

Research on the Innovative Construction of Oracle Bone Inscription Graphic Symbol Translation Model under Extensible Semantics

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Abstract:

This study aims to apply extension semantic theory to explore the deep cultural connotations of oracle bone inscriptions graphic symbols, establish a systematic translation model, and investigate methods for the innovative translation of these symbols in a modern context. By categorizing oracle bone inscriptions graphic symbols and analyzing their semantic features, the research demonstrates the compatibility between extension semantic theory and the study of oracle bone inscriptions translation. It constructs an extension semantic translation framework encompassing element selection, semantic expansion, and morphological implementation. Utilizing this framework, a quantitative analysis of oracle bone inscriptions is conducted to establish a cultural element model. This is combined with extension interval calculation to achieve formal expression of semantics. Graphic thinking is employed to accomplish semantic visualization analysis, and extension transformation is applied to carry out design practice. Finally, through a three-dimensional goodness evaluation system, scheme optimization is performed, resulting in the completion of a combined character design. This validates the feasibility of the model in terms of semantic quantification and morphological innovation. The results demonstrate that this model enables the dynamic extension of oracle bone script semantics, overcoming the limitations of traditional translation that rely on subjective experience. It provides a replicable and scalable research pathway for the creative transformation of traditional symbols.

Keywords:

Oracle Bone Inscriptions, Extenics Semantics, Translation Models, Innovative Design

1. Introduction

Oracle bone inscriptions are the earliest mature writing system discovered so far, serving as both a cultural code during the Shang and Zhou dynasties and a treasure trove carrying the wisdom of our ancestors in word-making. General Secretary Xi Jinping also proposed in the report of the 20th National Congress of the Communist Party of China to promote cultural self-confidence and self-improvement, and to forge new splendors in socialist culture [1]. Against this backdrop, the emphasis on

traditional culture from all walks of life has been continuously increasing. Oracle bone inscriptions, with their pictographic and abstract characteristics, have become entities carrying linguistic symbols and visual culture. However, current research on Oracle bone inscriptions mostly focuses on traditional philological fields such as interpretation and dating, and the field of transforming and applying Oracle bone inscriptions in modern contexts is still in the exploratory stage. Common digital methods tend to focus on static display in font databases, failing to effectively address the main contradictions encountered in the translation process of Oracle bone inscriptions, such as ambiguity and vagueness. This has caused Oracle bone inscriptions to be somewhat disconnected from contemporary cultural innovation practices, unable to meet the design needs in a multicultural context. Extenics semantics, based on extenics theory, describes the relationships between multiple semantics of research objects in a quantitative manner [2], and explores the audience's recognition degree after coupling semantic connotation with graphic symbols through the analytical paradigm of graphical thinking. It provides a new methodological perspective for studying the transformation of Oracle bone inscriptions from ancient symbols to modern creativity. Therefore, this study aims to integrate extenics and Oracle bone inscriptions research, construct a systematic extenics semantic translation model through extenics semantic analysis, provide an effective path for the wide application of Oracle bone inscriptions in modern design, and promote the deep integration of traditional culture and modern design.

2. Theoretical Basis and Feasibility Analysis

2.1. Classification and semantic features of oracle bone script graphic symbols

Oracle bone inscriptions document the political, economic, and social conditions of the Shang Dynasty [3]. Based on the social production and life of the Shang Dynasty as well as the logic of character formation, the oracle bone pictographic symbols can be systematically categorized into five major types: cultural heritage, economic activities, calendrical and astronomical phenomena, ritual and civilization, and social events. Symbols of cultural heritage are represented by ritual vessels, documents, and sacrificial offerings, directly reflecting the ritual system and cultural inheritance of the Shang Dynasty. Symbols of economic activities primarily record production and economic activities such as currency circulation, textile craftsmanship, transportation, and trade. Symbols of calendrical and astronomical phenomena reflect ancient people's understanding of temporal changes and natural phenomena. Symbols of ritual and civilization embody power hierarchies, ethical norms, and patriarchal order. Symbols of social events include major social events such as wars, natural disasters, and diseases. This classification framework comprehensively covers the core essence of ancient civilization, not only establishing a systematic category for the selection of design elements but also revealing the origins of their semantic generation. Based on this, the oracle bone pictographic symbols present a clearly structured and closely related semantic structure. Their textual characteristics exhibit the features of multiple forms for a single word, identical forms for different words, and combined writing where two or more characters are inscribed together [4]. The pictographic semantics of oracle bone inscriptions are intuitive and concrete, using highly concise lines to outline the contours of objects, forming intuitive and concrete visual references that allow viewers to quickly establish a connection between form and meaning. The associative semantics are abstract and related, deriving more abstract concepts through the spatial combination of multiple pictographic components, demonstrating

the semantic expansion ability of the symbol system from concrete to abstract. Overall, the semantic categories of oracle bone inscriptions closely align with the social life of the Shang Dynasty, satisfying the functional need for recording events while deeply embedding into the cognitive system of that time, forming a rich primitive semantic network that provides profound semantic resources and transformational basis for cultural translation and innovative design in contemporary contexts.

