



A Multidimensional Examination of the Development of Neolithic Bone Musical Instrument Design

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Abstract. Bone artifacts from the Neolithic era, particularly bone musical instruments, constitute an important component of Neolithic art, serve as a crucial reference for the development of contemporary musical instrument design, and also represent a significant form of aesthetic expression. This paper conducts an investigative study of a large number of bone artifacts unearthed from the Neolithic era, employing literature analysis to summarize and analyze the developmental trajectory of bone musical instrument design, uncover the aesthetic ideas embedded within bone musical instruments, and further reveal the interplay between the development of ancient societal technology, musical culture, aesthetic ideology, and social structure. It constructs a clear theoretical framework and developmental trajectory for the evolution of Neolithic bone musical instruments, laying a systematic foundation for future musical instrument product development and design.

Keywords: Neolithic Age; bone tools; bone musical instruments; design methods

1 Introduction

Neolithic human bone musical instruments serve as important artifacts of ancient civilization, embodying rich historical, cultural, and artistic value. This paper conducts an in-depth study of the design and development of Neolithic human bone musical instruments. Through an analysis of their production process, design characteristics, and functions, it reveals the unique charm and profound influence of the musical culture of this period. During this era, people began to manufacture and use more advanced tools while also creating a rich and diverse musical culture. Bone musical instruments, as an integral part of Neolithic musical culture, possess unique historical, cultural, and artistic value.

The earliest bone flutes in China can be traced back to the Neolithic era, approximately 7,500 to 9,000 years ago. In 1987, 16 complete bone flutes were discovered at the Jiahu Peiligang Cultural Site in Wuyang County, Henan Province. The discovery of the Jiahu bone flutes overturned the theories of the “western origin of the flute” and the “external origin of the seven-note scale” in China [1]. Not only are they the earliest and best-preserved wind instruments discovered in China to date, but they have also

been recognized by experts as the world's earliest instruments capable of playing a seven-note scale. Additionally, over 160 bone flutes have been unearthed at the Hemudu site in Yiyang, Zhejiang Province. These flutes are dated to the early Hemudu Culture period, approximately 7,000 years ago. Bone flutes dating back 6,000 years have also been discovered in Wales, UK, and some relatively recent primitive bone flutes have been found in the Americas. These discoveries indicate that humans have been exploring musical culture across different cultures worldwide since the Paleolithic era. Music is an integral part of China's excellent traditional culture and serves as the psychological foundation for the formation of China's traditional concept of harmony.

2 The Development of Bone Musical Instruments in the Neolithic Age

2.1 Origin and Development Worldwide

Across the globe, there have been numerous discoveries of bone musical instruments from the Neolithic era. Among these, the bone flute stands out as a significant example, showcasing humanity's early explorations in musical culture. The Divje babe bone flute discovered in Slovenia in 1995 (as shown in Figure 1) dates back approximately 60,000 years, though some sources suggest it may be around 43,000 years old. It is considered the oldest known Neolithic flute in the world [2], and the first flute attributed to Neanderthals. In September 2008, fragments of a German bone flute were excavated from the Hohle Fels cave in southwestern Germany, dating back approximately 31,000 to 40,000 years. Composed of 12 scattered pieces carved from vulture bones, it serves as crucial material for studying the early modern human civilization in Europe. The Pyrenees Mountains in France have also yielded 22 flutes made from deer bones, dating back approximately 30,000 years. In 1994, Austria uncovered a bone flute carved from the right tibia of a female domesticated reindeer, dating back approximately 19,000 years. In Central America, a deer bone flute from the Maya culture dating back approximately 3,200 years was excavated in San Ciro, Honduras. In North America, bone flutes dating back approximately 1,900 to 1,750 years were unearthed at the Yog site in the Oaxaca Valley of southern Mexico, and a bone flute from the Indian culture dating back approximately 1,000 years was discovered in western Iowa.

In northern Israel, seven miniature bone flutes dating back approximately 12,000 years to the Neolithic era were discovered (as shown in Figure 2). These flutes were carved from the wing bones of prehistoric birds. Although their exact purpose remains unclear, they may have been used for hunting or traditional song composition. This discovery fills a gap in research on musical creation during the Neolithic era and may also represent a significant finding in the history of musical instrument manufacturing. [3] According to an article published by the archaeological team in the journal *Scientific Reports*, these flutes are 63.4 millimeters long, with a diameter of approximately 4 millimeters, and produce a very high-pitched sound. Due to their small size and closely spaced holes, playing these flutes requires exceptional dexterity and significant training. The flutes were discovered at the Eynan site in Israel, which is a settlement of

the Natufian culture dating back to approximately 12,500 BCE to 9,500 BCE. The Eynan people subsisted on hunting and gathering, and the Huleh Valley, where the settlement is located, is now an important stopover for migratory birds.



