

Generative Control and Packaging Translation of the Fuxi Totem Symbolic Domain

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Abstract

Objective: This study addresses the decorative replication and semantic loosening of intangible-heritage symbols in packaging design by constructing a design research pathway centered on the Fuxi totem symbolic domain, covering generation control, packaging translation, and effect evaluation. **Methods:** A three-layer schema of morphology, usage, and meaning was used to curate and annotate an image-text dataset of Fuxi motifs. A diffusion-based text-to-image model was adapted through parameter-efficient LoRA fine-tuning, and generation was further constrained through structured prompts, negative prompts, and post-generation rule-based verification. The validated outputs were organized into a reusable symbol library and translated into a packaging visual system and interactive communication prototype, which were evaluated through 156 valid questionnaires and 12 semi-structured interviews. Results Scale reliability reached acceptable levels, and the data were suitable for factor analysis. Descriptive statistics showed relatively high ratings for the morphological and usage layers, particularly in motif recognizability, visual expressiveness, and media adaptability, whereas meaning-layer articulation remained comparatively weaker. A Friedman test further indicated significant differences across the three layers, with the meaning layer scoring significantly lower than the morphological layer. Group comparisons suggested that participants with relevant cultural backgrounds rated symbolic accuracy and deeper cultural understanding slightly higher, although these differences are better interpreted as trend-level distinctions rather than strong causal effects. Interviews further indicated that tensions between innovation and authenticity were primarily associated with mixed historical layers, decorative overload, and insufficient semantic scaffolding. **Conclusion:** Transforming the symbolic domain into a linked framework for annotation, generation control, and evaluation can improve the structural controllability, media adaptability, and interpretive transparency of AIGC-driven heritage packaging design. However, under the current prototype-based and descriptive evaluation conditions, the meaning layer

remains the weakest part of the system and still requires stronger provenance cues, layered narration, and more rigorous contextual validation.

Keywords

Fuxi Totem, Symbolic Domain, Multimodal Generation, Diffusion Model, LoRA, Packaging Design, Cross-Media Communication

1. Introduction

Generative artificial intelligence (AIGC) is profoundly reshaping the creative production process of packaging design. From brand key visuals and serialized patterns to e-commerce promotional materials, multiple design variants can now be rapidly generated through text-to-image systems [1] [2]. However, as “traditional cultural elements” are increasingly invoked at high frequency, two typical risks have emerged in packaging applications. The first is decorative replication: intangible cultural heritage symbols are reduced to stylistic pattern labels, detached from their ritual contexts and structural rules, and repeatedly applied merely as “guochao”-style ornamentation. The second is pseudo-authenticity: AIGC outputs create a sense of “historicity” through distressed textures and epic visual atmospheres, yet may contain errors in crucial structural aspects such as trigram sequence, orientation, and numerological correspondences, thereby misleading the audience’s cultural understanding. Accordingly, how to achieve the controllable regeneration and interpretable translation of intangible cultural heritage symbols has become an urgent methodological issue in packaging design involving traditional culture [3].

The Fuxi totemic system encompasses composite symbols such as the Eight Trigrams, dragon forms, the human-head serpent-body motif, and the numerological imagery of the Hetu and Luoshu. Its meanings depend on corresponding relationships among yin and yang, spatial orientation, numerical logic, and ritual practice, and therefore exhibit strong structural constraints and substantial interpretive depth. This makes it an appropriate case for examining whether AIGC can truly “innovate within boundaries” in cultural packaging contexts. On this basis, the present study does not treat the Fuxi totem merely as a visual motif available for direct appropriation; rather, it defines it as a “symbolic domain” jointly constituted by form, usage, and meaning. From this premise, the study establishes a research trajectory extending from the definition of the research object to technological implementation and design validation. Along this trajectory, the paper seeks to address three progressively linked questions: first, how the “symbolic domain” can be transformed into operational data annotations and design variables; second, how symbolic drift can be controlled through LoRA-based domain specialization, constraint-oriented prompting, and rule-based verification; and third, how the verified regenerated symbols can be translated into a packaging visual

system and cross-media communication prototypes, and how their performance in visual recognition, media adaptability, and cultural communication can be evaluated through user assessment [3].

2. Materials and Methods

2.1. Hierarchical Modeling of the Symbolic Domain and Design Variables

Drawing on the systematic perspective of cultural semiotics on symbolic space and the symbolic domain [4], the term “symbolic domain” in this study does not simply refer to a collection of a particular type of pattern; rather, it denotes a relational semiotic space jointly constituted by motif structures, media-specific uses, and conceptual meanings. On this basis, the Fuxi symbolic domain is operationalized into three layers (as Table 1): the **morphological layer** (perceptible graphic structures and compositional rules), the **usage layer** (ritual contexts, media materials, and behavioral scripts), and the **meaning layer** (cosmological worldviews and philosophical semantics). In the context of packaging design, the morphological layer corresponds to visual identity and information structure; the usage layer corresponds to materials, production techniques, and interaction flow; and the meaning layer corresponds to brand narrative and cultural interpretation [5] [6] (Figure 1).

Table 1. Three-layer structure of the Fuxi totem symbolic domain and coding examples.

Symbolic-domain layer	Coding dimension	Typical elements	Corresponding packaging function
Morphological layer	Motif/structure/composition	Trigram lines; dragon patterns; human-headed serpent-bodied motif; Hetu-Luoshu numerological imagery; symmetry axis	Main visual identity; layout grid; series motif
Usage layer	Context/medium/process/script	Ritual and divinatory imagery; stone carving/woodblock/mural grammar; foil stamping/embossing/UV; unboxing sequence	Material and process selection; interaction flow; communication entry point
Meaning layer	Cosmology/narrative/numerological relations	Balance of yin and yang; order of heaven and earth; number-image correspondences; narratives of creation and ritual order	Brand story; interpretive text; education and communication

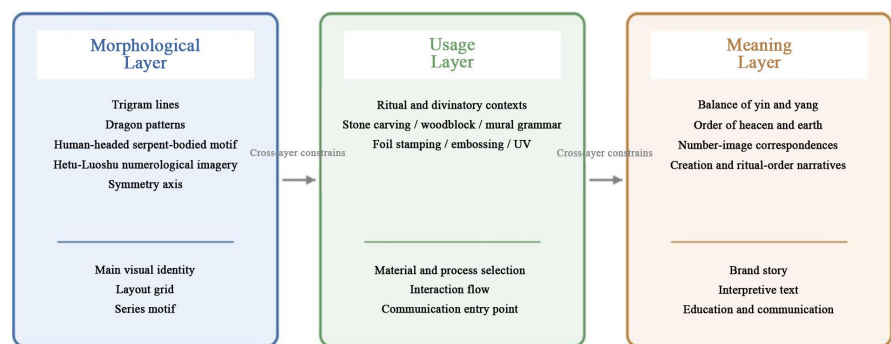


Figure 1. Three-layer model of the Fuxi totem symbolic domain and its mapping to packaging design.