2.2. The compatibility and problem-solving advantages of extension semantics theory

Extenics studies contradictory problems and explores the rules and methods for solving such problems through formalization [5]. Extenics semantics is a set of methods developed based on this foundation, incorporating graphical thinking. Its core is to use logical and mathematical means to quantify the multiple semantics of things, thereby reducing the interference of subjective experience in the decision-making process [6]. Its advantage lies in the use of mathematical logic to quantitatively describe and dynamically deduce the multiple semantics contained in the research object, providing methodological support for systematically solving the dilemma of oracle bone inscriptions translation. The applicability of extenics semantics theory is reflected in three main aspects: First, the primitive theory provides a structured model for semantic deconstruction. The primitive theory represents things and their relationships as computable units through the ternary structure of matter element, event element, and relationship element [7]. Second, extenics transformation provides an innovative engine for semantic expansion. Extenics transformation includes five basic transformations: permutation, addition and deletion, expansion and contraction, decomposition, and replication [8]. Starting from the original primitive model, it systematically derives rich semantics, providing a logical path for expanding design schemes. Third, extenics interval provides a quantitative basis for semantic selection. The extenics interval is an important quantitative indicator of the model, representing the product of cultural relevance and cultural value of a certain semantic. Through this indicator, the potential influence of semantics is transformed into objective numerical values, thus providing precise and quantitative optimization basis for design decisions among multiple possible expansion paths, overcoming the limitations of subjective experience.

2.3. Feasibility integration from theory to practice

The systematic characteristics of oracle bone inscriptions and the methodological advantages of extensibility semantic theory jointly lay the foundation for the possibility of this study from theoretical conception to practical application. Cai Wen defines the extensibility base element model as the smallest grammatical unit that describes everything, uniformly using the formalization of “object-feature-value” triples to describe things [9]. The emergence of the extensibility base element model provides a formalized tool for describing the vague and implicit cultural connotations of oracle bone inscriptions, making it possible to transform graphic symbols into computable units and solving the fundamental problem of long-term dependence on subjective experience in the translation process. On this basis, extensibility transformation and extensibility interval theory preset a clear logical path for the directional expansion and quantitative optimization of semantics, promoting the innovation process from random inspiration to controllable systematic derivation. The introduction of a comprehensive evaluation system that integrates semantics, visual aspects, and culture can provide objective evidence for the scientific verification of

translation results, ensuring that the final outcomes possess both cultural accuracy and modern communication power. This interlocking logical progression not only theoretically connects the transformation path from traditional symbols to modern creativity but also constructs a rigorous and reliable implementation framework for the subsequent specific methodological processes of this study.

3. Method for Constructing Extensible Semantics of Oracle Bone Inscriptions Graphic Symbols

3.1. Selection of design primitives

The essence of oracle bone inscriptions is symbols, featuring formal beauty and abstract, regular shapes [10]. Their graphic symbols are composed of several primitives with independent ideographic functions. These primitives are the basic units of oracle bone inscriptions' forms and serve as the core carriers of primitive semantics. The selection and determination of oracle bone inscriptions' design primitives is a crucial prerequisite for deeply analyzing their graphic symbol system and realizing innovative design of oracle bone inscriptions culture.

The candidate set for the design primitives of oracle bone inscriptions graphic symbols is denoted as $G = \{g_1, g_2, \dots, g_i\}$, where g_i represents the i th candidate primitive. The core extensible semantic features include $c_j (j=1,2,3)$ pictographic nature c_1 , which represents the degree to which the primitive simulates the form of things; semantic derivativeness c_2 , which represents the ability of the primitive to generate new semantics through deformation and combination; and system associativity c_3 , which represents the strength of the association between the primitive and other oracle bone inscriptions character forms. Then, m evaluation experts are invited to score each candidate primitive g_i based on the three core extensible semantic features: pictographic nature, semantic derivativeness, and system associativity. If the score given by the t -th expert for primitive g_i on feature c_j is $S_{t,i,j}$, then the single-feature scoring matrix for primitive g_i is expressed as formula (1):

$$S_i = \begin{bmatrix} S_{1,i,1} & S_{1,i,2} & S_{1,i,3} \\ S_{2,i,1} & S_{2,i,2} & S_{2,i,3} \\ \vdots & \vdots & \vdots \\ S_{m,i,1} & S_{m,i,2} & S_{m,i,3} \end{bmatrix} \quad (1)$$

The c_j average score of a single feature mean primitive g_i on a feature is expressed as formula (2):

$$\bar{s}_{i,j} = \frac{1}{m} \sum_{t=1}^m s_{t,i,j} \quad (j=1,2,3) \quad (2)$$

According to the importance of the features, weights are assigned, and the extensible semantic feature score is $w_1 + w_2 + w_3 = 1$, where pictographic $w_1 = 0.4$, semantic $w_2 = 0.3$, and system correlation $w_3 = 0.3$. The comprehensive score is calculated using formula (3):

$$T_i = \sum_{j=1}^3 w_j \cdot \bar{s}_{ij} \quad (3)$$

In the formula: T_i is the i -th overall score; w_j is the weight of the j -th indicator; $\bar{S}_{ij}$ is the average value of the i -th object on the j -th indicator.

