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Teotihuacan Whistling Vessels

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Abstract

This paper presents the study of a sample of pre-Columbian whistling vessels from Teotihuacan, Mexico, in terms of their organology (morphology, construction and functionality), sonority, iconology and sound symbolism, contributing to the interpretation of their possible uses and cultural contexts during the Classic period of Mesoamerica in a time range of 100–650 CE. In addition, the instruments are compared with possible predecessors, contemporary variants, and adaptations from Oaxaca and the Maya area, revealing interrelations with other cultures. Apart from a thorough examination of the accessible sound artefacts, and the comparison with published specimens, the construction and subsequent test of a series of experimental reproductions are also taken into account.

Keywords

Ancient music – Classic period Mesoamerica – Teotihuacan – Whistling vessels – Pre-Columbian organology – Sonority – Music iconography – Musical knowledge – Cross-cultural exchange

1 Introduction

The present study forms part of a research project on the sonic environment of Teotihuacan, a UNESCO World Heritage site situated in the Central Mexican Highlands at an altitude of 2280 masl and representing one of the most powerful cultures in Mesoamerica during the Late Preclassic and the Classic periods between 150 BCE and 650/700 CE.[1] One part of the project consists in the archaeological and organological documentation of the many sound artefacts excavated at the site, currently stored in several museums and research laboratories worldwide. Another part of the project consists of the experimental reproduction of these instruments and sound tools in the form of replicas (exact copies), reconstructions (exact copies of fragmented finds with reconstructed parts, if possible produced within the size ranges of comparable finds documented for the project), and

[1] TVSM (Teotihuacan Virtual Sound Map), H2020-MSCA Individual Fellowship, University of Huddersfield, United Kingdom (2019–2022). For more information, consult https://cordis.europa.eu/project/id/846012 [accessed December 21, 2023] and the website of the project, www.teosoundmap.com [accessed December 21, 2023].

experimental models (versions of the acoustically relevant organological parts designed for functional tests). In the manufacture of a series of specimens per instrument type, carried out by the author and the instrument maker Osvaldo Padrón Pérez with original material and only a few tools (which, in the case of ceramic objects included low fire clays, water, wooden sticks of different shape, and a blade, burning in the campfire and larger objects in a brick stove), we aimed to understand the organology involved in the construction of each instrument, particularly in relation to the way sound is generated and which particular sonic characteristics are produced. Analysis of the Teotihuacan whistling vessels, within this experimental process, produced a large amount of specific data with regard to the use and function of these enigmatic sound devices.[2]

Whistling vessels are instruments exclusively developed and employed in the pre-Columbian Americas by the cultures of Mesoamerica, Central America and the Andean region. The aerophones, which are in organological terms indirect-blown flutes, consist of manifold variations on two basic forms: one composed of a single chambered vessel (a form documented in Mesoamerica only for the Middle and Late Preclassic periods in a time range of 1400/1200–700/500 BCE), the other composed of a double vessel with two interconnected chambers, usually by means of a tubular conduit (documented in Mesoamerica from 750–400 BCE onwards). The double-chambered instruments always present one chamber open and the other chamber closed, with the latter being equipped with the whistle. The vessels of South America frequently present a spout that allows for blowing them with the mouth, with or without the use of a liquid.[3] The instruments are therefore either air-driven or liquid/air-driven. In contrast, the double-chambered instruments of Mesoamerica always show a cup-shaped open chamber whose large rim diameter usually does not allow for making an airtight seal with the mouth. Therefore, it can be suggested that most of the vessels documented in Mesoamerica were exclusively operated by means of the flow of a liquid poured into the container. The instruments are therefore liquid/air-driven, and constructed in a way that, when the vessel is tilted in forward motion, the rising level of the liquid flowing into the closed chamber pushes air through the airduct of the whistle, thus activating its sonic function (Figure 1).

Because of the absence of chemical analysis, the components of the employed liquids have not been verified. It has been commonly suggested that the instruments were operated with water, but the use of other liquids such as beverages produced from agave (*aguamiel*, *pulque*), corn (*atole*) or cacao beans, for Mesoamerica, or corn mixed with other substances (*chicha*), for South America, could not be excluded. Obviously, employment of different liquids has implications on the cultural contexts, especially when used as a component of ritual or ceremonial activity, but variability of the particular flow velocities also has an impact on the sonority of the vessels, as discussed further below.

[2] Regarding the experimental models of the whistling vessels included in this study, it was hoped to exactly reproduce the organological features and size of the whistles and, in copying the internal morphology of the chambers, the number of milliliters of the operational liquid, but not always the exact outer form, in particular that of the figurative elements.

[3] For cross-cultural comparison, and particular discussion of the organology and acoustics of the instruments, see Crespo Toral 1966; Pérez de Arce 2006; Schmidt 2006, especially for the South American particularities.

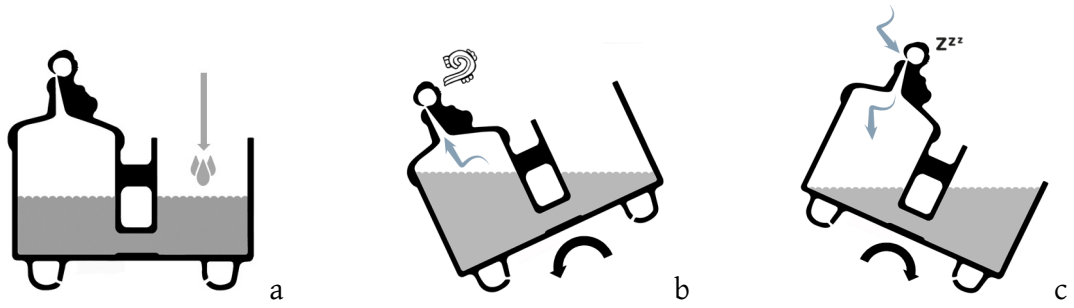

Figure 1: Cross-section of a Teotihuacan whistling vessel showing the principle hydraulic/eolic and sonic function of the instrument; a) liquid is poured into the vessel; b) infilling movement: the liquid flows into the closed chamber and air is pushed through the duct of the whistle, activating it; c) refilling movement: the liquid flows back into the open chamber and air is sucked into the closed chamber, producing respiratory sounds. Drawings made by the author.

Depending on the size and the morphology of the chambers, as well as the playing technique employed, liquid/air-driven whistling vessels generate a spectrum of very particular sounds. The activation of the instruments by tilting it forward and downward, which results in the flow of liquid towards the closed chamber (Figure 1b), generates a range of whistle tones of particularly high frequencies, varying between short strokes with triller effects and long and fragile tones, which fade out. Within the tonal range of the whistle, the sounds present microtonal variations, accompanied by the diverse noises produced by the flowing liquid. In addition, the instruments emit respiratory sounds, generated by the whistle when the vessel inhales air in the tilted retrograde motion, corresponding to the moment when the liquid flows back into the open chamber, thus creating a vacuum sucking air back into the closed chamber (Figure 1c). In general, the sound level of the instruments is low, having certain implications for the performance contexts.

As there is a constant succession and interaction of different sounds during the operation of the vessels, each instrument generates a sonic cycle with particular rhythmic accents, circumscribed by the particular flow of the liquid, which in turn is circumscribed by its consistency and amount, the form of the containers and the way they are interconnected. The moments of maximal (or minimal) quantity of liquid deposited in one of the chambers during the inflowing and reflowing motions create a sort of natural pulse. Depending on the morphological composition of the instruments and the consistency of the employed liquid, the individual cycles may be quite long, with pulses lasting between one or two seconds per motion. Also, the player can modify the pulse with the application of different movements. With stronger actuations it is possible to produce faster motions and shorter tones, with softer actuations slower motions and longer tones.

The technological level of design, construction, operation, and sonority of the whistling vessels shows that in the pre-Columbian world profound knowledge with regard to the function of aerophones was achieved, taking into account hydraulic effects in combination with the eolic effects of compression. Without doubt, these instruments represent some of the most complex products of pre-Columbian pottery design, reflecting the highest craftsmanship in the instrumental ceramic art.

Class	Subcategory	Size (length)
small	minor	< 12.5 cm
	major	12.5–15.0 cm
medium	minor	15.0–17.5 cm
	major	17.5–20.0 cm
large	minor	20.0–22.5 cm
	major	22.5–25.0 cm
	superior	> 25.0 cm

Table 1: Categorization of the whistling vessels according to size, taking the length as the reference point.

1.1 Measures applied for categorization and comparison

Whistling vessels are most comprehensively characterized and distinguished by a series of features, such as their provenance and chronological dating, ceramic type, form (including the organology of the whistle), size, weight, and iconology (figurative elements, relief and other forms of decoration). Taking into consideration these traits as a whole, it is possible to amplify and deepen the existing knowledge on the temporality, regionality, and cultural affiliation of the instruments, and the relation that they have among each other. Thus, find groups sharing certain elements, which are distinctive in comparison to other groups, can be established, and the diverse interrelations and developments can be better understood.

Earlier studies dedicated to whistling vessels had not taken into consideration the particular size of the finds. However, we observed that size appears to be an important factor not only with respect to the operation of the instruments, but as a general measure of comparison. We established three principal size classes for the whistling vessels by taking the length as reference point: *small* (vessels of a length of less than 15.0 cm), *medium* (vessels of a length within 15.0–20.0 cm), and *large* (vessels of a length greater than 20.0 cm). To create an even more precise categorization, we utilized two, and in one case three, further subcategories per class (Table 1).

Apart from the above-mentioned traits, we also took into account the quantity of the liquid in milliliters, required for the operation of the instruments. This particular measure appears to be more important than the total volumetric capacity of the chambers, as the latter does not bear any informative value for the operational function of the vessels. Effectively, for comparative means the quantity of the liquid would be as indicative as the size of the vessels. However, we decided to take the length as principal measure, as this data is by far more frequently published and also more easily obtained. Regarding the Teotihuacan specimens, only by making a series of reproductions could the range of milliliters be obtained. In order to establish the individual range per vessel, the lowest quantity of operational liquid corresponds to the amount required to fully fill the conduit (below this amount, air would escape the conduit and no compression would be generated). The maximum quantity of operational liquid corresponds to the amount of liquid making the whistle sound without entering its airduct.

Other factors contributing to the establishment of find groups is the organological and acoustical information of the whistles. For this categorization, the size of the resonator, the range of the generated frequencies, and especially the airduct-windway assemblage are to be taken into account. With regard to these features, particular organological traditions, aesthetics and musical knowledge indicative for a given culture become apparent. For example, certain frequency ranges indicative for the whistling vessels of different cultures can be established. For the Teotihuacan vessels, the resonators are very small and therefore the obtained frequencies are very high (approximately 2390–4370 Hz, equivalent to the tonal range between D_7+30 and $C\sharp_8$–26). In contrast, instruments with resonators considerably larger producing lower frequencies are reported for Mesoamerica for the Central Mexican Highlands during the Preclassic period,[4] one vessel from Oaxaca,[5] and the Epiclassic/Early Postclassic instruments from Xochicalco, Morelos.[6] In South America, lower-pitched whistling vessels with larger resonators are documented for the Peruvian cultures Vicús, Moche and Chimú, and the Ecuatorian Jamacoaque culture,[7] while the majority of other cultures in South America produced high-pitched instruments.[8]

1.2 The sample set of Teotihuacan whistling vessels

For the present study, twelve well preserved whistling vessels of Teotihuacan are documented in total. Two basic models have been concurrently employed: Teotihuacan-A (four finds: vessels no. 1–4, see Table 2) and Teotihuacan-B, the latter presenting two variants, B/Small (two finds) and B/Large (six finds: no. 7–12). Only four vessels have well documented archaeological contexts (Culpulalpan, Tlaxcala: no. 2; Teotihuacan, Zacuala Patios, 2:N2W2: no. 5; Teotihuacan, La Ventilla A, 5:S1W2: no. 7; Tecamachalco, Puebla: no. 8). Apart from the above mentioned finds from the actual states of Tlaxcala and Puebla, four further vessels are from sites of the Central Mexican Highlands, located within the domain of Teotihuacan (Huejotzingo, Puebla: no. 1; San Juan del Río, Querétaro: no. 3; San Martín Texmelucan, Puebla: no. 10; Tepeaca, Puebla: no. 11). Two further finds are without information of provenance (Reiss-Engelhorn-Museen, Mannheim: no. 4; Museo Nacional de Antropología, Mexico City, both possibly from Teotihuacan: no. 6). Finally, two exported Teotihuacan whistling vessels are from Oaxaca (Field Museum of Natural History, Chicago, possibly from Mitla: no. 9; Museo Frisell de Arte Zapoteca, Mitla, without information of provenance, possibly Valley of Oaxaca: no. 12).

