance must be validated through wet heat cycling, abrasion resistance and bond strength testing as well as volatile organic compound analysis. The illustration uses a high-saturation red–green palette on black, enhancing distinctiveness and playfulness and aiding memorability among younger consumers. This scheme is low-cost, lightweight, and portable, suitable for mass-market distribution and tourism-oriented cultural souvenirs.

Scheme D (P4 + M2). This design deploys Dai brocade and Yi geometric patterns as the core visual language, arranged symmetrically to present a fusion of ethnic memory and contemporary expression. The package is a cylindrical canister made of reusable composite eco-paper, with oak or beech used for the lid and base. Both woods offer high hardness and wear resistance, suitable for repeated opening and closing. The inner lid was milled with a recessed groove that fits tightly with the canister to improve sealing. The base was carved with concentric anti-slip grooves, and the bottom edge was rounded to prevent chipping. All wooden parts were coated with a matte lacquer, enhancing tactile quality and facilitating cleaning. The wooden lid and base provide good sealing and storage, and the material stability of oak or beech extends service life, aligning with eco-friendly goals.

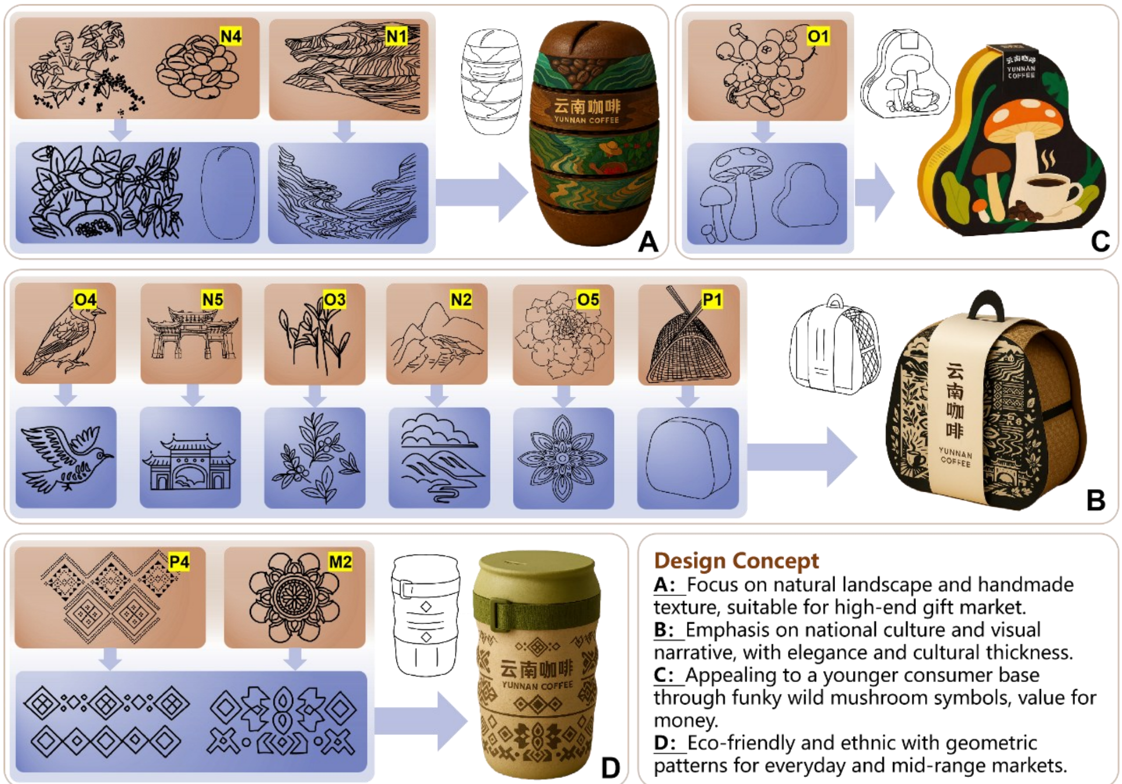

Fig. 4. Four Yunnan coffee packaging design schemes

Determination of Subjective Indicator Weights

Using FAHP, a hierarchical evaluation system was constructed for the localized and visual design of wooden coffee packaging. The goal layer (A) was defined as the overall objective: "wooden coffee packaging design with locality and visual effectiveness." The criteria layer (B) comprised six primary indicators: aesthetics, cultural expressivity, practicality, sustainability, market appeal, and packaging_cost. The subcriteria layer (C) comprised thirteen secondary indicators (Fig. 5).