Sort the comprehensive score T and select the top i elements with the highest score as the final design elements. The element expression is (4):

$$G' = \{g_i | T_i = \max\{T_1, T_2, \dots, T_i\}, i = 1, 2, \dots, i\} \quad (4)$$

3.2. Extensible semantic representation of oracle bone inscriptions graphic symbols

The extension semantic analysis design method is a creative design reference approach that emerges from the integration of extenics basic element theory and graphical feature semantic cognition [11]. Based on this reference method, cultural basic elements of oracle bone script graphic symbols are constructed, and the implicit connotations of oracle bone culture are formally, quantitatively, and modelled into explicit expressions, forming an extension semantic representation method suitable for innovative design of oracle bone script graphic symbols. The specific process is as follows:

Firstly, an ordered triplet system for the extensible semantics of oracle bone inscriptions' graphic symbols is established, denoted as $M = (Q, E, F)$. Here, M represents oracle bone culture, Q stands for oracle bone inscriptions' graphic symbol objects, E is the semantic vocabulary set describing their characteristics, and F denotes the extensible interval. The expression is shown in equation (5):

$$M = (Q, E, F) = \left\{ \begin{array}{ccc} Q, & E_1, & F_1 \\ & E_2, & F_2 \\ & \vdots & \vdots \\ & E_n, & F_n \end{array} \right\} \quad (5)$$

Secondly, F can be decomposed into $\bar{f}_x$ and $\bar{f}_y$, which respectively represent the degree of cultural association and cultural value. The larger the F value, the higher the degree of association between the feature vocabulary and oracle bone script culture, and the higher the cultural value provided in the process of redesigning oracle bone script graphic symbols, which can provide a reliable direction for design innovation [12].

Calculation of cultural relevance: It is used to indicate the strength of cultural relevance between oracle bone script graphic symbols Q and feature words E . The value range is $\bar{f}_x \in (0, 1]$, where the statistical number of scores a corresponding to the feature words is b_a , where $a \geq 1$; the highest value of a is taken as the maximum score, and the total number of volunteers participating in the evaluation of feature words is β . Based on this, the formula for calculating the cultural relevance degree of oracle bone script graphic symbols' extensible semantics is derived as shown in equation (6):

$$\bar{f}_x = \frac{\sum_{a=1}^a ab_a}{\beta \times \frac{\alpha(\alpha+1)}{\alpha}} \quad (6)$$

$\bar{f}_y$ Calculation of cultural value: This is $\bar{f}_y$ used to represent the cultural value of feature word E in the redesign process of oracle bone script graphic symbols, with a value range of $[1, \theta]$ (θ is the upper limit of cultural value evaluation). The evaluation

result directly reflects the degree of value. It is planned to invite β number of volunteers to participate in the evaluation work. The evaluation dimensions cover cultural inheritance value, artistic design value, and social cognitive value. The evaluation result is denoted as d_n ($n \in [1, \Phi]$), where Φ is the number of valid samples participating in the evaluation. Based on this, the formula for calculating the extensible semantic cultural value of oracle bone script graphic symbols is derived as Equation (7):

$$\overline{f_y} = \frac{\sum_{n=1}^{\phi} d_n}{\phi} \quad (7)$$

Based on the aforementioned calculations and derivations, the corresponding expression for the extension interval F is (8):

$$F = \overline{f_x} \times \overline{f_y} \quad (8)$$

3.3. Research process

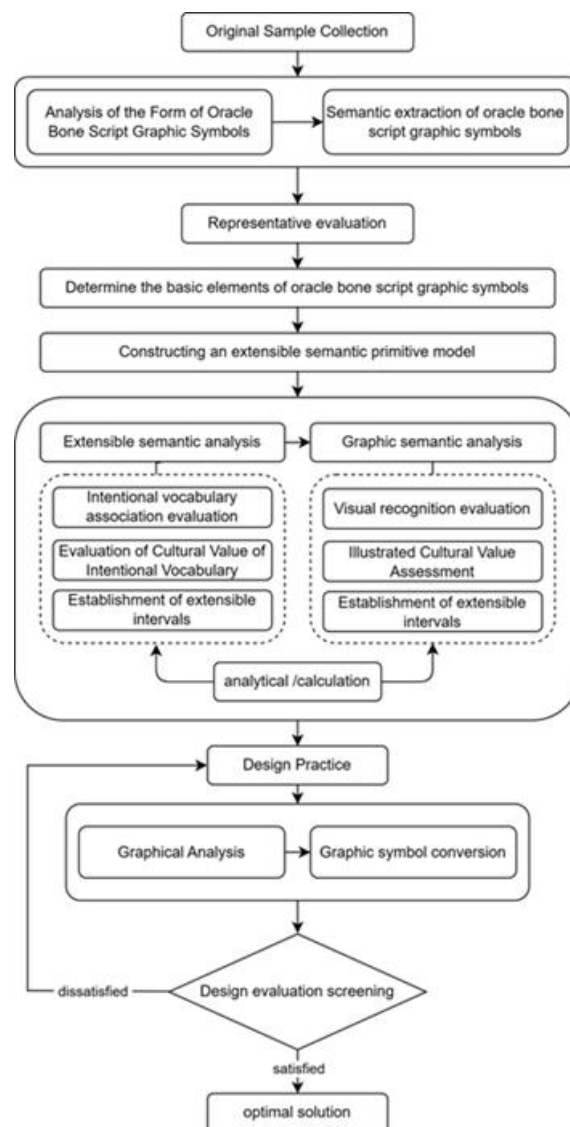


Figure 1. Research process.