Fig. 1. Divje babe bone flute

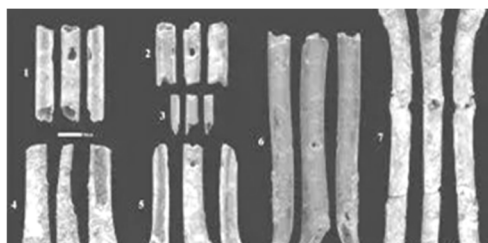


Fig. 2. Israel northern bone flutes

The earliest bone flutes in China date back to the Neolithic period, approximately 7,500–9,000 years ago, with the Jiahu bone flutes (as shown in Figure 3) being representative examples. In 1987, 16 complete bone flutes were discovered at the Peiligang Cultural Site in Jiahu, Wuyang County, Henan Province. These flutes were made from the long bones of cranes. Jiahu bone flutes come in forms with 5, 6, 7, or 8 holes, with the 7-hole flute being the most common. The earliest bone flutes with 5–6 holes could produce a four-note scale and a five-note scale. Mid-period flutes with 7 holes could produce a six-note and seven-note scale. Late-period flutes could produce a complete seven-note scale as well as some additional altered notes. Some bone flutes also have tuning holes drilled beside the tone holes and engraved with equal-division symbols, indicating that the techniques for making and playing bone flutes during this period had already reached a high level of maturity. The authoritative scientific journal **Nature**, published in the UK, featured an article introducing this discovery. The discovery of the Jiahu bone flutes has overturned the theories of “the flute originating from the West” and “the seven-note scale originating from outside China.” It is not only the earliest and best-preserved wind instrument discovered in China to date but has also been recognized by experts as the world's earliest instrument capable of playing a seven-note scale.

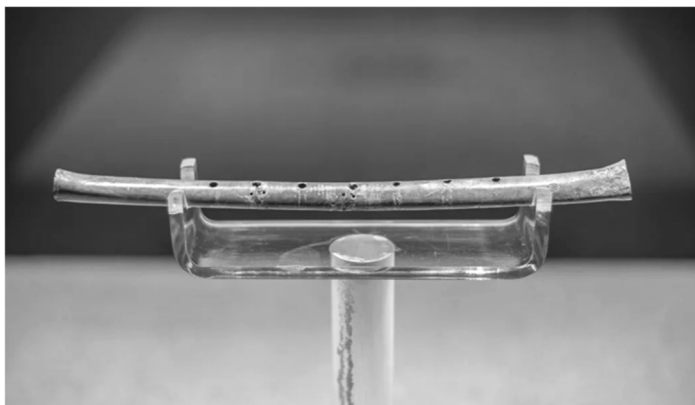


Fig. 3. Jiahu bone flutes

2.2 Main Types of Bone Musical Instruments from China's Neolithic Period

Bone flutes documented in Chinese historical records include the Hemudu bone flute, the Jiahu bone flute, the Hongshan bone flute, the Xinglongwa bone flute, and the Seda bone flute, among others, most of which were discovered in the Central Plains region and the northwestern inland plateau regions. The Hemudu bone flute is one of the most important representatives of bone musical instruments from China's Neolithic era [4]. In 1973, over 160 bone flutes were unearthed at the Hemudu site in Yiyang, Zhejiang Province. These flutes have been dated to the early phase of the Hemudu culture, approximately 7,000 years ago. Hemudu bone flutes are typically made from the bones of birds, such as the leg bones of red-crowned cranes. The craftsmanship is meticulous: the flesh is scraped clean from the bone, the ends are sawed off, the upper and lower openings are smoothed, and the bone marrow is removed. The Hemudu bone flute is generally 24–26 centimeters long, with a diameter of about 1.5 centimeters. The interior is hollow without a reed, and both ends are open holes. Starting from the lower opening and moving upward, there is a finger hole with a diameter of 0.7 centimeters (slightly elliptical) drilled every 2.2 centimeters or so, with a total of three finger holes. The distance between the finger holes is typically determined by the width of the index and middle fingers when spread flat on the bone tube.