2.2. Dataset Construction and Annotation

A total of 124 Fuxi-related images were selected from museum catalogues, plates in archaeological reports, illustrations in scholarly monographs, and field documentation, covering a range of media forms, including stone carvings, murals, woodblock prints, and contemporary folk media. The selection criteria included motif representativeness, structural clarity, and suitability for annotation. Scanned plates and field photographs were standardized in resolution and subjected to light denoising, while metadata on source, date, and medium were recorded to ensure traceability. Annotation was conducted along three dimensions: morphology, usage, and meaning. The morphological dimension included trigram elements, dragon-form types, the human-headed serpent-bodied motif, Hetu-Luoshu numerological imagery, and compositional axes; the usage dimension included ritual, divinatory, and festive contexts, as well as material and craft-related features; and the meaning dimension included thematic keywords such as yin and yang, the Five Elements, orientation, numerological principles, and the derivation of principle through images. The annotations were organized into structured captions, which, on the one hand, enhanced the learnability of motifs and structural relations during LoRA fine-tuning and, on the other hand, provided a unified semantic interface for the decomposition and reuse of subsequent prompt templates [7] [8].

To improve the verifiability of data sources and the consistency of subsequent training, all collected images underwent standardized screening and preprocessing after acquisition. An initial corpus of 412 images related to the Fuxi theme was compiled. After deduplication, image-quality screening, motif-identifiability screening, and source-traceability verification, 124 images were ultimately retained for the subsequent study, while 288 were excluded. Specifically, 92 images were identified as duplicates, 85 were excluded because of insufficient clarity or severe damage, 64 because the motifs were not sufficiently identifiable, and 47 because their sources could not be verified. The inclusion criteria were as follows: the main subject of the image had a clear association with Fuxi-related motifs; key structural elements were identifiable; source information was relatively complete; and image quality met the requirements for annotation and training. The exclusion criteria included severe blurring, missing main subjects, the coexistence of heterogeneous motifs that precluded reliable classification, or unverifiable source information. Before annotation, all images underwent unified resolution adjustment, light denoising, and edge cropping in order to reduce interference from non-content-related noise in subsequent training and controlled generation.

In terms of sample composition, the final dataset covered multiple media categories, including stone carvings, murals, woodblock prints, and contemporary folk media, comprising 52 stone-carving images, 31 mural images, 26 woodblock-print images, and 15 images from folk media. All images were uniformly resized and padded to 1024×1024 px, cropped using Smart-Resize, and processed with Real-ESRGAN for $4\times$ super-resolution enhancement and denoising. To monitor

training stability, the dataset was further divided into a training set of 105 images and a validation set of 19 images. Retaining samples from different media categories was not intended to produce a simple collage of visual styles; rather, it provided a more differentiated material basis for the subsequent three-layer annotation of morphology, usage, and meaning, thereby enabling generative control to establish a more nuanced correspondence between structural preservation and media translation.

To improve the reproducibility of the annotation process, a simplified coding manual was developed prior to formal annotation, in which the scope, judgment criteria, and illustrative examples for labels in the morphological, usage, and meaning layers were defined in a standardized manner. The annotation procedure comprised three stages: initial annotation, review, and revision. First, the author completed the preliminary annotation of all samples. Subsequently, 25% of the samples (31 images) were randomly selected for independent review by two researchers with relevant expertise, including one doctoral student in design studies and one researcher in folklore studies. For samples showing disagreement in trigram-structure identification, motif classification, or meaning-layer labeling, the coding manual was revised through discussion, and a final annotated version was established [9] [10]. The initial disagreement rate for meaning-layer labels was approximately 12%; these cases were subsequently resolved through joint discussion among the three researchers with reference to relevant literature on the *Yijing* (Book of Changes). The Cohen's kappa coefficient for the review results was 0.82, indicating a high level of annotation consistency. The purpose of this process was not to eliminate all interpretive differences, but rather to minimize arbitrariness in annotation as far as possible, so that the structured captions would rest on a relatively stable semantic foundation.

In terms of textual organization, this study did not adopt free-form descriptive captions; instead, the annotation results were organized into reusable structured captions. Their basic structure comprised three components: descriptions of motifs and composition, descriptions of media and craft vocabulary, and descriptions of semantic keywords. This structure served, on the one hand, the image-text alignment required for LoRA fine-tuning and, on the other hand, provided a foundation for subsequent prompt templating, thereby enabling the three-layer structure of the symbolic domain to maintain a consistent semantic mapping across training, generation, and evaluation [11] [12].

2.3. Model Selection and LoRA Fine-Tuning

A diffusion-based text-to-image model was selected as the base generator because of its advantages in high-quality image synthesis and conditional controllability [1] [2]. Given the scarcity of Fuxi-related symbols in general-purpose corpora, parameter-efficient LoRA fine-tuning was adopted. Under this approach, the weights of the base model were frozen, and only low-rank adaptation matrices were trained, thereby enabling domain specialization at relatively low computa-

tional cost and facilitating versioned model management [3]. The training process employed a multi-epoch regime and a repeated-sampling strategy to improve the learning stability of rare motifs. In addition, images were periodically generated using a fixed prompt set in order to monitor motif drift and mode collapse. To prevent distortion of trigram line structures caused by the overgeneralization of ornamental patterns, structured captions and negative prompts were introduced, including constraints against extra lines, random symbols, and excessive ornamentation. The generated outputs were then subjected to rule-based verification and manual review.