Based on the extension semantics theory, this study constructs a translation model for oracle bone inscriptions' graphic symbols. The specific research process is shown in Figure 1.

Firstly, we conduct morphological deconstruction and semantic mining of oracle bone script graphic symbols, selecting graphic symbol primitives with typical characteristics. Then, we establish an extension primitive analysis model to perform extension semantic analysis and value evaluation on the selected oracle bone script graphic symbol primitives. We screen out semantic words with the largest extension interval dimensions, and then construct visual diagrams and perform multi-dimensional evaluation and optimization for these semantic words. Afterwards, we integrate the optimized semantic diagrams for extension transformation. Finally, we evaluate the quality of the transformation results and complete the validity verification of the constructed model through the design of optimized schemes.

4. Construction of a Translation Model for Oracle Bone Inscriptions' Graphic Symbols Under Extension Semantics

4.1. Selection of oracle bone inscriptions primitives

Oracle bone script, as an early mature Chinese writing system, contains many technical and social factors in its handwriting, such as character structure, material selection, writing techniques, writing standards, etc., all of which may have an impact on the recording and presentation of history. Therefore, in order to ensure a high degree of unity among cultural typicality, semantic systematicity, and visual extensibility in the research sample, and to achieve the refined construction of extensible semantic models, it is necessary to select the most representative specific characters from oracle bone inscriptions as design elements. Based on the previous classification framework, this study selected some typical oracle bone script from various categories as the initial set of candidate elements G . In order to objectively quantify the representativeness of different oracle bone script cultures, eight paleontologists, ten oracle bone script enthusiasts, and ten design professionals were invited to quantitatively score the three main characteristics of each candidate element: pictographic C_1 , semantic derivation C_2 , and systematic correlation C_3 , with a value ranging from one to five points. Based on expression (3), all candidate oracle bone inscriptions were scored, and the oracle bone character "Ri" (meaning "sun" or "day") with the highest comprehensive score T_i was ultimately selected as the design element for this study. The results are shown in Table 1.

Table 1. Oracle bone script primitive selection.

Oracle bone inscriptions classification	Typical symbol	Name	Semantic vocabulary extraction	rating
Cultural heritage		Ding	Power, ritual vessels, inheritance, stability, and sacrifice	4.68
		Ce	Documents, history, law, inheritance, order	3.98
		You	Sacrifice, feast, brewing, intoxication, ritual system	4.12
Economic activities		Bei	Currency, wealth, transactions, value, rewards	4.51

Oracle bone inscriptions classification	Typical symbol	Name	Semantic vocabulary extraction	rating
		Si	Textile, Clothing, Exquisite, Trade, Craftsmanship	4.06
		Chuan	Transportation, migration, communication, expedition, convenience	4.10
Calendar and astronomical phenomena		Ri	Time, cycle, brightness, regularity, eternity	4.78
		Qiu	Age, farming season, growth, harvest, cycle	4.24
		Yu	Moisturizing, bountiful harvest, floods, divine will, impermanence	4.23
Etiquette civilization		Wang	Power, Rule, Core, Order, Destiny	4.25
		Li	Ritual, norms, reverence, harmony, hierarchy	4.16
		Xiao	Bloodline, Respect for the Elderly, Genealogy, Ethics, Inheritance	4.14
Social Chronicle		Fa	Expedition, force, conquest, killing, achievement	4.31
		Zai	Destruction, suffering, fear, divine retribution, loss	4.15
		Ji	Illness, fragility, divination, health, anxiety	3.98

4.2. Selection of oracle bone inscriptions primitives

The extensible interval is a core quantitative indicator for measuring the semantic expansion potential and scene adaptation value of oracle bone script graphic symbols. Its calculation is based on the extensible semantic representation system constructed in the above text, and revolves around the dual dimensions of “cultural relevance cultural value”. Through scientific weighting and data operation, the accurate quantification of semantic value is achieved, providing objective decision-making basis for subsequent translation design. Based on the classification and screening work carried out in the early stage for oracle bone script graphic symbols, as well as the representative evaluation, the research object has been determined as the graphic symbol of “Ri” in oracle bone script. Its semantics have been systematically extracted and summarized into five core characteristic words: time, period, brightness, regularity, and eternity. By combining these five characteristic words, an extensible semantic ordered triplet of the oracle bone script “Ri” graphic symbol can be constructed: Q is the graphic symbol of the evaluated oracle bone script “Ri”, E represents the image vocabulary used to describe the oracle bone script “Ri”, and F represents the extensible interval, that is, the corresponding value of the characteristic word. Based on equation (5), it can be expressed as:

$$M = \begin{cases} \text{Day} & \text{Time} & F_1 \\ & \text{Cycle} & F_2 \\ & \text{Brightness} & F_3 \\ & \text{Regularity} & F_4 \\ & \text{Eternity} & F_5 \end{cases} \quad (5)$$

Based on the five image vocabulary mentioned above, twenty enthusiasts of oracle bone script culture were invited to rate their level of association with oracle bone script culture, with a score range of one to five points, five points for close association, and one point for weakest association. According to formula (6), calculate the average cultural relevance of the characteristic vocabulary of “Ri” in oracle bone script. The higher the score, the higher the degree of cultural relevance. The results are shown in Table 2.

Table 2. Cultural relevance score of semantic meaning of image vocabulary.

