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Research Article

Analysis of Musical Cultural Characteristics, Harmony Factors and Harmony Value in Pre-Qin Bronzes

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ABSTRACT

The pre-Qin period was the golden age of the development of Chinese bronzes, during which the musical culture was very rich, and harmony and scales appeared. Previous studies mainly used the historical materials of pre-Qin Qingqi for theoretical analysis, but lacked practice and case studies, which could not provide practical support for archaeological research. Therefore, this paper takes the tombs of Zeng Houyi, Luoyang and Houchuan in Shaanxi Province as the research object, with the help of Panasonic 72x electron microscope observation (Tokyo, Japan, E7200), optical film analysis (China, Guangdong, 300 type), Analysis 2002 version, SPSS17.0 software, and Microsoft microphone (United States, 2020 version) and other auxiliary technologies to analyze the development of bronze and sound, as well as cultural characteristics and harmonious values, taking the Western Zhou Dynasty and the Spring and Autumn Period as examples. The results showed that spring and autumn were the key periods for the development of bronze musical instruments, and the harmony differences in bronze musical instruments were small ($P<0.05$). At the same time, the scale of the Xia and Shang period was 1~4, the Western Zhou was 1~5, and the Spring and Autumn period was 1~6, and the high and low scales gradually rose, and the change range of treble ~ bass was 2.54±0.23Hz. In addition, the variety of bronze musical instruments increased a lot during the Spring and Autumn Period, and instruments of various shapes appeared, forming local vocalization and overall vocal flow. Therefore, the instruments of pre-Qin bronzes were mainly in the Spring and Autumn Period, and the Xia, Shang and Western Zhou dynasties continued to prosper, which provided a reference for modern harmonic performance and unified the standards of harmonic performance in China.

Keywords: Pre-Qin Bronzes, Harmonic Factors, Music Culture, Features, Harmony Value.

INTRODUCTION

Because the ancient system of ritual music was incorporated into the country's statutes, it had a high status. Due to the many major social turmoil in the pre-Qin period, and the ritual system used in the Zhou Dynasty was not strict enough, the religious etiquette at that time was significantly shaken. At this time, the emergence of many great philosophers, such as Lao, Kong, Zhuang, etc. (Duan, 2023), brought ideological and cultural prosperity and caused musical aesthetic thought; therefore, in the pre-Qin period, musical aesthetics reached a new height (Eva & Pines, 2023). The classic concepts of musical aesthetics that emerged in this period include "beauty" and "goodness"(Feinman, Nicholas, Wang, Long, & Fang, 2021), "zhengsheng", "ritual music", etc., so the connotation of music culture in the pre-Qin period always contains aesthetic meaning, such as "happy but not lewd, sad but not sad", "loud sound and sound"(Huang, Wu, Chen, Tao, Wu, Shi, & Jin, 2021) "all music through politics", etc., all directly affect the precipitation of music culture in the pre-Qin period, and, in this process, Taoism has natural music theory, Confucianism has etiquette thought, yin and yang angle has five tones and twelve laws and five elements of December music view, etc (Luo, Yang, Liu, Huang, Wei, & Fan, 2023). They are all the embodiment of the aesthetic ideas of the integration of music culture at that time. According to the "Spring and Autumn of the Lü Family", the ancient Qin people mixed the musical aesthetic ideas of the above families and put forward a variety of different theories of musical aesthetics, such as "image theory" and "qiyun theory". These

are the theoretical foundations of the aesthetic music of the pre-Qin period in China (Lyutov, 2021), and they also have a profound influence on Chinese music in later generations. Pre-Qin period, from the Xia Shang Zhou to the Spring and Autumn Warring States period, Chinese bronze developed very rapidly, constituting a strong stroke in ancient Chinese art. During this period, the ritual music system gradually emerged and influenced China for thousands of years. And at this time, there were also great philosophers such as Lao, Kong, Zhuang, etc., who were also masters of ancient Chinese musical aesthetics, so they made unique contributions to the formation of some classical Chinese musical aesthetic concepts, such as "beauty", "goodness", "zhengsheng", "liturgical music". As we all know, the pre-Qin period was the most brilliant period in the development of ancient Chinese musical culture, so the study of bronzes from the pre-Qin period is necessary. Although there are many studies on Chinese pre-Qin bronzes around the world, the title of "Analysis of Music Culture Characteristics, Harmony Factors and Harmony Value in Pre-Qin Bronzes" has certain research characteristics because no one has specifically combined the musical cultural characteristics of pre-Qin bronzes with "harmony factors" before (Pollard & Liu, 2021). The research significance of this paper is to help more people understand the musical elements and musical and cultural characteristics in Chinese pre-Qin bronzes, have a complete understanding of the harmony factors therein, and at the same time, bring a little inspiration related to bronze research to relevant personnel.

THE DEVELOPMENT OF MUSIC CULTURE IN THE PRE-QIN PERIOD

Research Methods

With the help of Panasonic 72x electron microscope observation (Tokyo, Japan, E7200), optical film analysis (China, Guangdong, 300 type), Analysis 2002 version, SPSS17.0 software, and Microsoft microphone (United States, 2020 edition) and other auxiliary technologies, the bronze was analyzed to study the development of bronze and sound, as well as cultural characteristics and harmonious values Western Zhou and Spring and Autumn periods. The observed indicators include the content of brass, tin, iron and other metals in bronze instruments, the difference in harmony, the change of scale, high and low scale, the type, shape, local sound and overall sound flow of the instrument.

Iterative Replacement of Bronze Instruments

Bronze Musical Instruments from the Xia Shang Period

There is basically no historical material in terms of the pitch in the Xia Shang period. The music of this period mainly served some nobles; from the archaeological relics, it can be seen that the bronze musical instruments of the Xia Shang period represent the gong bronze bell these instruments (Pollard & Liu, 2022), plus the evolution of technology, so some metal musical instruments, such as bells and plutonium, cymbalium and so on. Therefore, in the Xia Shang period, music culture had a richer foundation. According to later research, the musical instruments of the Xia Shang period were divided into percussion instruments and wind instruments, as shown in (Table 1) below (Skrabal, 2022).

Table 1. List of Musical Instruments from the Xia Shang Period

Percussion instrument	Melody	Playing Instruments	Melody
1. Qing	c↑、a↑、f↑	7.Xun	a↑、f↑
2. Chimes	c↑、f↑	8.Tuna	c↑、f↑
3. Clock	c↑、a↑	9.He	c↑、a↑、f↑
4.bells	a↑、f↑	10.Taro	c↑、f↑
5.Yong	c↑、f↑	11.Ware	c↑、a↑
6.Drum	a↑、f↑	12.Fou	a↑、f↑、c↑

In this process, the temple has been well developed, and the three-tone hole and five-tone hole have been developed. In the Xia Shang period, the law pipe was a special tool for determining the pitch, and the use of the law pipe could determine the pitch more accurately. Moreover, people in the Shang Dynasty already had a certain understanding of music and had the concepts of "absolute pitch" and "semitone interval". From the archaeology of pre-Qin bronze musical instruments, the Xia Shang period is a relatively common musical instrument. The currently known Xiangfen pottery temple unearthed special, and the Palace Museum of Anyang Yin Wu stone and Xia County Dongxia Feng unearthed stone brick cultural relics prove that the rock at that time had a fixed range of pitch (Tang, Wang, Xiao, Chen, Hu, Yang, M & Yuan, 2022), according to modern sound measurement results, the above three Xia Shang period gong pitch is in a small character group of c ↑ , at the same time, all kinds of musical instruments also have a common tone with each other, mainly c ↑ , a ↑ , f ↑ , etc (vonFalkenhausen, 2021).

It can be seen from the study of pre-Qin bronzes that the original scale system was initially formed during the Xia Shang period.

