Application Path Exploration of Cross-sensory Design in Carved Paper Cuttings

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ABSTRACT

As a national intangible cultural heritage, carved paper cuttings face the dual challenges of inheritance and innovation. The purpose of this study is to explore the technical realization path of olfactory and tactile modes in the intangible cultural heritage cross-sensory design of carved paper cuttings, so as to promote its innovative development. The research adopts the literature research method to analyze the traditional craft and cultural connotation of carved paper cuttings, excavate the olfactory and tactile elements, and integrate and present them through modern design technology. The main results show that the construction of olfactory and tactile modes can be effectively realized by using spices, texture materials, etc., such as adding spices with local characteristics in paper cuttings works, and selecting paper and tactile materials with different textures. The research conclusions provide innovative ideas and technical support for the cross-sensory design of carved paper cuttings, help to enhance its attraction and communication in modern society, and promote the inheritance and development of intangible cultural heritage.

Keywords: *Carved paper cuttings, Intangible cultural heritage, Cross-sensory design.*

1. INTRODUCTION

In the dual context of global cultural digital transformation and the rise of the "new cultural and creative" industry, the inheritance mode of intangible cultural heritage (ICH) is undergoing a paradigm shift from "static protection" to "dynamic innovation". Carved paper cuttings, as a national intangible cultural heritage project, is facing severe challenges in the contemporary era: the gap between generations of handicrafts and mechanical replication has led to "cultural disenchantment", and the participation of young groups continues to decline. According to the statistics of Hubei Provincial Intangible Cultural Heritage Protection Center, the average age of paper cuttings inheritors across the province is 65. The number of manual paper cuttings workshops has dropped by 72% in the past decade, and the recognition rate of traditional patterns in Generation Z is less than 15%. How to activate the modern vitality of intangible cultural heritage through design innovation has become an urgent issue to be addressed. Carved paper cuttings are the crystallization of the wisdom of traditional Chinese creation, which has important symbolic significance. Exploring the way to combine it with the theory of cross-sensory design will help to inherit and carry forward the culture of Jingchu.

2. CROSS-SENSORY DESIGN THEORY

2.1 Overview of Cross-sensory Design Theory

Cross-sensory design is a design method that differs from the theory of five-sense design. Five-sense design refers to fully considering and utilizing the five sensory experiences of human beings in the design process, creating richer, deeper, and more immersive experiences for users through the stimulation and integration of visual, auditory, tactile, olfactory, and gustatory senses. Its goal is to break the limitations of traditional design that rely solely on visual or auditory senses, fully mobilize users' sensory systems, establish closer and deeper interactions and emotional connections between products and users, and enhance the attractiveness, influence, and market competitiveness of

products.[1] Cross-sensory design, on the other hand, is a design concept that places greater emphasis on the interaction and integration of senses. It emphasizes that the stimulation of one sense can trigger the experience and association of another or multiple senses, using the phenomenon of sensory synesthesia to create a unique user experience. It can bring users a more creative and in-depth design experience. A design paradigm can optimize user experience in a collaborative or complementary manner by integrating multiple sensory channels such as visual, auditory, tactile, and olfactory senses. The theory of cross-sensory design originates from the phenomenon of synesthesia in psychology. Synesthesia refers to the psychological process in which one-sensory stimulus triggers other sensory experiences. As a psychological phenomenon triggered spontaneously by a single-sensory stimulus, synesthesia provides the underlying cognitive logic and innovative path for cross-sensory design.[2] Cross-sensory design deliberately constructs correlations between senses, such as combining visual color with tactile temperature, simulating or enhancing human natural synesthesia mechanisms, in order to break through the limitations of single sensory information transmission.

2.2 Case Study on the Application of Cross-sensory Design in Intangible Cultural Heritage Innovation

Cross-sensory design is widely used in the innovation of intangible cultural heritage. In the case of intangible cultural heritage using cross-sensory design to achieve regeneration and activation, the researchers select representative works, analyze their advantages and innovation points, combine different intangible cultural heritage innovation and user needs, analyze the innovation direction and application prospect of cross sensory and intangible cultural heritage combination, and explore the innovative application path of cross sensory design in carved paper cuttings.

2.2.1 The Linkage Between Smell and Touch

The embroidered sachet of the Qiang nationality (as shown in “Figure 1”) links smell and vision to form a new memory anchor. In the production process of Qiang embroidery sachets, microcapsules of spices are embedded inside the sachet. Pressing them will release the unique scent of plants such as Minjiang fir and alpine rhododendron in Qiang settlements. While pressing the sachet, users can feel the "convex embroidery" embroidery pattern on the surface of the sachet through finger touch, which reflects the daily life, natural landscape, and social beliefs of the Qiang people.[3] This design allows users to receive both olfactory and tactile feedback when pressing the sachet, establishing cultural memory anchors through the method of "recognizing patterns by smelling fragrance" and strengthening cultural identity.