Apart from these twelve sound artefacts, at Teotihuacan and other Classic period sites of the Central Mexican Highlands no finds identified as fragments of whistling vessels are reported. In addition, no depictions of whistling vessels in Teotihuacan mural or figurative art are documented, a condition of non-representation, which the site has in common with virtually all other cultures

[4] Martí 1970: 38–9, fig. 19.
[5] Sánchez Santiago 2020: 11, tab. 1.
[6] Both 2014: 62–4.
[7] I express my gratitude for this information to one of my reviewers.
[8] Garret and Stat 1977; Both 2011.

in which whistling vessels were produced. As the finds are dated to different phases of the Classic period, roughly from 100/150–650 CE, and also come from different sites situated in the Central Mexican Highlands and Oaxaca, their standardized form and homogeneous size points to a strong stylistic continuity and a blooming music tradition that Teotihuacan shared with a number of related sites during a period of various centuries.

Of the Teotihuacan whistling vessels in our sample, nine are manufactured from Thin Orange ceramics employed for a variety of luxury objects, whose trade was controlled by Teotihuacan and whose geological source has been located in the south of the modern state of Puebla (Rattray 1990). Two whistling vessels of our sample were made from a bluff sort of the Thin Orange ware, called *Anaranjado Burdo*, a ceramic type with a reddish color and more granular texture (Teotihuacan-A specimens from Culpulalpan, Tlaxcala: no. 2; San Juan del Río, Querétaro: no. 3). One vessel of the sample is made from a ceramic type called *Café fino* (Teotihuacan-B/Small specimen from Zacuala Patios: no. 5). The latter vessels are likely to be of indigenous Teotihuacan production, while the Thin-Orange-ware instruments may have been produced in southern Puebla for particularly Teotihuacan-related trade or exchange.

2 Whistling vessels of the model Teotihuacan-A

The first group, Teotihuacan-A, consists of a sample of four small whistling vessels, which hardly differ in terms of general measurements. The most variable elements of the vessels within this group are the ceramic types (Thin Orange and Anaranjado burdo wares, two finds each), different forms of decoration, and figurative details such as the seated position of the effigy situated on top of the closed chamber, simulating a monkey. The general measures of the vessels are in the range of 13.5–16.5 cm in length, 7.0–8.0 cm in width, and 12.5–15.0 cm in height. Taking into consideration the above-established sizes categories, the vessels can be grouped in the classes small major (three specimens: no. 1–3) and medium minor (one specimen: no. 4). The weight of the finds varies between 350 and 450 g and the operational quantity of the liquid, corresponding to the size of the vessels, between 50 and 125 (small major specimens) and 75 to 325 ml (medium minor specimen). According to the presence of the Thin Orange ware in Teotihuacan, the vessels date from approximately 100/150–650 CE, with greater frequency in the Xolalpan and Metepec phases between 350 and 600 CE.[9] The latter dates also correspond to the most abundant presence of the Teotihuacan tripod vessels, which may possibly have served as a model.[10] The instruments produced from Anaranjado burdo only correspond to a later phase. According to Rattray, this ware was most common during the Metepec phase, between 550 and 650 CE.[11]

[9] Rattray 1979: 57.
[10] Kidder et al. 1946: 192.
[11] Rattray 1979: 58.

no	Find context	Current storage	Ceramic ware	Dating (CE)	Type	Size class	Size (cm) L x W x H	Range (ml)	Frequency range (Hz)	Direct obser-vation	Experi-mental model
1	Huejotzingo, Puebla	Museo Nacional de Antropología, Mexico City	Thin Orange	350–600	A	small major	14.08 × 7.6 × 12.3	50–125	whistle damaged	yes	yes
2	Culpulalpan, Tlaxcala (Burial 1)	Etnografiska museet, Stockholm	Anaranjado Burdo	550–650	A	small major	14.7 × 7.0 × 12.0	50–125	whistle damaged	yes	yes
3	San Juan del Río, Querétaro	Francisco Cabrera collection (currently untraceable)	Anaranjado Burdo	550–650	A	small major	13.5 × 8.0 × ? (>15.0)	c. 50–125	unknown	no	no
4	Unknown (possibly Teotihuacan)	Reiss-Engelhorn-Museen, Mannheim	Thin Orange, stuccoed	440–700	A	medium minor	17.0 × 8.5 × 15.5	75–325	3080–3360	yes	yes
5	Teotihuacan, Zacuala Patios (2:N2W2), Burial 11	Ceramotéca, ZMAT, San Martín Teotihuacán	*Café fino*	350–650	B/Small	small minor	11.2 × 7.8 × 8.8	25–75	4000–4370	yes	yes
6	Unknown (possibly Teotihuacan)	Museo Nacional de Antropología, Mexico City	Thin Orange	100/150–650	B/Small	small minor	11.0 × 8.0 × 7.2	25–100	3750–4330	yes	yes
7	Teotihuacan, La Ventilla A (5:S1W2), Structure 1, Patio 2	Museo Nacional de Antropología, Mexico City	Thin Orange	300–550	B/Large	medium major	18.0 × 11.8 × 14.2	75–325	2390–2740	yes	yes
8	Tecamachalco, Lomas de Santa Cruz, Puebla	Unknown (possibly Tecamachalco)	Thin Orange	c. 300–550	B/Large	medium minor	16.5 × 10.0 × 14.5	c. 75–300	unknown	no	no
9	Unknown (possibly Mitla, Oaxaca)	Field Museum of Natural History, Chicago	Thin Orange	350–550	B/Large	medium minor	16.0 × 12.0 × 15.0	c. 75–300	c. 3750–4370	no	no
10	San Martín Texmelucan, Puebla	Musée du quai Branly, Paris	Thin Orange	c. 300–550	B/Large	large minor	20.8 × 13.8 × 16.0	100–550	unknown	no	yes
11	Tepeaca, Puebla	Museo Regional de Puebla	Thin Orange, stuccoed	c. 300–550	B/Large (?)	unknown	unknown	unknown	unknown	no	no
12	Unknown (possibly Valley of Oaxaca)	Museo Frisell de Arte Zapoteca, Mitla (currently untraceable)	Thin Orange (?)	c. 350–550	B/Large (?)	unknown	unknown	unknown	unknown	no	no

Table 2: The sample set of Teotihuacan whistling vessels.

The Teotihuacan-A whistling vessels consist of a double vessel with two cylindrical chambers. The chambers are of the same size and volume, and connected by a conduit at the bottom and a small handle located above. One of the chambers is open, while the other one is closed by means of an element simulating a conical lid with a vertical rim, called a 'false lid', as the element is firmly attached and cannot be removed. The form of the closed chamber is a clear reference to the Teotihuacan tripod vases with lid. In place of the handle of the lid of the tripod vases, the false lid supports the small effigy of a seated monkey. On the basis of its characteristic crest, the animal can be identified as the Central American spider monkey (*Ateles geoffroyi*). The visual orientation of the monkey is always towards the open chamber. The vessels have three supports, which are similar to the hemispherical or conical supports frequently employed for tripod vases. Notably, the double-chambered vessels of this group still represent tripod vases, as one of the chambers (in general the closed one) has two supports while the other chamber has one. The supports are hollow with a small perforation on the side, made for the escape of air during the process of firing, but unlike the tripod vase forms with rattle supports, these supports never contain a ceramic pebble to make a rattling sound.[12]

Despite their size, the spider monkey figures attached to the false lid are represented in great detail. In contrast to the pregnant female monkey figures shown in the Teotihuacan-B vessels (see below), the monkeys shown in the Teotihuacan-A specimens are not shown with a curved belly and thus could be identified as representing males. The small whistle is placed in the head of the monkey, with the windway situated in its occiput. The whistle is connected to the interior of the closed chamber by means of a conical or tubular airduct, of which only the small circular or slightly oval exit hole is visible. Only one specimen of the sample (Reiss-Engelhorn-Museen, Mannheim: no. 4) has the windway intact, which in this case is circular in shape.

Vessel no. 1

As mentioned above, three Teotihuacan-A whistling vessels are grouped according to their size in the 'small major' class. One of these instruments was reported to be from Huejotzingo, Puebla (Figure 2; Table 2, no. 1). It was mentioned for the first time by Noguera without providing details about the find context.[13] At present, the vessel is preserved in the Museo Nacional de Antropología, Mexico City. It is made from Thin Orange ware and measures 14.8 cm in length, 7.6 cm in width, and 12.3 cm in height. The closed chamber is ornamented with, as part of the decoration of the false lid, five incised undulating lines, and around the vertical rim, six circular applications with a horizontal incision in the form of coffee bean type eyes. The monkey is shown with its arms resting on its knees, while the legs are bent and the feet placed together. The tiny exit hole of the airduct has a diameter of only 0.15 cm. The head of the monkey with the incorporated whistle has been

[12] Both 2021b.
[13] Noguera 1937: fig. 23.

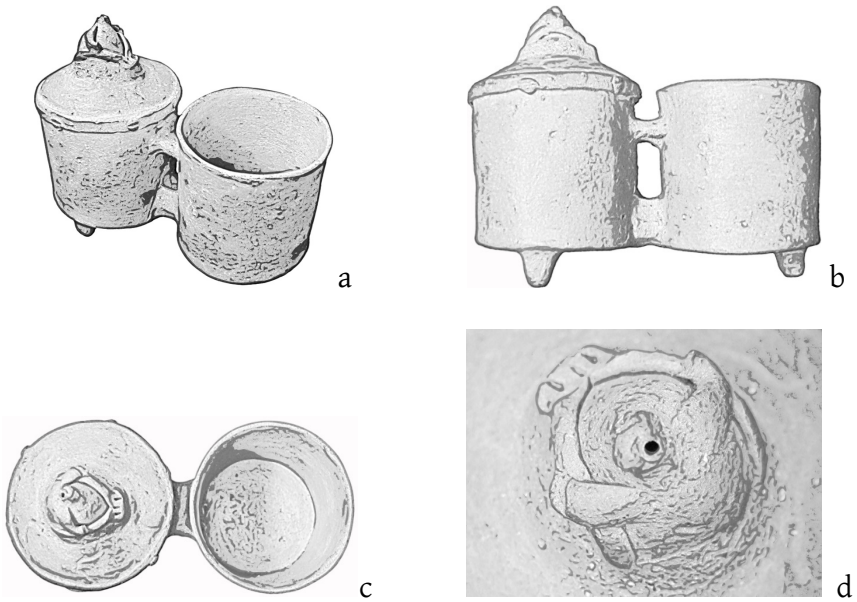

Figure 2: Teotihuacan-A whistling vessel from Huejotzingo, Puebla (L 14.8 cm, W 7.6 cm, H 12.3 cm; 350–650 CE); Museo Nacional de Antropología, Mexico City (Inv. 10–336582): a) three-quarter view; b) profile view; c) top view; d) detail of the monkey effigy showing the exit hole of the airduct. These and all following image-filtered whistling vessel drawings in this article are made by the author.

Figure 3: Reproduction of the Teotihuacan-A whistling vessel from Huejotzingo, Puebla, made by Osvaldo Padrón Pérez (2021), low fire clay. This and all following photos of whistling vessel reproductions in this article are made by the author.

knocked off. Possibly, this form of symbolic decapitation or ritual death of the vessel was related to the annulment of its sonorous function, indicating that the vessel originally formed part of a mortuary offering. For a reproduction of the find with replicated and reconstructed parts (Figure 3), the measurements of the preserved whistle of the Teotihuacan-A specimen from the Reiss-Engelhorn-Museen, Mannheim (see below, no. 4) have been applied.

Vessel no. 2

The second whistling vessel of the group is from Culpulalpan, Tlaxcala (Figure 4; Table 2, no. 2). The find measures 14.7 cm in length, 7.0 cm in width, and 12.0 cm in height and is currently stored in the magazine of the Etnografiska museet, Stockholm. It was excavated in 1935 by the Swedish

Figure 4: Teotihuacan-A whistling vessel from Culpulalpan, Tlaxcala, Burial 1 (L 14.7 cm, W 7.0 cm, H 12.0 cm; 550–650 CE); Etnografiska museet, Stockholm (Inv. 1935.09.0200): a) three-quarter view; b) profile view; c) top view.

archaeologist Sigvald Linné in one of the *teteles* or mounds of the site, and formed part of the mortuary offerings of Burial 1, which was associated with the topmost platform and temple structures of the building and therefore belonged to its last period of construction.[14] The vessel was located close to the back of the head of the deceased, who was buried in an extended position with the skull cap oriented towards the north and the sight towards the west (Figure 5). At approximately 150 cm in height, the buried person belonged to an adult age group, and the position of the burial indicates high status. Unfortunately, the condition of the osteological remains did not allow for sex determination. Further mortuary offerings consisted of a bowl decorated with *chalchihuites* (incised lines in the form of discs referring to something precious), a vessel without decoration, and a bead made from greenstone. All vessels were deposited in an inverted position towards the head of the deceased, possibly reflecting the thought that their physical and/or sonic contents were meant as a gift to the dead and an accompaniment of his travel into the underworld. The whistling vessel is made from *Anaranjado burdo* ware. As previously mentioned, this ware of Teotihuacan production was most common during the Metepec phase (550–650 CE), a time range which might well correspond to the latest construction stage of the excavated mound. Stylistically, the vessel could also be dated to an earlier phase, as suggested by Kidder et al.[15]

The decoration of this vessel presents engraved lines forming three flowers with five petals each, applied around each of the chambers. Notably, the flowers represent a variant of the Teotihuacan flower-symbol with four petals, supposedly related to the offering of sound or music and, according to a suggestion proposed by Manzanilla, representing the place glyph of Teotihuacan.[16] Additionally, the vessel shows a succession of *chalchihuites* engraved around the border of the false lid, and another incised line on its top side close to the vertical rim. The chambers also have a horizontally engraved line at the height of the conduit, possibly indicating the minimal quantity of liquid required for operation. Additionally, the vessel shows all over the surface, including the

[14] Linné 1942: 65–7, figs 115–17.