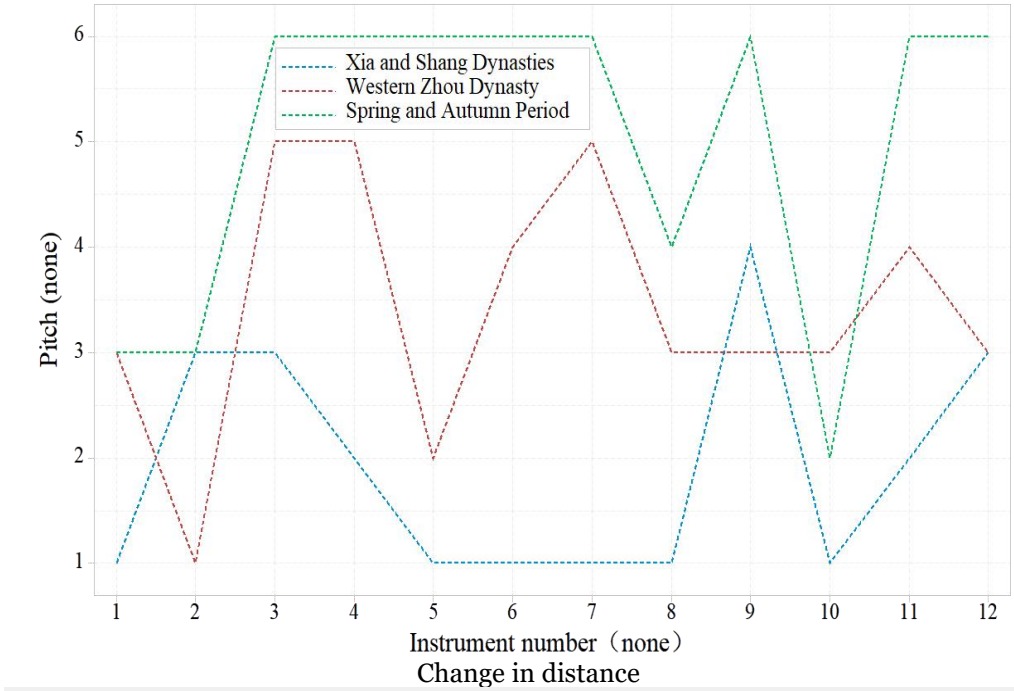
In the pre-Qin period, due to the development of bronze musical instruments, the rhythmic relationship of pitch was formed. For example, the weaving of the Xia Shang period was able to play a complete scale. In addition, bronze instruments with 2-3 tones as the main ones can also achieve different intervals, so the pitch of the Xia Shang period has been further developed, but the determination of the pitch of the instrument is mainly achieved by using the law pipe (Wei, 2022.)

Musical Instruments of the Western Zhou Dynasty

During the Western Zhou Dynasty, the rulers began to formulate their own means of rule, so the ritual music system of this period was formed, and there was a very strict hierarchical etiquette system with a special musical institution during this period, "Six Generations of Music and Dance" became the court music system, and court music and dance began to rise. According to historical records, there are about 70 kinds of musical instruments in the Zhou Dynasty, and their number and types are constantly increasing; in order to make various musical instruments get a certain classification, people in the Zhou Dynasty began to use a musical instrument classification method to classify musical instruments, that is, the earliest "eight-tone classification method". In the tomb of Zeng Yihou of the Warring States (Xu, Sheng, Xiong, Meng, Wei, Sun & Wen, 2022), there are many different characteristic musical instruments, which are manifested as dexterous features, such as Sheng, qin, pan flute, ni, ser, etc., reflecting the eight-tone classification. According to the classification of the production materials of musical instruments, the accuracy of the occurrence of musical instruments is high, and the timbre of instrumental music performance is diverse and changes obviously (Yang, Wu, Liu, Wang, Shi, Qu & Zhang, 2023), indicating that there are many types of musical instruments in the Western Zhou Dynasty. According to archaeological data, musicians during the Zhou Dynasty mastered the playing skills of the "pentatonic scale" and "seven-tone scale" and used mathematical methods to calculate China's first living law. Compared with the corresponding first law, there are more notes in the birth law, which makes up for the lack of the "three-point profit and loss law". At the same time, the "twelve laws of Lü" and "ancient scale" were also formally formed during the Zhou Dynasty, and the "eight classifications" classification of musical instruments were carried out (Zhang, Wang, Liu, Zhao, Wang, Zhang, Xu, 2023).

Musical Instruments of the Spring and Autumn and Warring States periods

The development of musical instruments in China reached its first peak during the Spring and Autumn and Warring States periods, when the guqin began to appear and became a key solo instrument. The instruments of this period are mainly percussion, and the representative of the bronze instruments of the Spring and Autumn Warring States that have been unearthed is the chimes of the tomb of Zeng Marquis Yi, and the bell and drum music is also a musical representative of this period. In the tomb of Zeng Marquis Yi, a wide variety of musical instruments have been unearthed, such as chimes, drums, pianos, pan flutes, hoops, weaving pans, sheng and so on, a total of 144 pieces. It can be seen that the funeral scale of the tomb of Zeng Marquis Yi is very large, and there is a complete underground band, with many types, many numbers and complete forms. According to the analysis, among these instruments, the largest number is the bell instrument, which reaches 115 pieces, which is very eye-catching, as shown in Figure 1.



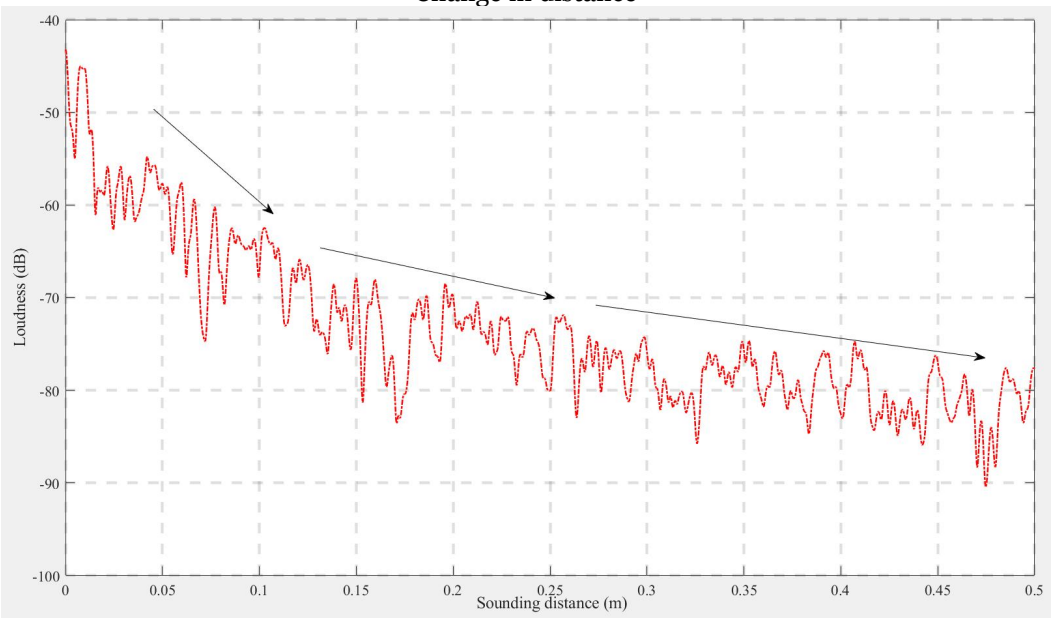


Figure 1. Comparison of Pitches Over Time

It can be seen from Figure 1 that the pitch of the Spring and Autumn Warring States period was 1~6 orders, the Western Zhou period was 1~5 orders, and the Xia Shang was 1~4 orders. In the tomb of Zeng Marquis Yi, the number of chimes is 64, according to the upper, middle and lower layers, that is, the upper layer puts the button bell, the middle and lower are Yong bells, the interval is a major third degree, a minor third degree, respectively, the positive drum sound, the side drum sound, the total range of the whole set of chimes reaches 5 8 degrees, and its tone is consistent with the modern C major, the central range of 12 rhythms is complete, can form a semitone scale within 3 8 degrees, and is very complete, and adopts a compound rhythm system of three profit and loss combined with pure law, which can play 7 scales of music, Among them, the concept of sound intervals is also expressed in the form of inscriptions, and there are terms "static", "less", "anti", "large", "voiced", "back", "horn", etc., which just correspond to the 1~7 intervals in modern music theory. It can be seen that in the early Spring and Autumn Warring States period, the ancient Chinese were already able to use special terms to express sound intervals. Moreover, during the Warring States period, in order to make the pitch relationship reflected in the five-tone twelve rhythms more reasonable, the length of the string was adjusted, and combined with pitch and pitch to complete pitch comparison in different periods.

