

Research on Morpho-Bionic Design Based on Ceramic Products

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Abstract. China's rapid economic development and cultural prosperity have elevated people's expectations for an improved quality of life, consequently raising the demand for high-quality household ceramic products. Incorporating morphological bionic design into ceramic product design emerges as a promising avenue to enhance both the quality and artistic expression of such products. This study systematically examines the methods of morphological bionic design in ceramics, presenting innovative approaches to induce creativity and exploring effective practices in ceramic product innovation and design. The comprehensive exploration aims to provide a thorough understanding of ceramic product morphology bionic design practices, contributing to both theoretical development and practical significance.

Keywords: Morpho-Bionic design, Innovative design, Ceramic modelling

1 Introduction

As the birthplace of ceramics, China has historically been a prominent producer and exporter of ceramic products. However, in the face of global trade dynamics, domestic ceramic products have faced challenges such as uneven quality and limited design diversity, lagging behind counterparts in Europe and the United States. This situation has significantly impacted the domestic ceramic industry, necessitating comprehensive innovation to enhance product quality and market competitiveness.

Contemporary consumer demands for ceramic products extend beyond mere functionality, with an increasing emphasis on artistic aesthetics and diversity. Bionic design, specifically morphological biomimicry, emerges as a prevalent and impactful concept in modern ceramic product design. Recognizing this, domestic ceramic designers seek effective methods to imbue practical ceramic items with humanistic sentiments, meeting the spiritual needs and aesthetic interests of modern consumers. Morphology bionic design prioritizes emotional communication between users and ceramic products, offering moments of relaxation and pleasure amid busy daily life. This research endeavors to apply theoretical insights from bionic design to practical ceramic product design, exploring effective methods for innovative design practices.

In this context, domestic ceramic product designers began to look for effective methods in design practice, so that ceramic products with practical functions also contain humanistic feelings, to meet the spiritual needs of modern human beings and aesthetic interests. Ceramic

products form bionic design attaches importance to the emotional communication between people and ceramic products, can give the user in the busy daily life to bring relaxation and pleasure in the use of feelings. Ultimately, the theoretical research of bionic design of ceramic products is applied to the design practice of ceramic products to explore effective innovative design practice methods.

2 Literature Review

The literature review reveals a wealth of cases concerning the application of morpho-bionic design, with a particular focus on ceramic products. Notable research in China has centred on ceramic tea sets, examining the bionic design concepts, artistic characteristics, and organic semantics of ceramic products from both domestic and international origins. The studies delve into the application of bionic design techniques, material selection, and design practices, presenting a comprehensive analysis of modern ceramic tea set design principles and trends (Yang Yi, 2022; Zhang Mingming, 2015; Li Boyang, 2020; Ni Na, 2019).[9,11,12,13,]

Similarly, research on ceramic furnishings explores the background and historical evolution of bionic design, emphasizing bionic concepts' impact on ceramic furnishing design in aspects such as shape, colour, function, science, technology, and cultural connotations (Song Mengyu, 2022; Chen Xiongjun, 2019)[3,16]. Through detailed analysis and sorting of relevant concepts, these studies contribute valuable insights into the core cultural connotations of bionic concepts and principles governing ceramic furnishing design.

Foreign literature complements these findings, examining the intersection of rhetorical techniques in literature and ceramic bionic design. This research explores the influence of natural artistic and linguistic symbols on product aesthetics and values. The application of rhetorical techniques, such as metaphors, symbols, narratives, and hyperbole, in ceramic design is discussed to enhance the individuality, infectiousness, and emotional conveyance of ceramic works (Feng Boyu, 2013; D.S.Halasi, 1975)[4,14]. Additionally, comparative analyses between ancient and modern ceramic vessels provide insights into changes in ceramic art requirements and the application of bionic design concepts in contemporary ceramic product design practice (Lee, Chungmin, 2008; Zhang Lijuan, 2016; Li Lei & Zhao Shouli, 2019)[8,10,15].