To improve methodological reproducibility, the training and generation parameters were specified in a standardized manner. The base generator was Stable Diffusion XL (SDXL) Base 1.0. The key parameters for LoRA training were as follows: image resolution, 1024×1024 px; batch size, 4; learning rate, $1e-4$ with a constant scheduler; total training steps, 2500 (approximately 80 epochs); LoRA rank, 32; alpha, 16; optimizer, Adafactor; and training hardware, an NVIDIA RTX 4090 with 24 GB VRAM [13] [14]. During training, periodic outputs generated from a fixed prompt set were used to monitor motif drift, mode collapse, and structural distortion. The final model version was selected on the basis of continuous sampling results showing relatively stable preservation of key motif structures, without evident aesthetic overgeneralization or repetitive visual stacking. These parameter settings were intended to support the verification of methodological feasibility rather than to pursue optimal model performance in a general sense.

It should be noted that the purpose of LoRA fine-tuning in this study was not to train a Fuxi totem model with universal generative capability. Rather, through parameter-efficient adaptation, the aim was to enable the base model to acquire domain sensitivity to specific symbolic structures and media vocabularies. Accordingly, this study is more concerned with the model's performance in terms of structural controllability and design translatability than with evaluating its generalization ability through large-scale benchmarking. From this perspective, the training results are understood as a domain-specialized tool for design research rather than as a general-purpose generative system intended for deployment in open-ended scenarios [15].

2.4. Constraint-Based Generation and Symbol Library Construction

The prompts were composed of three components: morphological constraints, usage constraints, and meaning cues. The morphological constraints specified motifs and structural features, such as “the sequence of the Earlier Heaven Eight Trigrams, clearly defined yin-yang line forms, a human-headed serpent-bodied figure, and surrounding dragon patterns”. The usage constraints specified media and craft vocabularies, such as “the texture of stone relief carving, multiblock woodblock printing, and gold-foil linear drawing for packaging”. The meaning

cues included expressions such as “the balance of yin and yang, the order of heaven and earth, and the correspondence between number and image”. During generation, negative prompts were employed to suppress common AIGC artifacts, while sampling steps and guidance scale were adjusted to balance structural clarity and stylistic diversity. After verification, the outputs were consolidated into a re-generated symbol library, organized by motif and hierarchical labels for subsequent use in the packaging system.

During the generation stage, this study adopted a four-step procedure consisting of prompt-based constraint, batch generation, rule-based verification, and manual review. For each prompt set, eight candidate images were generated in batch. The sampler used was DPM + 2M Karras, with the CFG scale set to 7.0, in combination with negative prompts to suppress common artifacts such as extra lines, random symbols, modern text, and excessive ornamentation. The preliminary outputs first entered the rule-based verification stage, where they were screened for the number and discontinuity patterns of trigram lines, the recognizability of trigram positions, the integrity of compositional axes, and the occlusion of key motifs. In this stage, line-counting, continuity checking, and preliminary occlusion/noise screening were handled automatically through rule-based scripts, whereas borderline cases involving semantic interpretation or historical-layer ambiguity were forwarded to manual review. This was followed by manual review conducted by the researcher [16]. Samples that could not be fully determined by rules alone but still allowed interpretive latitude were labeled as “requiring explanation” rather than being directly classified as erroneous. Through this mechanism, the study sought to maintain a relatively balanced approach between structural correctness and exploratory design potential.

2.5. Rule-Based Verification and Prompt Template Standardization

To address structural drift in trigram configurations and numerical correspondences, a two-tier mechanism combining post-generation verification and manual spot-checking was adopted. The verification criteria were as follows: (1) The number of trigram lines and their broken or unbroken forms had to conform to the basic structure of the Eight Trigrams; (2) Recognizability was treated as acceptable when the principal trigram contours and line breaks remained visually separable and when high-frequency noise did not substantially interfere with identification; (3) The occlusion ratio for key motifs was controlled at a low level, and outputs in which decorative elements blocked the main trigram positions or the human-headed serpent-bodied figure were excluded; and (4) when a motif–medium–meaning triplet was specified in the prompt, the generated result had to preserve the basic consistency of that triplet at the level of structure, medium vocabulary, and semantic cueing. In operational terms, line-form checking and preliminary screening of recognizability, occlusion, and noise were automated, whereas triplet consistency and historically ambiguous cases were resolved through manual

review. Cases that could not be conclusively determined were labeled as “requiring explanation” rather than being forcibly classified as erroneous [16]. At the same time, the prompts were standardized into three component types—motif components, media components, and meaning components—which could be rapidly recombined for repeated use, while also ensuring version consistency and output comparability in collaborative work. Owing to space limitations, only the template structure and its control logic are presented in the main text; the complete prompt templates and the fixed negative-prompt configuration can be provided upon reasonable request.

From the perspective of the verification workflow, the function of rule-based verification was not to replace human judgment, but rather to translate the key structural conditions of traditional cultural symbols into executable standards in advance. In total, 800 candidate images were generated in the study (100 prompt sets × 8 images each). After rule-based verification and manual review, 258 images were ultimately retained in the regenerated symbol library, corresponding to a retention rate of 32.25%. The principal reasons for exclusion included excess trigram lines (211 images), severe occlusion of motifs by cloud patterns (186 images), and distorted proportions in the human-headed serpent-bodied motif (145 images). From the resulting symbol library, 42 core symbol sets were further selected for use in the packaging visual system on the basis of four concise criteria: structural correctness, motif diversity, cross-media translatability, and low inter-sample redundancy. Making these criteria for exclusion and retention explicit helps to enhance the methodological transparency of the present study.

2.6. Cross-Media Packaging System and Prototype Design

Based on the regenerated symbol library, a packaging visual system for cultural and creative products was constructed. This system comprises four layers (**Figure 2**). First, the core identity layer employed the trigram structure and the human-headed serpent-bodied motif as the principal visual elements, with grids, axes, and proportional relationships defined to ensure structural stability. Second, the information layer translated the relationships between Hetu-Luoshu numerological imagery and trigram configurations into a serial coding system, including direction, numbering, and series differentiation, thereby establishing the information architecture of the packaging series. Third, the material and process layer combined gold foiling, embossing and debossing, spot UV, and textured paper, using the interplay of line, plane, and gloss to correspond to the generated meanings of yin-yang and order. Fourth, the communication and interaction layer incorporated AR triggers and H5 interactive modules [5], thereby creating a cross-media pathway of “trigram rotation-narrative unlocking–traceability linking”. The prototype covered the packaging appearance, the unboxing sequence, and the mobile interactive interface, and was intended to examine both the procedural boundaries and the semantic boundaries of the system.