In 1987, 16 complete bone flutes were discovered at the Peiligang Cultural Site in Jiahu, Wuyang County, Henan Province. The Jiahu bone flutes were made from the long bones of cranes and come in various forms, including 5-hole, 6-hole, 7-hole, and 8-hole designs, with the 7-hole flute being the most common. The earliest bone flutes, with 5 to 6 holes, could produce a four-note scale and a five-note scale. Mid-period bone flutes with 7 holes could produce a six-note and seven-note scale [5]. Late-period bone flutes could produce a complete seven-note scale and some additional altered notes. Some bone flutes also had tuning holes drilled beside the tone holes and engraved with equal-division symbols, indicating that the craftsmanship and playing techniques

of bone flutes had reached a high level of maturity by this period. The production process of Jiahu bone flutes was also highly meticulous, requiring precise measurements and calculations to ensure the accurate positioning of the tone holes. The section of the flute body with sound holes in the middle is covered with traces of fabric wrapping, which was intentionally reinforced by the tomb owner to ensure the quality of the sound. Some bone flutes also have engraved patterns and designs, demonstrating the mastery of the craftsmen. After completion, the bone flutes were smoked to turn them dark red before use. The Jiahu bone flute is not only the earliest and best-preserved wind instrument discovered in China to date, but it has also been recognized by experts as the world's earliest instrument capable of playing a seven-note scale. (as shown in Table 1)

Table 1. Comparison table of typical bone musical instrument types, sizes, and craftsmanship

Name of instrument	Types	Length (cm)	Diameter (cm)	Holes number	Material	craftsmanship
Jiahu bone flute	Type of Blowing	20-25	1.2-1.5	5-8	 Crane ulna	Precise perforation, tuning holes, smoke staining
Hemudu Bone flute	Type of Blowing	24-26	1.5	3	 Red-crowned crane leg bone	Oval holes, scraping clean the bone and flesh, polishing
Hemudu Bone flute	Type of function	6-9	0.8-1.0	1-2	 Bird hollow bone	Short, hunting-use sound-emitting horn mouth
Pseudo-bone resonator	Type of hitting	Unknown	Unknown	Unknwon	 Animal bones such as deer and bear	Flat bone fragments, or striking with a connecting rope

3 Design Characteristics of Neolithic Bone Musical Instruments

3.1 Material Selection and Design Features

During the Neolithic era, animal bones became the primary material for crafting bone-based musical instruments. These primarily included eagle bones, crane bones, and bear bones. These animal bones possess unique physical properties, providing an excellent foundation for instrument construction. Eagle bones are hard in texture, making them suitable for crafting instruments with slender tubular bodies, such as bone flutes. Their high strength allows them to withstand the air pressure generated during playing, while also offering good resonance properties [6]. Crane bones, with their hollow, elongated structure, are an ideal material for bone flutes. (as shown in Figure 4). Bone flutes made from crane bones typically produce a crisp, bright tone with high musical expressiveness. Bear bones, which are relatively thicker, may have been used to create bone instruments of special designs. The selection of these animal bones as musical instrument materials was, on the one hand, due to humans' utilization and understanding of animal resources at the time. During the Neolithic era, humans had a close relationship with animals, which served not only as a food source but also had their bones used to make various tools and musical instruments. On the other hand, the characteristics of these animal bones align with the requirements for musical instrument production, enabling the creation of specific timbres and pitches.

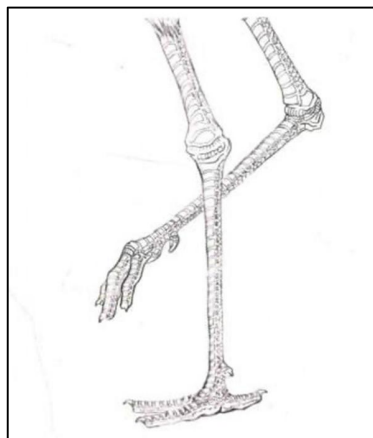


Fig. 4. Crane bone

Taking the Jiahu bone flute as an example, its craftsmanship is exquisite. The Jiahu bone flute is made from the long bones of cranes, with forms including 5-hole, 6-hole, 7-hole, and 8-hole designs, with the 7-hole bone flute being the most common. The earliest bone flutes with 5–6 holes could produce four-note and five-note scales. Mid-period bone flutes with 7 holes could produce six-tone and seven-tone scales. (as shown in Figure 5) Late-period bone flutes could produce a complete seven-tone scale and

some additional altered tones. Some bone flutes also had tuning holes drilled beside the tone holes and engraved with equal-division symbols, indicating that the craftsmanship and playing techniques of bone flutes had reached a high level of maturity by this period.