In conclusion, these diverse research results, employing various bionic concepts and methods, contribute significantly to the understanding and enrichment of ceramic design. The application of morpho-bionic design principles, methods, and practices in ceramic design serves as a valuable guide for further research and innovation in this field.

3 Research Method of Ceramic Product Morpho-Bionic Design

Ceramic product form bionic design entails the emulation of nature's characteristics through the processes of imitation, extraction, and transformation, employing morphological bionic design concepts and methods as the foundation for initial ceramic product modelling (Luo, S., Zhang, Y., Zhang, J., et al., 2020; Li, X., Hou, X., Yang, M., et al., 2022)[1,2]. Within the realm of ceramic product form bionic design activities, designers engage in more than a

straightforward imitation and extraction of natural world models; they are involved in an artistic creation process. The natural form only takes shape as a ceramic product through the designer's artistic processing, constituting an "input-processing-output" progression. Here, input information pertains to the natural form, processing information involves the creative stages of ceramic form bionic design, and output information denotes the expression of ceramic form bionic design.

The core challenge in ceramic product design lies in effectively integrating natural form and ceramic product form, constituting the primary quandary faced by ceramic form bionic design (Du Jie & Du Yu, 2011)[6]. Illustrated in Figure 1, the goal of ceramic product form bionic design, whether in the conceptualization of a bionic form design or its expressive process, is to craft exemplary ceramic products using the principles and methods of form bionic. This necessitates a dual consideration for forming a bionic design. First, morphology bionic is achieved through individual product modelling, termed ceramic product morphology bionic. Second, a combination of products can achieve morphology bionic, termed ceramic product combination morphology bionic.

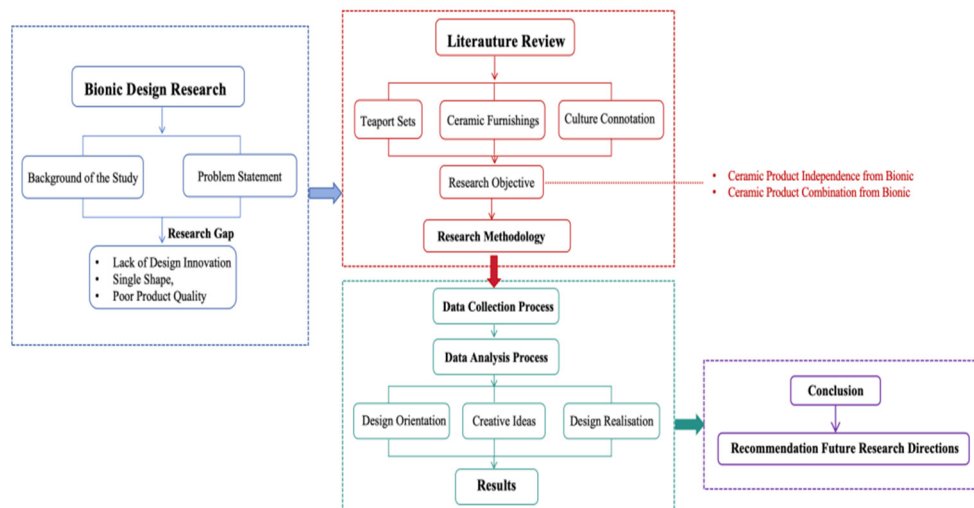


Fig.1. Research Framework.