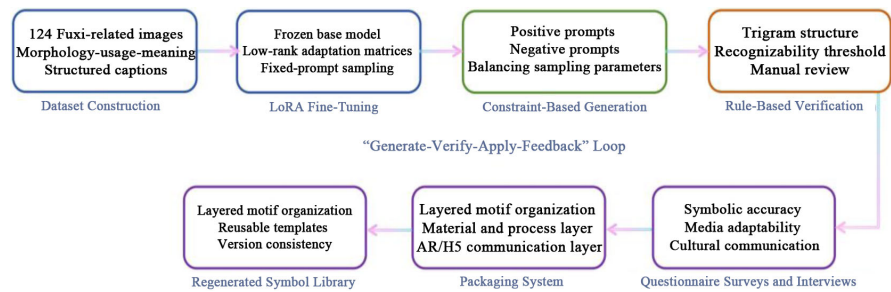


Figure 2. Workflow of multimodal generation and cross-media packaging design.

2.7. Evaluation Design

A mixed-methods approach combining questionnaires and interviews was adopted to evaluate the regenerated symbols and packaging prototypes. The questionnaire indicators were aligned with the three layers of the symbolic domain, with each layer including three core indicators and one supplementary exploratory indicator for consistency with the reporting structure: the morphological layer (symbolic accuracy, clarity of recognition, visual expressiveness, and stylistic innovativeness), the usage layer (media adaptability, rationality of information structure, interactive usability, and cross-media design performance), and the meaning layer (cultural communication, philosophical interpretation, emotional resonance, and perceived meaning generation). In addition, exploratory items on overall acceptance and purchase intention were included. The interviews focused on the criteria by which participants judged the tension between innovation and authenticity, the role of provenance information in shaping trust, and whether the interactive script facilitated understanding of trigram logic. At the statistical level, this study primarily reports scale reliability, descriptive statistics, and trend-level comparisons between groups in order to support a comprehensive analysis of prototype performance.

The regenerated symbols and packaging prototypes were evaluated through a combination of questionnaire surveys and interviews. A total of 182 questionnaires were collected. After excluding 26 invalid responses, including those completed in less than 60 seconds or those in which the same option was selected for all items on the five-point scale, 156 valid responses were retained for analysis. Participants were recruited through voluntary online distribution and university-based design/culture communication channels. Before participation, all respondents were informed of the academic purpose of the study, anonymity of data processing, and their right to withdraw, and electronic informed consent was obtained. Participants' demographic information included gender, age, disciplinary background, and whether they possessed relevant cultural knowledge. In this study, the "relevant cultural background" group refers to participants who reported prior coursework, research exposure, or sustained familiarity with Fuxi culture, the Eight Trigrams, or related traditional-symbol knowledge; the remaining respondents were classified into the general audience group, so the grouping reflected pre-existing knowledge rather than experimental assignment. Among

them, 64 participants were classified into the relevant cultural background group and 92 into the general audience group. The gender distribution was 46% male and 54% female, and the majority of participants were between 18 and 45 years old (88%). All respondents viewed the same prototype materials in the same presentation order under the same online interaction conditions; when AR/H5 functions could not be interactively tested on site, a standardized demonstration sequence was provided before rating. This grouping was used to compare differences in evaluations of structural correctness, media adaptability, and meaning comprehension across participants with different cognitive backgrounds.

The questionnaire items were developed on the basis of the three-dimensional framework of morphology-usage-meaning and were measured using a five-point Likert scale. Specifically, the morphological layer assessed symbolic accuracy, clarity of recognition, visual expressiveness, and stylistic innovativeness; the usage layer assessed media adaptability, the rationality of information structure, interactive usability, and cross-media design performance; and the meaning layer assessed cultural communication, philosophical interpretation, emotional resonance, and perceived meaning generation. In addition, overall acceptance and purchase intention were included as outcome variables to examine the relationships between the different evaluative dimensions and overall acceptance. These scales were mainly intended to provide a preliminary validation of methodological feasibility and design acceptance. Owing to space limitations, the complete questionnaire items are not presented separately in an appendix, but can be provided upon reasonable request.

To supplement the evaluative criteria that could not be fully captured through the scales, this study further conducted semi-structured interviews with 12 participants, including 5 experts and 7 general audience members. The interviews were conducted online via Tencent Meeting and were audio-recorded and transcribed. Each interview lasted approximately 35 minutes on average. The interview topics focused on the criteria used to judge the tension between innovation and authenticity, the effect of provenance information on trust, and whether the interactive script helped participants understand trigram logic. After transcription and organization, the interview materials were analyzed in NVivo 12 using three-level coding and thematic analysis in order to extract key viewpoints concerning structural authenticity, visual atmosphere, and pathways of cultural understanding.

In terms of statistical analysis, this study first employed Cronbach's α to test the internal consistency of the scales, and used the KMO test and Bartlett's test of sphericity to assess the structural adequacy of the questionnaire. The results showed a KMO value of 0.864 and Bartlett's test $\chi^2 = 1142.5$, $df = 66$, $p < 0.001$, indicating that the sample data had acceptable internal structural support. Descriptive statistics were then used to analyze performance across the three dimensions, and a Friedman test was conducted to compare differences among the three layers. For different audience groups, either an independent-samples t-test or a Mann-Whitney U test was used to compare differences in ratings on key indica-

tors. To keep the methodological chain consistent with the scope of reporting in the present article, exploratory factor analysis and regression analysis are not presented separately in the main text. The interview materials were analyzed through thematic induction to supplement the interpretive criteria that were difficult to capture in the quantitative results.

In summary, the methodological trajectory of this study may be characterized as the operationalization of the symbolic domain-generation control-design translation-effect evaluation. More specifically, the three-layer annotation transformed the Fuxi totem from a conceptual object into a learnable data structure; LoRA fine-tuning, constraint-based prompting, and rule-based verification jointly ensured the structural boundaries of the regenerative process; and the regenerated symbol library together with the packaging prototypes completed the translation from generated outputs into design applications. The questionnaire surveys and interviews were then evaluated for their performance across the three dimensions of morphology, usage, and meaning. In this way, the study establishes a relatively complete closed loop extending from the definition of the research object to technical implementation and design validation.

