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Research Article

Sounds in context: Archaeoacoustical studies of instruments from Comalcalco and Jonuta, pre-Hispanic Maya sites

Francisca Zalaquett[a], Miriam Judith Gallegos[b], Ricardo Armijo[b] and Dulce Espino[c]

[a]Centro de Estudios Mayas, Instituto de Investigaciones Filológicas, Universidad Nacional Autónoma de México, Ciudad Universitaria, Delegación Coyoacán, Mexico City 04510, Mexico; [b]Instituto Nacional de Antropología e Historia, Centro Tabasco, Plutarco Elías Calles 401 Colonia Jesús García, Villahermosa, Tabasco 86040, Mexico, and [c]Dulce Espino, Master's Student in Ciencias de la Complejidad, Universidad Autónoma de la Ciudad de México, Campus Valle S. Lorenzo 290, Delegación Benito Juárez, Mexico City 03100, Mexico

Abstract

Sounds produced by humans and their environment are perceived and codified based on people's experiences as members of social groups, resulting in some sounds being used as means of communication. In this article, we present an archaeoacoustic study of diverse types of instruments excavated or collected from Comalcalco and Jonuta, two important pre-Hispanic Maya sites located in the modern state of Tabasco (Mexico). We propose a methodology to analyze organological and acoustic characteristics for each type of instrument, considering their relevant archaeological information, so as to provide some interpretations of how sounds could have been materialized, shared, and used in specific moments of Maya ritual and daily life.

Resumen

Los sonidos producidos por los seres humanos y su medio son percibidos y codificados basados en sus experiencias como miembros de un grupo social, por lo tanto los sonidos también pasan a ser formas de comunicación. En este trabajo presentamos un estudio arqueoacústico de una diversidad de instrumentos excavados y recolectados en Comalcalco y Jonuta, dos importantes sitios prehispánicos mayas localizados en Tabasco, México. Proponemos una metodología para analizar sus características organológicas y acústicas, incluyendo la información del contexto arqueológico, lo que nos permitió plantear interpretaciones sobre cómo el sonido fue materializado, utilizado y compartido en momentos específicos de la vida ritual y diaria maya.

Keywords: achaeoacoustics; maya; pre-Hispanic musical instruments

In this article, we present an organological and archaeoacoustic study of sound instruments excavated or collected from Comalcalco and Jonuta, two important pre-Hispanic Maya sites located in the alluvial plains of Tabasco, Mexico, in the northwestern region of the Maya world (Figure 1).

Organological studies have formed an important part of comparative musicology. Many researchers dedicated to producing this knowledge reoriented their approaches after World War II toward an anthropology of music, and later toward ethnomusicology, which considered the study of the role of music in society and its interaction with the cultural, historical, and social context. This was proposed by McAllester (1954), followed by Merriam (1964), Blacking (1973), and Reynoso (2006). Merriam (1964:6) explains that music and sound are the result of human behavioral processes that are shaped by the values, attitudes, and beliefs of the people who understand a particular culture. Human behavior creates music in a continuous process, and the behavior itself is shaped to produce musical sound. Within this dialogical relationship, there are many ways that music and sounds affect and reflect a culture. For example, they are used as emotional expression; for aesthetic enjoyment; for entertainment; for communication; for symbolic representation of things, ideas, and behaviors; for trances; as well as to establish social norms and rules of conduct, which validates social institutions and religious rituals. Frequently, the members of a society carry out activities that require the coordination and cooperation of the group, which contributes to the integration of a society. Indeed, Blacking (1973:52) adds that music can evoke a state of consciousness that has been acquired through processes of social experience (Zalaquett 2021:16).

Specifically, in the materials made by the pre-Hispanic Maya, we can find some indications of this importance given to the senses that are aspects of perceptions dealing with music and sounds, especially hearing, seeing, and

Corresponding author: Francisca Zalaquett, franciscazalaquettr@gmail.com
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Figure 1. Map showing the location of the sites cited in the text. Drawing by Chrystian Reyes Castillo.

smelling. We count on writing as a medium for synesthetic communication (the release of one sensation through another—or, in technical language, a modality of cross-experience—in that the perception of sounds, for example, produces the sensation of colors). In this type of communication, most texts were read aloud, a point reinforced by the occasional appearance of references to the first or second person and other markings in Classic Maya texts (Houston and Taube 2000:263), which means that the Mayan writing was not a passive or inert document, but it could have been a mechanism to speak or sing via vocal readings or acts. When the inscriptions were observed in the plaza of Maya civic-ceremonial center, the spectators probably responded as cultural adepts in a synesthetic decoding, operating in visual and auditory modes (Zalaquett 2015:129). Among the pre-Hispanic Maya, it is not clear which deity was more directly related to sounds, given that in the codexes and in the images present on the vases there is a great variety of these divinities playing some instruments. Some proposals, such as Stone's (1995), compare God H with Xochipilli, the Nahua deity associated with music, dance, and the scent of flowers. On page 67 of the Madrid Codex, he strikes a drum and shakes a rattle, and on page 34c of the Dresden Codex, the glyph of his name appears in a text where Chaahk can be seen playing a drum on a mountain. Taube (1992:58–59) also relates the deity of the wind or God number 3 as God H in the Postclassic codexes, whose nominal glyph is T1059. The young God number 3 or God H are linked to the air that would be within the symbolic warp of the breath of life, whether from the earth or the gods, from the ethereal matter that transmits sound, or from the smell that emanates from a flower, which can be considered as divine breath (Nájera 2015:123; Zalaquett and Espino Ortiz 2018:3).

Regarding the background of research on pre-Hispanic Maya sound instruments, a great contribution to these studies was made by Felipe Flores and Lorenza Flores (1981), who specifically analyzed the organology of 355 Mayan whistles and included the study of their tone-internal volume. Arrivillaga (1985) completed his undergraduate thesis on the organology of pre-Columbian and contemporary Maya whistles, some approaches to their iconography, and a study on aerophone classification systems. Another study that addresses this issue is that of Velázquez Cabrera (2002). Rodens (2006) carried out an analysis of Maya drums in Guatemala, detailing a possible classification that abounds in a broad record of pre-Hispanic instruments identified in the country. Bourg (2005) studied the importance of pre-Hispanic Maya music and its dissemination in current materials such as multimedia (Zalaquett and Bautista 2017:107). Ishihara (2009) proposes a reconstruction of the Maya rites of the Late Classic period in

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Aguateca, based on the materials located in their excavation. Regarding iconographic studies, Houston, Stuart, and Taube (2006) made some observations and interpretations of music in their book *The Memory of Bones*. Ayala (2008) made various proposals for sound ensembles and types of instruments based on the images embodied in Maya vases. Looper (2009) proposes an analysis of the different types, and Regueiro (2014) makes a compilation and proposal for a typology of Maya sound instruments based on iconographic data and historical sources. At the same time, Duke (2014) presented his soundscape study on Maya palaces, and Regueiro (2017) studied dance in relation to politics in Yaxchilan.

Our work has been carried out since 2006 (Liendo and Zalaquett 2011). First, we have analyzed archaeoacoustics in public places in the Maya area and in some instruments obtained in excavations at the El Tigre archaeological site. Second, we have worked with the studies and analysis of sound instruments from Xcambo (Zalaquett et al. 2013) and from other Mesoamerican sites (Zalaquett 2021:18; Zalaquett and Bautista 2017; Zalaquett et al. 2014; Zalaquett and Espino Ortiz 2018).

This research considers the aspects of epigraphy, sound instruments and contexts, which in some cases can be worked with the archaeological record of these sound instruments—as we prefer to call them—because they offer greater access in terms of understanding and interpreting them as multifunctional objects made in a particular social group.

Research Area

Comalcalco and Jonuta are situated in the geographical union of important ceramic traditions, which includes different types of vessels and figurines made of fine ceramic paste (Gallegos and Armijo 2006:505–560; Jiménez et al. 2008), many of which represent individuals or animals. Interestingly, they also function as whistles, ocarinas, flutes, and rattles. Considering collections from various sites within this area, it is possible to distinguish three kinds of figurine and instrument production, with their own temporality, geographic localization, manufacture techniques, and iconography. The first kind derived from the Olmec tradition from the Preclassic (circa 1350 B.C.). The second type of production takes place during the Late to Terminal Classic (A.D. 600–1000), which corresponds with an overall increase and standardization of figurines and instruments in Maya sites. The third type takes place during the Postclassic period (A.D. 1000–1521), mainly in coastal sites, such as Juárez or Aguacatal. Most of them are zoomorphic pieces manufactured with ceramic of the Anaranjada Fina Matillas type, whose surface has a tar coat (Gallegos 2012, 2016).

