Archaeoacoustics Fieldwork for Aural Heritage Conservation

Collaborative Distributed Sound-Sensing at Chavín de Huántar, Perú

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ABSTRACT

Although sound has featured in archaeological narratives about the UNESCO World Heritage site Chavín de Huántar, Perú since 1976, as of this 2020 publication, aural heritage preservation has not been incorporated in its conservation plan beyond the formal inclusion of archaeoacoustics in site research since 2008. Sonic studies of heritage sites are novel with the exception of certain musical, theatrical, and religious venues. We assert that sound is fundamental to human communication and the social functionality of places; therefore, sonic concerns are pertinent to heritage conservation more broadly. In this article, we present a theoretical framework and methodology for aural heritage research, engagement, and conservation, relating acoustics to human experience. Our case-study discussion of 2018 fieldwork at Chavín builds on more than a decade of site-responsive, archaeometric archaeoacoustics research that documented acoustics, auditory perceptual and performance affordances of the architecture and conch shell horns (*Strombus pututus*) of this first millennium BCE monument in its Andean highland setting. The aural heritage fieldwork method we introduce here, "collaborative distributed sound-sensing," uses both human observers/performers and digital technologies to explore, document, measure, and map sound transmission and reception at Chavín, employing "performance auralizations" of archaeologically appropriate sound sources, replicas of the Chavín *pututus*.

INTRODUCTION

In this article, we discuss a case study in collaborative group archaeoacoustical fieldwork at the Andean Formative ceremonial complex of Chavín de Huántar, Perú, a UNESCO World Heritage site whose monumental architecture involved extensive landscape engineering during the first millennium BCE.[1] Our fieldwork took place in July 2018 as part of integrative archaeoacoustics at Chavín, research that employs acoustics and auditory science to address sonic concerns within the larger site investigation and conservation program. This ongoing archaeoacoustics project is known for site-responsive adaptations of acoustical and auditory science in fieldwork at Chavín since 2008.[2] The case study detailed in this article prototypes a methodology for a collaborative group approach to archaeological acoustical surveying with attention to contextual factors and human perception. We present this work as an "aural heritage" engagement, and discuss our definition of that term via research examples and contributions to site conservation and knowledge sharing.

With well-preserved stone-and-earthen architecture from its height of monumental construction, historiographical notoriety as "the sounding temple," and site-excavated, prominently depicted sound-producing instruments, Chavín is an exemplary archaeological site for sonic research and conservation.[3] Yet, despite the plentiful references to ritual sonics in site narratives, sonic concerns have been implemented tangentially to the site's formal conservation plan, via the integration of archaeoacoustics in its research program but without physical preservation applications. We see the potential to leverage our research products via future incorporations of sonic and experiential concerns in the preservation strategies and interpretative public interfaces at Chavín and in its local museum, to contribute more directly to site conservation. The enthusiastic reception of our work by colleagues in diverse fields and by local constituencies in Perú demonstrates interest in applications of our research, yet we are aware that resource pragmatics limit the potential for novel conservation implementations.

Although it is not uncommon for acoustical science to inform conservation planning, preservation strategies, and interpretative interfaces for renowned musical venues, historical theatres and some religious buildings, the socio-cultural importance of sound is overlooked and undervalued in heritage studies across fields. We pose that because sound is fundamental to human communication and the social functionality of places, sonic concerns are pertinent to the conservation of all heritage sites. Human perceptually contextualized site sonics—*aural heritage*, defined in the following section—are relevant to archaeology, and by extension, to heritage conservation. Therefore, we include theoretical and technical detail in our discussion here, to inform the normative intervention made by this sonically themed journal issue.

This publication arrives in a year when a global pandemic has abruptly altered access to archaeological and heritage sites, affecting the daily operations of many sites as well as their socio-economic relevance, and therefore changing the stakes for conservation resources and outputs. More than ever, research that documents human experiential aspects of heritage, such as sonic interactivity in archaeological sites, can aid in the development of new forms of preservation and access. Without data collected in sonic experiments, we can only imagine or estimate how sound moves around a site and is transformed by its architecture and setting. Acoustics imply embodied perceptual correlates for humans; experiential implications that can be studied directly via experimentation. By collecting data through on-site acoustical experiments as in our study, we discover and confirm what are contextually realistic possibilities for a fundamental communication medium and social substrate across human time: sound. Planned applications of our fieldwork data in virtual aural heritage interfaces will enable broader access and knowledge sharing of our research products, especially relevant in times when physical site access is limited.