Bronzes from the Tomb of Marquis Yi of Zeng and the Ancient Tomb of the Pre-Qin Dynasty in Luoyang

At present, among the pre-Qin bronzes that have been unearthed, the tomb of Zeng Marquis Yi with more numbers and types of chimes is the tomb of Marquis Yi, and because of its large scale, large number of chimes, harmony factors and musical value, it has been studied more. Among the 144 musical instruments unearthed in the tomb of Zeng Marquis Yi, there are 65 bronze chimes and 32 stone bells, which shows that bronze chimes, as the main percussion instruments at that time, accounted for the largest proportion, reaching 45%. The chimes unearthed from the tomb of Zeng Marquis Yi are currently the best preserved and largest set of large bronze chimes in China, for the types of chimes unearthed from the tomb of Zeng Marquis Yi, their respective number and proportion, please see Figure 1.

At the time of the excavation, the entire set of chimes stood directly, and the total number of these chimes reached 65, and they were all made in bronze and were very well made. On the bell frame, there are various bells arranged in 3 layers, the upper floor has a total of 19 pieces, and the middle and lower floors are divided into 3 groups and become the main part. In the middle and lower floors, there are three sets of bells, namely the "Amber Bell" composed of 11 long milk bells, the "Yingsi Bell" composed of 12 short milk bells, and the "Jie Bell" composed of 23 long milk bells. They are all inscribed with inscriptions in the wrong gold seal. On the obverse, in the position between the cymbals, all inscribed "Zeng Marquis Yi Zuo Shi", studying these inscriptions will contribute to the study of ancient Chinese musical rhythms, as shown in Figure 2.

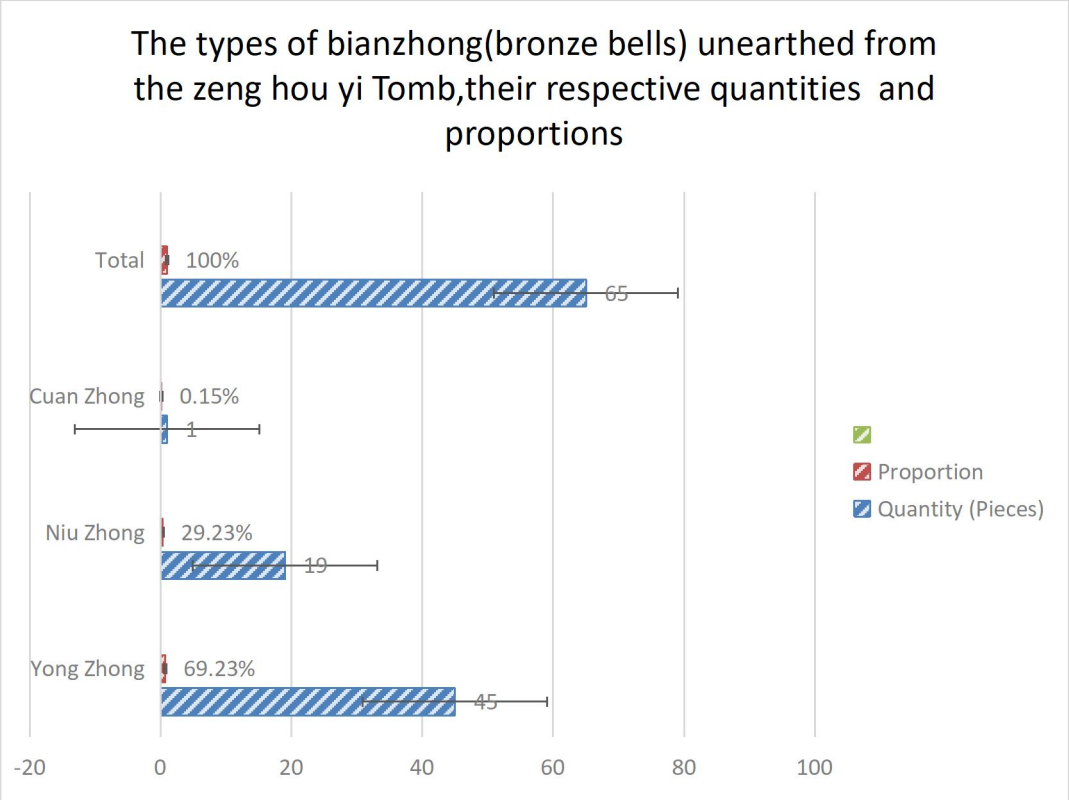


Figure 2. Type, Number and Proportion of Bronze Bells Excavated from the Tomb of Zeng Marquis Yi

It can be seen from Figure 2 that the types and quantities of bronze bells unearthed from the tomb of Zeng Marquis Yi are diverse, and the proportion of different musical instruments is relatively reasonable, which further illustrates the complete development of bronze musical instruments in the Spring and Autumn period. The specific information of the bronze chimes of the tomb of Zeng Marquis Yi is shown in (Table 2).

Table 2. Information on Bronze Chimes from the Tomb of Zeng Marquis Yi

Parameter	Content	Parameter	Content	Parameter	Content
Total	65 pieces	Hierarchical approach	Hang	The total weight of the chime	3500kg
Number of groups	8 groups	Emission mode	2 rows, upright	Time to date	More than 2400 years

Parameter	Content	Parameter	Content	Parameter	Content
Arrange shapes	Curved ruler	The number of polygons distributed	West and south, a total of 2 sides	West	It is 7.48m long and 2.65m high
South	It is 3.35m long and 2.73m high	Arrangement	3 layers arranged	The top	Button bell
Middle tier, lowest layer	Yong Bell	Minimum weight	2.4kg	Maximum weight	203.6kg

Musical Cultural Characteristics in Pre-Qin Bronzes

Copper Cymbal

Among the bronze musical instruments of the pre-Qin period, the bronze bell of the Xia Dynasty period is the earliest bronze musical instrument and has basic symbolic significance. In the Shang Dynasty, because of the vigorous development of bronze culture, new kinds of bronze musical instruments were born, such as cymbals and cymbals, copper drums, etc. During the Shang Dynasty, the copper cymbal began to appear, and it was also a bronze musical instrument with epoch-making significance. From archaeological data, we find that the copper cymbal of the Shang Dynasty is a bit like a bell, but has a cylindrical empty Yong, which is connected to the body cavity, and when performing, the mouth of the cymbal should be up, and the empty Yong can be placed on the wooden frame. After the emergence of the shang cymbal, it has always been a shingle structure, and it has also driven many different combinations of cymbals, since then, the "one bell and two tones" of the bronze bell have been formed, and at the same time, it has laid its own musical function, the pitch is fixed, and the melody of the 6-7 tone scale can be played. Because during the Shang Dynasty, musical instruments were still commonly used ceremonial instruments by the aristocratic royal family, so it was basically irrelevant to commoners. The land of the copper cymbal in the Shang Dynasty, with Yin Wu as the most, usually appeared in combinations, and a group had 3 large and small. Other times there will be groups of 5. According to archaeological findings and some records, since the Shang Dynasty, cymbals have rarely appeared outside the Yin ruins. According to the current archaeological findings, the copper cymbals of the pre-Qin period that have been unearthed, if they are unearthed in the same tomb, generally adopt the same shape, but there are often differences in size, so generally speaking, several copper cymbals of different sizes are woven into a group. The copper cymbal excavated in the Chemakeng Martyrdom Cemetery (Zhou) of Luoyang Lin School, a total of 3 pieces, is a broad-leaved cross-section, each side has a certain angle of inclination, in the middle of the bottom of the vessel, there is a tubular short stalk, just connected with the inner cavity, at the end of the handle is provided with a hoop, and there is no decaying wood inside, which shows that this is a testimony of the planting mode at that time. The shape of this group of copper cymbals is relatively large, and it is obviously different from the copper cymbals unearthed in Yin Wu, there is no obvious animal face pattern, but the style of square frame pattern is adopted. Therefore, the copper cymbals in pre-Qin bronzes have these characteristics

（1）During the Shang Dynasty, copper cymbals began to appear, and they had epoch-making significance;

（2）Shang cymbal is often a tile-shaped structure, and then the combination form of the cymbal has become diverse, so the emergence of the shang cymbal makes the bronze bell begin to form a "one bell double tone", the musical function is determined, the pitch is fixed, and the bronze instrument begins to be able to play the 6th or 7th order melody;

（3）Copper cymbals are generally in groups of 3 or 5 groups, mainly still in groups of 3;

（4）The copper cymbals of the Shang Dynasty still had a way of planting

Yong Bell

The Yong bell is also an integral part of the pre-Qin bronzes, because the number of Yong bells unearthed in the Luoyang area is large, the preservation is complete, and it contains the various periods of the pre-Qin bronzes, the archaeological significance is very complete, so there are many Yong bells unearthed in the Luoyang area see (Table 3), a total of 58.