[15] Kidder et al. 1946: 192.

[16] Manzanilla 2009: 28, fig. 2.6a. A connection of the Teotihuacan flower-symbol with the notion of sound or music is made clear, among others, by the facade decoration of the Temple of the Plumed Conches (Both 2010: 186, fig. 8) and murals showing priests with stick-rattles from the Great Compound (Cabrera 1995: 19–20, fig. 2.1).

interior side of the open chamber, black spots of a so-far unidentified substance.[17] The monkey effigy has its arms resting on its knees, and legs crossed in the style of a lord. Its head is knocked off, a situation also observed in the vessel of Huejotzingo, Puebla (vessel no. 1), and possibly related to the ritual killing of the instrument as part of the funeral ceremony.

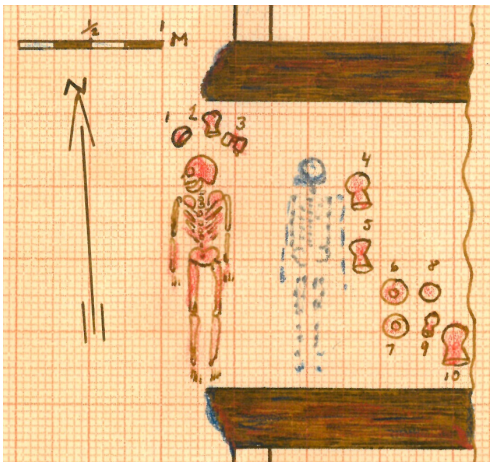

Figure 5: Sketch by Sigvald Linné showing the distribution of the osseous remains and mortuary offerings of Burial 1, Culpulalpan, Tlaxcala. The whistling vessel discussed is object number 3. Taken from the field notes of Sigvald Linné, Etnografiska museet, Stockholm.

Notably, the exit hole of the airduct of the vessel from Culpulalpan has exactly the same form and diameter as the find from Huejotzingo, which points to the close relation between these two instruments, despite their divergent decoration, differing type of ceramics and suggested place of manufacture (Teotihuacan for the vessel from Culpulalpan and southern Puebla for the vessel from Huejotzingo). As for the vessel of Huejotzingo, Puebla, the measurements of the preserved whistle of the Teotihuacan-A specimen from the Reiss-Engelhorn-Museen, Mannheim (see below, vessel no. 4), have been applied to create a reproduction of the find consisting of replicated and reconstructed parts (Figure 6).

Figure 6: Reproduction of the Teotihuacan-A whistling vessel from Huejotzingo, Puebla, made by Osvaldo Padrón Pérez (2021), low fire clay.

A unique feature among whistling vessels is the inclusion of three pebbles of porous volcanic stone (*tezontle*) in the closed chamber, deposited there before closing it with the false lid during the production of the instrument (Figure 7). In earlier publications these elements, which could be detected with a telescope camera, were never mentioned, although the pebbles clearly produce a sound when hitting against each other and the interior of the closed chamber, if the vessel is moved. In playing the above-mentioned reproduction with water it could be observed that the pebbles still produce sounds, although in this case the sound is perceived as less obvious.[18] Apart from the sound effects produced by the movement of the pebbles no effect on the flow velocity of the liquid or the acoustics of the whistle have been observed. It can be supposed that the inclusions were not deposited due to their sonorous effect but for another, rather symbolic motive. Possibly, they are related to

[17] Possibly, the spots represent drops of heated gum, which might indicate some ritual activity eventually carried out during the funeral, although it could not be excluded that the spots correspond to the remains of the operational liquid used for sounding the vessel.

[18] Therefore, the find could also be classified as a ceramic rattle, in organological terms, or even better as a whistling vessel-rattle, e.g. a hybrid aerophone-idiophone instrument, of which a number of conventional whistle-rattles are known at Teotihuacan as well.

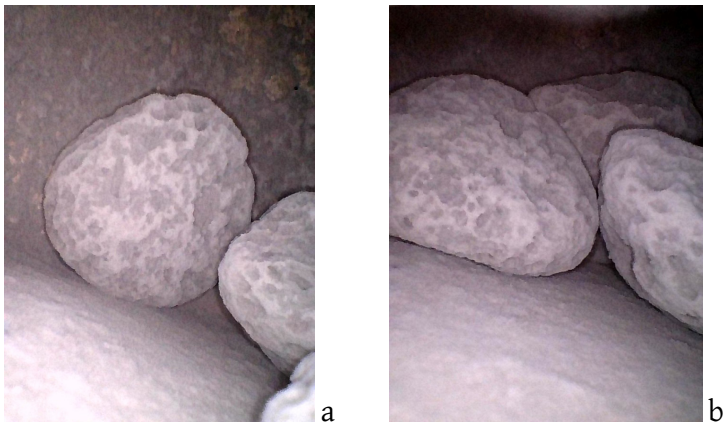

Figure 7: Photos taken by the author with a telescope camera, showing the stone pebbles deposited in the closed chamber of the whistling vessel from Culpulalpan, Tlaxcala.

the meaning of the Teotihuacan triple clusters consisting of three repeated elements reflected in multiple ways, such as in the architecture, the design of utilitarian objects, or the iconography.[19]

Vessel no. 3

Figure 8: Teotihuacan-A whistling vessel from San Juan del Río, Querétaro (L 13.5 cm, W 8.0 cm, H c. 15.0 cm; 550–650 CE); collection Francisco Cabrera, unknown repository: three-quarter view.

The third whistling vessel of the group is reported from San Juan del Río, Querétaro, and originally belonged to the collection of Francisco (José?) Cabrera (Figure 8; Table 2, no. 3). Its actual place of preservation is unfortunately unknown. The only existing and therefore quite valuable testimonials are a photo and the general measurements published by Martí.[20] According to the photo, the vessel is likely to be made of a granular ceramic, most possibly *Anaranjado burdo* like the aforementioned vessel from Culpulalpan, Tlaxcala (no. 2). The instrument measures 13.5 cm in length and 8.0 cm in width (Martí did not report its height, but roughly calculated it should not be greater than 15.0 cm). Each of the chambers has on the exterior wall a horizontal engraved line close to the bottom and a second line approximately located at the highest level of liquid for operating the instrument, framing engravings in the form of vertical or inclined bands composed of three semicircles each. These iconographic elements refer to clouds, sometimes applied in Thin Orange vessels and also found in the mural art. The monkey effigy seems to hold its hands in front of the mouth, as if it would whistle.

[19] Triple clusters are present, for example, in the array of three temples around a patio or in the erection of the three principal pyramids of the site (Pyramid of the Moon, Pyramid of the Sun, Temple of the Feathered Serpent), the number of supports of the tripod vessels, or the signs of three hills, three obsidian blades and three semicircles symbolizing clouds. It is also found in the form of three circles appearing in tassel headdresses, in the year sign, and in the sign of the marine shell/shell horn.

[20] Martí 1968: 117.

Figure 9: Teotihuacan-A whistling vessel, unknown provenance, possibly Teotihuacan (L 17.0 cm, W 8.5 cm, H 15.5 cm; 440–700 CE); Reiss-Engelhorn-Museen, Mannheim, collection Dieter and Evamaria Freudenberg (Inv. V Am 7231): a) profile view; b–c) details of the monkey effigy showing the circular exit hole of the airduct (b) and the circular windway (c) at the rear part of the figure.

Vessel no. 4

The only Teotihuacan-A whistling vessel belonging to the *medium minor* class is from the collection of Dieter and Evamaria Freudenberg currently preserved in the Reiss-Engelhorn-Museen, Mannheim (Figure 9; Table 2, no. 4). It is made from Thin Orange ware and measures 17.0 cm in length, 8.5 cm in width, and 15.5 cm in height. According to thermoluminescence dating, its period of production ranges between 440 and 700 CE, roughly during the phases of Late Xolalpan and Metepec.[21] The archaeological context of the find is unknown.

In contrast to the other whistling vessels of the Teotihuacan-A model, the instrument from the Freudenberg collection shows remains of a fine stucco layer covering the exterior surface, including the interior side of the open chamber. As in the instrument from San Juan del Río, Querétaro (vessel no. 3), the chambers have two horizontal engravings, one located at the bottom, the other one approximately at the highest level of liquid for operating the instrument. The three supports of the vessel present two falciform incisions each. The monkey attached to the false lid has its legs flexed, but not crossed. Unfortunately, the find was obtained in fragmented condition and restored in a way that prevents the whistle from sounding. It has an airduct with an oval exit hole of a diameter between 0.1 and 0.2 cm and a circular windway of a diameter of 0.2 cm. With an exterior diameter of 1.8 cm and a diameter of the resonator of approximately 1.4 cm, the whistle would sound

Figure 10: Reproduction of the Teotihuacan-A whistling vessel preserved in the Reiss-Engelhorn-Museen, Mannheim, made by Osvaldo Padrón Pérez (2020), whitish low fire clay.

[21] Freudenberg n.d. (unpublished catalogue of the collection). With the date of approximately 700 CE, Hickmann (2008: 176) only gave the latest date of the analyzed sample, information, which has been adapted subsequently, by that time unfortunately without knowledge of the Freudenberg catalogue (Both 2011: 74).

in a range of frequencies between 3080 to 3360 Hz, equivalent to a tonal range between G_7 (-31 cents) and $G\sharp_7$ (+19 cents), as tested on hand of a reproduction of the find with a functional whistle in the exact size of the original (Figure 10). The frequencies are higher than registered for the Teotihuacan-B/Large specimens and lower than registered for the Teotihuacan-B/Small ones.

3 Whistling vessels of the model Teotihuacan-B

The second group of Teotihuacan whistling vessels, identified as Teotihuacan-B, consists of a sample of eight specimens in total. The instruments of this group are composed of a double vessel whose chambers differ in terms of their form, size, and volume. The open chamber always presents the shape of a cup with slightly protruding walls. The closed chamber is always molded in the form of a female spider monkey effigy in seated position with the drawn-up legs only indicated. The monkey is shown to be in a more or less advanced stage of pregnancy, frequently in the position of caressing its belly. In contrast to the Teotihuacan-A model, the visual orientation of the effigy is in the opposite direction to the open chamber. As in the Teotihuacan-A vessels, the windway of the whistle is always situated at the occiput of the animal and at a higher position than the rim of the open vessel. Except for one specimen (Zacuala Patios: no. 5), the Teotihuacan-B instruments are all made from Thin Orange ware. As for the Teotihuacan-A models, the finds date approximately between 150/200 and 650 CE. In terms of size, two variants can be distinguished, denominated Teotihuacan-B/Small (two specimens: no. 5–6) and Teotihuacan-B/Large (six specimens, of which two are of unknown dimensions, but tentatively grouped here: no. 7–12). The B/Small vessels correspond to the *small minor* class (length less than 12.5 cm), and the B/Large vessels to the classes *medium minor* (15.0–17.5 cm in length, two specimens: no. 8–9), *medium major* (17.5–20.0 cm in length, one specimen: no. 7), and *large minor* (20.0–22.5 cm in length, one specimen: no. 10). Despite the homogeneous form of the vessels, apart from the divergent sizes some instruments differ in terms of figurative details of the monkey effigy and in the way the chambers are connected. A greater variability is also found in the organological composition of the whistles, especially in terms of the airduct-windway assemblages.