3. Results

3.1. Controllability and Drift in Regenerated Symbols

Within the generation workflow combining LoRA-based domain specialization and constraint-based prompting, the key motifs of the Fuxi totem exhibited relatively stable structural preservation across most samples. Taken together, observational results and subsequent evaluation data suggest that, after domain-specific fine-tuning, the clarity of trigram lines, the symmetry of composition, and the rendering of key structural motifs such as the human-headed serpent-bodied figure remained comparatively stable. At the same time, under the guidance of medium- and process-related vocabularies such as *stone carving*, *woodblock printing*, and *line drawing*, the generated outputs were able to achieve relatively consistent transfer across different visual styles [5] [16]. This indicates that the dual control mechanism centered on the morphological and usage layers helped improve motif recognizability and formal consistency in AIGC-generated outputs, although its effectiveness was demonstrated primarily at the level of prototypes and descriptive evaluation.

However, closer inspection of the generated outputs also showed that symbolic drift remained evident, mainly in two forms. The first was decorative overload caused by aesthetic overgeneralization. When prompts placed excessive emphasis on visual atmospheres such as “ornate” or “epic”, the outputs tended to accumulate large numbers of non-essential decorative patterns, which in turn obscured trigram structures [10] [11], line relationships, and compositional axes. The second was authenticity-related uncertainty caused by the conflation of historical layers. When vocabularies, media styles, and folk-cultural layers from different historical periods were combined within a single image, the resulting composition

often gained greater visual spectacle but lost historical consistency in cultural expression. These findings suggest that, while AIGC can enhance visual expressiveness, it may also push traditional cultural symbols further toward a stylized rather than structurally grounded mode of representation.

3.2. Visual and Informational Performance of the Packaging System

In the construction of the packaging system, the compositional strategy of central axis-symmetry-encirclement effectively reinforced the visual metaphor of “order generation” embedded in the Fuxi totem, while also improving recognizability in shelf-display contexts. Axial organization stabilized the visual center of the main graphic, symmetrical relationships enhanced the solemnity and ritual character of the overall structure, and encircling auxiliary patterns introduced continuous visual flow [9] [14]. These compositional strategies not only corresponded to the internal logic of order within the Fuxi totemic system, but also enabled the packaging series to establish a relatively coherent and unified visual identity.

At the informational level, the relationships between Hetu-Luoshu numerological imagery and trigram configurations were further translated into a coding system of direction, numbering, and series differentiation, thereby establishing a product distinction logic without requiring excessive explanatory text. In this way, abstract relationships derived from traditional culture acquired a functional role within the information architecture of the packaging system, enhancing the coherence and extensibility of serialized packaging design. However, when coding information became overly dense or lacked sufficient explanation, general audiences found it difficult to grasp the logical relationships among the numerological symbols in a short time. This suggests that, although information structure can indeed function as a vehicle for cultural translation, its complexity still requires careful control.

3.3. The Contribution of Cross-Media Interaction to Meaning Comprehension

At the level of cross-media communication, the AR/H5 interaction pathway showed a positive effect on audiences’ understanding of the meanings embedded in the Fuxi totem. Compared with static packaging graphics, dynamic interaction provided temporal sequencing and causal cues through a continuous mechanism of trigram rotation-interpretive prompting-provenance linking, allowing audiences to move beyond surface-level pattern recognition toward a deeper understanding of symbolic logic and cultural meaning. In particular, the addition of provenance links meant that the packaging no longer functioned merely as a terminal visual carrier, but instead became an entry point connecting graphic form, narrative structure, and knowledge-based interpretation [6] [7] [14]. This observation is broadly consistent with subsequent questionnaire and interview feed-

back regarding media adaptability and interpretive support.

At the same time, the results also showed that the meaning layer remained the weakest part of the overall system. Audience feedback indicated that when interpretive text was too brief, understanding tended to remain at the level of vague impressions such as “mysterious” or “ancient”, making it difficult to support deeper comprehension of concepts such as yin and yang, numerological imagery, and the generation of order. By contrast, when explanatory text became too long, users’ willingness to read and complete the interaction declined. Accordingly, in practical communication design, a layered interpretive mechanism of micro-narrative plus optional depth appears more appropriate: concise prompts can first provide an initial explanation, while links or expanded pages can offer more in-depth cultural information, thereby reducing cognitive burden while preserving space for deeper understanding.

3.4. Statistical Results and Trend-Level Group Differences

To examine whether the methodological pathway of symbolic-domain operationalization-generation control-design translation was supported at the user level, this study employed a five-point Likert scale to evaluate the regenerated symbols and packaging prototypes (Figure 3), yielding 156 valid responses. Reliability analysis showed that Cronbach’s α values for the morphological layer, usage layer, meaning layer, and the dimension of overall acceptance/purchase intention were 0.84, 0.81, 0.79, and 0.76, respectively, all of which reached acceptable or higher levels (see Table 2). In addition, the KMO value was 0.864, and Bartlett’s test of sphericity yielded $\chi^2 = 1142.5$, $df = 66$, $p < 0.001$, indicating that the questionnaire structure had acceptable internal adequacy. Descriptive statistics showed that, within the morphological layer, the mean scores for visual expressiveness and stylistic innovativeness were both above 4.50, while symbolic accuracy had a mean of approximately 4.48. Within the usage layer, the mean scores for cross-media design performance and interface/interaction experience ranged from approximately 4.37 to 4.41. By contrast, within the meaning layer, the mean scores for philosophical interpretive effect and perceived meaning generation ranged from approximately 4.26 to 4.29, making them relatively lower than those of the other two layers (see Table 3). A Friedman test further indicated significant differences among the three layers ($\chi^2 = 28.42$, $p < 0.05$), and post hoc analysis showed that the score of the meaning layer was significantly lower than that of the morphological layer ($p = 0.012$). These findings suggest that the methodological chain established in this study received relatively stable user support with regard to structural preservation and media adaptability, but still exhibited clear limitations in deep cultural interpretation.