Table 3. Yong Bells Unearthed in Luoyang Area

Excavated Cemeteries	**Name**	**Quantity (pcs)**
Zhou Tomb of the Eastern Zhou King City Site (Luoyang)	Yong Bell	8
Tomb of Yu Zhong (Luoyang)	Yong Bell	8
East Taicang Ancient Tomb (Luoyang)	Yong Bell	8
Sanmenxia Yuji Tomb	Yong Bell	14
Houchuan Warring States Tomb in Shaanxi County	Yong Bell	20

Total: 58

According to the archaeological findings of the Yong Bell in the Luoyang area, the characteristics of the Yong Bell include:

（1）In the music and sound performance are very good, the number is large, the shape is basically the same, but the size is different;

（2）Different from the Shang Dynasty Yong Bell is basically a combination of 3 groups, the Yong Bell unearthed in Luoyang area is basically a combination of 8 groups, so it can be proved that the scale of the Yong Bell combination of this set of chimes is larger than the combination of the Shang Dynasty Yong Bell, which is the result of expansion, which shows that the economy and all aspects of the conditions at that time have been improved;

（3）Has a second base tone. Several sets of Yong bells unearthed in Luoyang area are basically the same, all of them are double-tone bells, the so-called double-tone bells mean that one of them is located in the center of the drum, and the other tone is located on the side of the drum. The right drum of the bell body of the Yong Bell is specially cast with a phoenix bird pattern, which is also a specific percussion point symbol of the side drum sound, and the logo is based on the third bell. According to this rule, the first 2 bells generally only emit a single tone, so it can be seen that there are obvious missing in the 4 pieces of Luoyang Xigong's Yong Bell. According to the sound measurement, these Yong bells unearthed in the Luoyang area are all two-tone bells.

(4) There are five interval relationships, namely m2, M2, m3, M3, and P4.

(5) The tuning technology has been significantly improved. For example, Sanmenxia Yuji Yongdang, a total of 24 pieces, of which 8 are tuned, accounting for about 33.33%,

Button Bell

The button bell appeared after the Yong bell, the currently known button bell excavation site, a group of non-chick bells unearthed in the tomb of Prince Lingyu is the earliest known 1 button bell, the age is the early Spring and Autumn period, which is characterized by the bell body is tile-shaped, flat belly, flat dance, there is a tiny concave at the mouth, and there is a long round button on the dance, in the shape of a round bar. The difference between it and the Yong clock is not very big, the more obvious is that the side suspension part is no longer Yong, but replaced with a button, the purpose is to make the bell become a straight hang, in order to promote the bell has better stability, the internal logic of such a change is to improve the sound quality when playing. Therefore, it can be seen that the button bell is similar to the design of the basis of the Yong bell, and then change one of the parts, which is a variant of the Yong clock. At the same time, the button system of the button bell is borrowed from the "bell". According to the button clock unearthed in Luoyang, the chick bell is basically a combination of 7-9. Button bells of this period

It is more mature and stable in form, and at the same time, the marshalling sequence is very robust and more varied, which can maintain the high musicality of the instrument. After modern sound measurement, it is found that the positive drum sound and side drum sound of the chick bell unearthed in Luoyang area can reach a very complete 7-tone scale, and can also reach a variation tone other than 7 tones, and the melody performance is also relatively strong. That is to say, in the button bell of the pre-Qin bronze, it is actually in the same vein as the bell, and it developed relatively late. At the same time, the emergence of the button bell also means that people in the society at that time have a new aesthetic pursuit of music, paying more attention to the melody of the chime bell, and, compared to the Yong bell, the button bell is smaller and more convenient for popularity. Moreover, combined with various reasons such as etiquette and economic costs, button bells and small clocks are more popular. Over time, the button bell gradually replaced the larger Yong clock.

So, as mentioned above, button bells in the pre-Qin period have these characteristics:

(1) The difference between the button bell and the Yong bell is not much, mainly in the side overhanging Yong changed to the button, because the size of the button is smaller, the purpose of this is to adjust the stability of the clock, and then achieve the purpose of adjusting the sound quality and making the sound quality better;

(2) The button bell and the bell are in the same vein;

(3) The chimes are often a group of 7, sometimes a group of 9, and the sequence of the group is very sound and varied, reflecting the high musicality of the instrument

(4) From the end of the sound measurement, it is found that the positive drum sound and side drum sound of the chime bell in the pre-Qin period can reach a complete 7-tone scale and a variation outside the 7-tone scale, and have strong melodic performance;

(5) The body size is smaller, and later it becomes more popular.

Comparison of Materials of Copper Cymbals, Yong Bells and Button Clocks

Although the functions of the copper cymbal, Yong bell and button bell are different, as representatives of bronze ware at that time, there is no difference between the materials of their production, and the result is shown in Figure 3.

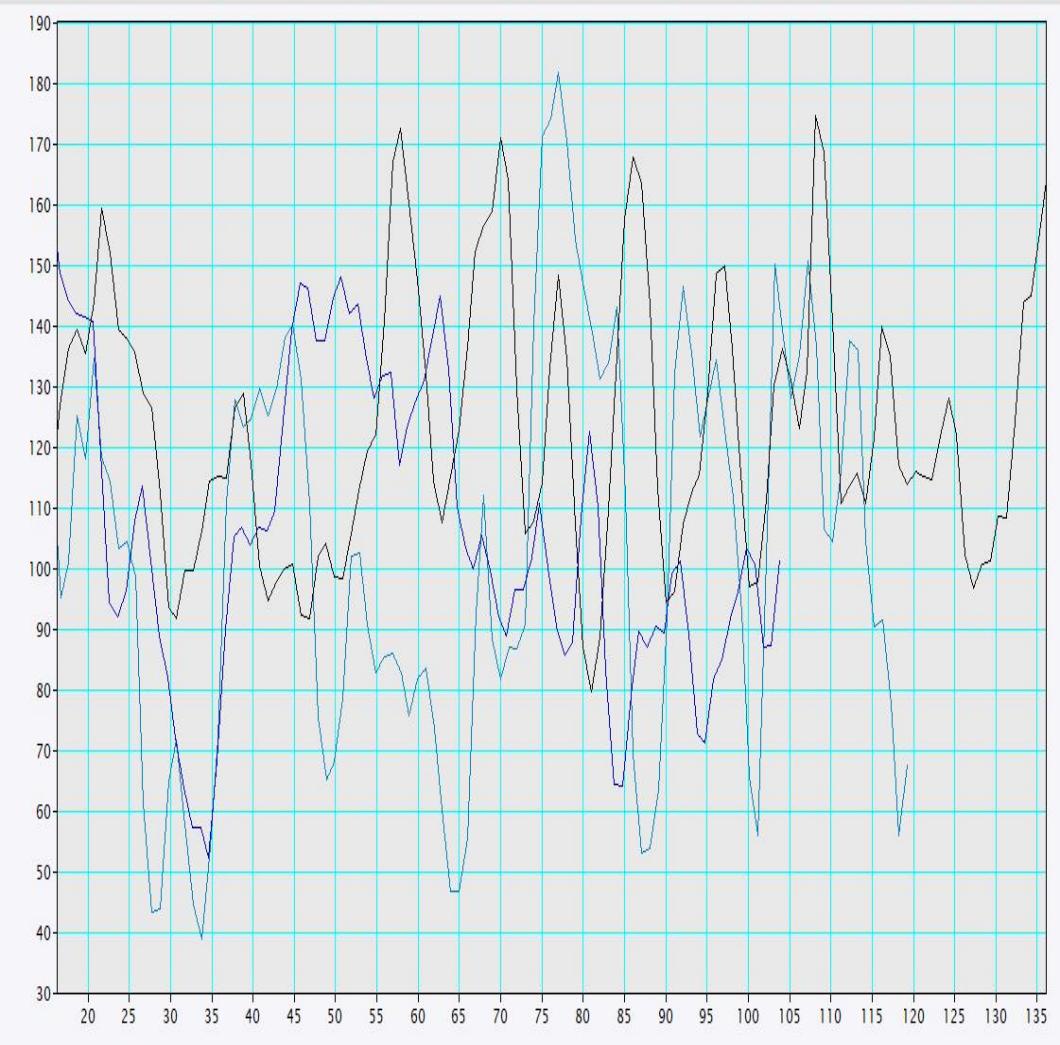


Figure 3. Material Comparison of Copper Cymbal, Yong Clock and Button Clock

As can be seen from Figure 2, the electron micrographs of the cymbals, bells and buttonbells are similar, with the same amplitude and wavelength