Experimental methods such as ours that "re-sound" archaeological sites and materials fit established methodological frames for *experimental archaeology*—the physical testing and replication of processes in order to understand archaeological evidence.[4] This is a form of physical experimentation that puts ideas into practice in real-world conditions. Note that the somewhat different subjective research paradigm of psychoacoustical experiments has been applied in previous research at Chavín, following methods common to auditory and perceptual psychology (we discuss our extension of those studies in the next section). Widespread lack of familiarity with both experimental archaeology and archaeoacoustics can present ideological obstacles to the implementation and reception of acoustical fieldwork, as well as the integration of its research products in site publications. To address such knowledge gaps, this article focuses on our methodological rationale, collaborative process, and intended contributions.

Our case-study method enables researchers to evaluate and produce extensible data on the sonic experiential implications of cultural heritage, via group experimental explorations. Acoustical fieldwork that accurately examines how a site's features shape human-sonic interrelationships is not only about generating standard acoustical metrics (such as reverberation time or sound levels across frequency bands). In site-contextualized, "human-centered" archaeoacoustics fieldwork, we employ both human observers and a range of equipment to document both sonic dynamics as well as the environmental features that influence sound propagation and the place-specific ways that humans sense sound (such as climate factors and patterns of human activities, on different temporal scales). This aural heritage fieldwork approach generates multifaceted data from multiple perspectives, a record of site sonics that enables the production of functionally realistic virtual auralization demonstrations.

To create interpretative sonic interfaces, data from fieldwork is applied in the development of computational acoustical models based on measured acoustics of site spaces. The contextual realism of these data-driven models depends not only on objective data, but on perceptual documentation, and the use of archaeologically known or hypothesized sound sources. Both data-driven models and their application in auralization interfaces are forms of archaeological reconstruction, whose veracity depends on comprehensive and systematic data collection and the preservation of structures being modeled. Such demonstrative interfaces are useful both for the virtual testing of research hypotheses and for public interfacing, especially when physical access to sites is limited. Planning for such applications productively informs data collection and documentation strategies, not only prior to fieldwork, but responsively, during the on-site discovery process that is experimental fieldwork. In our 2018 fieldwork at Chavín, we prototyped a collaborative site-responsive research process to collect data that added to site knowledge and will be used to explore aural heritage through virtual technologies under development.

Our case study, though specific to Chavín, offers theoretical and methodological examples pertinent to the inclusion of sonic concerns in heritage conservation more broadly. We offer conceptual and methodological details about our fieldwork in a discussion that compresses the developments of more than a decade of innovative archaeoacoustics research at the site. In this article, we summarize this research background, then give examples of how we activated and documented Chavín aural heritage via our distributed sound-sensing paradigm for group collaborative archaeoacoustics fieldwork. The methodology we detail here is a systematic and collaborative approach to "re-sound material culture"[5] in the testing and documentation of "sonic archaeological possibility space,"[6] informed by acoustical science and psychoacoustics. We explain and exemplify technical terms as they relate to our sonic explorations of material culture at a UNESCO World Heritage Site, propose conservation applications of produced knowledge, and provide processual details to enable the adaptation of this method in other heritage sites. To begin, we define and describe our archaeometric "aural heritage" framing of sonic cultural heritage.

Aural Heritage Engagement and Data Collection via Collaborative Sound-Sensing Experiments

Aural heritage encompasses a range of human auditory and sound-sensing perspectives in heritage contexts. We prefer "aural heritage" over the more common "sonic heritage" because of its reference to human perception: these words together emphasize the human subjective and cultural perspectives about acoustical environments of heritage contexts that otherwise might be evaluated only in objective terms. The term *aural heritage* calls attention to the ways that humans feel, understand, and interpret sound relative to particular settings, inclusive of humans' range of sound-sensing perspectives on a deaf to hearing spectrum. This definition was proposed by our collaboration leader Miriam Kolar, both to situate our work at Chavín and to frame a more recent NEH-supported aural heritage project that she co-organized with audio engineers Sungyoung Kim and Doyuen Ko: "Aural heritage emphasizes human sound-sensing perspectives in the interconnection of sites and materials with *intangible heritage*: experiential features of building and site acoustics shape intangible culture, from basic communication to musical expression."[7] Aural heritage fieldwork benefits from expertise in domains foreign to many archaeological and heritage practitioners: acoustical science, psychoacoustics, and audio engineering. Yet, heritage applications of basic principles and tools from these fields are possible and productive even for non-specialists. Thus, in the case-study discussion here, we give conceptual and technical background, and include procedural and equipment specifications to facilitate adaptations of this method in other sites.