Table 4 and Figure 4, Comparisons across different audience groups showed that participants with relevant cultural backgrounds gave slightly higher ratings on indicators such as symbolic accuracy, philosophical interpretive effect, and perceived meaning generation. General audiences, by contrast, relied more heav-

ily on materials and processes, narrative explanation, and the overall visual atmosphere when judging whether a design “resembled traditional culture”. In light of the between-group comparison results, these differences are more appropriately understood as trend-level distinctions with interpretive value rather than as strong causal conclusions. This suggests that, in practical communication contexts, a packaging system should not aim merely at visual resemblance to traditional culture, but should instead address the dual requirement of structural correctness and low-threshold interpretation.

Table 2. Reliability results of the questionnaire scales.

Dimension	Number of items	Cronbach's alpha	Reliability assessment
Morphological layer	4	0.84	Good
Usage layer	4	0.81	Good
Meaning layer	4	0.79	Acceptable
Overall acceptance/purchase intention	2	0.76	Acceptable

Table 3. Descriptive statistics of evaluation dimensions.

Dimension	Item code	Indicator	Mean	SD	Note
Morphological layer	M1	Symbolic accuracy	4.48	0.56	Relatively high perceived correctness of key structures such as trigram configurations and the human-headed serpent-bodied motif
Morphological layer	M2	Clarity of recognition	4.44	0.59	Overall motif recognition remained relatively stable
Morphological layer	M3	Visual expressiveness	4.53	0.51	Among the highest-rated items in the morphological layer
Morphological layer	M4	Stylistic innovativeness	4.55	0.49	Participants rated visual innovation highly
Usage layer	U1	Media adaptability	4.38	0.58	High degree of fit between regenerated symbols and packaging media
Usage layer	U2	Rationality of information structure	4.36	0.61	Serial coding aided understanding but required moderate explanation
Usage layer	U3	Cross-media design performance	4.41	0.55	AR/H5 extension enhanced systemic completeness
Usage layer	U4	Interface/interaction experience	4.37	0.60	Interaction methods were generally easy to understand
Meaning layer	I1	Cultural communication effect	4.31	0.62	Able to convey an atmosphere of traditional culture

Continued

Meaning layer	I2	Philosophical interpretive effect	4.26	0.66	Relatively limited capacity for deeper interpretation
Meaning layer	I3	Perceived meaning generation	4.29	0.64	Still lower than the morphological and usage layers
Meaning layer	I4	Emotional resonance	4.33	0.60	Demonstrated a certain degree of cultural affective appeal
Outcome variables	O1	Overall acceptance	4.46	0.54	Participants showed a relatively high overall level of acceptance
Outcome variables	O2	Purchase intention	4.34	0.63	Packaging design positively promoted purchase intention

Table 4. Comparison between culturally informed participants and the general audience.

Dimension/indicator	Mean (culturally informed group)	Mean (general audience)	Difference	Interpretation
Morphological layer overall	4.52	4.47	0.05	The culturally informed group rated structural preservation slightly higher
Usage layer overall	4.40	4.37	0.03	Differences between groups were small; both acknowledged media adaptability
Meaning layer overall	4.30	4.27	0.03	Both groups considered meaning-layer interpretation relatively weak
Symbolic accuracy (M1)	4.56	4.42	0.14	The culturally informed group paid greater attention to structural correctness
Visual expressiveness (M3)	4.51	4.55	-0.04	The general audience was more sensitive to overall visual impact
Cross-media design performance (U3)	4.43	4.39	0.04	Both groups acknowledged the value of interactive extension
Philosophical interpretive effect (I2)	4.31	4.22	0.09	The culturally informed group was better able to identify deeper cultural cues
Perceived meaning generation (I3)	4.33	4.25	0.08	Cultural background helped enhance depth of understanding
Overall acceptance (O1)	4.48	4.44	0.04	Overall acceptance differed little between groups
Purchase intention (O2)	4.36	4.32	0.04	The packaging prototype showed a certain degree of appeal to both groups