Figure 1 Intangible cultural heritage Qiang embroidery sachet.

2.2.2 The Linkage Between Vision and Touch

The Silver Jewelry Forging Technique of the Miao Nationality Is to Link Touch and Vision In silver jewelry forging, virtual patterns are projected visually through virtual simulation.[4] Users can overlay real silver pieces and carve according to the projected patterns (as shown in “Figure 2”). At the same time, users can touch the silver pieces at different forging stages and feel the temperature and texture changes of the silver pieces during the forming process, from rough blanks to polished finished products.

Figure 2 Miao Silver ·Cyber World.

2.2.3 The Linkage Between Smell and Vision

The performance of intangible cultural heritage Kunqu opera links smell and vision. In the immersive performance of Kunqu Opera's "Seeking Dreams at the Peony Pavilion", the theater will release corresponding scents according to the plot, such as the cold fragrance of plum blossoms during Du Liniang's garden tour, the sandalwood smoke in the underworld scene, and other olfactory elements (as shown in “Figure 3”). In the overall construction of the theater, the circular projection screen presents a dynamic ink background, and the pressure sensor on the ground will trigger the special effect of petals falling at a certain time, achieving the linkage from smell to vision. Through cross-sensory linkage and superposition, an immersive "in play" experience is constructed, attracting more young audiences to pay attention to the core of opera culture and realizing the activation and innovation of intangible cultural heritage Kunqu Opera.

Figure 3 Performance of Kunqu Opera "Seeking Dreams at the Peony Pavilion".

3. INTANGIBLE CULTURAL HERITAGE CARVING PAPER CUTTINGS: ITS TECHNOLOGICAL TECHNIQUES, CULTURAL CONNOTATION AND DEVELOPMENT STATUS

As a national intangible cultural heritage, Ezhou carved paper cuttings has constantly improved its technology in design practice. Choosing different intellectual disabilities and using different techniques can make carved paper cuttings models command different effects and artistic features.

3.1 Craft Techniques

The traditional craft of carved paper cuttings focuses on the unique combination of tools, materials and techniques, and its production process begins with the preparation of tools and materials. Firstly, it is necessary to use specially designed carving knives such as flat-edged knives, oblique-edged knives, and round-edged knives, as well as carving pads, wax plates, cones, and grinding stones to fix the paper, in combination with materials such as rice paper, red paper, or gold and silver foil,[5] to pursue a texture of "thin as cicada wings and transparent as yarn". Secondly, during production, craftsmen can design symmetrical patterns with flowers, birds, characters, or auspicious symbols as the main theme (as shown in “Figure 4”). Once again, craftsmen can stack multiple layers of red paper and fix them on a wax plate, entering the carving stage - using techniques such as intaglio, intaglio, or mixed carving, to showcase the fine patterns of "thousand engravings never fall, ten thousand cuts never stop". This technique combines both proceduralization and improvisation: it follows fixed paradigms such as "medallion" and "corner flowers", and achieves the unity of functionality and artistry through a hollow language that combines reality and virtuality.

Figure 4 Ezhou carved paper cuttings.

3.2 Cultural Connotation

Carved paper cuttings, as a multi-dimensional carrier of Chinese folk culture, its cultural connotation is deeply reflected in the integration of folk beliefs, regional differences and aesthetic philosophy. At the level of folk beliefs, it carries the collective consciousness of seeking good fortune and avoiding misfortune through visual symbols[6] - conveying auspicious meanings through homophonic symbols such as "fish (surplus) in the year of lotus (continuous)" and "pomegranate with many children", while intervening in ritual scenes such as Spring Festival window decorations, wedding flowers, and funeral paper wrapping, becoming a medium for communication between humans and gods. It also expresses worship of natural vitality through "flowers, birds, insects, and fish" patterns, echoing the cosmology of "life is easy" in the “Book of Changes”. In the dimension of regional culture, its style shows the division between north and south: northern paper cuttings can show boldness with rough outline, while southern paper cuttings can outline rhythm with fine lines; The ethnic characteristics are also contained in it. The totems of the extremely important symbol "Mother Butterfly" in Miao culture[7] (as shown in “Figure 5”) and the Manchu "Mammy"[8] (as shown in “Figure 6”) are both engraved with historical memories of the ethnic group. Furthermore, its aesthetic spirit is rooted in traditional philosophy - the hollow technique of the interplay between reality and virtuality[9], which is in line with the Taoist philosophy of "existence and non-existence complement each other". The symmetrical and balanced composition echoes the Confucian concept of "harmony of the mean", and the craftsman's focus on the process of "using the knife as a pen" interprets the cultivation realm of "technique advancing to the Tao". Because of this, the importance of carved paper cuttings transcends the art itself. As a "living intangible heritage", it is not only the crystallization of folk wisdom, but also the visual gene pool of Chinese myths, ethics and folk customs. It provides innovative inspiration for contemporary design, and continues to glow vitality in cultural inheritance and era dialogue.