The Hemudu bone flute is typically made from the bones of birds, such as the leg bones of red-crowned cranes. The craftsmanship is also highly refined. First, the flesh is scraped clean from the bone, the ends are sawed off, the upper and lower openings are smoothed, and the bone marrow is removed. The Hemudu bone flute typically measures 24–26 centimeters in length, with a diameter of approximately 1.5 centimeters. The interior is hollow without a reed, and both ends feature open holes. Starting from the lower end, there is a finger hole with a diameter of 0.7 centimeters (slightly elliptical) drilled every 2.2 centimeters or so, with a total of three finger holes. The distance between the finger holes is typically determined by the width of the index and middle fingers when spread flat on the bone tube. When playing, the bone flute is held vertically, with the right hand below and the ring finger, middle finger, and index finger covering the first, second, and third holes, respectively. The left hand is above, with the ring finger, middle finger, and index finger covering the fourth, fifth, and sixth holes, respectively. The flute is played using a flat-blowing technique, with a range from d' to e'. During performance, techniques such as glissando and vibrato are frequently employed [7].



Fig. 5. Details of Jiahu bone flutes

3.2 Aesthetic Construction and Cultural Semantics

Bone musical instruments are not only a medium for sound but also a material expression of cultural aesthetics [8]. Take the Jiahu bone flute as an example: its slender tubular form and precisely arranged tone holes embody the harmonious beauty of “form and function.” Some bone flutes also feature intricate engravings, symbols, and smoke-treated surfaces. These not only enhance the visual appeal of the instruments but may also carry symbolic meanings such as blessings, social hierarchy, or totemic significance. These symbols and totems are clearly visible on the bone flute, indicating that these symbols were either emblems of certain musical and dance rituals or a means of distinguishing the social status of the instrument's owner, reflecting a harmonious and

thriving society. This decorative expression that combines practicality and symbolism is a manifestation of the nascent aesthetic concepts of primitive society. The Hemudu bone whistle, on the other hand, exhibits a stronger “symbolic aesthetic.” Its simple, compact shape, elliptical hole structure, and decorative lines may have been designed to mimic bird calls for use in hunting. It is not difficult to imagine a scene: on a summer evening in the Neolithic era, two ancient hominids blew bone whistles on the plains. The whistle sounds attracted wild chickens from nearby grasslands. However, when the wild chickens followed the sounds and stood in place searching for their companions, an arrow flew from the shadows of the grasslands and struck the wild chicken's chest, ultimately leading to its capture by the hominids. This “nature-inspired” design language reflects the Neolithic humans' observation and aestheticization of animal behavior, demonstrating that ancient people had already mastered biomimetic onomatopoeic techniques, showcasing their hunting wisdom, and conveying the primitive aesthetic concept of “harmony between humans and nature.” [9].



Fig. 6. Hemudu bone flutes

In sum, the size of the two ancient bone musical instruments can roughly distinguish their actual function. The Jiahu bone flute is 23.6 centimeters long, relatively large in size, and inconvenient to carry, so it is suitable as a ceremonial musical instrument for performances in fixed settings. Its slender, flowing, and elegant design also serves as a symbol of status for its owner, highlighting its social attributes. The Hemudu bone whistle varies in length from 4 to 12 centimeters, with a smaller size that is convenient for carrying. As a bone musical instrument for hunting purposes, it is highly suitable.(as shown in Figure 6)

3.3 Manufacturing process

Taking the Jiahu crane bone flute as an example, it is made by removing the joints at both ends of a crane's ulna and drilling holes into it. The process involves careful calculations and the use of small holes to adjust the pitch. The intricate and complex craftsmanship of the Jiahu bone flute fully demonstrates the wisdom and technical skills of humans during the Neolithic era.

First, in terms of material selection, the Jiahu people chose the ulna of a crane, which was no coincidence. Crane bones have the characteristics of being hollow inside, slender, and hard in texture, making them highly suitable for making wind instruments. Cranes may also have held special symbolic significance in the culture of the time, further increasing the likelihood of choosing crane bones for musical instrument production. During the production process, the Jiahu people conducted careful calculations. They needed to precisely measure the flute's length, tube diameter, and the positions of the tone holes to ensure the flute could produce accurate pitches. This precise calculation indicates that people at the time already had a certain understanding of musical pitch and scales. In addition to calculations, the Jiahu people also used the method of drilling small holes to adjust pitch differences. This method demonstrates their high pursuit of musical accuracy. By drilling small holes in the bone flute, they could fine-tune the pitch, enabling the flute to play more accurate scales and melodies. Additionally, after the Jiahu bone flute was completed, it underwent a smoking process to turn it dark red before use. This process may have been not only for aesthetic purposes but also related to cultural beliefs or practical purposes at the time.