3.1 The whistling vessels of the variant Teotihuacan-B/Small

The instruments of this group correspond to the smallest whistling vessels documented for Mesoamerica. The measurements of the two documented finds are nearly identical, varying between 11.0 and 11.2 cm in length, 7.8–8.0 cm in width, and 7.2–8.8 cm in height. Due to their small size and the fine wall thickness the specimens are very light, ranging between 100 and 125 g. Compared to the greater volume of the open chamber, the closed chamber is always much smaller, which considerably reduces the maximum quantity of liquid that the vessel could contain for its operation. According to the experimental models, the quantity of operational liquid ranges between 25 and 75 ml (Zacuala Patios: no. 5) and 25 and 100 ml (MNA: no. 6), approximately.

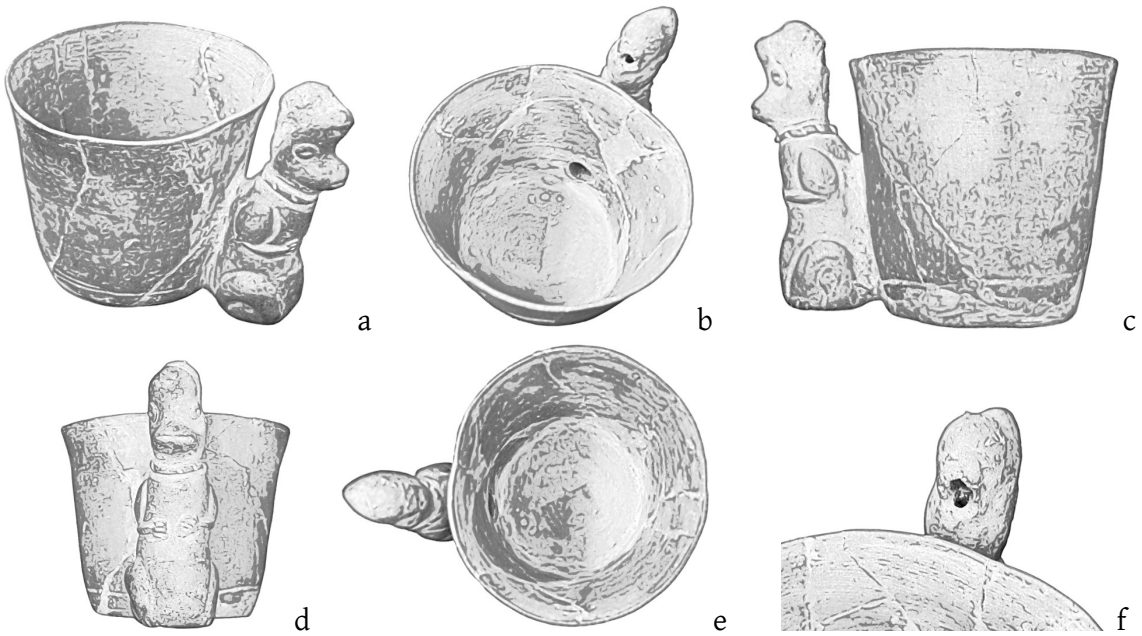

Figure 11: Teotihuacan-B/Small whistling vessel from Zacuala Patios (2: N2W2), Burial 11 (H 11.2 cm, W 7.8 cm, H 8.8 cm; 350–650 CE); Ceramotéca, ZMAT, San Martín Teotihuacán (Inv. 10–336626): a–b) three-quarter views; c) profile view; d) front view; e) top view; f) detail showing the airduct-aperture assemblage.

Vessel no. 5

One of the documented whistling vessels of this variant is currently preserved in the Ceramotéca, ZMAT, San Martín Teotihuacán (Figure 11; Table 2, no. 5). It formed part of the mortuary offerings of Burial 11 of Zacuala Patios (2: N2W2), excavated by Séjourné between 1955 and 1958.[22] The instrument measures 11.2 cm in length, 7.8 cm in width, and 8.8 cm in height, and its weight without liquid is 120 g. The ceramic style was earlier identified with Thin Orange ware, but according to our current analysis it is related to a ceramic type denominated by *Café fina*, particularly as its color does not have any orange or reddish components. According to Rattray, this ware represents a small group of special objects made from a local clay without the addition of any degrease, usually employed for the production of small cylindrical vases and cups of fine quality, especially during the phases of Late Xolalpan and Metepec, approximately dating from 500–650 CE.[23]

Burial 11 of Zacuala Patios belonged to an adult woman and was located below the wall of one of the rooms. In terms of its date, it was possibly related to the time of the construction of the compound during the Early Xolalpan phase, approximately between 350 and 500 CE, although the possibility that the burial dates to a later phase cannot be excluded.[24] The date is supported by the above-mentioned occurrence of the *Café fina* ware at Teotihuacan. According to the quantity and the type of the mortuary offerings, as categorized by Sempowski and Spence,[25] the woman

[22] Séjourné 1959: 57–8, lám. 31–2, fig. 38a; Séjourné 1966: fig. 153; Arndt 2015: 97–8, 102, fig. 2.37.
[23] Rattray 1979: 56.
[24] Sempowski and Spence 1994: 62.
[25] Sempowski and Spence 1994: 62.

belonged to a social group of high status. Apart from the whistling vessel, the burial contained a vessel with supports, 16 miniature vessels, an articulated figurine with movable arms and legs, osteological remains of a bird and a dog, a shell pendant (probably forming part of a row-rattle composed of shell tinkles before being offered), an obsidian blade, and the decayed remains of textile, a corncob and gourd (the latter probably forming part of one or two gourd rattles).[26]

The monkey effigy of the vessel shows the animal holding both hands over its chest. The belly is presented as slightly curved. In addition, the monkey wears an element in form of a cord around its neck, possibly showing a sling, although it could also simulate a necklace (see the whistling vessel from Tecamachalco, further below). In both cases the element indicates that a captured and domesticated animal is shown. With a diameter of 0.4 cm, the circular exit of the airduct is larger than the one of the whistling vessels belonging to the Teotihuacan-A model. In comparison, at 0.7 cm in width by 0.5 cm in length the oval windway is also quite large. On the other hand, the whistle itself is very small and therefore the generated frequency extremely high. The resonator presents an outer diameter of 1.4 cm and an inner diameter of approximately 1.0 cm. In operating an experimental model with accurate measurements of the whistle, frequencies from 4000 to 4370 Hz were produced, equivalent to the tonal range between B_7 (+21 cents) and $C\sharp_8$ (-26 cents).

Vessel no. 6

The second whistling vessel of the variant B/Small is currently exhibited in the Museo Nacional de Antropología, Mexico City (Figure 12; Table 2, no. 6). The instrument measures 11.0 cm in length, 8.0 cm in width, and 7.2 cm in height, and it weighs only 100 g. It is of Thin Orange ware, with a slightly reddish toned color, and the only decoration is an engraved line applied around the open chamber, more or less located at the maximum height of the liquid required for operating the vessel. The monkey effigy holds one of its hands over its belly and the other one above, slightly below the chest. The oval form of the exit hole of the aeroduct is identical to the form documented for the vessels' whistle from Zacuala Patios (no. 5). It measures 0.2 by 0.35 cm and is thus somewhat smaller. However, the windway is rectangular, presenting 0.5 in width by 0.3 cm in length, and thus differs considerably from the find from Zacuala Patios. Despite the difference, the measurements of the resonator of the whistle in terms of external and internal diameters are virtually identical to those of the vessel from Zacuala Patios, resulting in the production of comparable acoustical parameters. By blowing into a flexible tube inserted airtight into the entrance of the conduit, we managed to activate the whistle of the original find. It produces frequencies from 3750 to 4330 Hz, equivalent to the tonal range between $A\sharp_7$ (+10 cents) and $C\sharp_8$ (-41 cents). A reproduction was made with special emphasis on the correct measurements of the whistle, producing a comparable range in terms of the frequencies generated (Figure 13).

[26] A photo published by Séjourné (1959: 57, lám. 31) shows part of the mortuary offering.

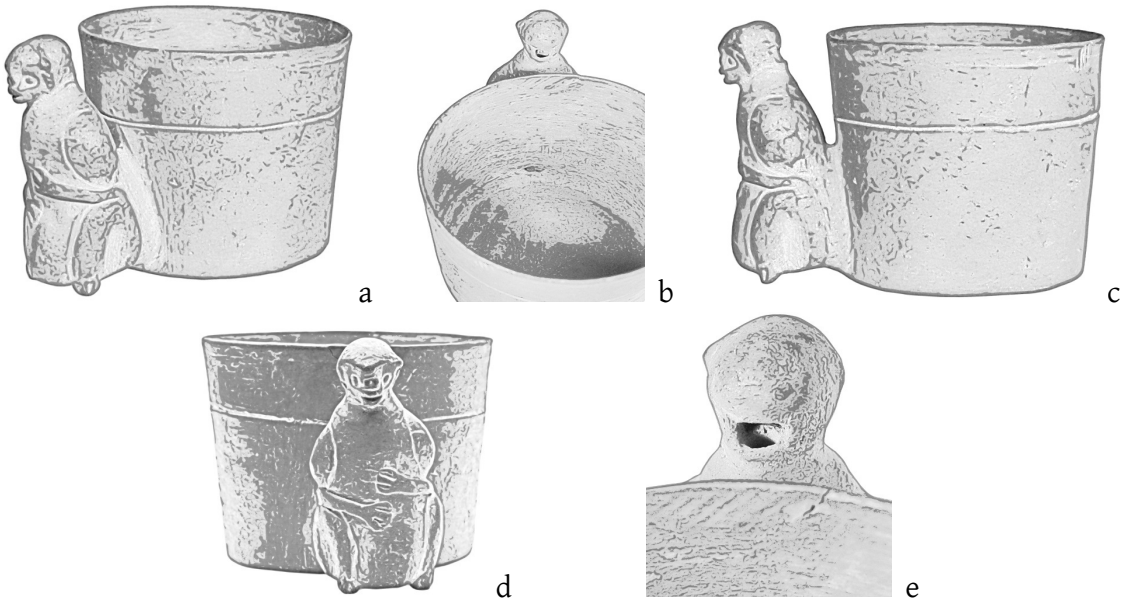

Figure 12: Teotihuacan-B/Small whistling vessel from Teotihuacan (L 11.0 cm, W 8.0 cm, H 7.2 cm; 350–650 CE); Museo Nacional de Antropología, Mexico City (Inv. 10–223557): a–b) three-quarter views; c) profile view; d) front view; e) detail showing the airduct-aperture assemblage.

Figure 13: Reproduction of the Teotihuacan-B/Small whistling vessel preserved in the MNA, Mexico City, made by Osvaldo Padrón Pérez (2021), low fire clay.

3.2 The whistling vessels of the variant Teotihuacan-B/Large

The instruments of this variant show a greater variability than the models previously described in terms of size and morphological details. Their size varies from 16.0 to 20.8 cm in length, 10.0 to 13.8 in width, and 14.2 to 16.0 cm in height. According to length, the majority belong to the classes medium minor and major (size range between 15.0 and 20.0 cm). Only one vessel of the sample (San Martín Texmelucan: no. 10) is a little bit larger, corresponding to the large minor class. The latter instrument also differs in terms of some construction elements. The weight of the instruments

ranges between 490 and 790 g. Compared to the volume of the open chambers, the closed chambers are still smaller, but much larger than in the Teotihuacan-B/Small variant. As a result, the vessels may contain a higher quantity of liquid, ranging between 75 and 325 ml (medium class specimens: no. 7–9) and 100 and 550 ml (large minor specimen: no. 10). The monkey effigies of the Teotihuacan-B/Large instruments show a belly by far more curved than in the Teotihuacan-B/Small models, indicating more strongly that these vessels show female monkeys in the state of pregnancy.

Vessel no. 7

One of the specimens of the variant Teotihuacan-B is currently exhibited in the Museo Nacional de Antropología, Mexico City (Figure 14; Table 2, no. 7). The instrument was made from Thin Orange ceramics. It measures 18.0 cm in length, 11.8 cm in width, and 14.2 cm in height, corresponding to the *medium major* class, and its weight is 490 g. It was excavated in 1963 by Piña Chan and Gonzales in Patio 2 of Structure 1, La Ventilla A (5: S1W2).[27] The burial has been dated to the phases Late Tlamimilolpa, 300–350 CE,[28] or Xolalpan, 350–550 CE.[29] Because of the poor osteological conditions, neither the sex nor the age of the deceased could be defined. Among the mortuary offerings were, apart from the whistling vessel, four bowls, a plate, a miniature florero, and the lid of a miniature vessel. On the surface of the instrument, including the interior of the open chamber, black spots are observed similar to those of the Teotihuacan-A specimen from Culpulalpan, Tlaxcala (no. 2). This possibly reflects a comparable funerary practice with an identical substance being offered, or identical remains of the operational liquid (see footnote 17). The whistle of this instrument has the exit hole of the airduct in the form of a slit (0.78 by 0.05 cm) and, such as in one of the Teotihuacan-B/Small vessels, a rectangular windway (0.65 cm in width by 0.3 cm in length). The resonator of the whistle has an exterior diameter of 1.8 cm and an interior diameter of 1.4 cm, approximately. The whistle is still intact, although a small perforation located in the wall of the whistle must be covered in order to measure its frequency range (as in the B/Small vessel described above, by blowing into a flexible tube inserted airtight into the conduit). According to our results, the whistle produces a frequency between 2390 and 2740 Hz, located in the tonal range between D_7 (+30 cents) and F_7 (-34 cents). Thus, the instrument sounds considerably lower than all other Teotihuacan specimens documented so far. Correspondingly, no other Teotihuacan whistling vessel documented presents a larger-sized resonator. Within the reproduction process a series of experimental test models from the find has been produced with the aim of better understanding the function of different organological parameters according to the whistling vessels' morphology, size and sound production (Figure 15).