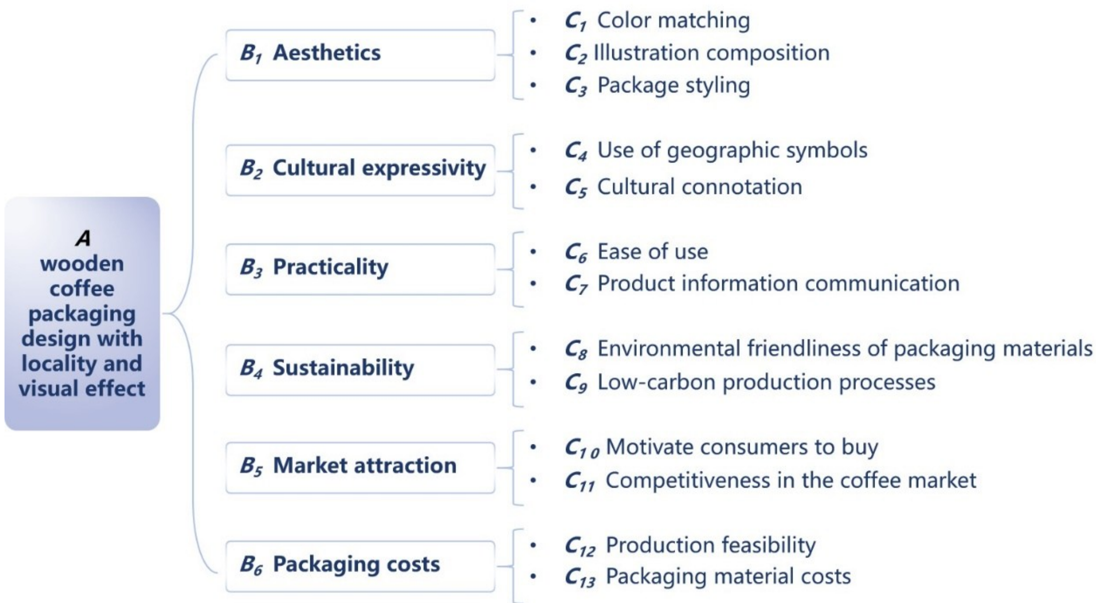

Fig. 5. Coffee packaging evaluation indicator system diagram

After the system was constructed, 10 experts in packaging design were invited to form an evaluation panel. Through interviews and questionnaires (online and offline), the experts performed pairwise comparisons of indicators using the 0.1 to 0.9 scale and provided ratings. Judgment matrices were built from these comparisons. The individual matrices were aggregated by arithmetic mean to produce a composite judgment matrix. The goal-layer matrix is denoted R_A; the criteria-layer matrices are R_{B_1}, R_{B_2}, R_{B_3}, R_{B_4}, R_{B_5}, R_{B_6}.

$$R_A = \begin{bmatrix} 0.5 & 0.3 & 0.7 & 0.6 & 0.4 & 0.8 \\ 0.7 & 0.5 & 0.8 & 0.7 & 0.6 & 0.8 \\ 0.3 & 0.2 & 0.5 & 0.3 & 0.3 & 0.6 \\ 0.4 & 0.3 & 0.7 & 0.5 & 0.3 & 0.6 \\ 0.6 & 0.4 & 0.7 & 0.7 & 0.5 & 0.9 \\ 0.2 & 0.2 & 0.4 & 0.4 & 0.1 & 0.5 \end{bmatrix}$$

$$R_{B_1} = \begin{bmatrix} 0.5 & 0.3 & 0.4 \\ 0.7 & 0.5 & 0.6 \\ 0.6 & 0.4 & 0.5 \end{bmatrix} \quad R_{B_2} = \begin{bmatrix} 0.5 & 0.6 \\ 0.4 & 0.5 \end{bmatrix} \quad R_{B_3} = \begin{bmatrix} 0.5 & 0.4 \\ 0.6 & 0.5 \end{bmatrix}$$

$$R_{B_4} = \begin{bmatrix} 0.5 & 0.6 \\ 0.4 & 0.5 \end{bmatrix} \quad R_{B_5} = \begin{bmatrix} 0.5 & 0.7 \\ 0.3 & 0.5 \end{bmatrix} \quad R_{B_6} = \begin{bmatrix} 0.5 & 0.4 \\ 0.6 & 0.5 \end{bmatrix}$$