Feature vocabulary	number of people					Mean Score $\bar{f}_x$
	5-point	4-point	3-point	2-point	1-point	
Time	10	6	3	1	0	0.82
Cycle	8	7	3	2	0	0.76
Brightness	12	5	2	1	0	0.85
Regularity	6	8	4	2	0	0.72
Eternity	9	6	3	2	0	0.78

We invited six experts in paleography and designers with practical experience to score the cultural design value of imagery vocabulary from their perspective. The score range is set between one and five, where five represents a high cultural design value and one represents no cultural design value. The mean value of the cultural design value of imagery vocabulary is calculated according to formula (7). The higher the score, the stronger the cultural value recognition of the imagery vocabulary. The scoring results are shown in Table 3.

Table 3. Cultural value scoring of semantic meaning of image vocabulary.

Imagery vocabulary	score						Mean Score $\bar{f}_y$
	n_1	n_2	n_3	n_4	n_5	n_6	
Time	4	5	4	5	4	4	4.33
Cycle	3	4	4	3	4	3	3.50
Brightness	5	5	4	5	4	5	4.67
Regularity	4	3	4	4	3	4	3.67
Eternity	4	4	5	4	4	4	4.17

Based on formula (8) and various data presented earlier, the F values of the extension intervals for each image vocabulary were calculated, and the specific results are shown in Table 4.

Table 4. Extensible interval of semantic meaning of image vocabulary.

Expandable range	Time	Cycle	Brightness	Regularity	Eternity
$\bar{f}_x$	0.82	0.776	0.85	0.72	0.78
$\bar{f}_y$	4.33	3.50	4.67	3.67	4.17
F	3.55	2.66	3.97	2.64	3.25

4.3. Selection of oracle bone inscriptions primitives

Based on the obtained extension interval, using graphic thinking [14], a graphic analysis was conducted on the five image words of the graphic symbol “Ri” in oracle bone inscriptions, with a focus on semantic words with larger threshold dimensions, to evaluate the recognition and social value of graphic semantics [15]. To establish an effective association between semantics and visual form, ten representative association diagrams were selected for each vocabulary, and at the same time, color removal was implemented using Adobe Photoshop software to provide better observation conditions for evaluators. Subsequently, twenty enthusiasts of oracle bone script culture were selected to participate in the scoring process, and five related matching diagrams were selected from existing materials based on each vocabulary; Then, six experts and designers in the field of paleography selected three optimal illustrations numbered s1, s2 and s3, as shown in Table (5).

Table 5. Extensible interval of semantic meaning of image vocabulary.

Feature vocabulary	Illustrative numbering		
	S1	S2	S3
Time			
Cycle			
Brightness			
Regularity			
Eternity			

To quantitatively evaluate its design potential, five professional designers were invited to rate these diagrams from two aspects: recognizability and cultural value. The recognizability rating range f_{sx} is (0, 1), and the cultural value rating range f_{sy} is [1,5]. According to equations (6) and (7), the recognizability and design value of each feature word's three diagrams are scored and calculated. Then, according to equation (8), the extensible range value of the diagram semantics is calculated, providing a diagram reference with both cultural accuracy and visual expressiveness for subsequent morphological translation. The specific conclusions regarding screening and evaluation are summarized in Tables 6 to 9.

Table 6. Recognition score of image vocabulary related illustrations.

Designer serial number	Illustrative coding	Time	Cycle	Brightness	Regularity	Eternity
d_1	s_1	0.9	0.9	0.8	0.8	0.9
	s_2	0.5	0.6	0.7	0.6	0.8
	s_3	0.8	0.4	0.3	0.4	0.5
d_2	s_1	0.8	0.8	0.9	0.9	0.8
	s_2	0.6	0.5	0.6	0.5	0.7
	s_3	0.9	0.5	0.4	0.3	0.4
d_3	s_1	0.9	0.9	0.8	0.8	0.9
	s_2	0.5	0.6	0.7	0.6	0.8
	s_3	0.8	0.4	0.3	0.4	0.5
d_4	s_1	0.8	0.8	0.9	0.9	0.8
	s_2	0.6	0.5	0.6	0.5	0.7
	s_3	0.9	0.5	0.4	0.3	0.4
d_5	s_1	0.9	0.9	0.9	0.8	0.9
	s_2	0.5	0.6	0.7	0.6	0.8
	s_3	0.8	0.4	0.3	0.4	0.5

Table 7. Cultural value scores of image vocabulary related illustrations.

Designer serial number	Illustrative coding	Time	Cycle	Brightness	Regularity	Eternity
d_1	s_1	3	2	5	3	4
	s_2	5	4	2	4	3
	s_3	2	3	3	5	2
d_2	s_1	5	4	4	5	5
	s_2	4	5	3	4	4
	s_3	4	3	4	5	4
d_3	s_1	2	3	4	2	3
	s_2	4	2	5	3	2
	s_3	3	4	2	4	3
d_4	s_1	4	5	3	4	4
	s_2	3	4	4	5	5
	s_3	5	2	5	3	4
d_5	s_1	3	4	5	3	2
	s_2	2	3	4	5	4
	s_3	5	4	2	5	4

Table 8. Semantic average score of image vocabulary related diagrams.