In the archaeological research context of our case study at Chavín de Huántar, and in continued work there, aural heritage research involves evaluating sonic interaction affordances of site materials in its highland setting, which can be measured via acoustical science techniques.[8] In our 2018 fieldwork, we conducted both metrical and perceptual documentation of researchers' systematic sound-producing interactions, as a group, within the extant built environment and its larger landform setting. We worked with an awareness—articulated during group discussions throughout our testing process—that Chavín's Andean Formative archaeological context for sound-sensing is distinct from the present social contexts of a World Heritage site where research, conservation, and tourism intersect daily. Despite this temporal and cultural gulf, extant site materials, the Andean highland environment, and human sound-sensing provide material and human physiological common ground between past and present.

The philosophical basis for our work is straightforward, yet not broadly applied in archaeological practice or heritage studies. We work from the premise that sound is a fundamental and immediate informant for humans; social and situational events and settings can be characterized in terms of acoustical features and their auditory perceptual correlates. Fieldwork that measures and describes what can be heard from where in a particular place, under what conditions, realistically informs archaeological use-function hypotheses and acoustical characterizations of architectural heritage. Acoustical, auditory and perceptual sciences together provide a rich theoretical and methodological foundation for evaluating the sonic interaction affordances of heritage sites and materials, to produce aural heritage data.

In our research, archaeometric archaeoacoustical fieldwork adds cultural contextualization to the paradigm established in spatial acoustics: to measure sound transmission and reception between sound source and receiver locations, producing extensible metrics. How spaces could have been used, based on their physical layout and material features is a fundamental archeological research problem that informs archaeological interpretations. In room acoustics and ISO-standardized soundscape research,[9] and in "human-centered" archaeoacoustics at Chavín, objectively measured sound is related to subjectively reported and/or metrically associated perceptual correlates. On-site sonic experiments in Chavín's well-preserved monumental core enable the physical and perceptual ground-truthing of sound transmission and reception, informing use-function analyses of extant site spaces, and providing data for computational acoustical models.[10] Detailed site acoustical measurements hone the precision of acoustical estimates derived from virtual architectural reconstructions: the accuracy of computational acoustical modeling techniques can be verified based on their alignment with measured data from the site spaces they model. Chavín's well-preserved architecture enables realistic evaluations of the sonic communication affordances of its architectural contours via field experiments.[11] Site contextualized computational acoustical modeling can leverage this data in virtual auralizations with the potential for architectural reconstructions.

Aural heritage fieldwork—as we characterize our case-study—involves collecting data on physical site features and contingencies of its setting relevant to sound generation, transmission, and reception, including human perceptual observations. On-site soundmaking enables the documentation of concurrent human activities, climate conditions, and the temporal patterns of these sonic contingencies, whose persistence over time can be estimated. In the fieldwork detailed here, we worked in a collaborative format to adapt our research procedures to each study location. Prior to our experiments, we tested sonics of site areas by moving, talking, and sounding instruments to determine survey locations for each set of recorded measurements. In collaborative discussions between experiments, we examined the relevance of our activities to hypothesized past configurations of people around the site. Throughout fieldwork, we developed and refined experimental configurations for survey locations of individual soundmaking and sound-sensing researchers, considering our assumptions about Chavín, acoustics, and listening. The data we collected reflect our testing of archaeological hypotheses about uses of site spaces, documenting sonic communication affordances with extensible metrics as well as individual perceptions.

In the following section, we provide research background through a summary of Chavín archaeoacoustics. In the subsequent methodological section, we highlight key aspects of our fieldwork process that was both an engagement and documentation of Chavín aural heritage. Throughout, we share observations about our research process via specific examples, rather than providing a metrical report of the data we generated: the adaptive way that researchers worked together in response to sonic activations of the site's built environment is central to this method. In conclusion, we re-visit the pragmatics of including sonic concerns in heritage conservation from the perspective of our research project and its potential for direct applications at Chavín.