In the archaeological sites of Comalcalco and Jonuta, almost all the ceramic instruments were elaborated with high-quality pastes, with a weight ranging from 10 g to 350 g and a height ranging from 2 cm to 25 cm (Gallegos 2018). We notice a variety of finishes that includes being polished or unpolished, the presence of slip, red or blue paint over some sections, and the addition of *chapopote* ("tar") (Gallegos 2012, 2009:1053). All these factors (including manufacturing techniques, iconography, and archaeological contexts) have an impact on the instruments' acoustics. Considering these aspects, we propose a methodology to analyze organological and acoustical characteristics of each type of instrument, including their relevant archaeological context information. This holistic analysis allows us to provide more reasonable interpretations of how sounds could have been materialized, shared, and used in various moments of Maya ritual and daily life at these sites.

The site of Comalcalco is in the northwestern part of the modern state of Tabasco, Mexico. During the last two decades, the National Institute of Anthropology and History (Instituto Nacional de Antropología e Historia [INAH]) has been excavating it and has obtained a huge amount of information and materials, as well as a wide variety of figurines (Armijo 2016; Gallegos 2012). Evidence suggests that potters in Comalcalco used molds for manufacturing some instruments in the nuclear area and in peripheral households, although there are no traces of kilns. Sanders (1963) and Baños (1999) did, however, register several kilns associated with figurines, some remains of clay, and ceramic tools in secondary sites such as Tierra Nueva, Palo Mulato, and Arroyo Hondo, all located east of Comalcalco (Gallegos 2018).

Most instruments were found in construction fill, architectural debris, and discarded areas found in some peripheral households and monumental structures at the center of the site; only a few of them were found in burials. It is important to point out that in the rescue excavations made between 2003 and 2006 in Comalcalco's surrounding sites, many offerings were found with figurines and various human remains (Gallegos 2009:1054). These figurines were manufactured mainly with type 1 and 3 clay, according to Bishop's paste analysis (Armijo et al. 2008). Type 1 clay matches the ceramic of the Cimatán Burdo group, and it has a domestic character (with a sandier texture), whereas type 3, which has more mica, is associated with the Comalcalco Negra fine paste ceramic group. These pastes originated from local sources—from muds of the Mezcalapa-Mazapa River basins, which are near the site. However, analyses show the presence of other types of pastes, whose chemical composition indicates that they originate from the region of Palenque and from the Usumacinta River. In Comalcalco, objects were produced and distributed using *cayucos* (little boats) traveling up the river to the Mexican Gulf, where merchants continued the circumpeninsular route, reaching as far as northern Yucatan (Armijo et al. 2008; Gallegos 2009:1053).

The site of Jonuta is located to the east of the modern state of Tabasco, in one of the last meanders of the Usumacinta River. The pre-Hispanic site lies below modern houses built during the nineteenth century, making it very difficult to properly explore it. Instruments that were analyzed come on the one hand, from an Instituto Nacional de Antropología e Historia (INAH) project (Proyecto Arqueológico Jonuta) and, on the other hand, from pieces gathered by the modern inhabitants of Jonuta and stored in the local museum. Materials manufactured in Jonuta

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were transported and exchanged throughout Palizada to Laguna de Términos. From there, they entered the commercial circuit that surrounded the Yucatan Peninsula (Gallegos 2007:28–30, 2009:1054, 2010:73, 2012; Gallegos and Armijo 2004). The instruments found were dated between A.D. 600 and 800, meaning that they were contemporaneous with the Comalcalco figurines.

Methodology

We analyzed the organological characteristics of whistles, ocarinas, rattles, and drums. In some cases (depending on whether we were able to play them), we will include the acoustic analysis as well as other relevant elements, such as details about their excavation context, chemical composition, and iconography.

Every sound emitted by any musical instrument is complex because it is composed of two or more simple sounds that are called "harmonics." The size, shape, and type of material of the object will determine the different frequencies and amplitudes of its harmonics. This is deeply related to the "tone color" (or timbre) of the instrument. An instrument sounds a certain way due to the volume of its harmonics, and what gives different timbres is the amplitude and location of the first harmonics. The first harmonic is called "fundamental," and it has a frequency that coincides with the tone's height, which is perceptible. The rest of the sounds are added to this without altering its apparent height, because the ear integrates all the harmonics into a single sound sensation. The intensity of each harmonic is represented in dBFS. We can see how it changes its height by covering and uncovering the holes in the figurines.

The acoustical analysis of the instruments was done in various steps. First, we measured organological details, then members of the team played them to get their fundamental frequencies, harmonics, and intensity, as well as spectrum shape (i.e., intensity and frequency). Wave shape (i.e., distribution over time) was then examined to determinate "tone color" (or timbre). Instruments were all played inside a soundproof mobile booth, which provides a controlled environment for recordings and insured comparability for analysis (Figure 2) (Zalaquett et al. 2018).

We obtained a recording for each whistle with different blows (soft, medium, strong, tremolos, etc.), ending with a free performance by the player. Recordings were then edited for their analysis. Instruments emit complex sounds that generate a harmonic series (a sequence of sounds whose frequencies are positive integer multiples of that of a base note, called "fundamental," and they are called "pure" when the multiples are exact and behave like the functions $sin(2\pi nx)$ and $cos(2\pi nx)$ with $n \in \mathbb{Z}$.), which are determined from integer multiples of the fundamental ($f_n \approx nf_n$; $n = 1, 2, 3...$). Consequently, the harmonics obtained from the spectrum conform linearly to the multiples obtained theoretically from the fundamental. As the graph is observed and as the frequency increases, they separate more from the theoretical harmonic series.

The acoustic function of a whistle is like a Helmholtz resonator (a chamber with a hole in its narrow neck (very similar to a bottle; see Figure 2), inside which the air behaves as a mass that emits resonant frequencies. However, these whistles have more complex acoustical characteristics because they have irregular resonance chambers or cavities (Zalaquett et al. 2018).

We implemented a time-frequency study (a set of techniques for the characterization and manipulation of signs where the frequencies are constants over time), applying a Fourier analysis (a study that represents functions and signals as a superposition of "basic" and "harmonic" waves), using the Fast Fourier Transform (FFT) algorithm (which allows one to calculate the Discrete Fourier Transform [DFT] and its inverse) in MATLAB (a software developed

Figure 2. Soundproof mobile booth. Photograph by Francisca Zalaquett. Helmholtz resonator. Drawing by Dulce Espino.

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for vectorials). Such analysis allowed characterizing the harmonic content of each recording, without using occidental tones terminology. Once we analyzed all the recordings, we obtained resonance frequencies, spectrums, and wave forms, which allowed us to establish a range of tessituras (Zalaquett and Espino Ortiz 2018:9; Zalaquett et al. 2018). Some organologic elements show significant differences in the ceramic traditions, such as the type of embouchure, its location, the size of resonance chambers, and the form of channel. All these features combined—along with types of ceramics, manufacture techniques, style, and iconography—allowed us to establish subtypes of instruments.

In the case of rattles, an analysis was conducted with different kinds of shaking (in a circular motion and along a straight line) and intensity (soft, medium, and strong), and with the different holes covered and uncovered. This kind of instrument displays an irregular acoustical behavior, which renders its analysis and study more complex. Therefore, it is of no use to try to determine the fundamental frequency. Instead, our study focused on evaluating the complete type of spectrum and how the sound behaves within this spectrum. With these instruments, it is crucial to consider pressure, speed, and the type of material. Furthermore, the sound will depend on each type of execution, and this makes measuring complicated because it changes constantly. When all the holes are covered, intensity and frequencies lower. In both cases, when the holes are covered and uncovered, the instrument exhibits tonal-dissonant and nonharmonic, but they do not generate entire successive multiples. We notice a continuous surround sound with constant contributions, but in other cases, the surround sound is continued but with intensity changes and a spectrum with fewer and separated lines. These changes depended on the type of performance technique applied.