[27] Martí 1970: 108–9, fig. 192; Arndt 2015: 98–9; 104, fig. 2.39.
[28] Sempowski and Spence 1994: 79.
[29] Teotihuacan 2009: 348.

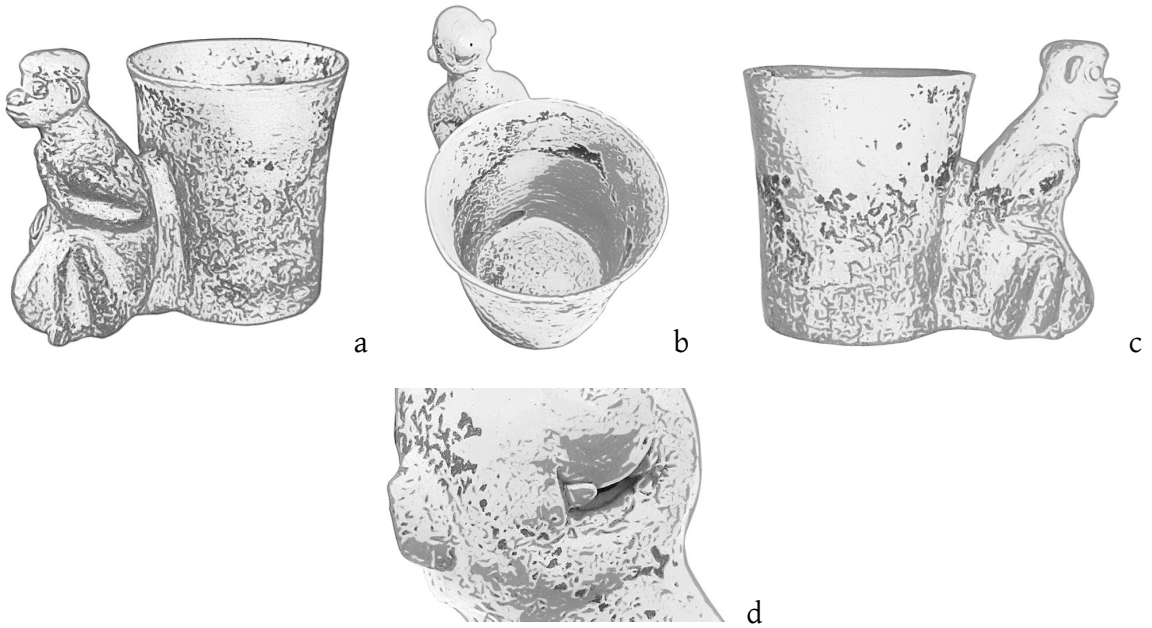

Figure 14: Teotihuacan-B/Large whistling vessel from La Ventilla A (5: S1W2), burial of Structure 1, Patio 2 (L 18 cm; W 11.8 cm, H 14.2 cm; 300–550 CE); Museo Nacional de Antropología, Mexico City (Inv. 10–0080673): a–b) three-quarter views; c) profile view; d) detail showing the airduct-aperture assemblage.

Figure 15: Reproductions of the Teotihuacan-B/Large whistling vessel from La Ventilla A: a) a production step of the experimental model without detailed figurative finishing made by Osvaldo Padrón Pérez (2020), low fire clay, sun-dried condition before burning (the whistle in front is a copy of the instrument built into the head of the monkey figure); b) version with accurately-sized containers made for experiments with different liquids made by Osvaldo Padrón Pérez (2021), low fire clay.

Vessel no. 8

Another instrument of the group was discovered accidentally in 1972 by the farmer Francisco Marin in the locality of Lomas de Santa Cruz of Tecamachalco, Puebla (Figure 16; Table 2, no. 8). The vessel is made from Thin Orange ware and measures 16.5 cm in length, 10.0 cm in width, and 14.5 cm in height, corresponding to the *medium minor* class. According to Hernández Reyes and Velázquez Cano,[30] who managed to review the find, the vessel might still be preserved under

[30] Hernández Reyes and Velázquez Cano 2017.

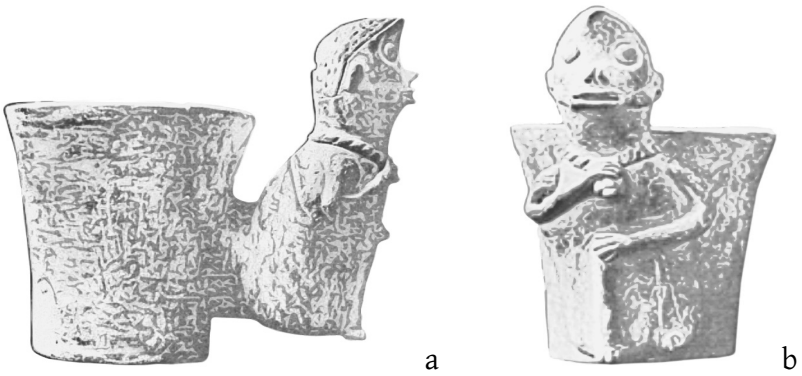

Figure 16: Teotihuacan-B/Large whistling vessel from Tecamachalco, locality Lomas de Santa Cruz, Puebla (L 16.5 cm, W 10.0 cm, H 14.5 cm); unknown repository: a) profile view; b) front view.

custody of the local authorities of the municipality of Tecamachalco. It formed part of a particularly rich burial, consisting of a cylindrical pit of 1.30 m in depth and a diameter of 0.9 m, excavated in the limestone bedrock. The pit was provided with a circular annex and covered by means of partially worked stones. The burial contained the osteological remains of three deceased people, one deposited in the annex and the other two in the pit, the latter in a seated position. Among the objects of the mortuary offering were, apart from the whistling vessel, 11 ceramic vessels of Thin Orange ware, such as a tripod vase with lid and a zoomorphic vessel in the form of a dog or coyote, 27 vessels of a ceramic type identified as *Café claro*, and 30 vessels of a type identified as *Café oscuro pulido*. Among other objects were two fragments of worked shell (possibly previously forming part of a shell rattle), four prismatic obsidian blades, three necklace beads, and a needle made from greenstone. Furthermore, the burial contained three superimposed sections of volcanic stone presenting remains of stucco, having the total height of 0.62 m (a cylindrical part, a conical part with steps, and a ball-shaped part decorated with four-petaled flowers in relief). Apparently, these sections formed part of a stela comparable to the ballgame marker discovered at La Ventilla, although the disk-shaped top section was missing from the mortuary offerings of the burial and the stela appears to be of smaller size and less ornate in terms of its relief decoration. Notably, the burial of Tecamachalco shows other relations with findings from La Ventilla. For example, burial pits excavated in the bedrock comparable in terms of their particular form and the seated position of their occupants were located by Vidarte in La Ventilla B (especially the Burials 3, 4, 10 and 16).[31] With respect to the offered objects, the zoomorphic vessel of a dog or coyote is similar to a vessel unearthed in Burial 86 of La Ventilla B,[32] while the whistling vessel is comparable to the previously described instrument from La Ventilla A (no. 7). The finds suggest close relations between the inhabitants of La Ventilla and the site of Tecamachalco, Puebla.

According to the available evidence, the open chamber does not present any decoration. Its form and the way it is attached to the open chamber show particularities not present in other vessels of the Teotihuacan-B model. Notably, the animal hardly shows a curved belly. Around its

[31] Vidarte de Linares 1964.
[32] Rattray 1997: 149.

neck it wears an element similar to the vessel from Zacuala Patios (no. 5), in this case undoubtedly simulating a necklace with a pendant composed of three sections, possibly to be identified with the Teotihuacan sign of the heart. In the context of the vessel, the pendant might be taken as a sign for any offering related to the context of the instrument as a sound-producing container for a sacred liquid. Particularly unusual is the way the chambers are attached. The base of the closed chamber is much higher than the base of the open chamber, making the latter the only proper stand of the instrument. The unique composition of the vessel also has an effect on the playing possibilities and its sonority, as the entrance of the conduit in the open chamber is placed much higher than usual. In operating an experimental model, we observed that the configuration does not allow for the full amount of liquid to flow into the closed chamber in a forward-tilting motion, with the result that some liquid always remains in the open chamber. Unfortunately, no information about the organological configuration of the whistle is present, apart from assuming its usual position at the occiput of the monkey. So far, no reproduction of the find has been made.

Vessel no. 9

The third whistling vessel of the group is currently preserved in the Field Museum of Natural History, Chicago (Figure 17; Table 2, no. 9). The instrument was first mentioned by Kidder and colleagues.[33] It is made from Thin Orange ware and measures 16.0 cm in length, 12.0 cm in width, and 15.0 cm in height, corresponding to the *medium minor* class. Probably, the find is from Mitla, Valley of Oaxaca, but there were always doubts about the exact provenance, except that it is likely to be from Oaxaca. If this is the case, it represents an object designed for long-distance export and interchange, which Teotihuacan maintained with several sites in the Valley of Oaxaca and beyond, from approximately 350 CE onwards for at least two centuries.[34] The design of the open chamber of the vessel is composed of engraved horizontal double lines, framing a band of undulating double lines with another undulating line of dot perforations in between, placed in the upper section of the outer wall. In the context of the whistling vessel, the iconography might refer to the operational liquid employed for the activities in which the instrument played a role. According to Rattray,[35] designs composed of these elements are characteristic to Thin Orange ceramics especially produced for export. The effigy of the closed chamber shows the crest of the spider monkey in a larger and therefore more emphasized form than in the previously described vessels. The face of the animal is slightly elevated and the mouth open, clearly showing it in a posture of vocal articulation. Below the eyes the effigy presents engravings simulating tears. This element could indicate that the vessel formed part of a funerary offering, such as the whistling vessels with archaeological

[33] Kidder et al. 1946: 192, fig. 197d-e.

[34] In terms of the interchange of musical knowledge the finds of Teotihuacan quadruple flute mouthpieces from Monte Albán are comparable testimonies (Winter et al. 2002: 631–2, fig. 3; Arndt 2014: 86–90, fig. 11; Sánchez Santiago 2016: 170, fig. 5.60).

[35] Rattray 1990: 188, fig. 6.

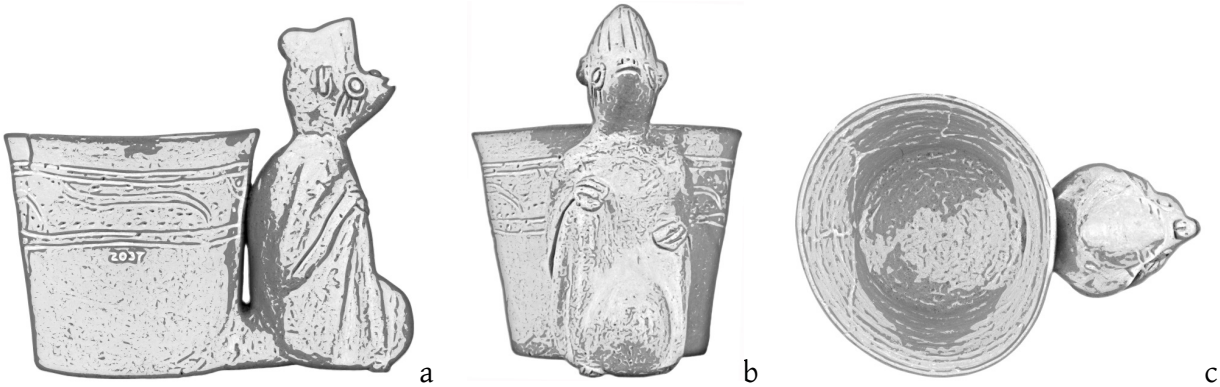

Figure 17: Teotihuacan-B/Large whistling vessel, possibly from Mitla, Oaxaca (L 16.0 cm, W 12.0, H 15.0 cm; 350–550 CE); Field Museum of Natural History, Chicago, collection W.H. Rice (Inv. 2037): a) profile view; b) front view; c) top view.

context previously described. According to the photos of the find published in the online catalogue of the museum,[36] the whistle presents a rectangular or trapezoidal windway, measuring approximately 0.45 cm in width by 0.25 cm in length. Neither the form nor the dimension of the exit hole of the airduct can be discerned. The outer diameter of the whistle measures approximately 1.5 cm and thus might produce a very high frequency located in the range of the B/Small whistling vessels mentioned above. So far, no reproduction has been made from this find.