Illustrative coding	average	Time	Cycle	Brightness	Regularity	Eternity
s_1	$\overline{f_{sx}}$	0.9	0.9	0.9	0.8	0.9
	$\overline{f_{sy}}$	3.4	3.2	4.6	3.8	2.8
s_2	$\overline{f_{sx}}$	0.5	0.6	0.7	0.6	0.8
	$\overline{f_{sy}}$	3.0	4.0	3.4	4.0	3.4
s_3	$\overline{f_{sx}}$	0.8	0.4	0.3	0.4	0.5
	$\overline{f_{sy}}$	4.4	4.2	2.8	3.2	3.0

Table 9. Extensible interval of image vocabulary diagrammatic semantics.

Illustrative coding	Time	Cycle	Brightness	Regularity	Eternity
s_1	3.1	2.9	4.1	3.0	2.5
s_2	1.5	2.4	2.4	2.4	2.7
s_3	3.5	2.9	0.8	1.3	1.5

5. Practical Verification of the Translation Model

The core of the extensible semantic translation of oracle bone script graphic symbols is to creatively transform ancient Chinese characters into modern visual carriers, and its operational logic needs to form a closed loop around “element selection semantic expansion morphological landing”. The verification will be based on the most representative oracle bone script graphic symbol “Ri” in the above analysis to develop the design.

5.1. Design Practice

As one of the earliest writing systems, oracle bone script did not occupy a dominant position in terms of artistic attributes during the Yin and Shang dynasties. Due to the limitations of writing activities at that time, its stylistic and visual features exhibited certain fluctuation characteristics. The oracle bone script “Ri” fully embodies the ancient people’s pictographic thinking in character creation. The graphic symbols are centered around pictograms and simulate the outline of the sun through the outer frame. The internal points or horizontal lines are either indicative symbols that emphasize the physical nature of the sun, or concrete observations of the morphology of sunspots; Due to the difficulty in presenting rounded lines in the carving process of turtle shell and animal bones, various variations such as square, pentagon, and diamond shapes have been derived from the outer frame. Although circular writing is rare, it still retains the original image of the sun, as shown in Table 10.

Table 10. The Different Forms of Oracle Bone Script “Ri”.

Coding	R_1	R_2	R_3	R_4	R_5	R_6	R_7
Form							

Through computer quantitative analysis of the morphology of seven oracle bone inscriptions with the character “Ri”, core morphological features such as contour regularity, structural symmetry, internal complexity, and Euler number were extracted. The analysis results showed that morphology R_1 performed the best in all tested dimensions. Therefore, based on the form R_1 , the graphic symbols were analyzed and standardized to remove the irregular edges of the original knife cut. The optimized contour ratio was 7:11 square circle, and the distance between the center circle and the outer frame was kept consistent. The results are shown in Figure 2.

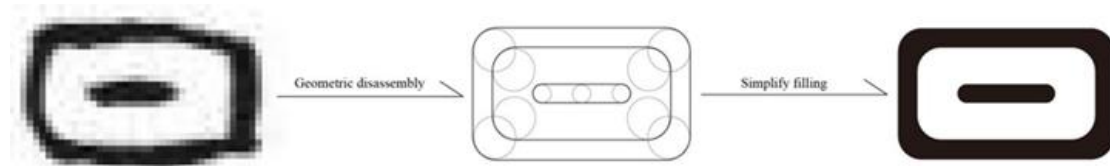


Figure 2. Graphic symbol normalization extraction.

Compared to the ambiguity of word semantics, graphic symbols provide a more intuitive inspiration and influence on design practice [17]. Therefore, this study

systematically analyzes the high-quality illustrations selected by the aforementioned extension semantic model and finds that the extension interval between time s_3 and brightness s_1 is relatively large, serving as the basis for visual graphic translation. The purpose of this practical design is to establish a graphic symbol system that embodies both cultural connotation and modern visual expression. By utilizing methods such as visual reconstruction and semantic feature enhancement, combined with application scenarios, it aims to achieve a systematic transformation of oracle bone script graphic symbols from ancient writing forms to modern design language, thereby achieving innovative expression of cultural imagery. The specific process is as follows:

The main tool used in the design execution phase is Adobe Illustrator. Based on the characteristics of the main form of the “Ri” symbol, the forms of the time diagram s_3 and the light diagram s_1 are extracted separately, and the visual symbol focus of the two types of diagrams is distinguished. The extraction results are shown in Table 11.

Table 11. *Extraction of Illustrative Design Elements.*

Illustration	Material extraction	Morphological extraction
Time Diagram s_3		
Bright Diagram s_1		

On this basis, the processed elements are uniformly numbered to form a standardized design material library. The specific element processing and numbering results are shown in Table 12.