Results

Whistles

Whistles are classified as aerophones (instruments in which the sound is produced by the air), which do not have any fingering hole. Depending on the performer, sound effects and modulations of tone pitch can be made.

We now turn to the analysis of two figurines, presented in Figures 3 and 6. Both are anthropomorphic whistles that carry an indirect diagonal flat embouchure in their right arm. The first figure is a representation of a male achondroplasty dwarf (Figure 3) that was manufactured with a mixed technique (molded and modeled). Following its silhouette, the manufacturer drilled an insufflation channel in the arm and managed to put it in an uncommon place, clearly showing the manufacturer's advanced skills. This also makes it harder to play. Palka (2002:436–439) proposes that throughout Maya history, the right side of the human body is related to the concept of "powerfulness" and "superiority." His interpretation is mainly because The in Classic Maya iconography, representations of rulers and other important ritual actors carry symbols that mark their social rank and hierarchy preferentially on the right side of their body. We suggest that the fact that the embouchure is on the right side of the figure is based on the same symbolism and signifies the political power of these characters. In addition, it is important to note that in Comalcalco, figurines of dwarves appear mainly with monumental architecture—places directly associated with rituals and Maya ruling elite. Occasionally, they also can be found in peripheral areas, in offerings that could be related to the Young Maize God and that could have served as intermediaries to obtain good harvests. The instrument presented in Figure 3 was found inside a funerary urn in the North Plaza of Comalcalco, considered the most significant space

Figure 3. Whistle C-82, P-N TIII-B, LN. Excavated in 1982 inside Urn 1 and located near the north facade of Temple III-B, this figurine formed part of a secondary burial of an elite male adult who only retained jadeite inlay mushroom-shaped dental pieces. In addition, there were other serpentine figurines, a crab clip fragment, and a fish vertebra, as well as thorns of tail stripe. The presence of a rare type of dental mutilation and the burial's location in the site's central plaza could indicate that this was a person of importance (Armijo et al. 2000; Armijo et al. 2015). This whistle is 4.71 cm tall, with Munsell color 7.5 YR 7/3. Photographs by Martín Martínez García. Funerary urn photograph by Reyna Cedillo, Instituto Nacional de Antropología e Historia.

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in the site. The dwarf is in a seated position, his hands over his belly, and he wears a loincloth, a necklace with a pendant, earmuffs, an oral prosthesis, and an eroded headdress.

The whistle was blown into several times, although due to its channel erosion, it was not always possible to obtain a sound every time. The following chart (Figure 4) shows the sound qualities and behavior of the figure, and it provides us with a basis for comparison for all the following instruments and to establish or discard possible sound patterns (Figure 5).

As presented in Figure 4, the harmonics are clearly defined by their intensity level. First, we can appreciate the tonal harmonics (harm. 1, 2, and 3), then the nonharmonics (harm. 4, 5, and 6). While the frequency increases, we notice a decrease in intensity with a tendency to becoming nonharmonic. This is the reason why: we do not detect a predominance of odd and even harmonics. The fundamental frequency is in the first harmonic, $f_1 = 2182.24[Hz]$, which generates several integer multiples of itself. In sum, the whistle has a low sound capacity and generates few harmonics.

The whistle in Figure 6 also originates from Comalcalco and Jonuta and represents an individual with a deformity, whose position and clothing seem to portray a man wearing earrings, a necklace, and a feathered shield headdress. This figurine was molded and has pastillage incrustations, but without any fine finish. The figure originates from an archaeological rescue conducted near Comalcalco. The clay used for the manufacture was from group 2 (according to Bishop), which is related to the Comalcalco Grey ceramic group, a common clay that characterizes the site's ceramics. However, because this piece does not fulfill all the diagnostic elements to clearly identify it as originating from Comalcalco, it can only be said to have been manufactured in the region (Armijo et al. 2008). Its manufacture technique differs from the instruments previously analyzed. This whistle can play either in its upright position or upside down. The following figure (Figure 7) shows the acoustic quality of the whistle interpreted with a soft blow, given that this type of embouchure is very narrow, so sounds can be obtained only with soft and medium blows.

As presented in Figure 7, the harmonics are clearly defined by their intensity level. First, we can appreciate the tonal harmonics (harm. 1, 2, 3, and 4), then nonharmonics (harm. 5–9). The intensities decrease, with a tendency to become nonharmonic while the frequency increases, and we do not observe a predominance of odd or pair harmonics. The fundamental frequency is in the first harmonic $f_1 = 947.47[Hz]$, which generates several integer multiples of itself. This whistle displays good sound clarity and definition because of its great sound capacity with soft blows, and it has greater number of harmonics, so it has a more complex timbre.

The following piece, presented in Figure 8, belongs to a different type of whistle. It was found in 2003 during an archaeological rescue in the Third Section East site, located at 4 km southwest of the Great Acropolis of Comalcalco, in its peripheral area. Surely, it must have been in the home of a significant family or a family member, because this figurine is unique in the entire site and its surroundings. This whistle was found inside an earthen mound containing a human burial that was destroyed by the passage of heavy machinery. It is a molded figurine representing some kind of fight between two individuals (Gallegos 2009:1054).

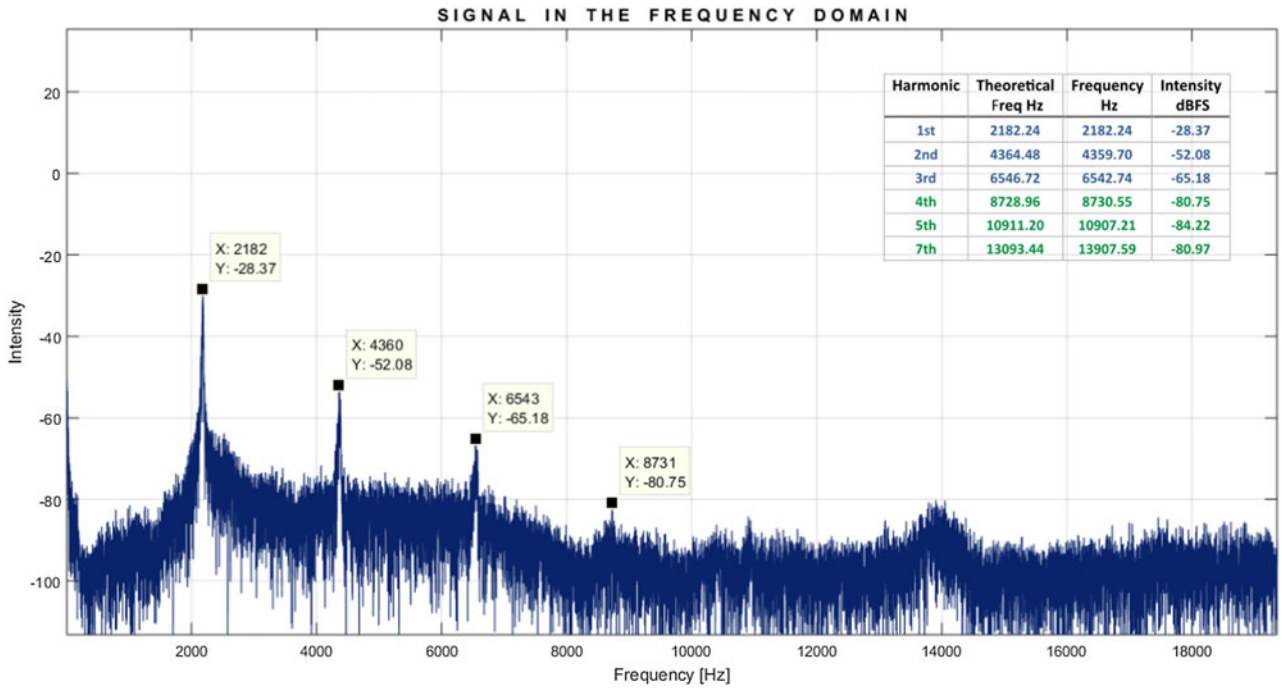

Figure 4. Whistle C-82, P-N TIII-B, LN, interpreted with a medium blow. This shows the frequencies and their location in the frequency spectrum, and full-scale intensity. The harmonics are in blue, and the nonharmonics are in green. Created by Dulce Espino.