A fuzzy-consistent approach was used to compute the criteria-layer weight vector, yielding $W_B = (0.187, 0.240, 0.113, 0.153, 0.220, 0.087)$ (using equations (2) and (3)). The adjusted consistency index was $CI = 0.039$, which is below 0.1, supporting the reliability of the criteria-layer weights (CI calculated per equations (4)–(5)). Using the same procedure, the subcriteria-layer weight vectors were computed and passed the consistency test. The final subjective weights and ranking are reported in Table 2, with all adjusted CI values equal to 0.000.

Table 2. Subjective Weights and Ranking of Each Indicator

Criteria layer	Weights	Subcriteria layer	Weights	Rank
B_1	0.187	C_1	0.044	12
		C_2	0.081	5
		C_3	0.062	8
B_2	0.240	C_4	0.144	2
		C_5	0.096	3
B_3	0.113	C_6	0.045	11
		C_7	0.068	6
B_4	0.153	C_8	0.092	4
		C_9	0.061	9
B_5	0.220	C_{10}	0.154	1
		C_{11}	0.066	7
B_6	0.087	C_{12}	0.035	13
		C_{13}	0.052	10

Determination of Objective Indicator Weights

Using the CRITIC method, ten packaging-design experts rated the thirteen subcriteria on a five-point Likert scale (1 = least important, 5 = most important). The ratings formed an initial matrix, which was normalized and processed according to equations (6) to (11) to obtain objective weights $\mathbf{V} = \{V_j\}$ for each indicator. Table 3 reports dispersion (σ_j), conflict intensity $\sum(1 - r_{jk})$, contrast information C_j, weight V_j, and rank for each subcriterion.

Table 3. CRITIC Weight Calculation Results and Ranking for Each Evaluation Indicator

Indicator	Dispersion (σ_j)	Conflict $(\sum(1 - r_{jk}))$	Contrast (C_j)	Weight (V_j)	Rank
C_1	0.337	10.899	3.678	0.073	8
C_2	0.369	11.543	4.259	0.084	3
C_3	0.369	9.449	3.486	0.069	13
C_4	0.459	9.883	4.541	0.090	2
C_5	0.337	11.080	3.739	0.074	7
C_6	0.316	12.526	3.961	0.078	5
C_7	0.322	11.281	3.633	0.072	9
C_8	0.337	11.358	3.833	0.076	6
C_9	0.333	10.794	3.598	0.071	10
C_{10}	0.350	13.708	4.792	0.095	1
C_{11}	0.350	11.562	4.042	0.080	4
C_{12}	0.333	10.508	3.503	0.069	12
C_{13}	0.284	12.413	3.523	0.070	11

Determination of Comprehensive Weights

After obtaining subjective weights and objective weights for each indicator, Eq. 14 was applied to compute comprehensive weights w_i for each subcriterion (Table 4). Based on w_i, the priority order was $C_{10} > C_4 > C_5 > C_8 > C_2 > C_{11} > C_7 > C_9 > C_{13} > C_6 > C_1 > C_{12}$. These results indicate that regional coffee packaging should foreground origin-related cultural symbols while effectively motivating purchase. Given the communication role of such products, packaging needs to convey cultural connotations clearly. In parallel, the growing cultural-creative market suggests that eco-friendly materials, paired with coherent illustrative composition, can enhance differentiation in the marketplace.