ANALYSIS OF HARMONIC FACTORS IN PRE-QIN BRONZES

Harmony Factors of Chimes Unearthed from the Tomb of Zeng Marquis Yi

The harmony coefficient of the chimes unearthed from the tomb of Zeng Hou Yi, the pitch has a strict proportional design, the pitch of the bell group is different, thanks to its "Hewa" bell shape, due to the unique bell shape, the bell cavity structure is special, so the bell has the characteristics of "one bell and two tones", the melody is very beautiful, in general, this set of bells can be divided into 2 timbres, the sound range is wide, can run through the 5 half octave group, whether it is treble or bass, it is obvious, 12 semitones are complete, there are three 8 degrees in the middle. Since the alto is complete, this set of chimes can flexibly "rotate" to any 1 note, and can play the complete piece, such as 4th, 6th, 7th, and combined with other instruments, such as wind

instruments, harmony instruments, etc., it can play many different harmonies, so the diversity of harmony coefficients is also a feature of it. In addition, there are detailed gold inscriptions on the bell body and accessories, which can help people better understand the correspondence between the pre-Qin music theory recorded in it and the "legal name-hierarchical name" of the vassal states at that time. It can be proved that the Chinese seven-tone scale matured more than 2,400 years ago, and it did not come from Europe and could "rotate". Zeng Houyi's bells in the early Warring States period had a wide range of sounds, divided into four groups: high, medium and low, and harmonic analysis was carried out using sound simulation software, and the results **are shown in Figure 4.**

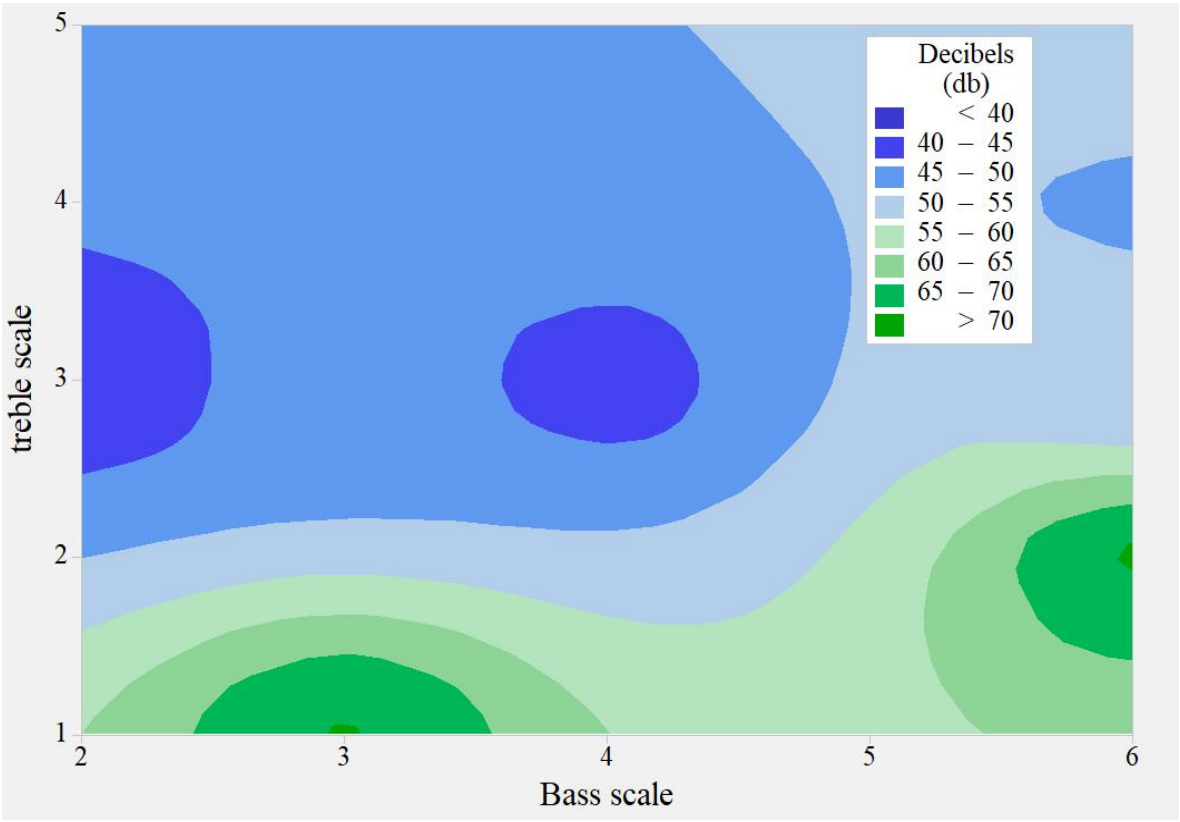
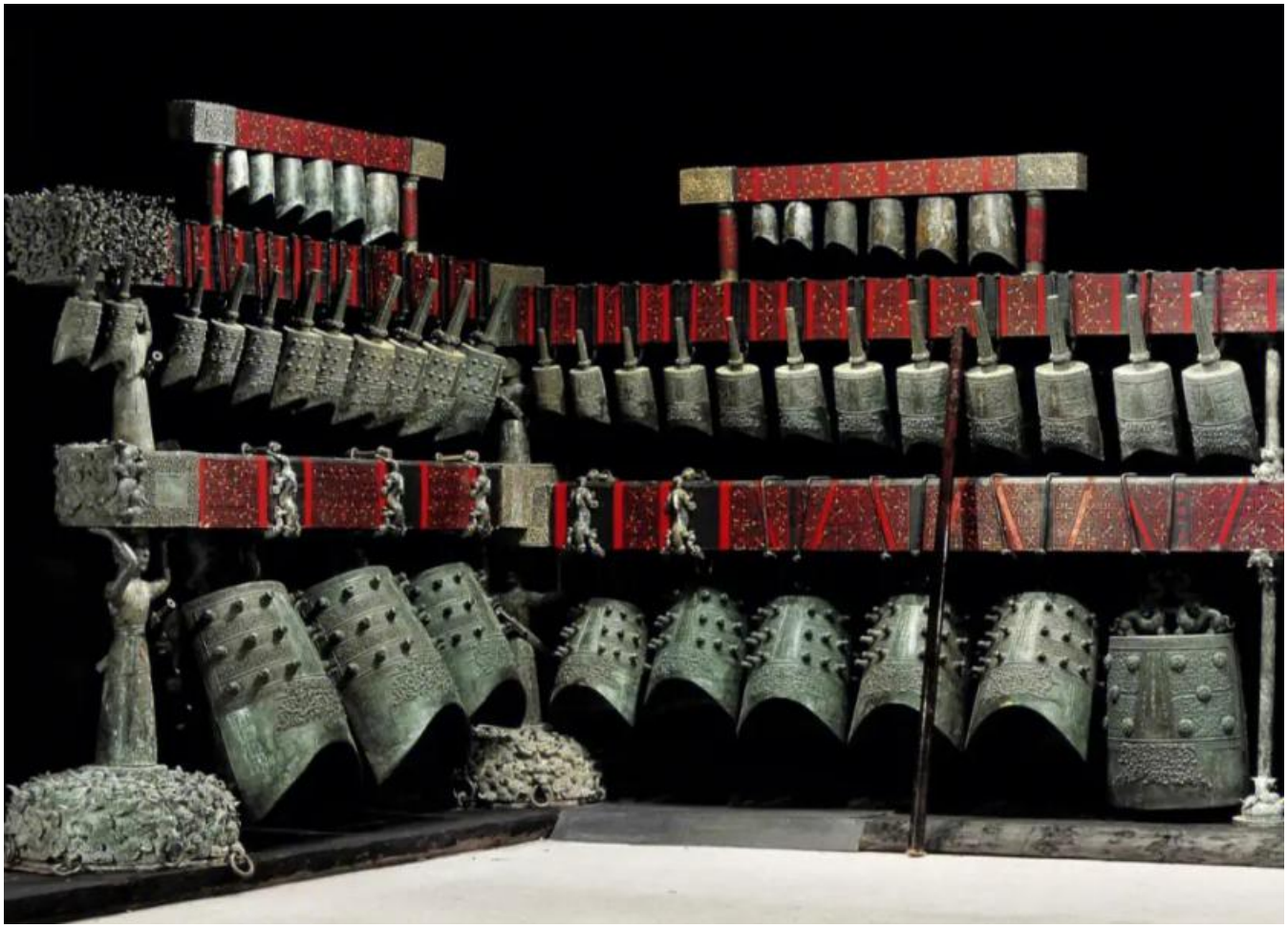
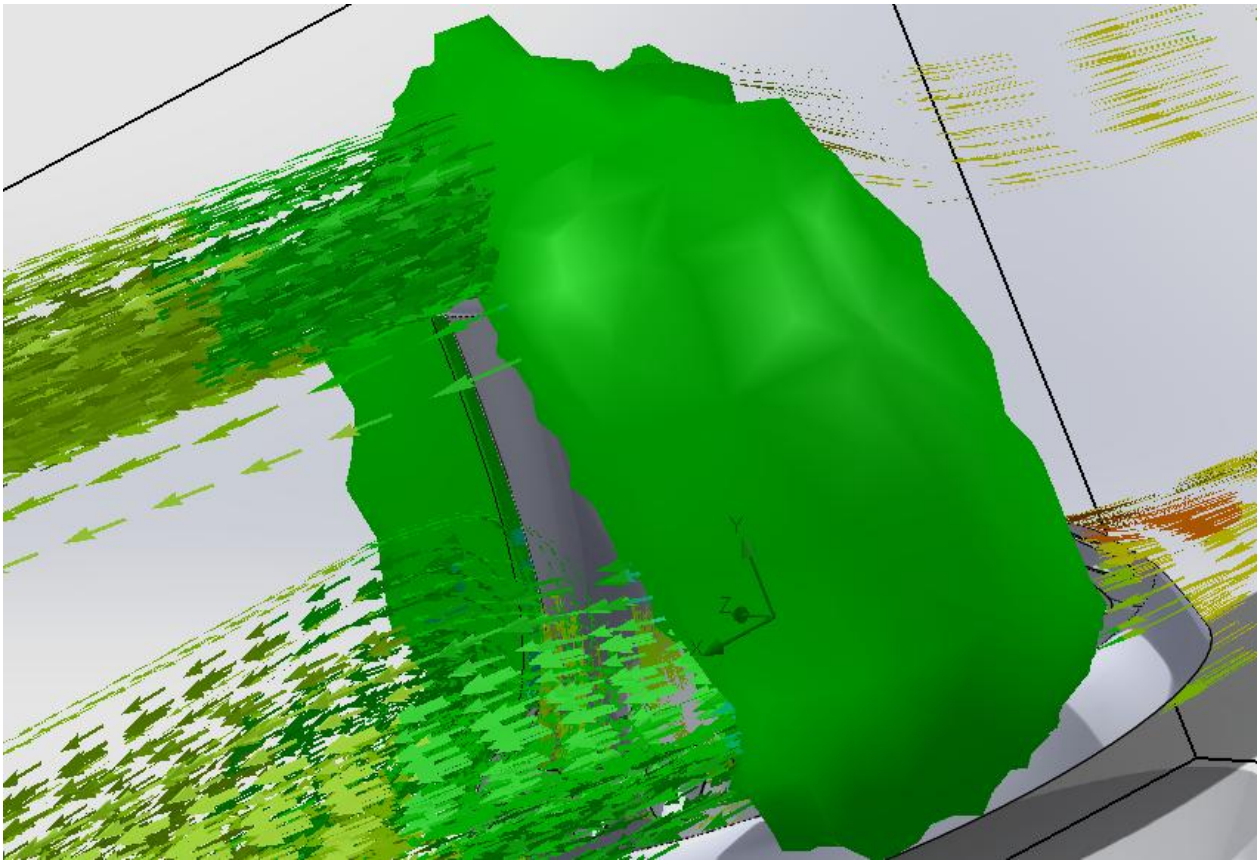


