Interaction Design Strategies for Bronze Jue in Digital Museums from the Perspective of Embodied Cognition

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Abstract

The bronze *Jue* is an important ritual vessel of the Pre-Qin ritual and music system. Its formal specifications, decorative implications, artifact combinations and usage rituals all embody the cultural connotation of "hiding rituals in artifacts", making it a material heritage of Chinese civilization. At present, research on the *Jue* (hereinafter referred to as the bronze *Jue* unless otherwise specified) in the fields of archaeology and history has reached a mature stage. However, in museums and various bronze artifact exhibitions, the *Jue* is primarily presented through static displays or basic information listings, lacking immersive presentation forms that hinder the public from deeply perceiving the ritual cultural connotations behind it. Therefore, based on archaeological empirical findings and digital technologies, and guided by the theory of embodied cognition, this study focuses on the current problems in the display and dissemination of the *Jue*—such as superficial presentation and insufficient visualization of ritual connotations. It designs an interactive process that aligns with the physical properties and ritual norms of the *Jue*, guiding audiences to comprehend ritual culture through the interaction between their bodies and the artifact, and transforming the ritual connotations of the *Jue* into participatory and experiential content. This research thus provides practical references for the digital activation of cultural heritage.

Keywords: Digital Museums, Bronze Jue, Ritual Culture, Interaction Design, Embodied Cognition, Cultural Heritage

1 Introduction

According to archaeological findings, the bronze *Jue* first appeared in the third phase of the Erlitou Culture, reached its peak in terms of shape and quantity in the Shang Dynasty, gradually became simplified and declined in the Western Zhou Dynasty, and completely withdrew from the historical stage in the Qin and Han Dynasties. The record in Shuowen Jiezi Chang Bu that "the *Jue* (see Fig. 1) is a ritual vessel [1]" further confirms its in-depth connection with the Pre-Qin ritual norms. Its shape, decorations, artifact combinations and usage rituals all contain rich ritual information, making it a typical material carrier of the Pre-Qin concept of "rites hidden in artifacts".

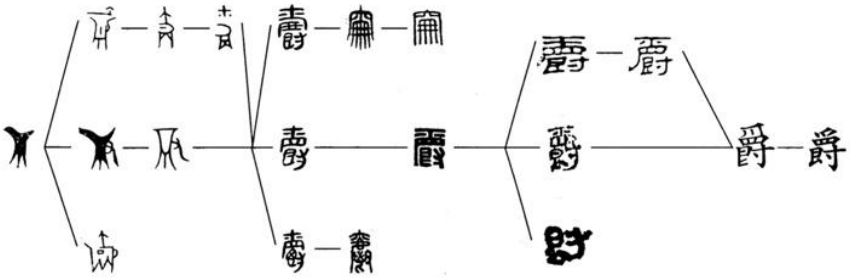

Fig. 1 The evolution of the Chinese character Jue

Currently, the display and dissemination of *Jue* in museums and various bronze exhibitions still suffer from numerous deficiencies. Traditional museums mostly adopt static display methods using glass cases, accompanied only by brief textual descriptions. The public can only observe the appearance of the artifacts from a distance, unable to perceive their detailed features and cultural connotations up close. Even in digital museum scenarios, the interaction design of *Jue* mostly remains at superficial levels such as virtual appearance display and basic information inquiry, failing to transform abstract ritual connotations into perceivable and participatory experiential forms. This makes it difficult to guide the public to deeply understand the core value of *Jue* as ritual vessels.

Therefore, based on existing research achievements in archaeology and history, this study takes embodied cognition theory as the core guidance, combines digital technology and design research methods, and focuses on solving the core problems in the current display and dissemination of *Jue*, including insufficient experience, difficulty in effectively conveying ritual connotations, and poor popularization effects. By systematically reviewing the historical development and ritual connotations of *Jue*, comprehensively analyzing the shortcomings of existing interaction designs, and constructing a targeted interaction design framework for *Jue*, this research aims to achieve effective popularization and living dissemination of *Jue* culture. Meanwhile, it provides a reference practice path for the digital activation of similar Pre-Qin bronze ritual vessels, contributing to the innovative development and sustainable inheritance of traditional culture.