Vessel no. 10

The largest whistling vessel of the sample is currently preserved in the Musée du quai Branly, Paris (Figure 18; Table 2, no. 10). The find is said to be from San Martín Texmelucan, Puebla.[37] It is produced from Thin Orange ware, and measures 20.8 cm in length, 13.8 cm in width, and 16.0 cm in height, corresponding to the class of *large minor* vessels. The size and form of the containers allow for a higher amount of operational liquid than in the previously described instruments. The instrument differs from the other vessels of the Teotihuacan-B model not only for the volume of the containers, but also in terms of a small handle placed between the open and the closed chamber, a constructive detail referring to the Teotihuacan-A model. Such as in the whistling vessels from La Ventilla A (no. 7) and Tecamachalco, Puebla (no. 8), the instrument does not bear any decoration in the form of engraved lines. The female monkey is shown in advanced pregnancy, holding its left hand over its belly. In the photos published in the online catalogue of the museum[38] the organological details of the whistle cannot be detected. Using a reproduction of the find (Figure 19) we observed that with the maximum amount of water the noises of the moving liquid and the respiratory sounds become very prominent.

[36] Consult the anthropological collections of the Field Museum online https://collections-anthropology.fieldmuseum.org/catalogue/1108518 [accessed December 21, 2023].

[37] Teotihuacan 2009: 348, Cat. 167b.

[38] A photographic documentation of different views of the find is published in the online collections of the museum http://collections.quaibranly.fr/ [accessed December 21, 2023]: search for "71.1878.1.1033".

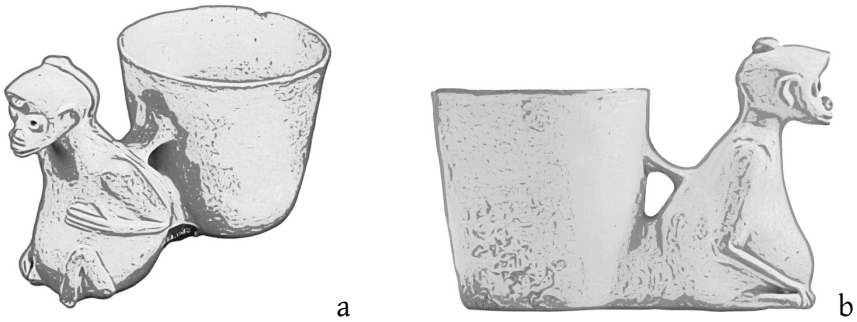

Figure 18: Teotihuacan-B/Large whistling vessel from San Martín Texmelucan, Puebla (L 20.8 cm, W 13.8 cm, H 16.0 cm; 350–650 CE); Musée du quai Branly, Paris, collection Eugène Boban (Inv. 71.1878.1.1033): a) three-quarter views; b) profile view.

Figure 19: Reproduction of the Teotihuacan-B/Large whistling vessel from San Martín Texmelucan, Puebla, made by Osvaldo Padrón Pérez (2021), low fire clay.

Vessel no. 11

Two further finds of the Teotihuacan-B model are documented but the only extant information available are photos and we cannot be sure if they form part of the B/Small or the B/Large variants, as the measurements are not given. Tentatively, we grouped these instruments here. One of the vessels is from Tepeaca, Puebla (Figure 20; Table 2, no. 11), and was first mentioned by Noguera.[39] Currently, the find is exhibited in the Museo Regional de Puebla. It is made from Thin Orange ware and in terms of its general form and design it is very similar to the specimen from La Ventilla A (no. 7). Apparently, it differs only in two details, the figurative simulation of the ears in form of a sound scroll, referring to the sonorous function of the vessel, and the application of a fine layer of stucco, whose remains are still visible on the photos published by Noguera. As previously described, stuccoed whistling vessels are also documented for Teotihuacan-A models (specimen from the Reiss-Engelhorn-Museen, Mannheim: no. 9). According to a more recent photo published in the Mediateca of the INAH, the remains of stucco are absent.[40] Notably, the instrument presents intentional damage in the exterior wall of the whistle placed at the monkey's forehead, similar to

[39] Noguera 1937: figs 21–2.

[40] https://www.mediateca.inah.gob.mx/islandora_74/islandora/object/objetoprehispanico%3A24887 [accessed December 21, 2023]. It might be that the stucco pulverized and flaked off, or that the remains were removed due to an inappropriate handling of the find. A comparable loss of stucco was documented for a whistling vessel from Oaxaca (Sánchez Santiago 2020: 6).

Figure 20: Teotihuacan-B whistling vessel from Tepeaca, Puebla (undocumented measurements; 350–550 CE); Museo Regional de Puebla (Inv. 10-203342): a) three-quarter view; b) profile view; c) front view.

the perforations observed in the whistling vessel from La Ventilla A and the further below described Maya instrument from Teotihuacan.

Vessel no. 12

For the last whistling vessel of the sample, only a photo in black and white is known (Figure 21; Table 2, no. 12). The find is currently preserved in the Museo Frisell de Arte Zapoteca, Mitla.[41] However, during a recent inventory, the object could not be located.[42] It can be assumed that the vessel is from a Teotihuacan-related site in the Valley of Oaxaca and represents an imported object, such as the previously described vessel preserved in the Field Museum of Natural History, Chicago (no. 9).[43] The instrument presents some elements similar to the described specimens, namely the ears in form of sound scrolls, comparable to the vessel from Tepeaca, Puebla (no. 11), and the element in form of a sling or a necklace without pendant, comparable to the vessels from Zacuala Patios and Tecamachalco, Puebla (no. 5 and 8, respectively).

Figure 21: Teotihuacan-B whistling vessel, unknown provenance, possibly from the Valley of Oaxaca (undocumented measurements; 350–550 CE); Museo Frisell de Arte Zapoteca, Mitla, collections of Robert Frisell and Howard Leigh: three-quarter view.

4 Cross-cultural comparisons

4.1 *Preclassic period whistling vessels*

The whistling vessels from Teotihuacan represent autochthonal forms, having little in common with the Preclassic instruments known from the Central Mexican Highlands, which are character-

[41] Boos 1966: fig. 453.

[42] Sánchez Santiago, personal communication, 2021.

[43] For the photo a rare perspective and probably also an inappropriate objective lens has been chosen, which appears to show the monkey effigy of the closed chamber as rather large in comparison to the open chamber, and the closed chamber by far slimmer than proposed.

ized by a single chamber, or the Preclassic double chambered vessels from Oaxaca, Chiapas, and Guatemala.[44] A trait the Teotihuacan instruments do share with some Preclassic specimens documented for the Mixteca Alta and the Valley of Oaxaca is their small size in terms of two important measures, namely the length, as the principle measure taking as reference point for comparison (see above), and the operational quantity of the liquid in ml. Effectively, these instruments and the Classic period Teotihuacan-B/Small specimens belong to the smallest whistling vessels documented in the Americas.

Another common trait is the presence of the closed chamber in the form of the monkey, a feature already observed in some Preclassic period whistling vessels of Oaxaca, the Highlands of Chiapas, and the Guatemalan Highlands. In one particular find excavated in Chiapa de Corzo, Chiapas, the effigy can already be identified as a spider monkey. The vessel from Chiapa de Corzo dates to the Middle Preclassic period, 750–400 BCE,[45] and thus represents the earliest double-chambered whistling vessel documented for Mesoamerica so far. As with the Teotihuacan whistling vessels, in this specimen the whistle is incorporated into the head of the animal, here in the place of the typical crest of the spider monkey and not in the back of the head, such as in the Teotihuacan specimens.[46] Engravings below the eyes of the monkey effigy simulate tears.

A roughly contemporary Preclassic period vessel from Oaxaca currently preserved in the Museo Nacional de Antropología, Mexico City, also has a closed chamber in the form of the spider monkey.[47] Undulating incised lines below the eyes of the animal symbolize tears. Its crest is shown in an overemphasized manner, such as in the Teotihuacan-B vessel said to be from Mitla (Field Museum of Natural History, Chicago: no. 9), the latter also presenting engraved lines representing tears, indicating that these monkeys are portrayed in the state of crying.[48] Across the chest, the vessel presents further engravings, probably referring to the operational liquid, while outlines of a penis between the legs clearly identify a male monkey, referring to fertility such as the female monkey effigies in the state of pregnancy of the Teotihuacan-B specimens.

Another instrument also dating from the Preclassic period, possibly originating from Kaminaljuyu, Guatemala, and of 24 cm in length, shows the closed chamber in the form of the face of a monkey, with two whistles incorporated in such a way that the windways are located in place of the eyes.[49] This feature results in the effect that, by using a sufficient quantity of liquid, the instrument may truly 'cry', and in this very moment would triller and eventually lose its sonorous

[44] Martí 1970: 38–9, fig. 19; Sánchez Santiago 2020; Bachand 2013: 41–2, fig. 15; Rodens et al. 2013.
[45] Bachand 2013: 41.
[46] In consequence, the crest presents an elongated and round form, possibly contributing to the interpretation of the effigy as a dwarf with a type of cap (Bachand 2013: 41).
[47] Caso et al. 1967: 164; 168, fig. 120; Sánchez Santiago 2020: 7–8, fig. 12.
[48] Paradoxically, only human beings shed tears of emotion, indicating that the monkeys are either humanized or that humans transformed into monkeys are shown. In both cases mythological thought might be inherent.
[49] Rodens et al. 2013; Matthias Stöckli, personal communication 2021.

function.[50] The repeating aspects related to the notion of grief and fertility documented for some of the Preclassic whistling vessels are certainly related to the possible uses and functions of these instruments.

4.2 *Classic period whistling vessels*

A series of Classic period whistling vessels, in particular from Oaxaca and the Maya area, show Teotihuacan influence and thus could be labeled as foreign variants representing adapted forms. So far, five vessels from Oaxaca related to the Teotihuacan-A model are known. Two of these instruments are currently preserved in the Museo Nacional de Antropología, Mexico City, and have a documented archaeological context. The better-known specimen has been excavated as part of a funerary offering in Tomb 109 of Monte Albán;[51] the other, unpublished and partially fragmented one is from Ejutla.[52] The other three, partially fragmented vessels belong to the Frisell Collection without archaeological context information.[53] All these instruments are larger in size than the Teotihuacan-A specimens. The vessels also differ in the absence of the three supports and the border of the false lid, the application of relief designs in the form of cartouches, and figurative details of the monkey effigy situated on top of the closed chamber. Some of the instruments show a higher form of the cylindrical chambers and thus could represent morphological bridges to contemporary Maya whistling vessels (Metropolitan Museum of Art, New York, see below) and the Epiclassic/Early Postclassic whistling vessels from Xochicalco, Morelos.[54] The acoustics of the whistle of one of the vessels from the Frisell Collection (Inv. 2964) was recently documented.[55] With frequencies between 2088 and 2222 Hz, corresponding to the tonal range between C_7-4 and $C\sharp_7+4$, the instrument sounds over a full tone lower than the Teotihuacan models.

Four Classic period Maya whistling vessels could be classified as adaptations representing a mixture of the Teotihuacan models with new elements. Three of the instruments are without documented archaeological contexts. One of these instruments, currently preserved in the collections of the Library of Congress, Washington (Inv. KISLAK PC 0128), refers to the Teotihuacan-B model, with the exception that the open chamber shows two supports and the pregnant monkey effigy has more strongly emphasized legs, which are a third support.[56] The find is possibly from the lowlands of Guatemala and presents a length of 24.0 cm, corresponding to the *large major* class of whistling vessels. Therefore, it is much larger than the Teotihuacan instruments. Teotihuacan iconography is copied by engraved lines representing ascending scrolls on the closed chamber and

[50] In operating the original instrument with water, it could not be sounded at all, likely due to either invisible damage of the airduct-windway assemblages or bits of earth blocking the airducts.
[51] Caso et al. 1967: 300, fig. 256b; Sánchez Santiago 2020: 9–10, fig. 15.
[52] A photographic entry of the latter find is to be found in the Archivo Fotográfico 'Manuel Toussaint', Instituto de Investigaciones Estéticas, UNAM, Mexico City (Sánchez Santiago, personal communication 2021).
[53] Caso et al. 1967: 164, 169, fig. 122; Boos 1966: fig. 45; Sánchez Santiago 2020: 10, figs 16–17.
[54] Both and Giles 2017: 62–4, fig. 16a–c.
[55] Sánchez Santiago 2020: 10–11; 13; tab. 1, figs 18 and 22.
[56] Dunkelman and Ehrenberg 2007: 26, Cat. 73.

especially by a border of scrolls in the form of waves below the rim of the open chamber. In the context of the vessel, these can be taken as a reference to the operational liquid of the instrument and its sound. Two cartouches engraved on the wall of the open chamber show snakes in profile view.