Figure 4. Chime Harmony Results

It can be seen from Figure 4 that the equivalence curve of the chime harmony shows that the loudness of the treble and bass is higher, greater than 79dB, and the degree of fusion between the treble and the bass is uniform, and the boundary of the contour curve is smooth, which further proves that the harmony effect of the chimes in the tomb of Zeng Marquis Yi is better. The specific characteristics of the bells of the tomb of Zeng Marquis Yi are as follow,This is shown in Figure 5.



Chime structure



Resonance of a single chime

Figure 5. Chime Effect of the Tomb of Zeng Marquis Yi

As can be seen from Figure 8, there is not much difference between the harmony of Luoyang Silk and Shaanxi Houchuan Aya, and the amplitude and change trend of the two are basically the same, indicating that the Spring and Autumn Period are gorgeous and gorgeous, and the harmony of Aya's is also unified in weaving, basically realizing the unity of Chinese bells and harmony. The tuning technology of chimes unearthed from various tombs in the Luoyang area has also been greatly improved compared with the Shang Dynasty, Table 4 shows the details.

Table 4. Comparison of chimes sounds

Bells	Single clock				Bells			
	bass	treble	Medium-low	Medium-high	bass	treble	Medium-low	Medium-high
Shaanxi Houchuan chimes	0.372	-0.272	-1.358	-0.539	-0.890	0.864	-1.384	0.101
Luoyang chimes	0.736	0.657	2.333	0.736	2.814	0.862	2.333	0.657
other chimes	-0.823	0.981	0.678	-0.310	-0.890	0.864	-1.384	0.101
Note: Average resonance coefficient = 0.718								

As can be seen from Table 4, the resonance effect of the chimes is obvious, which is 0.718, and there is a significant difference between the sound of a single bell and the sound of a chime, indicating that the chimes can make up for the shortcomings of a single bell and improve the loudness and transmission distance.

Analysis of Harmonic Factors of Bronze Chimes Excavated from Various Tombs in Luoyang

Among the chime combinations unearthed in Luoyang's Xigong and Yu Zhong tombs, Sanmenxia Yuji tombs and other cemeteries, the Yong bells also show good timbre, sound quality and harmony functions. Each of these bells is a "double tone of one bell", which is characterized by "one tone in the center of the drum and one tone on the side of the drum", starting from the third bell, striking the "phoenix bird pattern" marked by the right drum on each bell body, then the harmony can be struck, as shown in Figure 6.