2 Literature review

A. The rise and fall of the *Jue*

Existing archaeological data indicate that the earliest bronze *Jue* to date appeared in the third phase of the Erlitou Culture, while the Pottery *Jue* emerged as early as the first phase of the Erlitou Culture. There is still controversy regarding which one is the origin and which is the derivative. Due to its simple production process and low cost, the Pottery *Jue* was prevalent among commoners and lower-ranking aristocrats; in contrast, relying on the advantages of its craftsmanship and material, the bronze *Jue* became an exclusive ritual vessel for high-ranking aristocrats and even monarchs, embodying the concept of "hiding rituals in utensils" [2]. The bronze *Jue* with Nail-head Pattern unearthed from the Erlitou Site in Yanshi, Henan Province in 1975 is hailed as the "First *Jue* of China" (see Fig. 2). At this site, the bronze *Jue* has only been found in aristocratic tombs, whereas the Pottery *Jue* was widely distributed and can be seen in many ordinary tombs [3]. The Archaeological Report on Erlitou (1959—1978) records this corresponding relationship between material and social status [4]. Through implicit norms such as the craftsmanship and material of utensils, the Late Xia Dynasty elevated the bronze *Jue* to a ritual vessel for distinguishing social ranks, laying the foundation for the Pre-Qin bronze ritual vessel system.

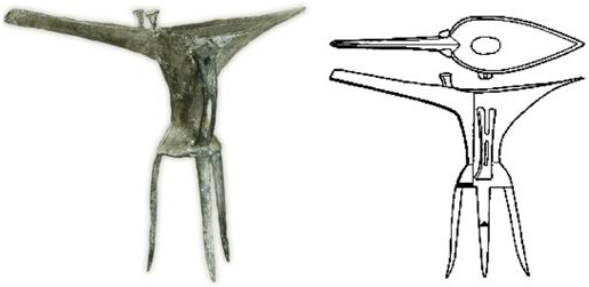

Fig. 2 Bronze Jue with nail-head pattern

The Shang Dynasty inherited the shape of the Erlitou *Jue* and further developed it: the *Jue* saw a sharp increase in quantity and a wide geographical distribution, forming a pattern where the number of unearthed *Jue* varied according to the rank of the tombs. The combination of the *Gu* and the *Jue* served as the core material carrier reflecting the hierarchical system of the Shang Dynasty. It is widely recognized in academic circles that the social rank of aristocrats could be distinguished by the number of *Gu-Jue* sets, and Song Zhenhao accordingly divided the ranks of Shang ritual vessels into nine grades [5]. Nearly 200 bronze artifacts were unearthed from the Fu Hao Tomb at the Yin Ruins in Anyang, Henan Province, among which there are 40 *Jue* (see Fig. 3) and 53 *Gu*; the inscriptions on these vessels can be divided into nine groups, corresponding to the usage norms for different sacrificial occasions, which confirms the ritual logic of distinguishing social ranks through ritual vessels [6]. During this period, the ritual vessel system became increasingly mature, providing an important reference for the ritual and music system of the Zhou Dynasty.

Fig. 3 Fu Hao Jue and rubbings of the two-character "Fu Hao" inscription on its handle

The *Jue* of the Zhou Dynasty followed an evolutionary pattern of inheriting Shang traditions in the early period and becoming simplified in the subsequent ages. After the middle Western Zhou Dynasty, the *Jue* featured a thin and light body with simple and elegant decorative patterns; its quantity plummeted in the late Western Zhou, and it gradually faded out of historical use with the advent of the Eastern Zhou Dynasty. This transformation stemmed from the core shift of the ritual system between the Shang and Zhou Dynasties. In the early Zhou, the Duke of Zhou issued *The Edict on Alcohol*, which strictly restricted alcohol consumption to solemn occasions such as sacrificial rituals, thus narrowing the usage scenarios of the *Jue*. Meanwhile, the focus of the ritual system shifted to food vessels such as the *Ding* and the *Gui*, the system of ritual tripods in graded rows took shape gradually, and the proportion of food vessels rose while that of wine vessels declined [7]. The Marquis Lu *Jue* (see Fig. 4) of the early Western Zhou Dynasty exhibited modifications including a simplified shape and localized decorative patterns; its inscriptions clearly identified the owner, as well as the purpose and function of the vessel's creation. This not only confirmed the historical documentary value of Western Zhou inscriptions, but also served as a material witness to the transformation of the ritual system from the Shang to the Zhou Dynasty [8].