RESEARCH CONTEXT & METHODOLOGICAL BACKGROUND

Archaeoacoustics at the UNESCO World Heritage Site, Chavín de Huántar, Perú

Chavín fieldwork and conservation over the past 26 years has been led by Dr. John Rick of Stanford University, with various Peruvian co-directors, including archaeologist Luis G. Lumbreras, who led site excavations in the 1960's and 1970's.[12] Sound has been part of Chavín's archaeological narrative since Lumbreras and colleagues' 1976 proposal for a "sounding temple" via architectural hydraulics; despite proposing architectural acoustical design as evidenced by "resonance rooms," they did not conduct acoustical fieldwork.[13] Rick's team's 2001 excavation of twenty use-worn, engraved *Strombus* conch-shell horns known as the Chavín *pututus* (plus an additional intact instrument excavated in 2018) evince acoustical specificity for ritual instruments previously associated with the site from depictions in stone and ceramics.[14] Initially, Rick and colleagues developed hypotheses about the *pututus* based on non-acoustical studies of these sound-producing instruments, although they made informal performance tests and enlisted an acoustician to estimate sounding metrics.[15] The most recent scholarship about the Chavín *pututus* includes their Pan-Andean contextualization by Mélanie Ferras, and Kolar's examination of their functionalities within the site's built environment and ritualscape, as multimodal tools in the expression of human-environmental relations at Andean Formative Chavín.[16] Sound-related, acoustical and performance research about the Chavín *pututus* began with the 2008 integration of an archaeometric archaeoacoustics project within the site research and conservation program, Programa de Investigación Arqueológica y Conservación Chavín de Huántar (PIACCdH), permitted by Peruvian governmental authorities.[17]

Acoustical documentation of the Chavín *pututus* initiated Chavín acoustics research by the Chavín de Huántar Archaeological Acoustics Project, a cross-disciplinary partnership inspired by a conversation between computer music pioneer John Chowning and archaeologist Rick at Stanford University in 2007.[18] With a preliminary goal of measuring the site's spatial and instrumental acoustics in order to develop customized computational acoustical modeling techniques based on archaeological data—models verifiable due to the site's well-preserved architectural contours—this project has pioneered archaeoacoustical methodologies, revealed ancient acoustical technologies, and contributed sensory analyses of site materials.[19] Following the team's 2008 fieldwork that included preliminary acoustical measurements of interior architecture known as "galleries" and acoustical measurements of 19 of the 20 Chavín *pututus* on display in the Museo Nacional Chavín, principal investigator Kolar moved her research base to Chavín to work year-round at the site through the 2012 field season.

One of the values of sustained and year-round fieldwork is the opportunity it provides to design, prototype, and refine site-responsive studies, informed by environmental factors such as annual climate cycles. During the initial seasons of archaeoacoustics fieldwork at Chavín, Kolar designed and implemented a systematic auditory evaluation of Chavín's architectural acoustics, a perceptual psychology experiment protocol approved by Stanford University's IRB for subjective research.[20] Over two field seasons in 2010 and 2011, local and international volunteers participated in a systematic study of auditory localization within Chavín's interior "gallery" architecture. The realism of studying humans' perceptions of actual architectural acoustics rather than collecting their responses to virtual simulations of spatial acoustics in a laboratory setting cannot be overstated: an on-site psychoacoustical experiment tests human sound-sensing in context rather than the mediation effects of loudspeaker or headphone simulations of acoustical environments. Although the Chavín auditory localization study generated direct auditory evaluations of architectural acoustics that accounted for participants' biases (the experiment design and findings are detailed in Kolar's 2013 doctoral dissertation), other forms of researcher-observer perceptual surveys without experimental controls can produce cross-temporally relevant data on aural heritage. One such approach is our method for collaborative distributed sound-sensing.

Performed Auralizations in Archaeoacoustical Fieldwork at Chavín de Huántar, Perú

Acoustical field experiments facilitate situational precision that is impossible in map-based modeling of sound transmission metrics; on-site testing captures real dynamics and enables contextual responsiveness in data collection. The sound sources in acoustical fieldwork are important; beyond standard acoustical test signals, contextually relevant sound sources ensure realistic testing for a particular archaeological site. At Chavín, the recent excavations of marine conch shell horns (the Chavín *pututus*, ocean animals transported to the highlands 3,000 years ago) evinced a ritually significant sonic communication device for that site. Therefore, we prioritized the use of replica *pututus* (*Strombus* shell horns functionally identical to the artifact instruments) in experimental testing as a proxy for one form of site-relevant sound. Using the language of experimental psychology, the *pututu* sound source established ecological validity (contextual realism) for our sonic experiments. To relate these specific, human-performed sound sources to more extensible acoustical metrics, we conducted acoustical calibration recordings for each of the replica horns used as sound producers (giving us actual sound level references and audio documentation to enable post-survey frequency analyses of each specific test instrument). In each of the test settings, we made impulse response measurements, an acoustical standard, for extensible comparison.[21] Our sonic experiments, primarily via *pututu* performance, constitute both a direct aural heritage engagement by researchers and on-site observers, and an application of "performative soundscape science"[22] with distinct advantages over abstract estimations and model-based simulations.