Table 12. *Basic element number.*

	Main element	Accessory elements	
Element			
Number	1	2	3

In the design practice stage, based on the standardized form of oracle bone script “Ri” and the semantics of “brightness” and “time”, five basic methods of extensible transformation were used to generate new visual graphic symbols. The graphic deduction process is shown in Table 13. Scheme one features a square frame texture enveloping a central radial array, forming a time-sequenced structure with interlaced light and shadow through replication and permutation transformations, evenly distributing the semantics of light and time. Scheme two employs a circular frame paired with a central dot, undergoing subtraction and replacement to create a minimalist form of spatiotemporal superimposition, emphasizing the regularity of time semantics. Scheme three adopts a structure of rings within rings, utilizing decomposition and expansion permutation to form a heavy symbol of circular inheritance, enabling the symbiotic circulation of light and time. Scheme four utilizes a double circular frame to support a central dot, undergoing shrinkage permutation to

form a spatiotemporal carrier of double light superimposition, highlighting the focal nature of light semantics. Scheme 5 replaces the radial lines with a square frame texture, adding a time dot in the center to form an interactive symbol where the frame emits light and the center keeps time, enhancing visual hierarchy. Scheme six adopts a radial frame texture nested within a central concentric texture, utilizing replication and shrinkage permutation to form a hierarchical structure of internal time and external light, achieving a balanced expression of dual semantics. Overall, the six designs revolve around the two semantics of “light” and “time”, presenting dynamic fusion to static stratification through the combination differences of extensible transformations. The design schemes are detailed in Table 14.

Table 13. Graph generation and deduction based on extensible changes.

Graphic generation scheme	Extensible transformation process
Option 1	The diagram for Option 1 shows two parallel transformation sequences. The top sequence starts with a spiral pattern (2), which is 'cut' into a circle (2-1). This circle is then 'Copy and Transform'ed into a concentric circle pattern (2-2), which is finally 'replacement'ed with a square frame pattern (2-3). The bottom sequence starts with a starburst pattern (3), which is 'cut' into a triangle (3-1). This triangle undergoes 'Mirror replication' to become a diamond shape (3-2), which is then 'Rotate Copy'ed into a starburst pattern (3-3). Finally, this starburst is 'Shrink and Replace'ed with a smaller starburst pattern (3-4).
Option 2	The diagram for Option 2 shows two parallel transformation sequences. The top sequence is identical to Option 1's top sequence: spiral (2) → cut → circle (2-1) → Copy and Transform → concentric circles (2-2) → replacement → square frame (2-3). The bottom sequence starts with a starburst pattern (3), which is 'cut' into a solid black circle (3-5). This circle is then 'Shrink and Replace'ed with a very small solid black circle (3-6).
Option 3	The diagram for Option 3 shows two parallel transformation sequences. The top sequence starts with a spiral pattern (2), which is 'decompose'ed into a solid black circle (2-4) and an empty circle (2-5). These two are then 'reorganize'ed into a single empty circle (2-6), which is finally 'Expand substitution'ed into a thick black ring (2-7). The bottom sequence is identical to Option 1's bottom sequence: starburst (3) → cut → triangle (3-1) → Mirror replication → diamond (3-2) → Rotate Copy → starburst (3-3) → Shrink and Replace → smaller starburst (3-4).