Fig. 4 Marquis Lu Jue and rubbings of the inscription cast inside the vessel

B. Design of ritual vessel combinations and ritual procedures

The ritual vessels of the Shang Dynasty centered on the *Gu-Jue* combinations. When in use, they had to follow a specific procedure: first, offer wine to the *Shi* (ritual impersonator of the deceased) with the *Jue*, then toast the ministers with the *Jue*, and finally toast all the guests with the *Gu*. The use of each vessel corresponded to a specific link and object [9]. This form reflected

the Shang ritual system in the interaction between humans and vessels; by completing the procedure consistent with their own social status, users upheld the ritual principle stated in *Zuo Zhuan* that "Only ritual vessels and noble titles must not be lent to others" [10].

In the Zhou Dynasty, the focus of ritual vessels shifted to the *Ding-Gui* combinations, but the *Jue* still served as a high-grade ritual vessel. Its matching with the *Ding-Gui* combinations further standardized the ritual forms. *The Rites of Zhou Spring Officials Grand Minister of Ceremonies* records: "Offer sacrifices to the former kings through display, presentation, and *Guan* (libation ritual)", indicating that wine vessels such as the *Jue* were required when sacrificing to the former kings. The procedure was: first, place sacrificial offerings in the *Ding* for sacrifice, then perform the *Guan* by pouring wine with the *Jue* and finally place millet and sorghum in the *Gui* to complete the sacrifice [11]. The design of this regulation transformed abstract ritual concepts into operable ritual procedures, enabling the ritual system to be better understood in the interaction between humans and vessels.

Based on historical evolution and archaeological findings, the ritual connotations of the *Jue* not only distinguish aristocratic ranks through differences in material, decorative patterns, form, and the number of combined sets, but also restrict the user's behavior of using the vessel through the form design of each component to fulfill ritual requirements. Furthermore, through inscriptions and specific scenarios such as sacrifices and enfeoffments, it became a material carrier for the legitimation of aristocratic power, highlighting the hierarchical norms of the ritual system and the exclusive connotation of the vessel's name [12] (see Fig. 5).

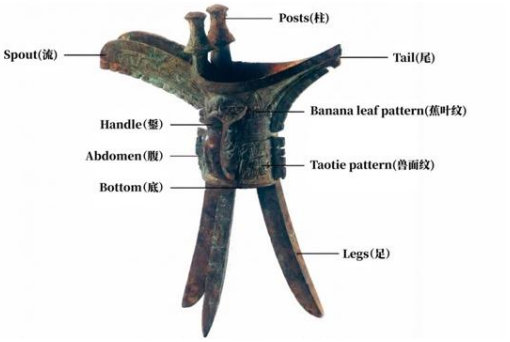

Fig. 5 Names of the Jue's components

C. Contemporary translation of ritual connotations

In traditional static exhibitions, audiences can only observe cultural relics as onlookers. In contrast, interactive design can enable audiences to experience the connection between the design of the *Jue* and ritual practices not as onlookers, but as participants, through means such as scene restoration and immersive experience. Through digital visualization technology, the ritual information contained in the design concepts of the *Jue's* form and decorative patterns, ritual vessel combinations, and usage procedures is transformed into forms perceivable through interactive operations. For example, designing an interactive function of ritual ceremony role-playing allows audiences to explore the connection between the *Jue's* design and ritual culture in the process of participating in human-vessel interaction, thus realizing the new development

of traditional ritual culture in the new era.

3 Analysis of ways of cultural relic interaction in digital museums

A. Overview of the application of *Jue* interactive technologies

In accordance with Article 2 of the *Regulations on Museums,* a museum is an institution dedicated to education, research and appreciation that collects, preserves and exhibits to the public the witnesses of human activities and the natural environment. Traditional static exhibition modes are restricted by geographical, temporal and spatial limitations, which make it difficult to meet the public's demand for active exploration. The intervention of digital technologies has turned interactive experiences into an important way for audiences to integrate into exhibition scenarios and realize role transformation, and this demand has become the core driving force for the development of interactive technologies in digital museums.

Several representative museums in China have carried out explorations on interactive technologies for the *Jue* [13]. However, the existing interactive designs still have shortcomings: they prioritize the form of technological application over cultural connotation, with inadequate excavation of the historical and cultural implications of the *Jue*; the restoration of its ritual usage scenarios is insufficient, and the combinatorial relationships between related artifacts are not presented. In summary, there remains considerable room for improvement in the design of *Jue* interactions in China's digital museums.