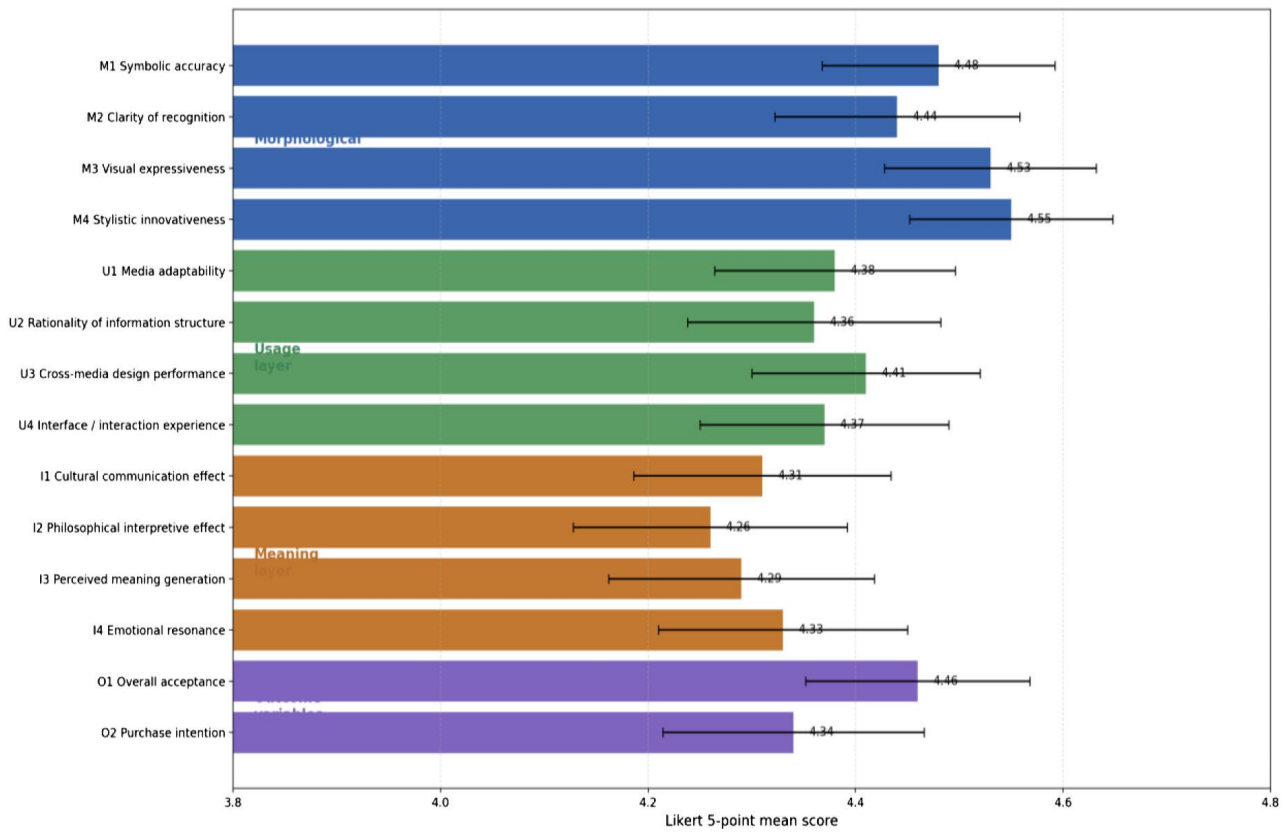


Figure 3. Evaluation of regenerated symbols and packaging prototype (mean scores).

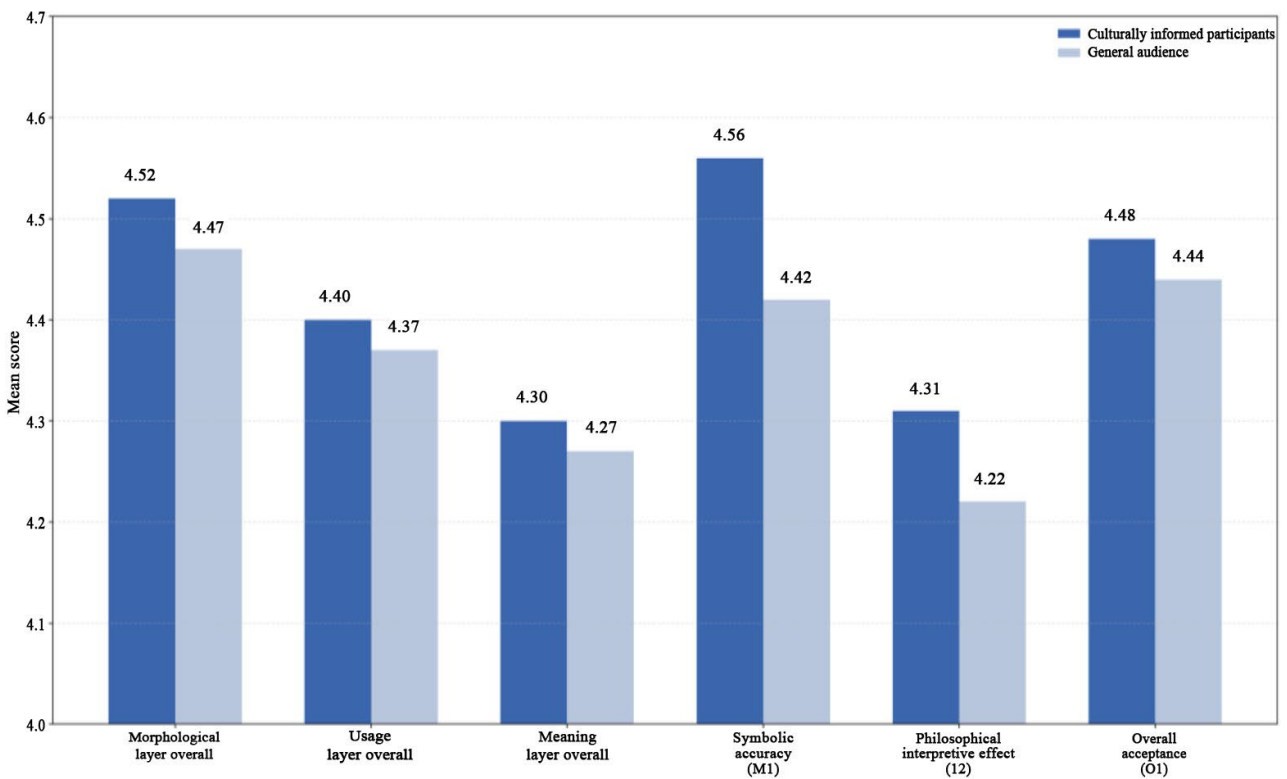


Figure 4. Comparison between culturally informed participants and the general audience on key dimensions.

3.5. Key Points of Process Implementation (Engineering Reproducibility)

To enhance the practical implementability of the method, this study further decomposed the packaging realization process into five categories of parameters: graphic, layout, material, process, and interaction. Graphic parameters prioritized the preservation of trigram lines, compositional axes, and numerological nodes, so as to ensure that the core symbolic structure would not be compromised by decorative elements. Layout parameters controlled the proportion of the main visual through a grid system and symmetrical reference lines, thereby preventing shifts in visual balance when generated images were translated into applied design; in principle, the main visual should occupy approximately 55% - 65% of the front-facing area [6] [9] [14]. Material parameters recommended the combined use of textured paper and black card to produce a yin-yang contrast, while also taking into account the image contrast required for AR recognition. Process parameters required prior verification of minimum line width and minimum spacing in complex line drawings, which in principle should not be less than 0.15 mm and 0.2 mm, respectively, in order to reduce the risk of line breakage in combined embossing and foil-stamping processes. Interaction parameters emphasized that the interaction entry point should maintain a consistent mapping with symbolic nodes, so as to prevent QR codes or trigger markers from disrupting the main visual composition. More detailed specifications for layout and process parameters can be provided upon reasonable request.

From the perspective of engineering reproducibility, the boundaries of traditional cultural symbols should not remain only at the level of semantic and visual description, but should be further translated into executable process constraints and design specifications [6] [9] [15]. Only when cultural boundaries are simultaneously transformed into graphic rules, layout proportions, material selections, process controls, and interaction logic can AIGC-generated cultural packaging solutions acquire genuine reproducibility, stability, and practical value.