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Figure 5. Orthophotography of Comalcalco with the location of the figurines. ARQUEOVANT 2017-Comalcalco-INAH Archaeological Project. Made by Ricardo Armijo and Miriam Judith Gallegos.

Note that similar figures were also found in Lubaantun (Belize) (Joyce 1933:33, Plate VIII) (Figure 8). This whistle has an indirect embouchure at the middle right of the back side, and its channel is half blocked, so we were unable to conduct an acoustical analysis. Because it is incomplete and presents an irregular hole in its front section, a possible

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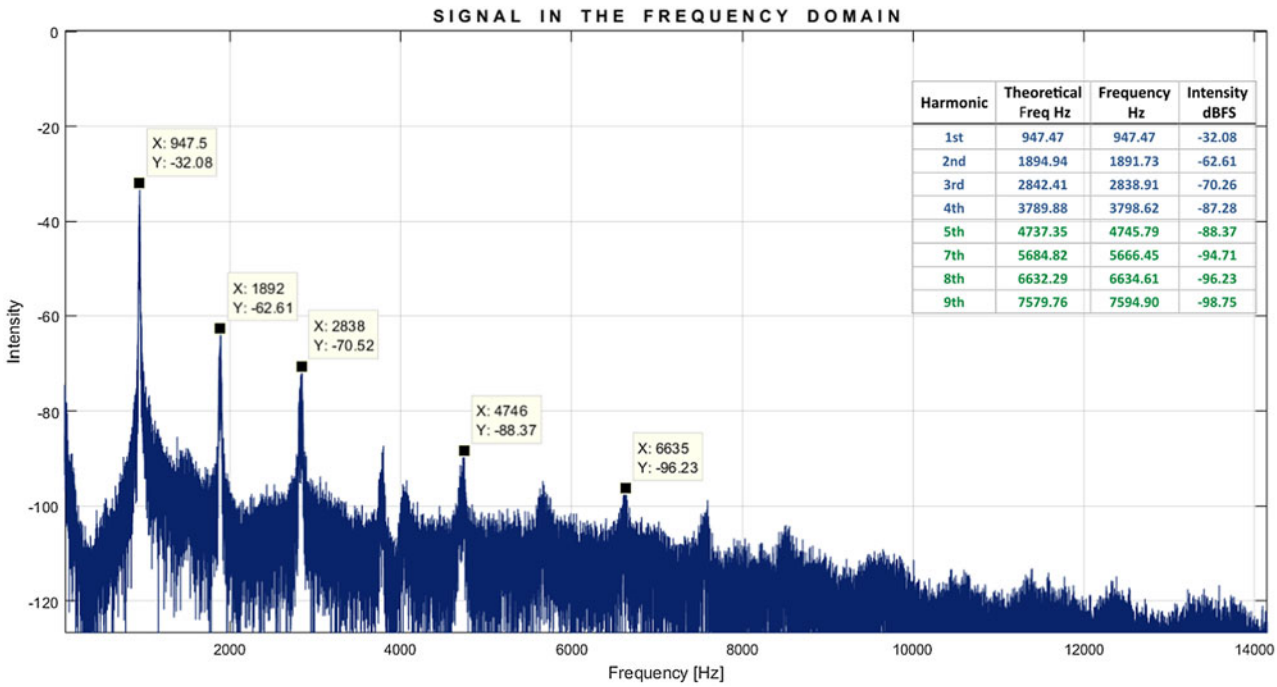
Figure 6. Dwarf figurine from archaeological rescue 8 in Comalcalco's periphery, number 2098. It is 6.75 cm tall, with Munsell color 10 YR 6/3. Photographs by Martín Martínez García.

interpretation is that it has been ritually "killed," following a common practice in Mesoamerican culture, so as to take away any performative power of these figures and liberate them from its intrinsic quality.

Whistles with indirect border embouchure located in the rear of the figurine. Instruments of this type encountered in the excavations display monkey and a funerary bundle iconography. It seems that these whistles were processed in two steps. First, the front section was done using a mold. Then, they modeled the rear and encompassed the resonance chamber ending with pastillage incrustations that formed the embouchure. In these cases, embouchures are quite short, measuring between 0.8 and 1 cm long and from 0.9 to 1 cm wide. Because of their manufacturing process, these pieces are fragile and are often found incomplete during excavation.

Two monkey figurines that were analyzed (Figure 9) come from a similar mold. Both show a monkey lifting its left arm to its mouth while its right arm and hand rest over its right leg. Its tail curls over its left shoulder. The presence of a tail suggests that it may be a representation of a black-handed spider monkey *(Ateles geoffroyi)*. Both monkeys carry earmuffs and a pendant composed of three elements (some kind of drops), and because of these human attributes, they can be classified as anthropomorphic presentations. The black-handed spider monkey is



Harmonic	Theoretical Freq Hz	Frequency Hz	Intensity dBFS
1st	947.47	947.47	-32.08
2nd	1894.94	1891.73	-62.61
3rd	2842.41	2838.91	-70.26
4th	3789.88	3798.62	-87.28
5th	4737.35	4745.79	-88.37
7th	5684.82	5666.45	-94.71
8th	6632.29	6634.61	-96.23
9th	7579.76	7594.90	-98.75

Figure 7. Whistle from archaeological rescue 8 2098, interpreted with a soft blow. This shows the frequencies and their location in the frequency spectrum, and full-scale intensity. The harmonics are in blue, and the nonharmonics are in green. Created by Dulce Espino.

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Figure 8. Figurine from Comalcalco-Cunduacan Square I Level 4. It is 12.31 cm tall, with Munsell color 5 YR 7/4. Photographs by Martín Martínez García; drawings taken from T. Joyce (1933: Plate VIII).

associated both in real life and in iconography as an important cacao disperser. It is considered by modern Maya groups to be a lively animal that often exhibits erratic behavior. In many Maya myths, it is either linked to music and dance (Nájera 2012) or associated with previous humanities. In the case of the figurines examined here, because of their human attributes, it is more likely that they were related to symbolic realm (Nájera 2012; Zalaquett et al. 2017:23). The first was found in a rescue site on the north side of a platform located west of the monumental area of Comalcalco. The second one was excavated in a household located 2,147 m from the central area of the same site. The latter figurine was found in a refuse dump with other materials—fragmented and complete figurines—some of them representing the so-called Lady Comalcalco figurines, because they wear an stereotypical attribute of local women (Gallegos 2003, 2012). The monkey figurines were found along with a great number of spindle whorls, which might indicate that the building could have been the house of a weaver. Monkeys seem to have been related, on the one hand, to women (because of the association with the "Lady Comalcalco" figurines and the spindle whorls) and, on the other to cacao, given that the Comalcalco region was an important producer of these seeds. This could also explain that high number of spider monkey images in the bricks of Comalcalco.

Figure 10 show the acoustic quality of the whistle interpreted with a strong blow. As presented in this figure, harmonics are clearly defined by their intensity level. First, we can appreciate the tonal harmonics (harm. 1–5), then the nonharmonic (harm. 5–11). Although the frequency increases, there is a decrease in intensity, and there is no predominance of odd or paired harmonics numbers. The fundamental frequency is in the first harmonic, $f_1 = 829.08$ [*Hz*], which generates several integer multiples of itself. This whistle has a great sound capacity with strong blows, and its sound quality and definition can be obtained with any of the three types of blows.

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Figure 9. This figurine was found on the north side of mound 231 of Comalcalco 502-PJ 10-576797. It is 7.6 cm tall, with Munsell color 5 YR 6/8. The second figurine, with reference number PAC-94 2954, was found under Chichicapa Household S4 E4, level 17. Number 171, excavated in 1994. It is 7.54 cm tall, with Munsell color 5 YR 6/8. Photographs by Martín Martínez García.

The figurine presented in Figure 11 is another example of a whistle with indirect border embouchure at the rear. This one depicts a mortuary bundle, and it was found associated with burial 24. It was recovered in a rescue excavation at the base of mound 231 in the sector west of the North Plaza. It comes from a series of boreholes and an uncontrolled excavation cove made for the installation of sewage drainage for the new service unit of the archaeological zone. It represents a shrouded individual, with his eyes closed and mouth opened. It was molded and modeled. When played, the face of the figurine is oriented downward, toward the ground. Because of this peculiar position, it might have been related symbolically to the earth, the underworld, or perhaps the ancestors.