Table 4. Comprehensive Weights and Ranking for Each Subcriterion

Indicator	Comprehensive weight	Rank
C_1	0.040	12
C_2	0.085	5
C_3	0.053	9
C_4	0.162	2
C_5	0.089	3
C_6	0.044	11
C_7	0.061	7
C_8	0.087	4
C_9	0.054	8
C_{10}	0.182	1
C_{11}	0.066	6
C_{12}	0.030	13
C_{13}	0.045	10

Selecting the Optimal Scheme

Ten packaging-design experts evaluated the four Yunnan coffee packaging schemes using TOPSIS. According to Eqs. 12 to 14, the weighted normalized decision matrix was constructed (Table 5). Equations 15 to 17 yielded distances and closeness coefficients. The ranking was B>A>D>C, indicating that Scheme B was the top-ranked design.

Table 5. Weighted Normalized Decision Matrix

Indicator	Scheme A	Scheme B	Scheme C	Scheme D
C_1	0.259	0.222	0.296	0.222
C_2	0.267	0.300	0.200	0.233
C_3	0.214	0.286	0.250	0.250
C_4	0.259	0.333	0.185	0.222
C_5	0.231	0.308	0.192	0.269
C_6	0.258	0.226	0.226	0.290
C_7	0.242	0.242	0.273	0.242
C_8	0.208	0.250	0.250	0.292
C_9	0.222	0.278	0.278	0.222
C_{10}	0.250	0.286	0.214	0.250
C_{11}	0.286	0.286	0.214	0.214
C_{12}	0.212	0.273	0.273	0.242
C_{13}	0.211	0.263	0.316	0.211

Table 6. TOPSIS Results for Each Scheme

Scheme	Distance to the Positive Ideal D+	Distance to the Negative Ideal D-	Closeness C	Rank
A	0.060	0.046	0.433	2
B	0.027	0.088	0.764	1
C	0.085	0.036	0.295	4
D	0.064	0.044	0.408	3

Eye-Tracking Experiment

To corroborate the TOPSIS results, the TOPSIS-based rankings were compared with findings from an eye-tracking experiment. Prior to data collection, a detailed experimental protocol was prepared (Fig. 6). A total of 44 participants were recruited (male to female ratio of 1:1, age 18 to 25). All participants reported experience with or willingness to purchase coffee and cultural-creative products, had normal or corrected-to-normal vision (⩾ 1.0), and no color-vision deficiencies.

During the experiment, the infrared sensitivity setting of the eye-tracking camera was adjusted to ensure proper tracking of pupil and corneal reflections, after which the system was calibrated and validated. A remote eye-tracking system was used to record gaze data while participants were instructed to view naturally. Each packaging design was presented for 20 seconds, enabling assessment of between-scheme differences in visual attention. There were 44 valid datasets obtained. For each participant, the computed items were total fixation count, total dwell time, average fixation duration, and overall scan speed; each metric corresponded to a predefined evaluation criterion (Table 7). Heatmaps for the four schemes were compared. After the recordings, brief post-task interviews were conducted in which participants rated each design on a five-point scale (1 = "not at all attractive", 5 = "very attractive"). These subjective ratings, together with the eye-tracking metrics, were used to triangulate the results.