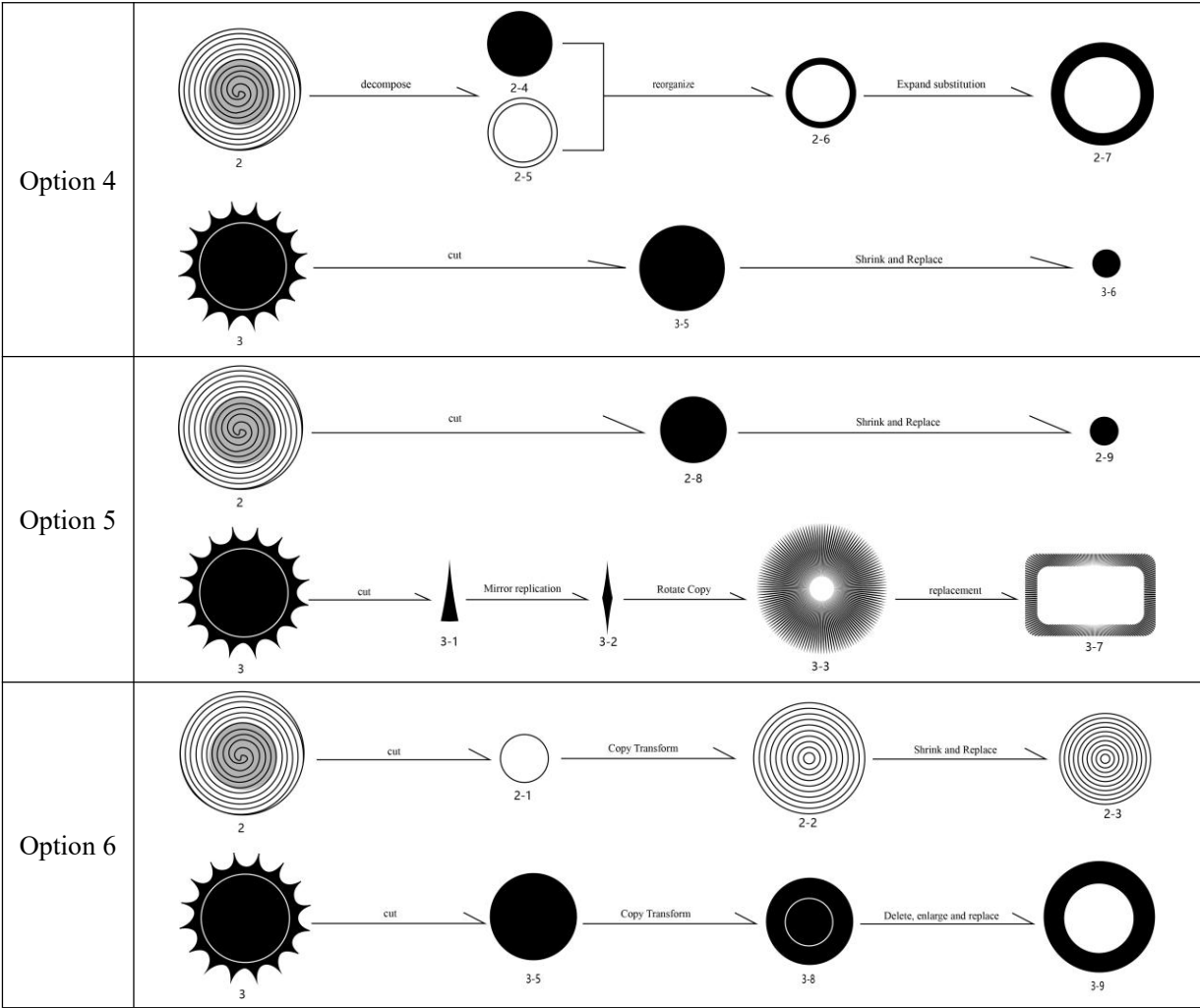


Table 14. Graphic design proposal.

Number	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Graphics						

5.2. Verification process

Excellence evaluation [18] is a fundamental method in extenics innovation theory for conducting comprehensive evaluation of research objects. The excellence evaluation method is utilized to perform a three-dimensional evaluation of each scheme based on “semantic accuracy - visual communication - cultural inheritance” to select the optimal design scheme [19]. Assuming semantic accuracy is K1, visual communicability is K2, and cultural fit is K3, and based on expert evidence, the weights of each dimension are determined as K1=0.4, K2=0.3, and K3=0.3, respectively. An evaluation team consisting of five paleography experts, five senior designers, and ten oracle bone culture enthusiasts was invited to conduct a 10-point quantitative scoring for six sets of translation schemes. The results are shown in Table 15.

According to the above evaluation results, the overall superiority level of design Option 6 is relatively high. Its graphic symbols adopt a circular hierarchical structure to correspond to the pictographic core of the oracle bone script “Ri”. The concentric

circle texture in the center also implies the semantic extension of time cycle and bright radiation, fully preserving cultural genes and achieving accurate transmission of core semantics, achieving a translation effect that combines form and spirit; At the same time, the combination of extensible transformations not only reflects the systematic innovation of form, but also balances the cultural and artistic unity of hierarchical structure, which meets the main standards of the three-dimensional evaluation system.

Table 15. Comprehensive score of cultural value.

Solution Number	K_1	K_2	K_3	Overall Score
1	8.9	8.5	8.7	8.70
2	7.6	7.8	7.5	7.61
3	9.1	8.3	8.9	8.76
4	8.7	8.6	8.5	8.61
5	7.8	8.0	7.7	7.83
6	9.3	9.0	8.9	9.09

5.3. Verification process

For the selected scheme, with a focus on implementation verification, we will visually design the graphic symbols of option 6, incorporating user feedback and expert suggestions. We will achieve the transformation from symbol prototype to practical carrier through semantic integration and scene adaptation, realizing the closed-loop implementation of cultural symbols in specific scenes, and ultimately forming a reusable translation model process.

The redesign of the “Ri” symbol this time adopts the visual framework of optimal solution 6, using the form of compound characters. Firstly, identify the core recognition features of the “Ri” and retain the basic semantics of the time cycle; Extract the symbol elements of “jin”, “dou”, and “jin”, integrate the structure with “Ri” as the visual center, use the lines of “dou” to create a smooth connection with the texture of “Ri”, use the lower form of “jin” to carry the details of “jin”, unify the rounded line style of all symbols, weaken the sense of fragmentation in splicing, and finally form a composite character of “ri jin dou jin” with cultural imagery and visual integrity, as shown in Figure 3.

In summary, the design scheme strengthens the basic imagery of the “Ri” symbol of time and brightness, expands the extended narrative of daily gains and good fortune, conveys the auspicious meaning of “making money every Ri”, and can be applied to various scenarios such as cultural and creative products and commercial space signage, completing the complete loop of cultural symbol optimization from prototype to scene implementation, as shown in Figure 4.



Figure 3. Redesign presentation.



Figure 4. Solution application demonstration.

6. Conclusions

Oracle bone script, as an ancient symbol system carrying the genes of Shang and Zhou civilization, is a valuable resource for innovation in traditional visual culture. This article starts with the core semantics and structural features of oracle bone script, and establishes an extensible semantic model for translating oracle bone script graphic symbols. This model establishes a complete design process for primitive screening, semantic evaluation, morphological innovation, and scheme optimization. Taking the oracle bone script “Ri” as an example, the design verification is completed, and the final “Ri Jin Dou Jin” composite character design is obtained. The model retains the cultural genes of oracle bone inscriptions and has adaptability for modern visual communication, proving its feasibility in terms of cultural accuracy and morphological innovation. This study integrates the quantitative advantages of extensible semantics with the cultural characteristics of oracle bone inscriptions, breaking the traditional translation dilemma of relying on subjective experience and providing a new path for the creative transformation of traditional symbols. In the future, by expanding the sample library and combining artificial intelligence technology to optimize translation efficiency, the adaptability and practical value of the model in the modernization application of traditional symbols can be further expanded.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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