Figure 5 Totem of Miao mother butterfly.

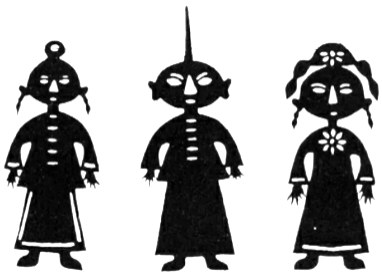

Figure 6 Manchu Mammy paper cuttings.

3.3 Development Status

At present, carved paper cuttings has initially achieved the survival of its skills through digital filing, learning base construction and technology empowerment under the framework of intangible cultural heritage protection. VR/AR dynamic exhibition, intelligent material application and other cross-sensory design practices promote the transformation of carved Paper Cuttings from "static craft" to "immersive experience"; Cultural and creative derivatives attempt to graft modern consumer scenarios, partially reaching young people. However, such innovations mostly remain at the surface level and have not yet formed a systematic paradigm for activating intangible cultural heritage.

In the inheritance of carved paper cuttings, there are several problems at present. First, in the production of carved paper cuttings, mechanized production simplifies the traditional "line to line" knife logic of carved paper cuttings, diluting the value of manual work; Secondly, there is severe homogenization of products and a lack of differentiated competitiveness. The contradiction between high-cost handmade production and fast-food consumption demand is prominent, and innovative achievements are difficult to achieve sustainable transformation; Finally, some designers have insufficient understanding of traditional craftsmanship, resulting in a "separation of form and spirit" between innovative solutions and traditional craftsmanship.

In this context, cross-sensory design, with its ability to deeply translate cultural symbols and integrate multimodal experiences, provides a possible path for reconstructing the contemporary value of intangible cultural heritage. Through the collaborative narrative of vision, touch, and smell, it can not only restore the intricate tactile logic of "line connected" knife work, but also break the homogenization of products with differentiated cross sensory design labels; More importantly, its underlying logic of "experience is dissemination" can reduce users' dependence on fast food consumption through immersive interaction, and instead focus on the cultural texture behind the craftsmanship. However, this process still needs to be wary of the masking of the craft itself by technology. Only a design strategy that takes "senses as the bridge and culture as the core" can achieve a dynamic balance between the survival of skills and the transformation of innovation.

4. THE APPLICATION OF CROSS-SENSORY DESIGN IN INTANGIBLE CULTURAL HERITAGE CARVING PAPER CUTTINGS

The application path of cross-sensory design in carved paper cuttings mainly starts from the construction of tactile mode and olfactory mode. Only by keeping pace with the times in an all-round way can the carved Paper Cuttings of intangible cultural heritage glow with new vitality and realize the activation and innovation of the carved paper cuttings of intangible cultural heritage.

4.1 The Construction of Tactile Modes: Texture Materials and Interaction Design

In carved paper cuttings, the tactile physical properties of paper, such as hardness, roughness, temperature, etc., will directly affect users' perception of carved paper cuttings. Through new material technology innovation, the tactile sense of traditional carved paper cuttings technology is also simulated, giving it new cultural metaphors. Through embossing, composite material collage and other processes, the tactile difference between "incised inscription" and "intaglio" in traditional carved paper cuttings is simulated. In combination with intelligent materials such as temperature sensitive materials and flexible electronic fabrics, the tactile dynamic feedback is given to transform cultural symbols into tangible physical language. Through the construction of tactile mode, the carved paper cuttings have changed from "static viewing" to "dynamic perception", providing a practical path of "hand to heart" for the living inheritance and innovation of intangible cultural heritage.