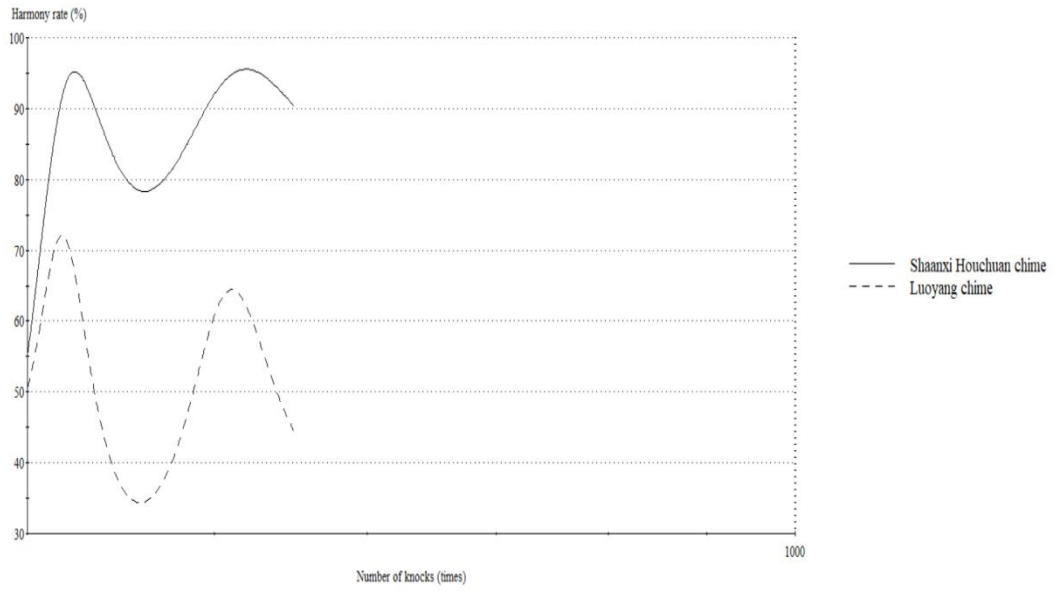
Figure 6. Bronze Chimes Unearthed in Luoyang

It can be seen from Figure 6 that the harmony of the bronze chimes unearthed in Luoyang is complete, with a harmony of the 1~5th order. A total of 20 chimes unearthed in Houchuan, Shaanxi County, all of which show the

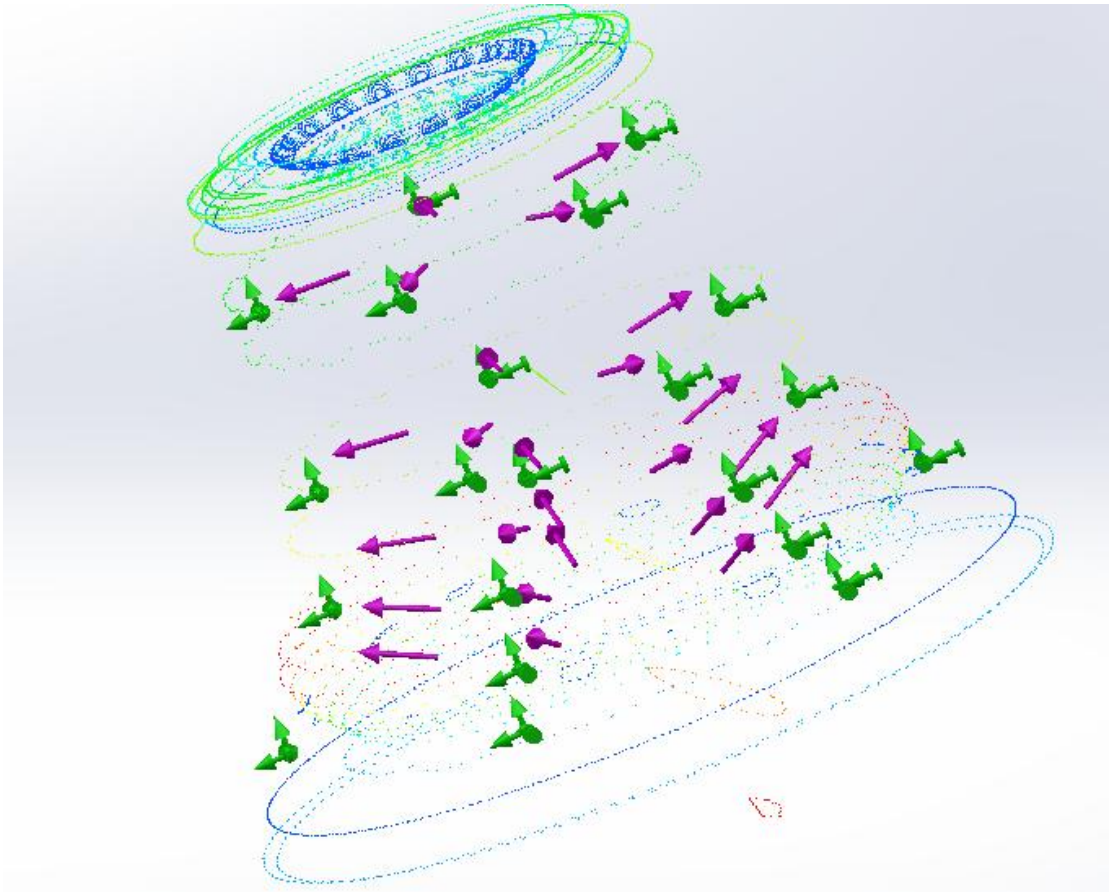
characteristics of relatively thin walls, through modern technical means of sound measurement, it has been clear that 8 of the smaller Yong bells are "double tone bells", the bronze double tone bells unearthed in Luoyang are basically Yong bells, it can be seen that the small Yong bells at that time generally play a good harmony function, as shown in Figure 7.

Figure 7. Chimes Unearthed in Houchuan, Shaanxi

It can be seen from Figure 7 that the interval relationship of the chime is complete, and there are four minor second degrees; (2) major second degree; (3) minor third degree; (4) major third degree; (5) pure fourth degree. The harmony test of Luoyang chimes and Shaanxi Houchuan chimes is shown in Figure 8.



Contrasts of harmony



Direction of harmony (green for Shaanxi Houchuan chimes, purple for Luoyang chimes)
Figure 8. Harmony Comparison of Luoyang Chimes and Shaanxi Houchuan Chimes

As can be seen from Figure 8, there is not much difference between the harmony of Luoyang Silk and Shaanxi Houchuan Aya, and the amplitude and change trend of the two are basically the same, indicating that the Spring and Autumn Period are gorgeous and gorgeous, and the harmony of Aya's is also unified in weaving, basically realizing the unity of Chinese bells and harmony. The tuning technology of chimes unearthed from various tombs in the Luoyang area has also been greatly improved compared with the Shang Dynasty.

Analysis of Harmonic Value in Pre-Qin Bronzes

According to the analysis of this article, it can be seen that in the bronze silk of the pre-Qin period, a complete set of silk can achieve the effect of "turning the palace and transposing" each note, such as the Jiang unearthed from the tomb of Marquis Yi of Zeng, which has a wide vocal range. In Zeng's time, people arranged according to the arrangement of multiple voices in the vocal range grouping, which may not only be because of playing melody, but also because of the need to be able to play a variety of different intervals, in addition, the use of a complete set of chimes can produce a variety of timbres, timbre changes, pitch adjustments, etc., which can be adjusted by the small yongling at the bottom to make the harmony beautiful and harmonious，Table 5 shows the details.

Table 5. Comparison of Harmonic Values of Different Chimes

	bass(n=1)	treble(n=4)	Medium-low(n=2)	Medium-high(n=2)	Overall homophony	Different of homophony
Shaanxi Houchuan chimes	1.67±null	2.91±0.20	1.32±0.08	2.37±0.24	34.417	0.001**
Luoyang chimes	191.67±null	192.91±0.20	191.32±0.08	192.37±0.24	34.417	0.001**
other chimes	1.02±null	1.00±0.00	1.01±0.00	1.00±0.00	12.773	0.009**
* p<0.05 ** p<0.01						

The results in Table 5 show that there are differences in the local homophony of the chimes, but the overall homophonic effect is mainly due to the insufficient design of the bronze instruments themselves and the inability

of bronze materials to produce high-frequency sounds. The difference between Shaanxi and Luoyang bells is small, mainly because the process used in different bells is basically the same, so there is not much difference.

RESULTS

The vocal system of pre-Qin bronze musical instruments is complete Due to the closed conditions, the performance sound, pitch trajectory, change trend and other information of the pre-Qin bronzes were tested, and the results showed that the occurrence of the pre-Qin bronzes was complete, and there was a homophonic phenomenon between the syllables, indicating that the bronzes could complete large-scale ceremonial activities during the performance. There is no large musical difference between the instruments of the bronze instrument, which indicates that its performance system is complete, which can make up for the lack of inaccuracy of the sound of a single instrument. By more. times of sound exploration analysis. A detailed study and demonstration of the tomb bell of Zeng Houyi shows that the transition between each note will maintain a relatively harmonious transition, which confirms the integrity and completeness of the pre-Qin bronze generation system.