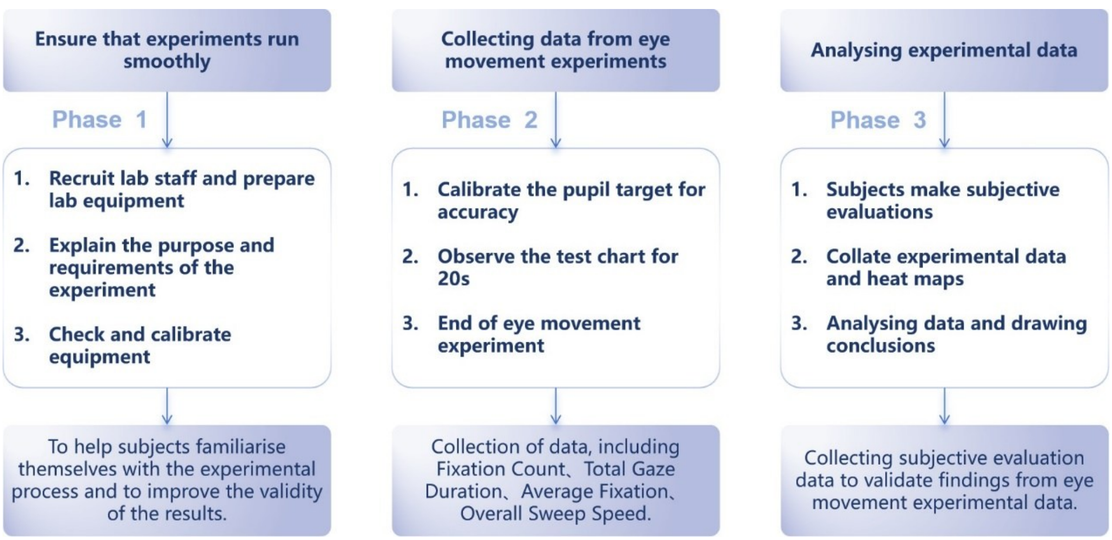

Fig. 6. Eye-tracking experiment flow chart

To enhance internal validity, the on-screen positions of the four designs were rotated clockwise across participants, and polygonal areas of interest (AOIs) were defined for analysis (Fig. 7). The 44 participants were assigned to four groups of 11. In the heatmaps, red indicates the highest attention, yellow indicates moderate attention, and purple indicates the lowest attention. Scheme B elicited more fixations and exhibited a more pronounced red hotspot than the other schemes. Across all four stimuli, visual attention clustered around core information regions, notably the product name and key illustration segments.

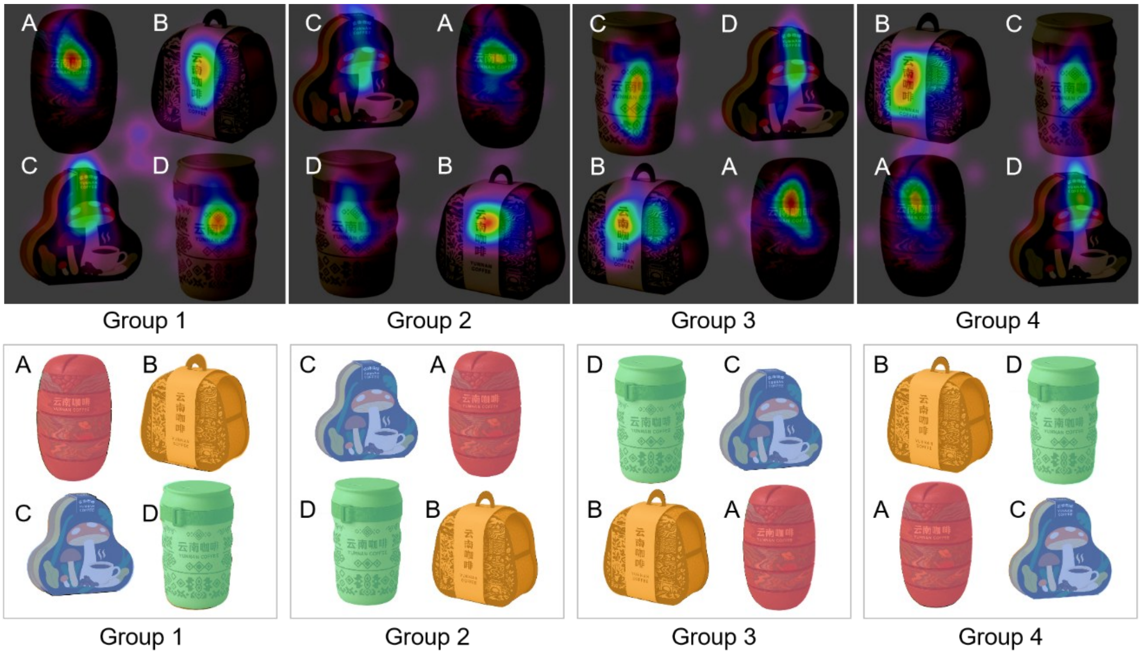

Fig. 7. Areas of interest and heatmaps for the four schemes

Analysis of Table 7 indicates that Schemes A and B performed strongly across the test images. Both showed high visual appeal and detail richness, as reflected by longer average fixation durations, slower overall scan speeds, and greater total dwell times. Scheme D showed the weakest visual engagement, with no metric notably high. Scheme B achieved the highest fixation count, the longest total dwell time, and the slowest overall scan speed, suggesting that its design elements sustained viewer interest for a longer period and supported stronger visual engagement.