4.2 Construction of Olfactory Modality: Selection and Integration of Local Characteristic Spices

In carved paper cuttings, the construction of olfactory modality is relatively rare. With smell as the medium, the cultural symbols of carved paper cuttings, such as relevant regional folk customs, patterns and related arts and crafts, such as paper, paste materials, etc., will be transformed into smellable narrative language, and the emotional connection of users to carved paper cuttings will be strengthened through the "Proust effect[10]" in the sense of smell. Spice selection is based on three aspects: regional natural elements, memory of craftsmanship materials, and symbolic metaphors of patterns. For example, in terms of regional natural elements, people can choose the local plant smell corresponding to the theme of carved paper cuttings, such as wormwood in the Dragon Boat Festival folk custom, osmanthus in Xianning, and citrus flowers in Sanxia, and integrate it into the paper of carved paper cuttings, so that users can add memory anchor points and strengthen emotional connection in the experience of carved paper cuttings. The corresponding cultural symbols can be translated into olfactory symbols and further into narrative language. Through the refined design of olfactory modality, carved paper cuttings break

through the limitation of "silent art" and becomes a cultural carrier that can be smelled and recalled, providing a practical path of "smell seeking pulse" for intangible cultural heritage innovation.

4.3 Construction of Visual Modality: Coexistence of Virtual Reality Between Dynamic Light and Shadow Narration and Digital Paper Cuttings

Traditional carved paper cuttings belong to visual expression, which is limited by two-dimensional plane carrier. Its dynamic cultural image and space-time virtual and real potential have not been fully expressed. If digital light shadow technology is combined with paper cuttings patterns, it can be transformed into an interactive "dynamic visual symbol system". Through the combination of reality and reality, a new visual mode can be constructed to activate the space-time narrative dimension of intangible cultural heritage paper cuttings, enabling users to move from audience to participant. The visual expression of traditional carved paper cuttings mainly presents carved paper cuttings in the physical world, which carves meaningful pictures through paper and carving knives. However, if more audiences want to participate in and understand the paper cuttings of intangible cultural heritage carved paper cuttings, they need to take the audience into the process of making the paper cuttings of intangible cultural heritage carved paper cuttings to experience it. Only after experiencing it personally can the audience understand carved paper cuttings more. Now it is possible to capture the gestures of the audience with the help of computer vision to achieve real-time interaction in the physical space of paper cuttings. For example, the waving of the audience will trigger the restructuring of paper cuttings patterns, giving the audience a better sense of experience and participation. Through the refined design of visual mode, carved paper cuttings break through the limitations of "static art" and become a visual and narrative space-time medium, opening up a practical path of "light and shadow weaving vein" for the innovation of intangible cultural heritage.

4.4 Construction of Auditory Modality: Reconstruction of Sound Scene of Paper Cuttings Rhythm and Interactive Sound and Picture Resonance

The auditory dimension of carved paper cuttings has long been at the edge of cultural expression, and the acoustic potential of its technological rhythm and pattern metaphor has not been fully tapped. Through the construction of the auditory mode of paper cuttings, the physical sounds in the creation of paper cuttings, such as cutting and scraping, paper tearing and other sounds, and the regional cultural sounds are integrated into an interactive "sound symbol system", and the user's immersive perception of intangible cultural heritage skills is strengthened through the synaesthesia effect. The pressure and speed data of the engraving blade movement can be captured through high-sensitivity sensors, and converted into dynamic sound effects. Through the refined design of the auditory mode, carved paper cuttings break through the inherent cognition of the "silent art" and become an audible and resonant acoustic file, opening up a practical path of "voice trace" for intangible cultural heritage innovation.

5. CONCLUSION

Based on the cross-sensory design theory, this paper systematically discusses its innovative application path in intangible cultural heritage projects such as carved paper cuttings. Cross-sensory design can effectively overcome the dilemma of "audience loss" in intangible cultural heritage inheritance by integrating multidimensional perceptions such as touch, smell, sight, and hearing. In the research on the cross-sensory design path of intangible cultural heritage carved paper cuttings, the construction of tactile mode transforms the "ingenuity" of traditional crafts into perceptible experience language, reducing the threshold of skill transmission; The fusion strategy of local spices in the olfactory modality has awakened the emotional resonance of cultural memory through the "Proust effect"; The dynamic light and shadow narrative system of visual mode, relying on digital twin technology, transforms paper cuttings patterns into an immersive medium of "time-space folding", and reconstructs the multi-dimensional cognitive interface of intangible cultural heritage; The auditory modal technique of rhythmic soundscapeization strategy achieves perceptual transfer through synesthesia effect, deepening the

emotional resonance intensity of regional culture in sound wave vibration. Simultaneously analyzing relevant cases, sensory linkage not only enhances the immersion and dissemination efficiency of intangible cultural heritage, but also achieves contemporary translation of traditional symbols through technological empowerment.

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