An important contribution of our work is its performative re-appropriation of the term "auralization," a term used in acoustics and audio research to designate computationally generated simulations of acoustics, such as virtual re-creations of musical performances in historical venues.[23] Kolar has proposed that on-site archaeoacoustical experiments should be considered "performed auralizations" of archaeological scenarios, because the process of producing any auralization is both reconstructive and interpretative, just as for creating computational auralizations.[24] However, unlike archaeological auralizations, computational auralizations are not typically evaluated in terms of their contextual realism; rather, they are assessed according to technical fidelity, including the translation of standardized acoustical parameters and metricized human listener perspectives. Performed auralizations in on-site fieldwork, in contrast, leverage the reconstructive realism of re-sounding site settings with contextually plausible soundmakers, enabling the documentation of perspectives of in-situ listeners. The representation accuracy of *virtual* archaeological auralization interfaces developed from such comprehensive sounding-sensing fieldwork data is improved by the contextual realism translated in that data. These conceptual and functional distinctions are important to our project, and they informed our development of research protocols to collect acoustical and aural heritage data that can be used in the creation of realistic auralization interfaces for virtual preservation and access.

Site-interpretative performed auralizations, as employed in our 2018 fieldwork at Chavín, mediate between present-day site experiences and archaeological knowledge, producing data and documentations that can later inform computational auralizations for interpretative public interfaces as well as research modeling. Performed auralizations "re-sound material culture," a form of "reconstructive interpretation . . . [that] emphasizes the plausible rather than speculative."[25] The material-functional premise of performed auralizations in archaeological sites ensures an objective basis both to experiential research, and to applications of the data in virtual reconstructions.

COLLABORATIVE DISTRIBUTED SOUND-SENSING: A CASE-STUDY AT CHAVÍN

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Figure 1. Archaeoacoustics researchers position audio recorders, sound level meters, and a mobile wind-metering device as visitors pass through the site's interpretative route that includes the 49-meter-wide Plaza Mayor at the UNESCO World Heritage site at Chavín de Huántar, Perú.

A Site-Responsive Method for Aural Heritage Fieldwork: Premises and Process

The site-responsive, research-reflexive, and iterative archaeological fieldwork process we describe here was efficient and effective in producing data representative of simultaneous multiple sound-sensing perspectives on humanly performed sound sources in acoustical contexts. Beyond its contribution to Chavín research, our collaboration was a proof-of-concept trial for a sound-sensing team strategy to employ consumer mobile devices for sound-level metering, using a variety of portable sound recorders. The use of readily available tools can broaden the possibilities for doing aural heritage fieldwork, enabling metrical sonic research.

In our fieldwork, we extended the comparative methodology developed by Kolar in previous experimental archaeoacoustics fieldwork at Chavín and Huánuco Pampa.[26] That paradigm builds on the spatial acoustical measurement practice of tracing sound transmission and reception. Pairs of researchers test and document relationships between acoustical survey points for 1) sound production (source) and 2) reception (receiver) across multiple survey points within a study location. In Kolar's method, human-performed, archaeologically realistic sound sources are repeated for each pair of survey points, in addition to standard acoustical test signals, in order to establish contextual realism in soundmaking and produce cross-comparison analyses of acoustical affordances.[27] We calibrated sound source production via direct sound-level metering and audio recording of representative soundings (e.g., the readily produced sounding tones, on *Strombus pututus*) taken at 1m, on-axis from the source, repeated to produce average and range data for both level metering and frequency content.