Ocarinas

These instruments are globular flutes that can generate several tones and melodies. Male figurines with a war serpent headdress were found mainly in dumps from the Late Classic period (Halperin 2004, 2014) in Motul de San José, Altar de Sacrificios, or Quirigua. In Comalcalco however, these figurines were found in offerings (Gallegos 2009:1051).

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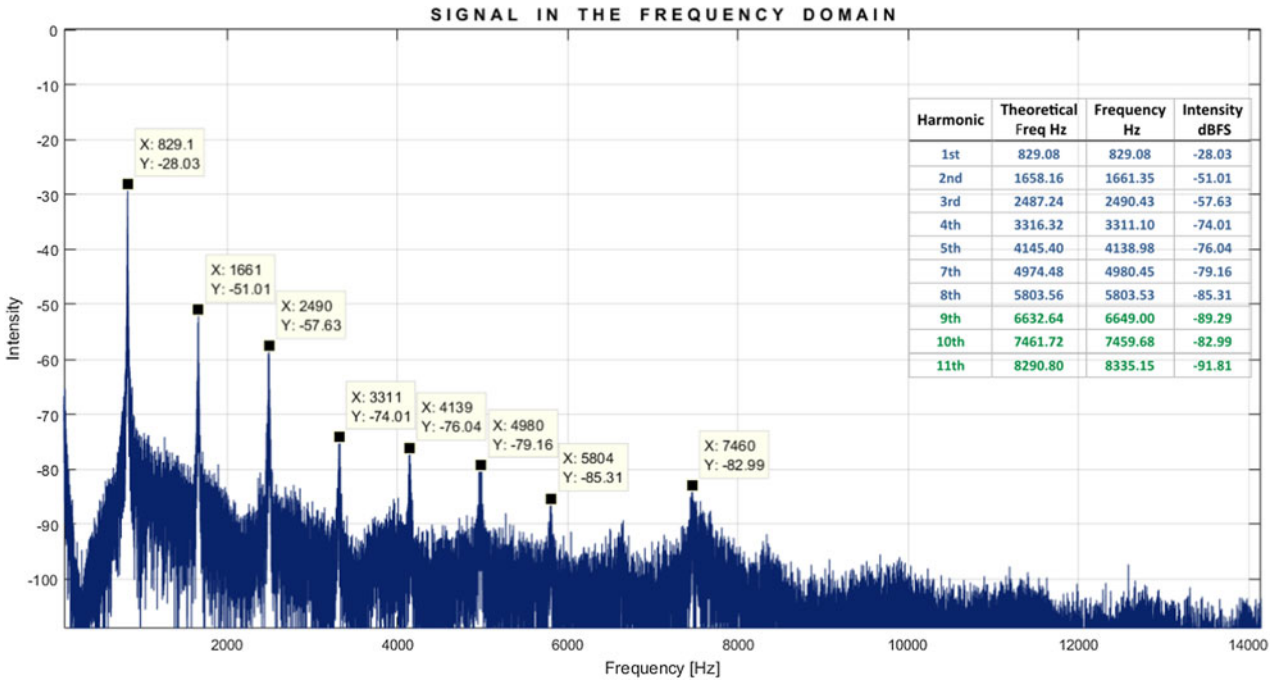

Figure 10. Whistle with reference number PAC-94 2954, interpreted with a strong blow. This shows the frequencies and their location in the frequency spectrum, and full-scale intensity. Created by Dulce Espino.

These two figurines (Figures 12 and 13) have loincloths, earmuffs, bracelets, and scarifications (Gallegos 2006, 2015:42). The war serpent headdress, with its big reptile eyes, is related to high-ranking people, such as the *k'inich* or *k'uhul ajaw* (Halperin 2014:47). These iconographical features are also linked to Teotihuacan, and they expressed the highest level of prestige. Most of the figurines represent a person kneeling with their arms over their knees, a common position of rulers, like the one represented in Structure 33 of Yaxchilan. These figurines exhibit features of the ruling class and its attributes o1-10n a small object (Halperin 2014:45). The characters represented in the figurines can be interpreted as participants in court life, often illustrated in paintings of political ceremonies (Halperin 2014:46).

This ocarina (Figure 12) was found in 2003 in a rescue excavation located on a road that connects Comalcalco to Cunduacan. In this case, the burial that contained it had been destroyed by heavy machinery that had passed over it. The ocarina has a headdress with earmuffs and double necklaces, and it could represent a ruler. The two figurines were manufactured in the same way: the front section was molded, and the rear sections were modeled. All three items have an indirect cylindric ellipsoid insufflation channel located at the rear that indicates a unique manufacturer or that the figurines were produced in the same workshop.

As presented in Figure 13, harmonics are clearly defined by their intensity level. First, we can appreciate the tonal harmonics (harm.1-10), then the nonharmonics (harm. 11–29). The fundamental frequency is in the first harmonic, $f_1 = 634.45[Hz]$, which generates several integer multiples of itself. This ocarina has its harmonic series well defined, which shows that it is a rich harmonic instrument. In Figure 13, there are 20 harmonics, but it generates almost 40, some of which do not belong to the series. It has a predominance in an odd number of harmonics because they are more intense. The ocarina was manufactured with molds and with the same type of clay. As a result, they all display similar acoustical qualities. It produces one fundamental, five harmonics and eight nonharmonics.

Contemporary with the molded figurines analyzed above, small-sized pieces with an orange talcum consistency clay (like the Matillas ceramics, for instance) were also modeled, sometimes with the surface protected with a tar coat. These ocarinas are generally made in the form of birds (Figure 14) or small animals (such as coati) (Gallegos 2009:1053). A coati figurine was recovered in excavations carried out by Francisco Cuevas in 1992 in Temple IIIA, a compacted earth construction located in the main square of the settlement. Given that the presence of 15 burials (some inside urns) with offerings was reported, it was a ritual building. The bird figurine (Figure 14) was found associated with other seated male figurines wearing the so-called Teotihuacan war serpent headdress.

In various Mesoamerican cultures, the coati is often depicted eating corn or pumpkins. In the alluvial plains of Tabasco, it was represented as of the Preclassic period at the site of La Venta (Drucker 1952:139), and it was also found in Tres Zapotes, Veracruz (Weiant 1943). In many Maya cultures, the coati relates to ceremonies that seek fertility and plant regeneration (Morales 2006; Thompson 1930). Although coati figurines are scarce, whistles and ocarinas with bird forms are by far the most common figurines in the Maya area. They were excavated in Altar de Sacrificios, Motul de San José, Chäkokot, Pook's Hill,

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Figure 11. This figurine was found at rescue 2008, Trench 3, Square 7, Layer 6, Level 12, Burial 24. It is 7.68 cm tall, with Munsell color 5 YR 6/6. Photographs by Martín Martínez García. Drawings by Guillermo Wilhelm de Alba.

Figure 12. Figurine from rescue Comalcalco-Cunduacan Squares 13 and 17, Cala 1, Levels 11 and 9.5. It is 9.72 cm tall, with Munsell color 5YR 6/8. Photographs by Martín Martínez García. Drawing by Guillermo Wilhelm de Alba.

Barton Ramie, El Tigre, Palenque, Jaina, and Comalcalco, among other sites. Many of these whistles emit sounds very similar to birds' songs, although not all of them. Among modern Maya groups, many of these sounds are regarded as messages from supernatural entities and are transmitted through meteorological phenomena, such as rains and winds (as several Maya informants from Yucatan explained). The sounds also relate to good or bad omens regarding people's lives, that can be protected or avoided though ritual practice and special offerings.

Horizontal biglobular ocarinas. Horizontal biglobular ocarinas are so named because their chambers are interconnected through a small channel or section. A direct mouthpiece with a labial bow allows the performer to produce a variety of sounds and effects depending on how the instrument is moved or handled. These instruments are rare, probably because they were not manufactured in the area. Their form is more common in the Peten region and in Copan, although the vast production comes from Valle de Sula, Honduras (Zalaquett et al. 2017).