B. Analysis of *Jue* interactions – a case study of two museums in the central plain's region

As an important material carrier of Pre-Qin civilization, the *Jue* features a complex shape, exquisite decorative patterns and unique craftsmanship, and bears profound ritual and cultural connotations, making it a key research object for interactive design in digital museums. At present, the mainstream technical approaches for *Jue* interactive design include touch-based interaction, VR immersive interaction and AR augmented interaction. The following is an analysis based on two representative museums in the central plain's region. (see Fig. 6).

- A certain site museum: taking the *Jue* with nail-head patterns as its core exhibit, this museum's interactive design focuses on the technical restoration of bronze casting craftsmanship. The museum has constructed a digital interactive system by combining OLED transparent screens and Augmented Reality (AR) technology. Audiences can scan QR codes via mobile terminals or wear AR devices to realize 360° panoramic viewing of the digital *Jue* and observe the scenes of craftsmen's casting processes.
- A certain provincial museum: the interactive design of bronze artifacts in this museum presents the technical characteristics of multimodal integration. In its integrated media digital special exhibition on bronze civilization, audiences can view high-definition detailed images, chronological pedigree information and archaeological excavation processes of the *Jue* through touch-based interactive interfaces; its AR scanning system enables the decorative patterns of bronze artifacts to dynamically display in conjunction with

sacrificial music and dance, realizing the cross-modal integration of vision and hearing.

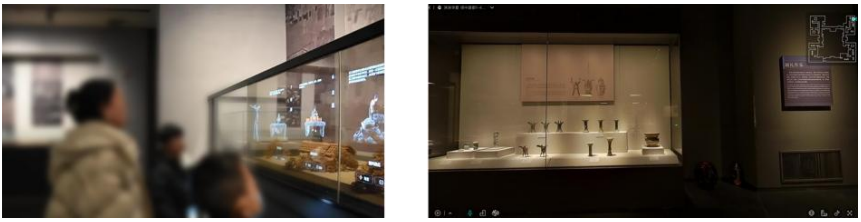

Fig. 6 Digital exhibitions of two museums in the central plain's region

C. Problems in *Jue* interactions

• Supercivilization of interactive content

"Hiding rituals in artifacts" is the core cultural attribute of the *Jue*, meaning that its morphological characteristics such as shape, decorative patterns, size and quantity all embody the ritual connotations of the Pre-Qin period. However, most existing interactive content neglects this core cultural logic, only focusing on superficial information such as material and craftsmanship, and failing to establish a semantic connection between the morphological characteristics of the artifact and its ritual connotations.

The AR interactive system of the aforementioned site museum mainly restores the casting process of the *Jue* but does not systematically elaborate on its ritual connotations; although the digital special exhibition of the aforementioned provincial museum is equipped with multiple interactive interfaces, the presentation of information about the *Jue* still mostly describes technical parameters, failing to elaborate on the semantic connection between the artifact's characteristics and its ritual functions, nor to restore the ritual scenarios involving the combined use of related artifacts.

• Insufficiency of ritual procedure visualization

The Pre-Qin ritual system was elaborate and rigorous, encompassing various ritual occasions such as sacrifices, enfeoffments, court visits, feasts and funerals. However, the current interactive designs for the *Jue* lack a systematic construction of ritual procedures, making it difficult for audiences to comprehend the overall logic of the Pre-Qin ritual system.

The interactive design of the site museum takes visual display as its main technical approach, lacking the contextual restoration of the *Jue*'s usage scenarios; the interaction of the provincial museum still takes passive viewing as its main mode, and does not set up interactive sessions for audiences to participate in the ritual procedures of the *Jue*.

• Problem-solving ideas

The core cause of the problems is that existing interactive designs neglect the fundamental role of physical experience and environmental interaction in the cognitive process. Therefore, this study introduces the theory of embodied cognition and constructs a multi-level interactive design framework [14]. By restoring the physical characteristics and ritual scenarios of the *Jue*, it guides audiences to interact with the artifact through physical movements that conform to ritual norms, realizing the transformative experience from physical perception to cultural identity, and thus providing theoretical support for subsequent design practices.