3.4 Musical Function

The Jiahu bone flute has a beautiful tone and a complete scale, capable of playing music similar to a seven-note scale. However, its seven finger holes do not necessarily correspond directly to the seven notes of the scale. The musical properties of the Jiahu bone flute have long been a focal point of academic research. Based on existing studies and experiments, the finger holes on the Jiahu bone flute are not arranged strictly according to the ascending or descending stepwise patterns of the scale. The scale of the bone flute is a result derived by researchers through rearranging its tone sequence. Some of the altered tones in the bone flute's tone sequence can be considered as scale degrees, while others should not be regarded as such. The scale of the finger holes on the bone flute cannot be equated with the actual musical scale used in performance. The seven finger holes on the Jiahu bone flute do not necessarily correspond to the seven-note scale, nor are they necessarily linked to or equivalent to the musical practices of the time. From a global perspective on musical archaeology, the Jiahu bone flute is roughly contemporaneous with late Paleolithic bone flutes in terms of chronology, but it represents significant advancements in manufacturing techniques and technology, resulting in markedly improved musical performance.

For example, during the excavation of the Jiahu site, bone flutes with different numbers of holes were unearthed. The earliest bone flutes with 5–6 holes could produce a four-note scale and a five-note scale. Mid-period bone flutes with seven holes could

produce a six-note and seven-note scale [10]. Late-period bone flutes could produce a complete seven-note scale as well as some additional altered notes. Some bone flutes also had tuning holes drilled beside the tone holes and evenly spaced markings engraved on them. These features indicate that the manufacturing and playing techniques of Jiahu bone flutes were continuously developing and improving, with their musical performance gradually enhancing. Additionally, the musical performance of Jiahu bone flutes is reflected in their beautiful, ethereal tone, complete scales, and the possibility of multi-key transposition playing, making them highly valuable for research into Chinese musical scales. Experts have used it to perform pieces such as “Little Cabbage,” fully demonstrating the musical expressiveness of the Jiahu bone flute. In summary, the musical performance capabilities of the Jiahu bone flute hold a prominent position among Neolithic human bone musical instruments, providing important physical evidence for the study of the musical culture and human civilizational development of that era [11].

4 Design Analysis of Bone Instruments

4.1 Styling Design

Neolithic bone musical instruments are uniquely distinctive in their design. Take the bone flute as an example: its body is typically crafted from the wing bones of a vulture or the leg bones of a crane, making it shorter and slimmer than a bamboo flute. This unique design gives it a distinctive feel and tone when played. The upper opening of the body is sealed with a narrow slit serving as the blowing hole, while the rear end features a slanted sound hole, and the lower front section has six finger holes. The positions and sizes of these tone holes were carefully designed, reflecting not only the people's understanding and pursuit of music at the time but also their advanced craftsmanship.

Additionally, bone musical instruments from different regions exhibit variations in design. Although both the Jiahu bone flute and the Hemudu bone flute are made from bird bones, they differ in terms of tube length, diameter, number of tone holes, and their positions. These differences reflect the cultural characteristics and variations in craftsmanship across different regions. The Jiahu bone flute combines the natural bone texture with polishing marks, resulting in a simple and natural appearance, reflecting early humans' pursuit of “functional beauty.” The Hemudu bone flute, on the other hand, leans more toward symbolic and decorative craftsmanship, with some featuring carvings or reliefs that serve both as musical instruments and totemic symbols. Comparing the two flutes, it is evident that the Hemudu bone flute emphasizes the expression of “ideational beauty.”

The early design approach of the Jiahu bone flute can inspire future generations' “function-form” dual-track design thinking, teaching them how to achieve complex functions with the simplest forms, balancing minimalism and practicality. This can be applied to design “musical” cultural and creative products, such as small whistles or simple speakers, emphasizing practicality and playful design considerations. Additionally, drawing inspiration from the totemic designs of the Hemudu bone flute, symbolic

forms can be employed to carry cultural symbols. Through “symbolic-aesthetic” narrative expression, product design can incorporate elements such as anthropomorphism, biomimicry, and cultural totems, endowing products with narrative depth and distinctiveness. The “material-craftsmanship” reconstruction method offers insights, as both emphasize the use of raw materials to present a sense of refinement within roughness. In subsequent cultural and creative product designs, natural materials (such as pottery, wood, bone, and bamboo) or their textures can be used to convey a sense of simplicity and beauty. The bridging method from historical heritage to contemporary products can leverage the cross-temporal value of cultural and creative products. The structural form of bone flutes can be reinterpreted into modern cultural and creative items such as earrings, bookmarks, incense holders, and pendants, visually conveying a sense of “spanning the ages” in cultural expression. (as shown in Table 2)