The figurine presented in Figure 15 is shaped like a small bird with an open mouth and a small crest. This piece must come from the survey carried out in the vestibule of Temple I in the North Plaza, associated with a burial of multiple infants.

When the instrument is played, if the frontal left hole is covered, the intensity decreases. The sound quality clearly improves when the two holes of the left chamber are covered. However, when the right chamber hole is covered (where the embouchure is located), it generates fewer harmonics than when the other shutters are covered.

Reverberating Chamber Ocarinas and Whistles. Reverberating chamber whistles, like the horizontal biglobular ocarinas, are also made of two chambers. However, in this case, the first chamber functions as a feeder cavity, and the second as a recipient and backflow chamber. When blown, the air mass passes through the first hole to the second chamber, making air molecules crash and air vibrate, resulting in a velvety sound (Méndez and Pimentel 2010:87).

In the Maya area, these reverberating chamber whistles are scarce, and the ones encountered were excavated in

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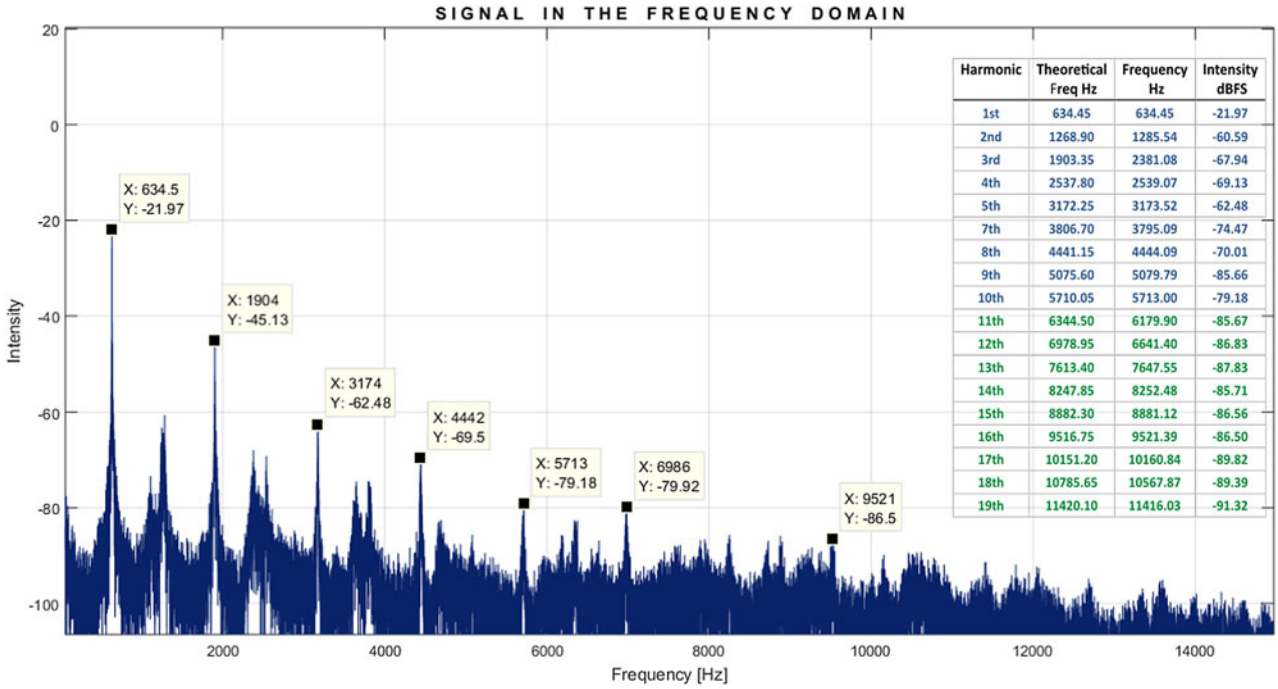

Figure 13. Figurine RCC-2003, interpreted with a soft blow and with the hole covered This shows the frequencies and their location in the frequency spectrum, and full-scale intensity. Created by Dulce Espino.

burials of high-ranking persons in Jaina, Motul de San José, Tonina, and Calakmul, among other sites. The Comalcalco collections have only two of them; unfortunately, both are incomplete. The first has a zoomorphic representation and was uncovered in the dump of Temple IV (Figure 16), associated with a cup, a bowl, and a stucco sculpture of the Chan Tok ruler. The other comes from a residential peripheric context at 2,147 m.

From the nuclear zone of the site. The presence of the same kind of instruments in two different places can indicate that such an instrument was related to both elite and domestic ritual practices.

In Figure 17, we present a summary of the sound capacities and qualities for each instrument.

These aerophones showed variabilities in their manufacture techniques and acoustic qualities. We were, however, able to regroup them in various categories that indicate some traits of the potters, mainly through distinct organologic and acoustic features. Obviously, the contexts in which they were found, and the inferred last use also validate these categories.

These instruments have a higher sound quality when played with soft and medium blows. This is because the harmonics are clearer and more stylized in the spectrums which generate greater clarity and definition in the sound. Some instruments do not have a stable continuous harmonic series (i.e., integer multiples), but some harmonics are lost, and sometimes nonharmonics are associated with some harmonics. It is also observed that the instruments that generated the greatest number of harmonics and nonharmonics have a greater intensity in their odd partials. As for the perception of sound, a database is being made that will be compared with the isophone curves, which we will include in a future publication.

Rattles. Rattles, according to Von Hornbostel and Sachs's (1961:14) definition, are instruments that produce sound from the material from which they are made. Among the many types of rattles, the shaking rattle is usually a hollow figurine filled with little clay balls, which generates sound while being hit against the inside cavity walls of the figurine and with each other. Rattles are made from cucurbits, wood, basketry, or pottery, and some are affixed to a handle glued with beeswax or copal gum.

Most of the rattles found in Comalcalco represent women, and they exhibit variable numbers of holes in the front, back, or lower section. These holes, according to Gallegos and Armijo (2004) could have been used to pass a string or a strip of skin through them, which could be held in the hands of dancers or be hung. We propose alternate explanation for these holes, however. One possibility is that the holes were used to modulate sounds when covered. Another explanation could be related to the process of fabrication. When figurines are made of very fine paste without permeable materials, such as sand, and without holes, the figurine might burst when fired.

A larger number of these rattles comes from households located at the southern sector of the Great Acropolis, mount 231, west of the Northern Plaza, and from the Chichicapa household unit, located 2,147 m southeast of the Great Acropolis. These figurines might have been associated with textile work, a theory supported by the fact that they were found in contexts with various winches and bone needles. They were also accompanied by zoomorphic and ruler's figurines, which could reinforce messages

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Figure 14. Coati figurine registered as Comalcalco 92, Cala 6, number 2137, which was excavated in 1992. It is 6.62 cm tall, with Munsell color 7.5 YR 7/4. Bird with crest from rescue Cunduacan, Square 7, Cala 1, Level 12, excavated in 2003. It is 4.67 cm tall, with Munsell color 5 YR 6/6. It has two holes in its neck that enable the figurine to be hung. Photographs by Martín Martínez García. Drawing by Guillermo Wilhelm de Alba.

Figure 15. Ocarina registered as C-81 1763, number 1763. Is 4.32 cm high, with Munsell color 5 YR 7/6. Photographs by Martín Martínez García.

about their owner's social hierarchy (Gallegos 2009, 2012; Gallegos and Armijo 2016). In other Maya sites, members of the elite, who sometimes lived at peripheral site units, would also engage in textile fabrication, and sometimes would exchange cloth among themselves. Therefore, one could assume that the Chichicapa household could have been directly related to the rulers of Comalcalco.

These instruments portray female characters, usually young and adults, although some represent very young girls and elderly women (Gallegos 2015:41). When representing young women, the hair is straightened and parted in the middle of the head. In contrast, adult women put their hair in a bun braided with strips of cloths and beads, usually at the back of the head. In some cases, the front of the hair is cut to frame the face, either as a simple bang, but more elaborated cuts "in steps" are also common (Gallegos 2015:42). Elderly women are represented with

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Figure 16. Zoomorphic whistle registered as PAC-94, number 1870, excavated in Temple IV in 1994. Photographs by Martín Martínez García. Whistle registered as PAC-94, 2971. Chichicapa household unit S4E4 Level 18, Number 1251, excavated in 1994. Photographs by Martín Martínez García.