4 Embodied cognition theory and interactive design

A. Core connotations of embodied cognition theory

This theory was gradually improved by many scholars in different periods [15]. Heidegger proposed "Being-in-the-World", emphasizing that humans are not isolated individuals from birth, but holistic beings embedded in the body, environment, history, and society, denying the cognitive premise of subject-object dualism [16]. From the perspective of phenomenology of perception, Merleau-Ponty argued that the subject of perception is not the brain but the complete body, and that perception, the body, and the world form an indivisible unity—without the participation of the body, there can be no true cognition. James and Dewey, from the perspective of evolutionism, regarded consciousness as the body's adaptation to the environment. Piaget, from the source of human cognition, demonstrated that infants' cognition initially relies entirely on physical movements. For example, infants can only gradually form an understanding of objects' shape, weight, and mobility through actions such as grasping objects with their hands, putting toys in their mouths to bite, and pushing objects to observe their movement. In this cognitive process, physical movements and activities play a crucial role. In summary, the core of embodied cognition is to emphasize that physical experience and interaction with the surrounding environment are the sources of cognition [17]. This provides theoretical support for the interactive design of the *Jue*—through interaction, allowing audiences to take the body as a medium to perceive the connotations of ritual culture [18].

B. Compatibility between embodied cognition theory and interactive design of the *Jue*

The ritual connotations of the *Jue* have distinct embodied characteristics: its form imposes physical constraints on the user's physical movements, the ritual procedures put forward clear norms for physical behaviors, and the decorative patterns and inscriptions enhance the ritual significance of the *Jue*. This connection is highly consistent with the core logic of the embodied cognition theory.

The embodied cognition theory provides three guiding principles for the interactive design of the *Jue*. First, perceptual experience is the direct foundation for the formation of cognition. Through sensory stimulation through vision and touch, audiences can intuitively perceive the physical characteristics of the *Jue* and the implied meanings in its decorative patterns. Second, the motor system is an important connection channel between the brain, the body, and cognition. By restoring ritual scenes, it guides audiences to interact with the *Jue* through physical movements that conform to norms, deepening their understanding of ritual procedures. Third, cognition is embodied: the brain is in the body, and the body is embedded in the environment, with the three together forming a cognitive system. By constructing a real ritual environment, audiences can form identification with ritual culture through the interaction between the body and the environment. This principle lays a theoretical foundation for the construction of the three-layer interactive design framework (see Fig. 7).

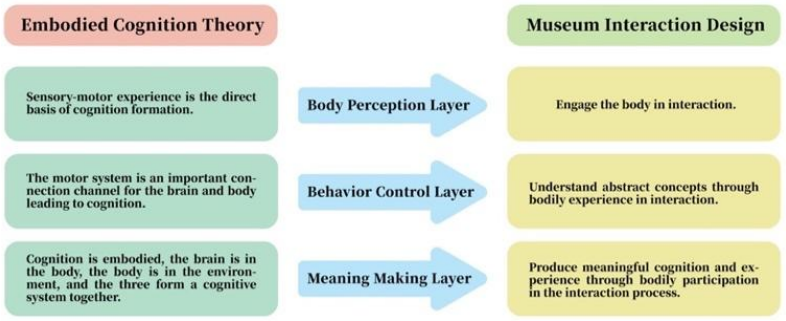

Fig. 7 Analysis of the correlation dimensions between embodied cognition theory and museum interaction design

5 Conclusion

This study addresses the core issue of overemphasizing form over connotation in the interactive design of digital museums. Conducted a systematic study under the guidance of the embodied cognition theory, integrating archaeological documents and design theory, it clarified the rise and fall context of bronze *Jue* in the Xia, Shang, and Zhou dynasties, and identified the ritual connotations embodied in their shapes, decorative patterns, combinations, and usage procedures. In response to the existing problems in current interactions, such as supercivilization and insufficiency of ritual visualization, a three-layer interactive design framework was constructed. Through the design of immersive ritual scenarios, inquiry-based interactions and other links, the perceptibility of ritual culture was realized. In the future, this interactive design framework can be further extended to other Pre-Qin ritual vessels such as *Zun, Ding, Jian, Nao, Qi,* as well as various cultural heritage. Meanwhile, relying on the advantages of digital communication, it will break geographical and spatial limitations, enabling more people to participate in the exploration and dissemination of cultural heritage, endowing cultural heritage with vitality in the new era, and realizing the sustainable inheritance and innovative development of traditional culture.

DECLARATIONS

Dataset to be available

All data generated or analyzed during this study are included in this published article.

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