Table 2. Distinguishing between the two bone flutes in terms of design

Item	Jiahu Bone Flute	Hemudu Bone Flute
Functional Orientation	Musical performance, strong systematization	Sound expression, or symbolic function
Craft Complexity	Finely polished, precise hole spacing	Carved modeling, emphasis on symbolic expression
Aesthetic Style	Functional beauty, simple and natural	Zoomorphic beauty, image symbolism
Creative Expression	Primitive musical system	Primitive modeling language
Structural Form	Cylindrical shape, with finger holes	Fish/bird shape, relatively short

4.2 Functional Design

Musical Performance Function: Bone instruments from the Neolithic era were primarily used for musical performance. Bone flutes such as the Jiahu bone flute could play traditional pentatonic or heptatonic scale melodies, and even perform music from minority ethnic groups or foreign cultures. Bone flutes with different numbers of holes exhibit distinct characteristics in musical performance, capable of producing a rich variety of scales and melodies. The Hemudu bone flute also has unique playing techniques, such as using flat blowing and overblowing, and frequently employing glissandos and vibratos [12]. These bone musical instruments possess exceptional musical expressiveness, providing crucial physical evidence for understanding Neolithic musical culture. The Jiahu bone flute has a complete interval logic, making it more suitable for performance. It is reusable, portable, and suitable for collective or ceremonial use, though it demands higher breath control from the performer.

Cultural Symbolic Function: As a rare prehistoric artifact, the Jiahu bone flute laid the foundation for the origins of Chinese culture, exerting significant influence on China's ritual and musical systems, as well as its culture and civilization. The material used for the Jiahu bone flute is crane bone, and the crane symbolizes longevity, elegance,

and purity in traditional Chinese culture. The Jiahu ancestors created bone flutes using crane ulna bones, reflecting ancient respect for nature and embodying the Daoist philosophy of “unity between heaven and humanity.” The Hemudu bone whistle, among others, may have been used during hunting to produce sounds as a tool for trapping wildlife, reflecting the lifestyle and wisdom of the time. Its simple operation made it more suitable for daily life (hunting, bird control) or ceremonial expressions. (as shown in Table 3)

Table 3. Differences between the two bone flutes in terms of functional design

Comparison Dimension	Jiahu Bone Flute	Hemudu Bone Flute
Pitch Control	High, capable of playing a complete scale	Low, only produces fixed pitch or whistle sound
Operational Complexity	High, requires breath control and finger-ing coordination	Low, sounds with simple blowing
Usage Scenarios	Performance, rituals, social ceremonies	Hunting signals, ornamentation, symbolism
Functional Orientation	Musical expression, artistic expression	Information transmission, symbolic meaning
Structural Complexity	Multi-hole, precise	Simple, mass-producible
User Group	Artisans / Shamans	Ordinary tribe members

4.3 Craftsmanship Design

In terms of material selection and processing, during the Neolithic era, animal bones became the primary material for human-made bone instruments, with eagle bones, crane bones, and bear bones being the most commonly used. The selection of these animal bones as musical instrument materials was driven by two factors: first, the utilization and understanding of animal resources by humans at the time—animals were not only a source of food but their bones were also used to make various tools and musical instruments; second, the characteristics of these animal bones met the requirements for musical instrument production, enabling the production of specific timbres and pitches. The processing of materials during the manufacturing process was also highly refined. For example, before making the Jiahu bone flute, precise measurements and calculations were required to ensure the accuracy of the tone hole positions. When making the Hemudu bone flute, the meat was first scraped off the bone, the ends were sawed off, the upper and lower tube openings were smoothed, and the bone marrow was removed. These processing methods not only ensured the quality of the instruments but also demonstrated the craftsmanship of the people at the time [13]. The production process of the Jiahu crane bone flute is intricate and complex. Before production, careful calculations are made, and small holes are drilled to adjust the pitch. After comple-

tion, the flute undergoes smoking treatment to turn it dark red before use. This production process fully demonstrates the wisdom and technical skills of humans during the Neolithic era. (as shown in Table 4)

Additionally, modern innovations in bone instrument craftsmanship include 3D-printed bone flutes. Using 3D scanning, 3D imaging, and 3D design technology, the dimensions, specifications, and model data of bone flutes are standardized, addressing issues such as bone material shortages, lack of standardized production methods, and inability to produce in bulk. Subsequent cultural and creative product designs should explore biomimetic material design, antique-style accessories, and museum-derived products, ultimately resulting in replicas such as bone-patterned clay flutes, bone-shaped USB drives, bone-shaped earrings (as shown in Figure 7) and bone-patterned printed pen holders. Additionally, the precision of Jiahu bone flute craftsmanship can be referenced to emphasize structural functionality, innovating high-precision mini whistles, tuned instrument modules, and bone-structured microphone housings.