Table 7. Eye-tracking Metrics within Areas of Interest

Test group	Scheme	total fixation count	Total gaze duration (ms)	Average fixation duration (ms)	Overall sweep speed (px/s)
Test group 1	A	69	29582	428.72	966.83
	B	78	30772	394.51	1094.05
	C	85	32371	380.84	1060.26
	D	68	27227	400.40	1197.67
Test group 2	A	66	38641	585.47	833.98
	B	78	38597	494.83	864.13
	C	58	23037	397.19	987.39
	D	54	22829	422.76	868.21
Test group 3	A	63	28292	449.08	1183.10
	B	83	43595	525.24	1042.72
	C	50	18124	362.48	1151.50
	D	84	37159	442.37	1263.98
Test group 4	A	56	33853	604.52	1497.11
	B	104	44896	431.69	895.41
	C	42	24016	571.81	1185.46
	D	54	23344	432.30	1367.92

After confirming that Scheme B was the most visually engaging in the eye-tracking data, the five-point ratings were averaged (Fig. 8). The ranking of subjective attractiveness was B>A>C>D. Scheme B received high approval, performing especially well in cultural expressivity by showcasing multiple Yunnan cultural symbols. These outcomes align with the eye-tracking findings and support Scheme B from a consumer-perspective standpoint.

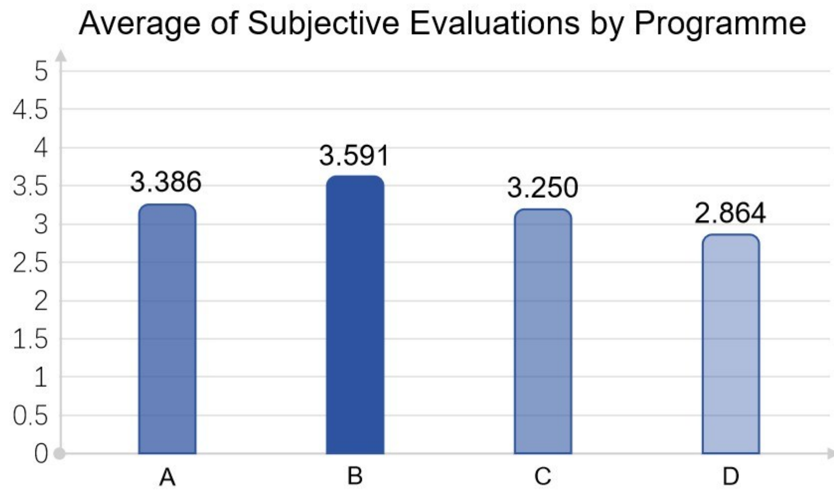

Fig. 8. Mean subjective attractiveness ratings for each scheme

This study had limitations in symbol selection and sampling. The selection and reconstruction of regional symbols primarily relied on desk-based curation from literature and open sources, which may not capture the full breadth of Yunnan culture. Due to time and facility constraints, the eye-tracking sample was small (n = 44) and predominantly young, which limits generalizability; results may differ across age groups or regions. Future work should co-create motifs with local stakeholders, broaden the participant pool, and pair eye-tracking with behavioral outcomes (*e.g.*, choice or willingness to pay) for stronger triangulation.

CONCLUSIONS

1. The Fuzzy Analytic Hierarchy Process – Criteria Importance Through Inter-criteria Correlation – Technique for Order Preference by Similarity to Ideal Solution (FAHP-CRITIC-TOPSIS) model was applied to the design and decision-making of wooden coffee packaging, and the outcomes were corroborated *via* an eye-tracking experiment. The experimental findings aligned with the evaluation results: Scheme B was top-ranked, outperforming the others in cultural expressivity, aesthetics, and market appeal. This framework provides actionable priorities and decision support, improving methodological transparency and reproducibility in the design process.
2. The study established a six-dimension evaluation framework for wooden coffee packaging integrating aesthetics, cultural expressivity, practicality, sustainability, market appeal, and packaging cost. A hybrid weighting strategy combining FAHP subjective weights with CRITIC objective weights was employed to derive indicator weights, enhancing robustness and accuracy in weight estimation.

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