The second instrument is currently preserved in the Metropolitan Museum of Art, New York (Inv. 1978.412.90a,b), and shows similarities to the Teotihuacan-A model, with the exception that the vessel presents four supports instead of three and that both chambers are equipped with lids, a false one for the closed chamber and a real one for the open chamber.[57] The false lid shows, in place of the monkey effigy, a figure representing the Principal Bird Deity, whereas the removable lid presents a male human figure wearing a headdress and assuming position of praying or offering.[58] A third figure identified as a jaguar is attached at the intersection of the chambers at the height of the conduit. In comparison with the Teotihuacan-A vessels, the instrument is larger (18.7 cm in length), placing it in the *medium major* class. As the height of the chambers is roughly two times greater than in the Teotihuacan-A vessels, a far greater amount of operational liquid could have been used.

The third Maya instrument has been documented without reference to the actual storage in the Precolumbian Portfolio published online by Justin Kerr (K4009).[59] The vessel differs in terms of the closed chamber, shown not in the form of a monkey, but of a person represented in the seated position of a lord, with his mouth open as if talking or singing. The visual direction of the effigy towards the side of the vessel is particularly unique. The open chamber resembles the cylindrical form of the Teotihuacan-A model and even shows a miniature form of the characteristic support.[60]

Most interestingly, the fourth Maya find, which has not been published so far, has been excavated in Teotihuacan (Figure 22). Currently, it is preserved in the Museo Nacional de Antropología, Mexico City. Unfortunately, information on its find history is lacking in the museum records. The vessel is made from orange-reddish ceramics with black spots, strongly resembling the Usulután ware of the Maya area, dated to the Late Preclassic period dating from 400 BCE–250 CE.[61] Notably, a Maya whistling vessel from San José Escuintla, Guatemala, is also made from Usulután ware,[62] and as the Escuintla region maintained close contacts with Teotihuacan, it is likely that the vessel originates from there. For its presence in Teotihuacan, it could be dated roughly 200–250 CE or to the beginning of the Early Classic period from 100–250 CE. The instrument measures 17.8 cm in length,

[57] Newton 1978: 189. Photographic views of the find are published in the online collections of the MET https://www.metmuseum.org/art/collection/search/310542 [accessed December 21, 2023].

[58] For an interpretation of the scene, see Taube 1987.

[59] Consult http://research.mayavase.com/kerrportfolio.html [accessed December 21, 2023]: search for "4009".

[60] Vessels with anthropomorphic effigies combined with open chambers in cylindrical form are also documented for Postclassic finds from the modern states of Puebla and Michoacan (Noguera 1937: 16, figs 15–16; 20; Kidder et al. 1946: 191–2, fig. 78f), representing legacies of the Classic period Teotihuacan-A and related Maya vessels.

[61] Demarest and Sharer 1982.

[62] Kidder et al. 1946: 191, fig. 78c.

Figure 22: Maya whistling vessel from Teotihuacan (L 17.8 cm, W 10.7 cm, H 16.3 cm; 200–300 CE); Museo Nacional de Antropología, Mexico City (Inv. 10-223556): a) profile view; b) front view; c–d) details of the effigy showing the exit hole of the airduct and the windway.

10.7 cm in width, and 16.3 cm in height, corresponding to the *medium major* class, and it has a weight of 630 g.

The find shares a series of elements with the vessel documented by Kerr mentioned above (K4009). In the form of the closed chamber, it presents another version of the male person shown in the seated position of a lord, with the difference that the visual direction is in the opposite direction to the open chamber, like in the Teotihuacan-B vessels. His face presents very similar traits, especially in terms of the form of the eyes and the open mouth. The figure stands out for its hairstyle, having very long hair bound together with a knot at the back of the head. Furthermore, the person wears large earspools and a necklace of massive beads, both elements simulating greenstone jewelry. The position of the hands is unknown, as they are knocked off, possibly as a result of intentional damage. The wall of the open chamber is slightly protruding and thus is similar to the form of the open chambers of the Teotihuacan-B vessels, while the conduit at the bottom and the handle above resembles constructive details of Teotihuacan-A specimens.

As in the Teotihuacan-B instruments, the windway of the whistle is situated at the occiput of the effigy. However, differences in terms of its organological configuration can be observed. The exit of the airduct is falciform (shape of a slightly curved slit) and the windway is circular, a combination not observed in the Teotihuacan whistling vessels and also not in other wind instruments from the site. Notably, the wall of the resonator presents a small circular perforation, which is nearly identical to the damage documented in the vessels from La Ventilla A and Tepeaca, Puebla (no. 7 and 11, respectively). According to our interpretation, these damages, such as the knocked-

off effigy heads documented for the Teotihuacan-A vessels, reflect forms of intentional destruction or ritual killing of the instruments, related with the annulment of their sonorous function.[63] The resonator has an outer diameter of 2.0 cm, and an inner diameter of approximately 1.5 cm, and is thus slightly greater than the largest one documented for the Teotihuacan whistling vessels (La Ventilla A: no. 7). Maybe because of its damaged part, but more likely because of invisible damage or insufficient cleaning of the airduct, the whistle does not sound. In playing a replica of the whistle (the whistling vessel has not been reproduced so far), frequencies between 2390 and 2580 Hz were obtained, corresponding to the tonal range between D_7 (+30 cents) and E_7 (-38 cents).

In summary, the contemporary instruments from Oaxaca and the Maya discussed represent variations or adaptations of Teotihuacan forms. They generally consist of larger vessels, which might contain a higher amount of operational liquid, and their whistles are characterized by larger resonators, resulting in somewhat lower frequencies. In the organological configuration of the whistles, different combinations of the airduct-windway assemblage can be observed. In the Teotihuacan-A and B/Small vessels consistent combinations are present (airduct with circular exit – circular windway in Teotihuacan-A, airduct with circular or oval exit – rectangular or trapezoidal windway in Teotihuacan-B/Small), while the combinations of the B/Large instruments and their respective sizes present a greater variability. The foreign instruments show comparable configurations, but also combinations not documented for the Teotihuacan models. An example is the above-described Maya vessel found in Teotihuacan, which has an airduct with slit-shaped/falciform exit and a circular windway. This unique configuration clearly demonstrates that the instrument is an imported object. It can be supposed that the different configurations reflect different musical traditions developed within the cultures and in constant interaction with others.

5 Considerations regarding the construction and functionality of the Teotihuacan whistling vessels

For the instruments of both Teotihuacan models, especially those grouped into the *small* class of whistling vessels (most of the Teotihuacan-A and the B/Small specimens), we observed the highest craftsmanship in the design of the instruments, achieving a precise equilibrium of the morphological composition and its related hydraulic/eolic and organological/sonic functions. Among the principal elements are the general form of the chambers (defining the volume of the liquid required for the compression of the air and the acoustical function), the length and the diameter of the conduit (defining the flow velocity of the liquid and therefore also related to the generated air pressure), and the position of the whistle and its organological configuration (defining its acoustics). Through the production and operation of the replicas and experimental models we managed to analyze the effects of the different forms and sizes of these elements, a process which must have also occurred during the development of these instruments in pre-Columbian times. This approach

[63] In the case of the small circular perforations, it is possible that they were made by means of a precise blow with an obsidian arrowhead.

revealed the technological and organological knowledge inherent in the Teotihuacan whistling vessels.

One result of the experiments is that the conduit is the crucial hydraulic device for the operation of the instruments. In terms of its size, the difference between a functional and a nonfunctional instrument lies within the range of millimeters. If the length of the conduit is too short and the diameter too small, the flow velocity of the liquid is reduced, resulting in the effect that the hydraulic movement does not generate sufficient air compression for activating the whistle. In general, by means of the experiments it could be verified that the conduits require a diameter of at least 0.7 cm in the B/Small vessels, 1.0 cm in the Teotihuacan-A vessels and 1.4 cm in the B/Large vessels. The gradual augmentation of the diameters is clearly related to the respective size of the instruments. For all the models, the length of the conduits could not be shorter than approximately 2.5 cm.

Another crucial element for the functionality of the whistling vessels is the quantity of the liquid required for acoustic operation. In addition to the size of the conduit, the volumetric capacity has an effect on the flow velocity of the liquid and the air compression generated by the hydraulic movement within the containers. Because of its reduced weight, a smaller volume of liquid results in a lower amount of pressure. In handling the experimental models, we observed that instruments with volumes of operational liquid lower than for the model Teotihuacan-B/Small do not operate well, as not enough air pressure is generated. These instruments are among the smallest whistling vessels so far documented for the Americas. They hold only 25–100 ml of liquid, while the largest whistling vessels known may hold ten times that amount, up to one liter or even more.[64] Based on these observations it is clear that it was much more difficult to produce a functional whistling vessel of smaller size than a larger one. In the larger specimens, the required air compression depends less on the morphology of the constructive elements, as the higher pressure generated by the liquid always guarantees that the whistle sounds.

The placement of the whistle in a higher position than the height of the open chamber is related to the functionality of the instruments, as the probability that liquid enters the airduct, escapes, and finally blocks the windway is reduced. Moreover, the functionality is related to the construction of the whistle, produced so precisely (in terms of avoiding clay residues that might make the inner walls of the airduct and the windway uneven) that the instrument may sound with even the gentlest breeze, corresponding to the lowest pressure generated by the moving liquid.

By operating replicas and experimental models we could document that the length of the airduct has no great effect on the operation of the whistle, especially if its exit is small, as in the vessels of the Teotihuacan-A model (in which the exit of the airduct was the size of a needle point). In addition, we observed that by means of shorter airducts the probability that liquid enters the duct and stops the function of the whistle is reduced. This could represent one of the possible reasons for the implementation of short tubular or conical airducts with circular exit holes in place

[64] Both 2011.

of longer airducts with slit-shaped exit holes, especially for the Teotihuacan-A specimens. It should be mentioned that because of the absence of radiographies or computed tomographies of the Teotihuacan whistling vessels we could not verify the shape of the entrance of the airducts in the closed chambers. In the experimentations carried out with the Teotihuacan-A experimental models it was observed that it is possible to reduce the size and the form of the airduct to a constricted passage with a very small diameter and a length of not more than five millimeters, corresponding to the wall thickness of the false lid. The effect of such a configuration is that, even with the greatest inclination of the closed chamber in forward motion, virtually no liquid could enter the airduct. Such construction effectively means that the whistle cannot be prevented from sounding.

By contrast, in the tests carried out with the Teotihuacan-B reproductions mentioned above, we observed that it is virtually unavoidable that liquid escapes through the airduct and blocks the windway, especially when using the maximum amount of operational liquid. Usually, the sonorous function is stopped in such cases, as the airstream is interrupted. However, the liquid frequently does not fully block the windway, resulting in the effect that the remaining drops around the exit hole of the airduct and the windway produce trill effects. A possible organological support for this is the fact that the exit holes of the airduct and the windways are considerably larger than those of the Teotihuacan-A model. However, the continuous production of trill effects as part of the sonic cycle of these instruments is difficult to control in continuous playing, as the whistle will eventually be blocked. Operating the models with edible oil, we observed that with more viscous liquids than water the probability that the liquid will enter the airduct, escape, and block the windway is reduced. This could indicate the possible employment of a substance other than water for the Teotihuacan-B models, and in smaller amounts.

As previously mentioned, the earliest cultures in Mesoamerica in which double-chambered whistling vessels corresponding to the *small minor/major* class were produced, were situated in the Preclassic period regions of the Valley of Oaxaca and the Mixteca Alta. During the Classic period *small* class whistling vessels were exclusively produced in Teotihuacan. The reason for the production of such small instruments is a question still unanswered. The construction of these acoustic devices required the highest technological and artistic perfection. It certainly reflects an impressive level of knowledge or, in other words, is a sign of an elaborate culture. But there could also be other reasons, possibly related to the use of these instruments and their cultural context. Apparently, the vessels are associated with the employment (and possibly the consumption) of very small quantities of liquid.

The resulting sounds produced by different whistling vessel sizes and corresponding quantities of liquid is that larger instruments produce diverse noises of the moving liquid, while smaller quantities of operational liquid do not produce such sound effects. An interesting observation is that some of the largest whistling vessels documented in the Americas, having a length of 32.5 cm or more and thus corresponding to the *large superior* class, were employed contemporaneously to Teotihuacan in a region of contact, the Maya area (one of the largest known finds is from Tomb A-I, Kaminaljuyu; even larger specimens are known from the Bahía and Jamacoaque cultures,

Ecuador).[65] In other words, two Classic period cultures related to each other through a network of contacts employed whistling vessels of diametrically different sizes, one of the smallest ones and one of the largest ones documented for all pre-Columbian societies so far. Important in this context is the existence of foreign variants and adaptations of the Teotihuacan models produced in the Maya area on one side, and the Maya whistling vessel from Teotihuacan on the other side. This demonstrates the mutual knowledge of different-sized whistling vessels from the other cultures. Apparently, certain instrumental contexts required different sonorous aesthetics, with the sounds generated by the moving liquid preferred among the Maya, while these sounds were reduced in the smaller vessels documented for Teotihuacan.