3.1 Ceramic Product Independence from Morpho-Bionic

Morphometry serves as a modelling language grounded in the artistic manipulation of natural forms, wherein prototypes can encompass animals, plants, or scenic elements. Its objective is to instil novelty into product modelling by biomimicking entire natural entities, a process called "whole imitating whole" (Bin, Song, Md Ishak Siti Mastura, Shaari Nazlina, Perumal Velu & Yang Wei, 2022)[7,]. Illustrated in Figure 2, a representative example is the Song dynasty Ru porcelain lotus bowl, wherein the lotus flower shape serves as the basis for distortion, generalization, and abstraction. The resulting product exhibits well-proportioned features, with the bowl mimicking the ten-petal lotus shape, presenting a semblance of a blooming lotus flower. The bowl's undulating contours and the lotus mouth's smooth lines evoke a sense of elegance and grace. Resembling a ten-petalled lotus in soft bloom, the Ru

porcelain lotus bowl exudes a dignified and serene aura, symbolizing holiness, beauty, and elegance. This aesthetic resonance is closely tied to the preferences of ancient cultures, which esteemed freshness and a connection to nature. While the overall form of ceramic products derived from bionic design may exhibit a high degree of complexity, its artistic impact is commensurately heightened. Concurrently, designers must consider their target audience and make scientifically informed choices in the actual modelling design, aligning with the characteristics of the intended audience group.

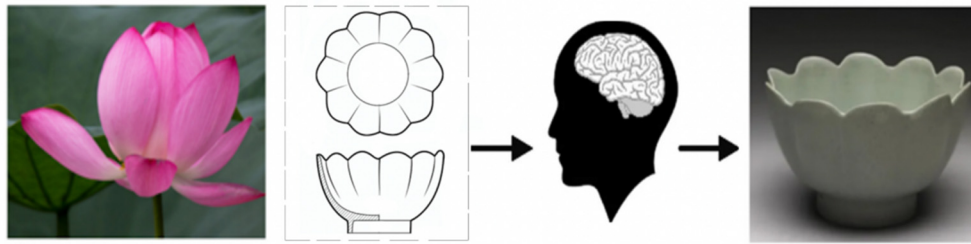


Fig.2. Typical Song dynasty Ru porcelain lotus bowl.

3.2 Ceramic Product Combination from Morpho-Bionic

Combined-form bionic design involves incorporating the overall characteristics of natural forms or local features into the bionic design process. This design approach entails deconstructing and subsequently reconstructing the characteristics of the bionic prototype form, leveraging various advantages in object modelling to combine single models. This strategy serves to surpass the limitations inherent in individual models, ultimately achieving a refined product form.

Within the realm of bionic design for ceramic products, numerous instances are showcasing the deconstruction and reconstruction of a single shape (Zhang Yalin & Jiang Xianjia, 2016)[17]. Illustrated in Figure 3, a noteworthy example involves the attempt to design a landmark building through the deconstruction and reorganization of its architectural shape using biomimetic design principles. This innovative process involves assembling ceramic tableware components to emulate architectural features. Comprising a series of bowls and plates, when combined, these elements perfectly encapsulate the architectural characteristics. In practical use, this set of tableware not only exemplifies the product's elegant silhouette but also underscores the functional features inherent in tableware design.

To delve deeper into the practical realization of bionic design for daily-use ceramic products, the specific methods are analyzed. The conception, presentation, and realization process of ceramic products through bionic design are examined. Drawing from practical cases, this analysis highlights the most prevalent method for achieving bionic design in daily-use ceramic products: the deconstruction and reorganization of bionic elements.



Fig.3. A landmark building of biomimetic design.

4 Analysis of Ceramic Morpho-Bionic Design Results

Building upon the preceding research, the application of morpho-bionic design methodology to practical ceramic product design is implemented, resulting in the creation of ceramic products rooted in morpho-bionic principles. The subsequent analysis delves into the process of bionic design practice, considering the object and positioning of design, the conception and emergence of creativity, and the deepening and realization of the scheme.

4.1 Design Object and Position

In the realm of bionic design practice for ceramic products, careful consideration is given to the type, function, and decoration of ceramic items from the consumer's perspective. This entails categorizing products based on daily needs, and distinguishing between daily-use ceramics (e.g., tableware) and furnishing ceramics (e.g., vases) that serve material and spiritual needs, respectively. The study addresses the scarcity of innovative ceramic tableware designs in the market and aims to meet the evolving demands for both practical functionality and artistic expression. Consequently, ceramic tableware design practice is undertaken based on theoretical insights from the study of bionic design, culminating in the creation of comprehensive and creative ceramic tableware products.

