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Digitized Maya music: The creation of a 3D database of Maya musical artifacts

Jared Katz

University of California, Riverside, Department of Anthropology, 1334 Watkins Hall, Riverside, CA 92521-0418, United States

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ABSTRACT

The largest challenge facing the study of ancient Maya music today is the inaccessibility of the instruments, which are housed in the labs of archaeological projects or museums across Mesoamerica. In order to facilitate the study of ancient Maya music, it is necessary to create a database of numerous instruments from the Maya area that transcends geographical and temporal boundaries. This article will discuss how the Maya Music Project is using photogrammetry to create 3D models of musical instruments as a step towards achieving said database. By creating an online database of 3D instruments (www.mayamusicproject.org), the Maya Music Project will allow scholars around the world to study the musical artifacts in detail. This article also serves as a case study demonstrating the usefulness of digital, experimental archaeology to the study of archaeomusicology. Finally, this article will demonstrate how 3D models can be successfully used for public outreach in order to help generate interest in the study of ancient Maya culture.

1. Introduction

Ancient Maya music is an important, but understudied, topic of academic inquiry. There is a wide array of evidence available for analysis ranging from iconographic depictions of musicians to musical instruments discovered during excavations. This evidence provides archaeologists with enough data to analyze the various ways in which the ancient Maya used music in their daily lives and in ceremonial activities. Because the topic of music transcends categories such as class, gender, and age, it can be used to analyze numerous aspects of ancient Maya society. Different types of musical instruments have been excavated in different parts of the Maya area, and the author has been performing typological analyses of the artifacts. There are many iconographic depictions of musicians that provide evidence demonstrating the importance of music in Maya mythology, the presence of musicians at ceremonial events such as the ballgame, and the role of music in violent interactions (Katz, In press, Katz and Stanton, N.D. The study of music is a powerful one, because it allows for the analysis of many facets of Maya culture and society.

This research relies on the iconographic, the archaeological, and the ethnographic records to expand upon existing works. Until recently, there have been few scholars who have written specifically about ancient Maya music, the most notable being Norman Hammond. Hammond's work, titled Classic Maya Music (1972), discusses numerous excavated instruments and provides a good introduction to the field, but does not provide a great amount of detail. There are few scholars currently writing about ancient Maya musical artifacts, and those who do have made significant contributions to the field, but their work tends to focus either on the analysis of music at a particular site or on analyzing a specific type of musical instrument (Arndt, 2014; Healy, 1988; Healy et al., 2008; Ishihara, 2008; Rodens, 2007; Stöckli, 2004, 2007; Triadan, 2007). Scholars have also written about the importance of music in Classic Maya iconography, and they have made many important discoveries about the role music played in ceremonies and in Maya religious practices (Houston et al., 2006; Looper, 2009; Taube, 2001, 2004, 2006; Zender, 2004, 2010; Stone and Zender, 2011). Finally, there have been ethnomusicological studies performed on the importance of music to contemporary indigenous groups throughout the Maya area, such as the Achi (Pellicer, 2005). There are also scholars working with the music of other ancient cultures throughout Mesoamerica, whose work helps to provide a broader understanding of ancient music throughout the region (Barber et al., 2009; Both, 2002, 2005, 2007). There is not, however, work that systematically analyzes music throughout the Maya area.

The largest challenge currently facing the study of ancient Maya music is the inaccessibility of the musical instruments (Katz, 2016). The majority of instruments are housed in archaeological labs and museums throughout Mesoamerica, making it difficult to perform detailed side-by-side comparisons of artifacts that are from different collections. An additional challenge is that many instruments are not indexed as

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musical artifacts, meaning once in the museum or laboratory, the instruments are often stored with other ceramic artifacts, figurines, or faunal remains. This means that in order to study Maya musical artifacts, scholars need to receive permission from each individual lab and museum, travel to many different locations, and once there, spend time identifying and locating all of the instruments by manually searching through the collection. The difficulty and amount of time it takes to gain access to the numerous instruments in various labs and museums in different countries is most likely the primary reason that more scholars have not attempted a systematic analysis of music throughout the Maya area. 3D technologies, however, provide an opportunity for the dissemination of archaeological data. This paper will focus on how the Maya Music Project has been using existing 3D technologies and methodologies to facilitate and make feasible the study of ancient Maya musical instruments. The goal of this article, therefore, is not to demonstrate a methodological leap, but rather to provide a case study demonstrating how this technology can be used for the analysis of ancient instruments. More specifically, this article will focus on the existing methodologies used to make 3D scans, the experimental archaeological approach used to 3D print playable instruments, and the successful use of the models for outreach purposes.