4. Discussion

The foregoing results indicate that the method proposed in this study has already demonstrated relatively stable advantages at the morphological layer and the usage layer, whereas the meaning layer remains the weakest part of the overall system. Accordingly, the discussion section does not repeat the results themselves, but instead addresses three interrelated questions: why the pathway of symbolic-domain operationalization-generation control-design translation-effect evaluation can enhance structural controllability and media adaptability; why such improvements are still insufficient to automatically produce deep cultural understanding; and what this method implies, relative to common AIGC packaging workflows, in terms of governance logic and engineering implementation.

4.1. From Differences in Results to AIGC Governance: Boundary Constraints and Provenance Transparency

The statistical results reported in Section 2.4 show that the evaluations of the morphological and usage layers were higher than those of the meaning layer. This difference does not imply that form is inherently more important than meaning; rather, it suggests that, when AIGC is applied to packaging design involving traditional culture, structural control and media translation are comparatively easier to proceduralize, whereas deeper cultural interpretation depends more heavily on boundary setting and communicative supplementation. For this reason, the engineering attributes of packaging design require not only visible outcomes, but also reproducible procedures and traceable judgments. The layered modeling of the symbolic domain and the three categories of boundary constraints proposed in this study constitute, in this sense, a governance framework extending from data and generation to application: iconographic boundaries safeguard structural correctness, procedural boundaries ensure that interaction and material selection conform to ritual and customary logics, and semantic boundaries ensure that prompts, interpretive texts, and evaluative dimensions cover the core meanings of the symbol system. At the same time, the risk of pseudo-authenticity in AIGC also requires the introduction of provenance transparency at the packaging and communication levels. By labeling content as “generated”, “adapted”, or “source-based”, and by providing motif origins and interpretive links, audiences can distinguish between historical grounding and design elaboration.

4.2. From Controlled Generation to Acceptable Innovation: Design Tuning and Evaluation Alignment in the Tension between Innovation and Authenticity

If the previous subsection addressed why boundaries are necessary, the present subsection concerns how innovation can occur within those boundaries. Audiences' judgments of authenticity do not inherently reject innovation; rather, they are more concerned with whether innovation still preserves recognizable structural grounds, historical layers, and interpretive pathways. In light of the group comparisons reported in Section 2.4, participants with relevant cultural backgrounds gave slightly higher ratings on indicators such as symbolic accuracy and philosophical interpretive effect. This suggests that different audiences are sensitive to authenticity in different ways: the former are more concerned with whether structure and meaning are internally coherent, whereas the latter rely more heavily on materials and processes, narrative explanation, and overall atmosphere in forming trust. Accordingly, design tuning and evaluation alignment should proceed simultaneously. At the level of generative strategy, it is useful to distinguish between a core series and an exploratory series: the former prioritizes structural correctness with moderate stylistic variation, whereas the latter permits boundary-conscious elaboration in materials, color, and line quality, provided that it is explicitly labeled as creative interpretation. At the level of evaluation, success

should not be judged solely in terms of aesthetic novelty; instead, symbolic accuracy, media adaptability, and meaning comprehension should be treated as parallel criteria [4] [15]. In this way, the tension between innovation and authenticity can be made visible, interpretable, and continuously adjustable.

4.3. From One-Off Image Generation to Systematic Design Translation: A Comparison with Common AIGC Packaging Workflows

Once governance boundaries and evaluative principles have been clarified, the differences between the present method and common AIGC packaging workflows become more apparent. Conventional workflows typically center on “style prompts + rapid image generation”, with the main advantage being efficiency, but with weaknesses including semantic uncontrollability, poor version reproducibility, and outputs that often remain at the level of one-off visual production. By contrast, although the present method introduces slower preliminary stages such as data annotation, LoRA adaptation, and boundary verification, its value lies not merely in making images resemble a particular style more closely. Rather, it transforms traditional cultural symbols from one-time visual material into a reusable symbol library, a callable information structure, and an extensible interactive script. In other words, the purpose of this study is not simply to optimize image-generation efficiency, but to incorporate AIGC into a systematic process of research-object definition-generation control-design translation-effect evaluation. Such a process may not always be the most time-efficient option for one-off display-oriented works, but it is better suited to serialized packaging, cross-media communication, and subsequent version governance.

4.4. From Methodological Closure to Engineering Implementation: Practice-Oriented Design Implications

On the basis of the above discussion, the key to engineering implementation does not lie in the continued accumulation of stylistic features, but in translating cultural boundaries into executable and reviewable design specifications. Unlike Section 2.5, which focuses on specific process parameters, the emphasis here is on methodological implications for practice. First, visual innovation should be built on the premise of clear trigram structures and stable compositional axes, so that key motifs are not degraded into interchangeable style labels. Second, information coding should be linked to product attributes and interpretive mechanisms, allowing abstract numerological relations to acquire a clear reading entry point. Third, the selection of materials and processes should not function merely as formal embellishment, but should serve line-printability, tactile recognizability, and interaction recognition. Finally, the communication layer should simultaneously provide generative disclosure, source links, and the necessary interpretive scaffolding, so that users can distinguish between design elaboration and documented historical basis. Only through the combined operation of these elements can

AIGC-based cultural packaging move from one-off visual production toward a sustainably iterative design system.

5. Conclusions

Taking the symbolic domain of the Fuxi totem as its research object, this study constructs a research pathway for intangible-heritage packaging design centered on symbolic-domain operationalization-generation control-design translation-effect evaluation. The results show that embedding the three-layer structure of morphology-usage-meaning into data annotation, LoRA fine-tuning, constraint-based prompting, rule-based verification, and packaging prototype design can improve, at the prototype level, the structural controllability and media adaptability of key motifs in the Fuxi totem. When considered together with 156 valid questionnaires, 12 semi-structured interviews, and the statistical results, the morphological and usage layers received relatively high overall evaluations, whereas the meaning layer, particularly in terms of philosophical interpretation and perceived meaning generation, remained comparatively weak. This indicates that the proposed method has achieved a certain degree of effectiveness in the stability of symbolic generation and the clarity of design translation, but still remains insufficient in conveying deeper cultural meanings.

Overall, the significance of this study does not lie in claiming that AIGC has already resolved the interpretive difficulties of traditional cultural packaging design. Rather, its contribution lies in proposing a research pathway capable of forming a closed loop among structural control, media translation, and user evaluation. Future research should further test its stability and limits of generalization through more rigorous controlled experiments, real-world application scenarios, and cross-case comparisons.

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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