Additionally, design positioning is implemented by selecting a domestic city landmark as an element. The overall form of ceramic tableware is simplified and categorized into different parts. The size and connections between utensils are determined to ensure both visual appeal and practical usability. This approach imbues each ceramic vessel with a distinct life, contributing to a culturally rich attribute when combined as a set. The design concept allows diners to engage with local architectural culture in an enjoyable and informative manner during meals.

4.2 Design Conception and Creative Ideas

Following the establishment of the object and positioning of ceramic products through bionic design practice, design creativity is conceived and presented based on the functions and characteristics of combination tableware. The modelling characteristics are analyzed, and a creative approach involving figurative imitation, abstract generalization, and imagery transformation is adopted. The morphological characteristics of architectural prototypes are imitated, generalized, and transformed, resulting in the final bionic design shape of ceramic tableware (Alcaide-Marzal, J., Diego-Mas, J.A., Acosta-Zazueta, G., 2011)[5]. This creative scheme is then presented through rendering drawings, as exemplified in Figure 4.

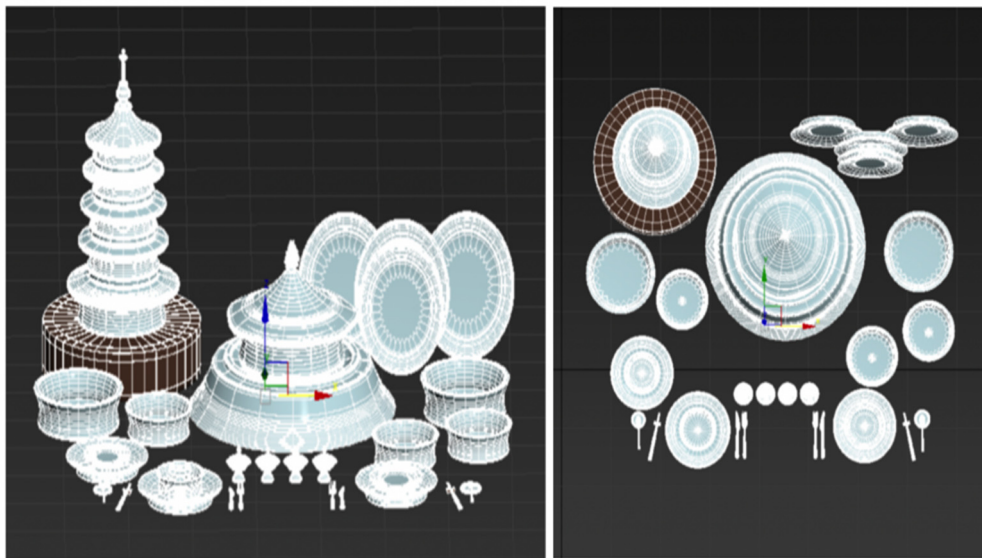


Fig.4. The 3D shape of architectural ceramic tableware.

4.3 Design Deepening and Presentation

The design process is further deepened and presented using 3D modelling software to produce a three-dimensional digital model diagram of the creative program. Potential production challenges are considered and adjusted accordingly. To accentuate the product form's characteristics, simple decoration is chosen for the decorative effect, rendering the expected outcome. The final physical object's cross-section is drawn in proportion to its actual size, resulting in the production of the final effect diagram, as depicted in Figure 5.



Fig.5. Architectural ceramic tableware.

5 Conclusions

As the theory and method of bionic design for ceramic products advance, this study systematically synthesizes innovative methods and approaches in the bionic design of ceramic products. It explores effective design practices, aiding ceramic designers in creating outstanding products. The findings contribute specific and practical methodologies for the design and production of ceramic products in China, fostering continued advancements in this field.

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