Among the possible operational liquids already mentioned are water, or a series of beverages produced from agave, corn, or cacao, some of which contain alcohol and could have been enriched with extracts from psychotropic plants. Some of these liquids, especially the above-mentioned beverages, are thicker or more viscous than water and therefore flow in a slower motion. This condition also has an impact on the handling and the sound characteristics of the instruments. By means of playing the experimental models with olive oil (instead of using one of the above-mentioned beverages, which were not available), we tested different operational and acoustical effects compared to playing the instruments with water. The reduced velocity of the liquid in this experiment resulted in considerably longer sonic cycles and a longer duration of the tones generated by the whistle. Furthermore, virtually no noise was generated by the moving liquid.

Another factor related to the handling of the instruments is the additional weight added by the employment of different liquids. When operating the B/Small models with water, the liquid does not add more than 25–100 g to the weight of the vessel, while in the largest known instruments the quantity of water would add one kilogram or more. Thicker liquids would add even more weight. Certainly, the question of the type of operational liquid is related to the use of the instruments, their meaning, and cultural contexts, especially if the substance was considered sacred and therefore exclusively reserved for ritual or ceremonial activities. And the type of liquid may also have been dependent on whether the use of the liquid was restricted to certain groups of the society, and/or if handling the vessels included its consumption, during or after playing.

6 Meaning and cultural context of Teotihuacan whistling vessels

The existence of different models and variants of whistling vessels employed in Teotihuacan and other contemporaneous sites of the Central Mexican Highlands, evidence for exported Teotihuacan instruments in Oaxaca, and foreign variants and adaptations produced in Oaxaca and the Maya area, are indicators of a flourishing and charismatic music culture. Common elements related to the specific meanings and the cultural contexts of the instruments can be found between the different societies. However, it cannot be taken for granted that instruments virtually identical in

[65] Kidder et al. 1946: 190–91, fig. 77; 179h; 179i.

terms of their form were necessarily employed in identical contexts. Depending on the cultural developments and interactions across time, it can be assumed that a kaleidoscope of different associations and uses is present, of which only portions can be deciphered at present. Because of the absence of a greater sample, especially in terms of more finds with better documented archaeological contexts, the meanings and cultural contexts of the instruments are difficult to interpret. Also, it is still difficult to deduce information on the playing postures and movements, whether the instruments were employed in solo performances or in groups, if playing was a ritual activity only carried out by religious specialists and/or a courtly activity reserved to the chiefs and clan leaders, if the use of the instruments was gender specific, if the employed liquids were the subject of shared consumption, or other factors already discussed, such as the nature of the operational liquid.

6.1 Archaeological contexts

An important factor for understanding the meanings and cultural contexts is the archaeological find situation of the instruments. According to the available data, the vessels represent a very special and, compared to other mortuary offerings, rare group of burial objects. For the Thin Orange, *Anaranjado burdo* and *Café fino* wares, the amount and type of the other mortuary offerings deposited in the burial (especially rich the finds from Zacuala Patios and Tecamachalco, Puebla), and the position of the burials (especially the find from Culpulalpan, Puebla), indicate that the instruments were elite utensils related to persons who occupied higher ranks within the society. The position these persons occupied might never be known, but as the finds are quite rare in comparison to other, more conventional grave goods, it could be that the vessels were the personal objects of the buried persons. Apparently, the instruments were of such importance that they were offered in order to accompany the deceased to the world of the dead. The possibility that the instruments were specifically produced for the mortuary offering and that the occupants of the burials in fact never listened to their sound cannot be excluded, however. In this context it can be assumed that the instruments were sounded exclusively in the funerary rite and that the sounds of the vessel and the employed liquids were offered during the funeral.

6.2 Iconology

Certain aspects of the iconography of Teotihuacan whistling vessels might also be related to their possible function as objects forming part of the funerary rite. The effigies of pregnant monkeys especially in the Teotihuacan-B specimens could be related to the imaginations of the world of the dead, although ostensibly representing signs of life. We know that in the pre-Columbian thought the idea of a subaquatic underworld full of life existed, also believed to be the place of life-giving forces for the terrestrial realm.[66] In consequence, the pregnant monkeys could be understood as representatives of a new life generated in the world of the dead. However, this is only one of several

[66] For the Teotihuacan-specific concept, the Tepantitla mural with the flower-world realm in the lower portion can be taken as a reference.

possibilities, as the vessels could also stand as signs for terrestrial prosperity and fertility, and may not have been specifically produced to form part of a mortuary offering. As mentioned above, the Teotihuacan-A models are most probably provided with male monkeys and therefore might have been used in different contexts. Unfortunately, currently no sufficient information on the gender of the deceased is present. In only one of the three documented burials could the gender of the deceased be determined, and in this case the deceased was found to be a woman, accompanied by a Teotihuacan-B/Small vessel showing a pregnant monkey (Zacuala Patios). Because of this reason we still cannot deduce whether the gender of the monkey on the instrument was correlated with the gender of the possible owners/players.

Between the vessels with female monkeys (Teotihuacan-B/Small and B/Large) and those with male monkeys (Teotihuacan-A) a certain duality becomes apparent, also related to the different forms of the containers and the visual directions of the effigy. Another duality can be observed between the variants B/Small and B/Large. As indicated earlier, it can be supposed that these characteristics reflect different meanings and contexts of employment. A comparable duality between instruments produced according to the same form but in clearly different sizes is also observed in the case of the Teotihuacan quadruple flutes, with larger and smaller versions.[67] In the pre-Columbian world, such organological diversification rarely existed.[68] Certainly, the employment of different-sized instruments of the same model is the sign of an elaborate culture with a somewhat stratified musical system, in which a distinguishable set of tonal ranges played a role (comparable to the current employment of alto and soprano instruments).

According to the set of iconographical data, the symbolism of the Teotihuacan whistling vessels is generally related to concepts of life, and possibly intoxication (spider monkey, flower-sign), sacred sound and offering (scroll-sign, flower-sign, heart-sign), fertility, and water or other liquids (scroll-sign, cloud-sign, undulated engravings and dotted lines). Some of these elements, such as the five-petaled flower-sign and the cloud-sign in the Teotihuacan-A vessels made from *Anaranjado burdo* ceramics could equally represent toponyms and/or emblems of political entities. If the four-petaled flower-sign is understood as an emblem for Teotihuacan (see above), the five-petaled flower-sign could be related to the site and political dominion of Culpulalpan, Tlaxcala (no. 2), and the cloud-sign of the whistling vessel from San Juan del Río, Querétaro (no. 3), related to the latter site. If this is the case, these particular finds could represent signs standing for the relation between the sites, for example as official gifts interchanged between the elite groups. Iconographic elements showing possible toponyms or emblems of political entities are also documented for some of the foreign variants and adaptions from Oaxaca and the Maya area.

[67] Both 2021a: 524–32.

[68] Examples are the conical flutes of Xochicalco, Morelos (Both and Giles 2017: 52–5, figs 2–5), or the Nasca panpipes from Peru.

6.3 Sonority and sound symbolism

Among the factors that aid in interpretation of cultural settings for the use of these instruments is the low sound level of the vessels and their fragile tone quality, with delicate whistle tones in the infilling motion and barely perceptible breath sounds in the refilling motion, accompanied by the subtle noises generated by the flowing liquid. These particular sonics indicate a probably exclusive use among smaller groups in interior and ajar spaces within the urban environment, such as in the rooms, temple shrines, and smaller patios of the apartment compounds and other ceremonial structures, which were designated for gatherings, performances, and ritual activities. Outside these environments, such as in the larger open courtyards in front of the principal pyramids of the site or along the great processional pathway, the whistling vessels could not have been heard over large distances, especially not if large groups of people were present. Outside atmospheric conditions such as wind or humidity would also reduce the sonic perception of the instruments significantly.

Interpretation of the possible sound symbolism of the whistling vessels, including the possible psychoacoustical effects, supports reconstructing their meanings and cultural contexts. According to our observations, the sound symbolism is in line with some of the above-mentioned aspects. It might be related to life and fertility, on one hand, and the notion of grief, on the other hand.

At first, some sounds emitted by the vessels are strongly reminiscent of birdsong, which at first sight might represent a paradox, since in the case of the Teotihuacan whistling vessels the animal shown is not a bird. This condition is also frequently observed in other whistling vessels of the Americas (and in many other instruments worldwide), whose sounds are rarely related with those emitted by the beings shown in the decoration or figurative form of the instruments.[69] Among the vocalizations of the spider monkey is a sort of neighing for distance communication and a sort of barking when frightened and nervous, but these sounds have nothing in common with those generated by the instruments. However, spider monkeys also whistle and produce trills.[70] The latter vocalizations present comparable sonorous characteristics with the Teotihuacan whistling vessels. In consequence, it can be suggested that in the particular case of the instruments discussed here a sonic association with the effigy indeed might be present.

If the monkey, especially the female monkey in state of pregnancy, can be seen as a sign of prosperous life and fertility, according to Mesoamerican thought, the noises generated by the operational liquid are clearly related to this aspect. This might be especially the case if water was employed, but other liquids might stand for comparable notions, especially the alcoholic or psychotropic beverages that might have been employed for ritual activities and ceremonial gatherings. Water sounds, however, would be most predominant, as water creates greater turbulence due

[69] Pérez de Arce 2006: 167. At least for Mesoamerica, however, many wind instruments are reported, which do reproduce the sounds of the animal represented (for example, a large amount of vessel flutes representing owls, eagles, and other birds, or double whistles representing frogs).

[70] To obtain an idea on the diversity of the vocalizations of the spider monkey, the online database of the Macaulay Library may be consulted, https://search.macaulaylibrary.org/catalog?searchField=animals [accessed December 21, 2023]: search for "Central American spider monkey".

to its higher flow velocity. In continuously operating the larger Teotihuacan instruments (B/Large models) with water, sounds are generated reminiscent of a streamlet.

Other sounds generated by the whistling vessels, especially the fragile whistle tones produced in forward motion with a gradually lowering frequency and sound level towards the end of the sonic cycle, which finally exhale and die, do not present any similarity with the vocalizations produced by an animal or a noise present in the natural environment. This particular acoustic emanation of the instruments fortifies the subjective notion of grief, which is particularly interesting as all instruments with documented find contexts were deposited in burials. Remarkable in this context is that the vessels produce respiratory sounds in the reflowing motion. These effects are more predominant in the larger vessels (Teotihuacan-B/Large), for the augmented vacuum generated by the higher quantity of liquid flowing back into the open chamber. For the size of the smaller vessels (Teotihuacan-A and B/Small), the respiratory sounds are softer, reminiscent of the sounds made by a person sleeping in peace.

During our experiments we observed that during operation of the vessels the impression might occur that the instruments become almost animated. The sensation is tactile, due to the moving liquid inside the chambers, and visual, as the represented monkeys seem to whistle properly. Also, the fragile tones and the respiratory sounds strongly fortify the impression. Furthermore, it has been observed that the acoustic emissions could stimulate the brain in such a way that altered states of consciousness could be generated (for example, time perception could be altered, or olfactory and visionary sensations generated).[71] Contributing factors are the repetitive physical and acoustical movements, the slow pulse of the sonic cycles, and especially the generation of high-frequency tones located in a highly sensitive human hearing range.

7 Conclusions

It has been demonstrated that the Teotihuacan whistling vessels are extraordinary sonic devices in many ways. As tested on a series of replicas and experimental models, their morphology, construction, and functionality required a high level of technological and organological/musical knowledge. The principal parameters are comprehensively understood and a range of particular playing techniques, including the possible use of different liquids, and a range of different acoustic effects, were documented. According to the finds from various sites of the Central Mexican Highlands and Oaxaca, the production of foreign variants and adaptions in Oaxaca and the Maya area, and the presence of a Maya adaption in Teotihuacan, it can be shown that in terms of the employed sound artefacts a mutual interaction between Teotihuacan and related sites existed, in which Teotihuacan apparently played a dominant role. The find contexts of the vessels and the ceramic types indicate use by members of the elite. In taking all available data into consideration, including the

[71] Garret and Stat 1977; Wright 1992.

archaeological, iconographical, and acoustic information, the complex meanings and diverse cultural contexts of the discussed instruments can at least partly be deciphered.

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