Pre-Qin bronze musical instruments contain a variety of metallic elements

From the short frequency of the wave, it can be seen that copper cymbals, yongdang, and button bells contain a small amount of copper sulfate and iron oxide. In addition, some domestic literature has studied the bronze musical instruments of the Warring States period unearthed from the tomb of Zeng Houyi, and used modern scientific and technological means such as laser holography and scanning electron microscope to conduct a detailed composition analysis of this group of bells, and finally concluded that three chimes contain copper, lead and tin, which is similar to the results of this study, which indicates that the pre-Qin bronze musical instruments contain a large number of elements such as tin, lead, etc. The fusion of elements such as tin, lead, and bronze affects the occurrence of the instrument, especially the proofreading of the pitch. Tin and lead oxidation problems in later use can lead to changes in the occurrence of bronze instruments.

The harmonic level of a pre-Qin bronze instrument

The chimes unearthed in the tomb of Zeng Hou Yi can achieve multi-part harmony, each bell can achieve "melody palace transposition" on any note, the bell in the middle will play the main theme of a piece of music, and then, the Yong bell at the bottom can achieve the harmony function, after the whole set of chimes is played, it can span 5 octaves, the vocal range is wide, the timbre is beautiful, and at the same time, through the harmony, a harmonious structure can be realized. The rhythm, timbre, interval, scale, melody, and harmony of the chimes in the tomb of Zeng Houyi are very complete, and they can be played close to the modern level, and can play music with a 7-degree scale. The vocal range spans 5 octaves, just 1 octave less than a modern piano; (2) The law is very accurate, the sound quality is very pure, the timbre is beautiful, and the timbre = C major; (3) There are two kinds of interval relations, namely, minor 3rd degree and major 3rd degree, which are the main drum sound and the side drum sound; (4) The middle voice occupies about 3 octaves, and as long as the chimes with the same sequence structure are used, 3 overlapping voices can be formed, which can play 5, 6, and 7 scales, and can play a complete 12 semitones; (5) The three sets of chimes in the middle can play the main theme of the whole song, and the bass bells arranged in the lower layer can be used as harmonies after being struck; (6) The structure of harmony is very harmonious and balanced, which can make the sound of harmony more attractive; (7) follow the 12-tone rhythm system; (8) The middle and lower chimes have the name of the score, the name of the sequence, and the name of the diacritic; (9) Inscription identification: there are many inscriptions, and there are few inscriptions on the upper layer; (11) Sound name marking: all, of which the upper layer only has the sound name

The vocal range of a pre-Qin bronze instrument

Among the 65 chimes of Zeng Hou Yi, there is no lack of "two-tone bells", all of which are percussion instruments, and the rhythm of the instruments can make the rhythm of the harmonic bells achieve the harmony pursued by modern music. The range of the whole set of bells can reach 5 octaves, with a total of 4 sound groups, i.e. high-middle-low times low. Each bell is engraved with a sound name, and the central tonal zone employs a twelve-rhythm system. In the same chime, the drum and tunnel are 3 degrees, 3 degrees and sound intervals can be played at the same time, and pre-Qin bronzes are able to play 3, 6, 4 or 5 degrees, showing the characteristics of harmonic elements. From the known sound measurement data, it can be seen that each bell can emit 2 fundamental tones. The inner lip has shown very visible filing marks and has 8 different grooved strips, 1 each for 2 mills, 3 on the front and 3 on the back. Among the 65 chimes, each chime has a corresponding inscription, such as a sound name, a dharma name, and a corresponding preface.

DISCUSSION

The smelting technology of pre-Qin bronze musical instruments was lacking

The metallurgical technology of pre-Qin bronze musical instruments was not perfect in purification, mainly based on metal copper and iron, containing a large number of impurities such as tin and lead, and it was impossible to obtain relatively pure bronzes. In addition, due to the limitations of smelting technology, there is also smelting in the production of bronze musical instruments. The problem of non-standard refining environment leads to the production of different musical instruments in the smelting process of bronzes, and the occurrence effect of musical instruments is poor. There are also great differences in the treatment process of reduction and oxidation of bronzes, which makes it more difficult to maintain and maintain bronzes in the later period.

The pre-Qin bronze instruments are rich in harmony and emotion

The bronze instruments in the tomb of Marquis Tsang clearly do not represent the highest level of musical harmony in the pre-Qin period, and we classify it as medium. The Yuji bronze woven bell unearthed from the cemetery of Zeng Hou Yi, 8 pieces have been tuned to achieve a better pitch effect, and its tuning part is at the inner lip of each bell mouth, there are file marks, after analysis and analysis, the file marks are shallow and shallow, some form grooves, and some file marks are very heavy, indicating that the Chinese in the pre-Qin period had a higher pursuit of tuning voice, pitch and acoustic effect. Among the 8 jade pole bronze bells, the third bell mouth is very standardized, which shows that the symmetry and balance of the tuning position are very standardized in the pursuit of the tuning position. At the same time, this also proves that in the pre-Qin period, the rhythm, pitch and timbre of the bronze bell were relatively good.

The harmonic standards of pre-Qin bronze musical instruments tended to be unified

Especially because some tuning traces in the mouth and tongue of some yongdang are very obvious, so it reflects the Chinese's pursuit of musical quality and the importance of musical rhythm, in addition, this also reflects the characteristics of music culture at that time, that is, the pursuit of harmony, the pursuit of multi-part harmony acoustic effects, following the twelve-tone rhythm. This shows that the Yongzhong in Luoyang area in the pre-Qin period has been able to grasp the pitch well through tuning, reflecting that there was already a very complete tuning system and tuning knowledge at that time. The tuning function was already used at that time, and people at that time had a high pursuit of pitch, timbre, and sound quality. The harmony of the pre-Qin chimes is very distinctive, and it is relatively rich, there is no problem with the vocal range, and at the same time, the tuning standards tend to be unified, and the overall timbre level is higher.

Pre-Qin bronze musical instruments are complete

The whole set of chimes unearthed from the tomb of Zeng Hou Yi is complete, large-scale, intervals and chord relationships between various voices, etc., can maintain different interval combinations in the ensemble process, such as stable interval combinations, tense interval combinations, etc., so it can well maintain the stability and harmony of harmonic relationships, At the same time, it can also create tense harmony, complete functions, comprehensive and diverse functions, and can cooperate with the transmission of emotions to achieve the beautiful performance effect of complete composition. It can be seen that the pre-Qin bronze musical instruments have harmonic value that meets the requirements of modern music development, and can provide certain research value for the study of ancient music culture and ancient harmony, which is of great significance.

CONCLUSION

Besides, with an increasingly rich social media environment, more types of social media should be taken into account.In the pre-Qin period, musicians had a very complete knowledge system of music performance, and had a very vivid and specific understanding of the interval, scale, pitch, rhythm, range, sound quality, sound measurement, tuning, harmony, harmony combination, arrangement, etc., forming a 12-law system, and there were special tools for determining the rhythm, at the same time, there was also an "eighth" in terms of musical instruments, which could be classified according to the material of the instrument. In addition, according to some historical materials, this study and the research of predecessors, it can be seen that the Chinese of this period has a strict distinction of sound names, and there is already a complete "palace-shang-jiao-zheng-feather" 5-tone scale. Among them, bronze musical instruments in the pre-Qin period have completely reflected the pitch and number of tones in the 12 average laws, although there are still some differences, but it can still be proved that bronze chimes such as the tomb of Zeng Marquis Yi and the bronze chimes unearthed in Luoyang have included the use of the 12 laws。 In addition, the pre-Qin period used the music suspension system. From the research of this article, it can be seen that the bronze chimes of the pre-Qin period have reflected the system of music suspension used by people at that time. The music suspension system was not only the core of the music system in the pre-Qin period, but also a special way to reflect the sound conditions of chimes and arrangements and the aristocratic status of users. Therefore, the study of pre-Qin bronzes is of great value for understanding the ancient Chinese bronze music culture, and provides case support for archaeological research.

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