Instrument	minimun [Hz]	tone	maximun [Hz]	tone	octaves approximate
Ocarinas C-81 1763	1058.06	Do 6 $^{18.58}$	1683.60	Sol #6 $^{31.56}$	0.7
Ocarinas PAC-94 2923	1887.25	La #6 $^{20.38}$	2392.81	Re 7 $^{31.13}$	0.3
Ocarinas RCC-03 Rse c13	709.29	Fa 5 $^{26.09}$	2351.28	Re 7 $^{1.40}$	1.7
Ocarinas RCC-2003	959.91	La #5 $^{49.75}$	1131.00	Do #6 $^{33.77}$	0.2
Ocarinas RCC-2003 cuadro 13 y 17	634.45	Re #5 $^{32.97}$	1980.21	Si 6 $^{3.98}$	1.6
Ocarinas C-82	2182.24	Do 7 $^{71.70}$	no aplica	no aplica	no aplica
Silbato Comacalco 78	546.06	Do 5 $^{73.31}$	605.82	Re 5 $^{52.95}$	0.1
Silbato J2-09,B7-3	812.36	Sol 5 $^{60.85}$	843.39	Sol #5 $^{25.88}$	0.5
Silbato PAC-94 2954	782.09	Fa#5 $^{95.68}$	829.08	Sol 5 $^{96.71}$	0.1
Silbato Rescate #8 Cmlco 2098	947.47	La #5 $^{27.31}$	1111.15	Do #6 $^{3.67}$	0.2
Silbato RCC-2003, cuadro1, nivel4	792.15	Sol 5 $^{17.50}$	855.80	Sol #5 ^{51}	0.1

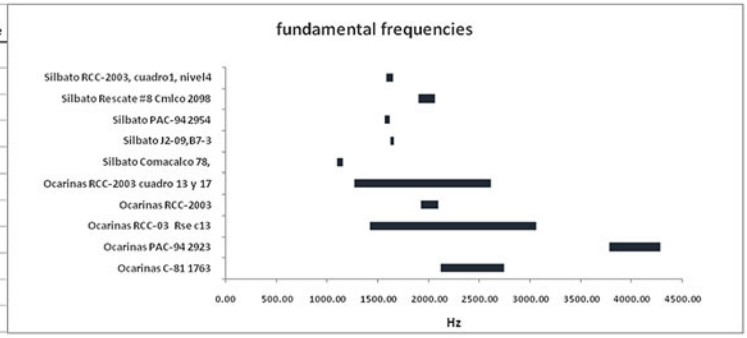

Figure 17. The range of tessitura in hertz and the occidental musical tones for each instrument, including the fundamental frequencies.

their hair in a bun, sometimes the hair parted in the center of the head but always without ornaments (Gallegos 2015:42). In addition, women could have their teeth modified, present scarifications, and use a variety of necklaces, earmuffs, bracelets, etc. Presumably, these figurines were used in domestic rituals, and their large number suggests a constant manufacture, either because they were broken or because they had to be replaced regularly. These figurines were found in construction infills and discard areas in Comalcalco, demonstrating their high consumption (Gallegos 2015:43).

Because of their generic faces, some researchers have suggested that these figurines represented idealized categories of women, young girls, adult women, and elderly females. Both Gallegos (2003, 2012, 2018) and Nakamura and Meskel (2009:227) suggested that some figurines portrayed the local feminine ideal of each site, as in the case of the so-called Lady Comalcalco figurine, and were not representations of individuals. Marcus suggests that although these figurines are generic by design, they do get individualized during ritual action. It might have been case that this individualization process was realized with the mention of the person's name during ritual speech or singing, and /or with the use of the person's ornaments (little pieces of clothing) (Marcus 2018:2). Such practice is common in many Maya groups, either using dolls made of black wax with the person's hair and nails (for the ritual of soul retrieving among the Mopan; Le Guen, personal communication 2019), or with candles associated with the deceased among the Yucatec Mayas (Le Guen 2003, 2009; Villa Rojas 1945).

These figurines are commonly found in sites along the Mexican Gulf Coast. They have the same body pose: both arms raised from the elbow, with the palms facing away from them. This pose led the researcher Goldstein (1979) to call them "praying priestesses." A similar gesture appears in scenes found in polychrome vessels, and it seems to indicate either salutations or dances—events during which this instrument could be used. It also is associated with the birth of different kinds of beings.

These "praying" women usually wear a short huipil or only an *enredo* (entanglement clothing)— which leaves the torso shirtless—with big earmuffs and a necklace (see Figure 18). They are represented with loose hair falling on their shoulders, but some have headdress. The figure on the left comes from a test pit atop the Great Acropolis, the area of residence and worship of the elite. Specifically, it comes from the excavation of the west façade of Temple V.

Another figurine of a "praying priestess" was excavated in an archaeological rescue context from the Tulipan site, located inside what used to be Comalcalco's control area during the Classic period. This figurine was found in the burial of a young female. She shows signs of tabular erect cranial deformation and suffered anemia and hearing

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Figure 18. Figurine registered as PAC-94 Comalcalco. Excavated from a test pit in 1994 in the Great Acropolis. It was found at a depth of 4.20 m in the building filling. It is 11.96 cm tall, with Munsell color 2.5 YR 7/4. Photograph by Martín Martínez García.

exostoses. This burial is part of a massive burial resulting from multiple sacrifices that included male adults, deposited southwest of the young female. The figurine was placed in front of the female's skull facing west. It was a foundational burial in a mound where nine skeletons of both sexes were excavated, of which two complete ones were recovered, as well as ceramics and lithics, clay spindle whorls, turtle shells, shells, and a sea snail. The study of the skeleton associated specifically with the figurine corresponded to a young woman around 17 years of age, with scars on her ribs and anemia. Her body was placed on a shell base and a textile whose imprint was engraved on its surface, in addition to some cotton filaments. During a police seizure in Campeche, another figurine of this type was found, but it was made from a different type of clay, which indicates that these objects could have been used by people from different areas in ritual practices (Gallegos 2016, 2018).

Among modern Yucatec Mayas, the sound of a rattle is said to help call rain (Giovani Balam, personal communication 2018). Modern Yokot'an Mayas of Tabasco still perform a traditional dance involving rattle shaking, with drums and a reed flute. Along with incense smoke and dancers' shouting, music plays a fundamental role in offerings. The main purpose of this ritual is to communicate with the saint who is said to appreciate the dance performed in his honor and who will listen to the prayers and petitions

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performed in the local language (Yokot'an), all accompanied with music and sounds (Gallegos and Armijo 2016).

Drums

Drums are instruments whose sound is produced by a membrane extended over an object (Arrivillaga 2006:25; Von Hornbostel and Sachs 1961:17). In the Maya area, drums were made from diverse material types, such as wood, cucurbits, and clay, but only drums made from clay are preserved in the archaeological context. The acoustical quality of drums depends on the thickness and tension applied to the membrane (which could be made with the skin of deer, jaguar, monkey, or iguana), as well as the type of percussion—direct (with hands) or indirect (with drumsticks)—and the place where the membrane is hit. The membrane was tensed using the heat of the sun, a stove, or even charcoals placed near the patch.

The drums presented in Figure 19 are hand drums with a cup shape that show some incisions on the outside. These were found in two household in Jonuta. The first was manufactured with a bright red surface finish and a granular clay that is different from the local clay. It was found in a construction infill, along with polychrome vessels very similar to those encountered in the Peten region. The second drum was found located under a platform floor, with some fragmented vessels. Iconography from polychrome vessels shows this type of drums and how they were used in dancing scenes. In two of them (Kerr 2023:K 3463 and K 1549), a woman raises her left hand away from her body while her right hand is extended with the palm facing forward (her fingers pointing down). She also has her left foot half raised, giving her a dynamic expression. In front of her, a man carries a rattle and is clearly dancing. Both are accompanied by two musicians, one striking the hand drum and the other scraping a *rasca* ("scraper"). These scenes have been interpreted by Looper (2009:56) as depicting a matrimonial alliance between sites. The drums found in Jonuta (Figure 19) were associated with vessels from the Peten region. Because they were deposited under a floor and in a construction infill of a household, they could have been part of an offering done in honor of an alliance realized between sites.