2. Data

Data was collected over the span of several research trips to Belize and Guatemala. These trips were, in part, funded by UC Riverside's Center for Ideas and Society. Currently, the database is comprised of the instruments excavated from all of the sites associated with the Belize Valley Archaeological Reconnaissance project, the Cival and Holmul project, and the Ceibal project. Instruments from numerous museums have also been documented, including the Museo VICAL de Arte Precolombino y Vidrio Moderno, the Museo Casa Santa Domingo, and Casa K'ojom, the Maya music museum, all located in Guatemala. The instruments housed in the Museum of Fine Arts, Boston and the Peabody Museum at Harvard University were documented over the fall of 2016. The database is currently comprised of nearly 430 instruments in various states of preservation. Out of those instruments, 160 have been 3D scanned. This is the largest database of ancient Maya musical instruments to date.

3. Methodology

Originally, three different technologies were being considered to complete this research, laser scanning, photogrammetry, and structured light scanning. The project ultimately decided to rely on photogrammetry due, namely, to the ability to produce photo real texturing, the lower cost when compared to the equipment needed when using other methodologies, and its portability.

The equipment used for this project included a Nikon D-3300 26 Megapixel DSLR camera and two Neewer battery powered LED light panels. This research was completed using two photogrammetry software packages, Agisoft Photoscan Pro and Autodesk's Recap 360. Photoscan was primarily used to create the 3D models as it does not require internet access, making it ideal for use in the field.

Due to the size and shapes of the instruments, each half of an instrument was photographed separately, and a model was generated for each half. The two halves were later joined together. Each scan contained overlapping material, which allowed for the two halves to be joined. The number of photographs taken per side ranged from 150 to 600 photographs, depending on the size of the instrument. One hundred to two hundred photographs were then selected and used to make the model. Using Photoscan, the photographs were aligned, a dense point cloud was generated, the mesh was generated, and finally the texture was generated. Photoscan is largely automated, requiring very little interaction from the user. The benefits and shortcomings of using a largely automated process are discussed by Remondino and El-Hakim (2006), as well as the general Image-based modeling process. For the purpose of this research, the models produced by Photoscan were sufficiently accurate. The two models, one of each half of the instrument, were then joined using the align chunk and merge chunk features of Photoscan, which again proved to be sufficient, and more accurate than manually combining the two models. The completed scans were then exported as an.*obj* file.

Next, Autodesk Maya was used for editing and modeling the resonance chambers and air ducts within the models (a process that will be described in more detail shortly), and then Autodesk Meshmixer was used to add the Maya Music Project logo and to generate the.*stl* file. Finally, ReplicatorG was used to generate the GCode for the 3D printer. This project used a 2016 Flashforge Creator Pro.

4. 3D printing ancient instruments

3D scanning and printing opens up a new way of engaging with experimental archaeology. 3D printing and editing models of ancient instruments allows for a better understanding of the technological attributes found in ancient Maya instruments. The discussion below will focus on a complex instrument that has been modeled over the past months.

The instrument in question is a globular flute from Guatemala that dates to between 300–900 C.E (Fig. 1). The original instrument is housed in the Museuo Vical. The instrument would be classified as an end blown flute in the Hornbostel and Sachs classification system, a system used by musicologists to categorize instruments. The definition of an end blown flute is "[a]ny flute blown from the end, including Duct Flutes, but specifically one blown across the open end. The end is usually chamfered externally to form a sharp edge, either all round the circumference or at the base of a notch" (Montagu, 2017). The flute's embouchure hole is well designed, with an intuitive place to position one's mouth when playing to most effectively channel the stream of air to the strike the far edge of the embouchure hole at the proper angle, thus producing the desired tone. One of the largest challenges in designing the 3D model of the flute was correctly modeling the embouchure hole. The far edge of the embouchure hole needs to be the right thickness and at the right angle in order to produce the appropriate tone when played.

In the future, these artifacts will be x-rayed to better understand the internal structure, which was the approach used by Avanzini et al. (2015) when analyzing an ancient pan flute from Egypt. Unfortunately, that technology is extremely expensive, and was not feasible at this time. Currently, this research has relied on caliper measurements taken on both damaged and intact instruments and on a form of experimental digital archaeology. It took four trials to correctly edit the embouchure hole so that the far edge of the mouthpiece correctly divided the air stream, thus allowing the instrument to sound (Fig. 2). After each print,

Fig. 1. Flute housed in the Museo VICAL.