Table 4. Distinguishing between the two bone flutes in terms of craftsmanship and design

Application Scenario	Cultural & Creative Product Design Suggestions	Craft Inspiration
Museum Derivatives	Bone flute instrument models, 3D-printed bone whistles, antique-style keychains	Reproduce Jiahu bone flute structure and perforation techniques
Educational Interaction	Bone flute assembly kits, music experience sets	Disassemble bone instruments, paired with melody demonstrations
Aesthetic Living	Bone-style earrings, bone-pattern ceramic water cups	Simulate bone texture, simplified totem modeling
Digital Integration	Bone flute-shaped Bluetooth speakers, bone-shaped USB drives	Combine modern structures with traditional forms
Hands-on Experience	DIY bone instrument models, bone-texture pendants	Encourage users to “recreate” ancient craftsmanship hands-on



Fig. 7. Silver earrings with Jiahu bone flute

5 Comparative Development of Other Cultures in the Neolithic Age

This paper focuses on comparing the bone flutes from the Yangshao Culture's Jiahu site and the bone whistles from the Hemudu Culture, providing a detailed analysis of the bone flutes' characteristics, including their length, craftsmanship, decorative patterns, and cultural uses. To gain a more systematic understanding of the developmental trajectory of Neolithic bone musical instruments, the following analysis will be conducted from both horizontal and vertical dimensions: on one hand, comparing the differences in material, form, function, and aesthetic aspects of bone musical instruments across representative cultural circles such as the Yangshao, Longshan, and Hemudu cultures; on the other hand, tracing the craftsmanship evolution and cultural role transformation of bone musical instruments over time. (as shown in Table 5)

Table 5. Other cultural developments in the Neolithic period

Comparative latitude	Yangshao Culture (c. 5000–3000 BCE)	Longshan Culture (c. 3000–2000 BCE)	Hemudu Culture (c. 5000–3000 BCE)
Geographical area	middle reaches of the Yellow River	Lower reaches of the Yellow River, Shaanxi, Shanxi	lower Yangtze River
Material selection	Eagle bones, deer bones	crane bones, pig bones	Red-crowned crane leg bones, small bird bones
typical artifact	bone flute, bone whistle	Bone flute, bone reed, bone tube with decorative symbols	Bone whistles, bone flutes, bone rattles
Process characteristics	Porous arrangement, simple shape	Symmetrically arranged sound holes, decorated with totem patterns	Coexistence of porous and non-porous areas, with emphasis on dyeing and polishing techniques
functional positioning	Equal emphasis on performance and ritual	Reinforcing ritual functions and hierarchical symbols	Hunting and practical functions are the main focus
aesthetic orientation	Structural beauty, simple decoration	Exquisite carving, symmetrical proportions	Totem symbols, natural imitations

Bone musical instruments from the Yangshao period were primarily practical in nature. Bone flute production was still in its primitive stages, with simple tubular structures and a limited number of holes, primarily designed to play basic scales. Their design emphasized “functional aesthetics,” prioritizing practicality. During the Longshan Culture period, bone flute-making techniques significantly improved, with the emergence of complex structures featuring tuning holes and symmetrical engravings. These artifacts were no longer merely practical tools but also became symbols of ritual and social hierarchy. The aesthetic concept of “ritual and music as one” gradually took

shape. In the Hemudu Culture of the Jiangnan region, bone musical instruments primarily served daily life and hunting functions. For example, although bone whistles have a simple structure, they achieve a unity of function and decoration through elliptical sound holes and dyeing techniques. Such instruments reflect the primitive design philosophy of “tools as artworks,” emphasizing natural biomimicry and symbolic meaning. Therefore, from a temporal perspective, bone-made musical instruments evolved from “sound tools” to “ritual and musical media”; from a regional perspective, the northern cultural sphere emphasized musical scales and ritual systems, while the southern cultural sphere focused on practicality and onomatopoeic devices. These differences not only reflect technological evolution but also reveal deeper disparities in aesthetic values and social structures.