Figure 19. Hand drums: (a) excavated in Jonuta in 2009, J2, Operation B, Squares 3–4, Levels 3 and 5; (b) excavated in Jonuta in 2009, J3, Operation A, Square 1, Level 5. Photographs by Martín Martínez García.

Set of instruments found in a Jonuta offering

This last section examines a set of female whistle figurines found together in a Jonuta offering (Figure 20). The four figurines are of the "praying priestesses" type (Figure 21). All are dressed in an *enredo*, all wear big earmuffs, and all have the same hairstyle. One of them is carrying a necklace with a pendant, is wearing a cape, and is holding a man by the hair. This set was excavated from a platform that was partially destroyed by the Usumacinta River. Originally, they were all standing and looking east, directly at the river. Placed next to them were a pitcher and a miniature dish, both manufactured in fine ceramic. One of the vessels associated with the figurines of the offering tested positive for the presence of theobromine according to the studies carried out at the Autonomous University of Yucatan by Lilia Fernández. They formed a scene that recalled the fourth offering from La Venta (Drucker 1952) and the female offering from San José Mogote (Marcus 1998). In the Jonuta scene, all the female figurines were made from a standardized mold. This kind of offering could have been related to a household dedication, but their wide distribution also suggests that they were used in fertility rituals (Gallegos 2012, 2018). These figurines were made during the Late Classic period, and they belong to the second tradition of manufacturing in the region.

Discussion

Current theoretical perspectives from sociology and anthropology provide us with some new concepts for archaeology and consider objects as the result of dynamic interpretations linked to people's experience and specific roles inside their own society. This theoretical perspective allows us to account for the agency of the potter and the musicians who interpreted the instruments. Such operations of creation and their interpretations reveal specific understanding and knowledge of the society and are simultaneously reflected in the materials as well as in the symbols that accompany them. The possibility of recruiting such resources in ritual or political practices reflects the agent's power over these resources and allows him or her to communicate effectively to the society, which results in an act of power (Zalaquett 2012:409). In contrast with fixed objects, these objects are mobile and can therefore acquire a different symbolic relation to their ergonomics, symbolic relations and with the context (spatial or temporal) in which they are interpreted. The performance alludes then to specific memories, past experiences, expectations, and desires from the agents (Zalaquett 2012:410). All the above can be related to the manufacture and use of the sound of each instrument. In other words, the specific use and symbolic

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Figure 20. Georeferenced topographic map of the city of Jonuta and its urban layout. In the blue rectangles, the structures that are conserved—or of which there is information that they existed—are identified. To the south, with blue dotted circles, there are also six elevations on a west–east axis, which will be verified in the field as mounds of pre-Hispanic origin. Image © SIGET-INAH Jonuta Archaeological Project, April 2009.

charge could have been marked by the sound quality obtained by each instrument.

Molded figurines could point to a tendency toward mass production, which implies standardization and can allow less experience artisans. One possible motivation for producing identical figurines might be the performing of a similar and recurrent ritual. For instance, in Lagartero, Chiapas, Ekholm (1979) excavated a dump without stratigraphy, which contained thousands of broken vessels and figurines, apparently discarded after a short period of use. Based on the homogeneity of the vessels and the figurines, the author considers that those could have been the waste from a specific ritual. In fact, in sites located along the Mexican Gulf Coast, the same type of figurines has been identified in domestic and burial contexts, which can indicate that there was some common beliefs and ritual practices (Gallegos 2011, 2018; Gallegos and Armijo 2016).

Researchers have not yet come to an agreement about whether the molds were made by one potter, and whether they remained the potter's property (with right of use), or whether they could have been used by one or more members of the workshop. There also is no certainty about the extent to which those molds might have been exchanged. In fact, it must be considered a possibility that a mold

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Figure 21. Whistle registered as J1-B9-2-5; whistle J1-B9-1-5, whistle J1-B9-4-5, and whistle J1-B9-5-5 excavated in 2009. Photographs by Martín Martínez García. Drawing by Guillermo Wilhelm de Alba.

could have been used to manufacture various figurines, but with different ceramics (i.e., from different sites) (Marcus 2018:9). Some specialists have now started to document the phases in the figurines' manufacture process and (ritual) use. The process starts with identifying where the clay was obtained and how it was modeled, and where the newly made figurine was fired. It also implies to understand (1) how a person could have held a figurine while reciting words or singing, (2) how figurines were arranged into scenes, and (3) how there were buried or discarded (Faust and Halperin 2009; Lesure 2011; Marcus 2018:11).

Final considerations

Marcus (2018), along with others (Faust and Halperin 2009; Lesure 2011), propose that many rituals involved the transformation of inanimate objects into living beings through the performance of songs and dances. When figurines are found intact in final depositions, and sometimes in complex formed scenes, it might suggest that the object was still animated. In contrast, when figurines are found fractured or in a dump, this could indicate that their symbolic life was purposely terminated (Marcus 2018:14).

Performance and ritual practices include recurrent and dynamic interactions that involve objects (such as figurines), places, persons, traditions, memories—and most of the time, prayers, and either singing in or communicating with the supernatural world. For instance, figurines placed in a burial could have facilitated the interaction between the living and dead as the result of a ritual action.

In Comalcalco, the figurines' superficial erosion is evidence of their constant use, and the reason for being constantly substituted, discarded, and placed in dumps close to households, or in the infills of buildings in the Great Acropolis. However, others were used to accompany burials (Gallegos 2009:1056, 2018).

Zoomorphic figurines were encountered in the central residential monumental area of Comalcalco and its surroundings. The most common were birds, monkeys, owls, and different turtles.

Female representations were predominant in Comalcalco, and there were plenty in Jonuta. These figurines might have portrayed an ideal or a stereotypical image of local women. They also served as sound instruments that accompanied some ritual activities.

Male representations, on the other hand, generally correspond to rulers, ball players, warriors, or ritual specialists. Those pieces are usually found in temples and elite households in the Palace and the Great Acropolis of Comalcalco. There are, however, fewer in households, which seems to indicate their predominant use in restricted places or by designated individuals (Gallegos 2007, 2009, 2016).

The dwarf whistle is associated with palace contexts and rituals, and emits high frequencies, with a fundamental of 2182 Hz. In contrast, the monkey whistles that are related to cocoa and women and that were in housing units have a lower range of frequencies, with fundamentals of 829 Hz.

Within aerophones, ocarinas show a greater tessitura than whistles, in part due to the presence of holes that allow for a bigger variety in tones and harmonics. Smaller instruments can emit higher frequencies than bigger ones. The two ocarinas with the serpent headdress have a wider range of tones and harmonics and emit fundamental frequencies of 634 Hz. Interestingly, although the biglobular horizontal Ocarina C-81 was made with a much more complex manufacture technique, it emits lower frequencies and has a shorter tonal and harmonic range.

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It was crucial in our study to consider harmonics as they define the color tone of each instrument and its musical behavior. Furthermore, it allowed us to compare instruments with each other by applying statistical analysis that determined sounds groups. Additionally, this information was correlated with each instrument's archaeological context and the possible social actions related to them. We postulate that color tone could have been related to the surrounding (ecological) environment and that some sounds could have been created for certain religious and communication purposes. In some instances, the manufacture technique, sounds, and iconography are closely related, but at other times, it depends on their context of use and deposition whether sounds or the iconographic elements are going to stand out, which is clearly related to the decisions and agency of the people who used them.

Some of these instruments were used along with other instruments (forming an instrumental assemblage) in ritual and everyday actions (in plazas, households, processions, royal visits, hunting, harvests, etc.). Following Gell (1998), we propose that these instruments have the potential of being persons, whose essences can be shared with other beings. These essences are united through the ritual practices that involve objects and places. The manufacture of these instruments and their presence within ritual deposits, under the floors, or in burials, could have been a process that enabled the transmission of elements of human essence into objects, turning them into special objects that allowed people to interact with their ancestors and with other supernatural beings. Along the same line, sounds and music (defined by Blacking [1973] as sounds organized by humans) are strongly associated with memory and emotions, helping in the transmission of sensations and behaviors, and promoting social cohesion (Huron 2001).

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