6 Conclusion

Neolithic bone musical instruments represent a crucial origin of Chinese civilization and global musical culture, with their design and evolution intertwined with technological advancements, artistic creativity, and socio-cultural contexts. From the breakthrough of the seven-note scale in the Jiahu bone flute to the practical innovations of the Hemudu bone whistle, and from the natural wisdom in material selection to the precise calculations in craftsmanship, these instruments reflect the ancient people's exploration of musical principles and the awakening of their aesthetic consciousness. These instruments were not merely carriers of sound but also served functional roles in primitive religion, hunting activities, and social rituals. For instance, the practical value of bone whistles in trapping and the symbolic significance of bone flutes in rituals reflect the survival wisdom and spiritual world of Neolithic humans.

The “function-form” dual-track thinking of bone musical instruments (such as the minimalist practicality of the Jiahu bone flute and the totemic symbolism of the Hemudu bone whistle) provides rich inspiration for contemporary cultural and creative industries. Modern design can transform the primitive aesthetics of bone flutes into tangible products through biomimetic materials, form replication, and technological integration, such as 3D-printed musical instrument models and bone-patterned ceramic jewelry, thereby preserving cultural memory while revitalizing their modern vitality. Future research could further focus on the acoustic principles and social functional associations of bone musical instruments, combining cross-regional archaeological discoveries to deepen understanding of the dissemination pathways of early musical civilizations. These ancient artifacts are not only witnesses to history but also cultural bridges connecting the past and future, continuously providing key clues for understanding the origins of human bone artworks and the design thinking behind bone tools.

References

1. Lu Song, Zhao Mingqi. Jiahu Diyin Yueqiannian [N]. Henan Daily, 2023-12-31 (001).
2. MORLEY I .MOUSTERIAN MUSICIANSHIP? THE CASE OF THE DIVJE BABE I BONE[J].Oxford Journal of Archaeology,2006,25(4):317-333.

3. Wang Geyang. A Comparative Study of Prehistoric German Bone Flute and Jiahu Bone Flute [J].Chinese Musicology, 2024, (02) : 77-84 + 4.DOI : 10.14113 / j.cnki.cn11-1316 / j.2024.02.024.
4. Liu Zaisheng. Unearthed a new member of the drum family in the primitive society-the first ' pottery face drum ' in China was found in Qinghai [J].People ' s music (review), 2002 (5) : 38-39.
5. Chen Ruiquan. Jiahu eight-hole bone flute music archaeological experiment and prehistoric seven-tone scale [J].Music Art (Journal of Shanghai Conservatory of Music), 2024, (06) : 17-30.DOI : 10.19359 / j.cn31-1004 / j.2024.06.002.
6. Shen Yingying. Study on the Neolithic Musical Instruments Unearthed in China [D]. Central Conservatory of Music, 2012.
7. Lu Wenhan, Lu Fulin. Empower to innovate the flute to save its playing skills [J].instruments, 2024 (11) : 20-23.
8. Li Siru, Ma Dongming. Artistic Features and Cultural Connotations of Jiahu Bone Flute [J]. Beauty and the Times (Aesthetics) (II), 2019 (1) : 105-107Yang Haotian. Research on the Neolithic rocker unearthed in the Yellow River Basin [J].Human World, 2020, (08) : 91-95.DOI : 10.16737 / j.cnki.rwtx81281190.2020.08.030.
9. Zhang Xiaowen. The historical significance and artistic value of Jiahu bone flute [J].Art Grand View, 2024, (06) : 100-102.
10. Chen Ruiquan. Jiahu eight-hole bone flute music archaeological experiment and prehistoric seven-tone scale [J].Music Art (Journal of Shanghai Conservatory of Music), 2024, (06) : 17-30.DOI : 10.19359 / j.cn31-1004 / j.2024.06.002.
11. Fang Jianjun. Research on the Music Performance of Jiahu Bone Flute [J].Music Research, 2024, (04) : 5-17.
12. Prince Chu. Research on the ' seven tones ' of Jiahu bone flute and the music civilization of the two rivers in East Asia [J].Chinese Musicology, 2022, (03) : 5-11 + 73 + 4.DOI : 10.14113 / j.cnki.cn11-1316 / j.2022.03.006.
13. Chen Ruiquan, Fang Jianjun. The imitation experiment of Jiahu seven-hole bone flute and the new exploration of scale structure [J].Chinese Musicology, 2025, (02) : 54-64.DOI : 10.14113 / j.cnki.cn11-1316 / j.2025.02.012.

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