Our group method emphasizes systematic, comparative and corroborative research design. Comparisons across multiple points of reference regarding the same event, and repeated measurements of different events using the same soundmakers in the same survey points are two strategies we used to ensure precision in data capture, to account for variations in the performances of soundmakers or environmental conditions. We calibrated audio recordings to real-world sound-level measures taken of the recorded soundmaking events, for an absolute reference. Systematic research design with reference measures can help compensate for the lack of precision in measurement and documentation equipment (such as the variety of audio recorders and sound-level metering tools we used), enabling data collection that is reasonably representative of measured contexts yet logistically feasible for a wide variety of projects. For example, variations in human-performed sounds can be ranged and averaged over repeated performances; variation in equipment-sensing capabilities can be comparatively assessed via interchange of sensors between measurement positions, and/or via calibration measurements of metering devices.

In *collaborative distributed sound-sensing*, the term we are using for this fieldwork paradigm, each researcher has a role in the collective group experiment to track and document the transmission and reception of sound in a particular test, with some researchers serving as sound producers. As a group of twelve researchers, we worked together simultaneously in each surveyed area, with researchers distributed spatially to occupy different sounding and sensing survey points within that area. This spatial distribution of sound-sensors (humans outfitted with different forms of measurement and documentation equipment) enables the efficient documentation of sound reception at several locations simultaneously, as well as analytical cross-comparisons to address variations in sound production and sensing. In our study, spatial acoustics were systematically tested and documented across the survey points that we determined by 1) group evaluation of human-spatial scenarios afforded by the built environment, and 2) suggested by archaeological site knowledge: What places might humans be in relationship to one another, in a site area, given particular social use scenarios for that space? Through iterative testing and frequent dialoguing regarding observations of different team members located across the multiple sensing points, we identified setting contingencies, and refined or generated new site-responsive research questions, as discussed in the next section.

The group reflexivity built into our research paradigm is a strategy more often associated with post-processual archaeology than with experimental science, yet we consider research reflexivity intrinsic to rigorous work on human experience. Our regular and contextually responsive dialoguing (Fig. 2 {ED note: previously "Fig. 4" -- the 3-part image of group discussion}) provided opportunities to check in with each other and to confer with other Chavín researchers, such as archaeological project leader Rick and geoarchaeologist Daniel Contreras.[28] Our discussions while exploring research settings included observations of functional contrasts between fieldwork areas, critiques of our documentation strategies, and clarifications of our assumptions and knowledge regarding Chavín, sound, and archaeological inference-making. We found, as Goh had previously expressed in her discussion of "sounding situated knowledges" that "archaeoacoustics . . . can act as a disruption in what the knower knows, or believes to know, or be able to know."[29] Aware of the inferential positionality of our present experiences with respect to different forms of knowledge about the past, we worked our way into the sonic communication substrate of the Chavín "ritualscape."[30]

<<INSERT FIG 2 NEAR HERE {FORMERLY FIG 4 (3-part image with group discussion)}>>

Figure 2. Dialoguing during fieldwork enabled us to define and refine research questions, experimental configurations, and workflow processes (*left* and *right*). The multi-researcher, distributed-sensing paradigm allows for simultaneous exploration of contrasting human situational perspectives, such as standing vs. sitting (*center*), here in Chavín's Plaza Mayor.

Our fieldwork was simultaneously an investigatory process and a sensory engagement of archaeological materials for both researchers and the observers of our fieldwork, who often became impromptu research participants and shared in the experience of processual heritage engagement (as shown in Fig. 10). Tangible research products beyond multifaceted acoustical, perceptual, and climate data include photo and video documentation that can aid in the contextualization of the other forms of data, or contribute to knowledge sharing, as with this article. We discuss our conservation contributions and proposed research extensions in this article's conclusion.

Tools for Aural Heritage Experimentation: Site-Realistic Sound Sources and Distributed Sound-Sensors

Our collaborative engagement of Chavín sonic communication dynamics extended prior site archaeoacoustics research regarding sound transmission and reception affordances of key locations in the site's built environment: the outdoor setting of the Plaza Mayor (Fig. 1 and 2, above; Fig. 4, 5-7, and 10, below), and the indoor settings of the Laberintos and Doble Ménsula Galleries (Fig. 3, 8, and 9, below). We conducted distributed sound-sensing studies of indoor (gallery) spaces for methodological complements and contrasts to Kolar's previous acoustical research and psychoacoustical study of those Chavín galleries via auditory localization experiments in 2010 and 2011 fieldwork.[31] Sound production for our experiments was based on systematic performed auralizations with replica *Strombus pututus*. *Strombus* replica horns such as those we used were tested and verified during the archaeoacoustics team's 2008 acoustical measurements of the Chavín *pututus* within the same acoustical production range as the site-excavated *pututus*.[32] For our indoor studies, we re-enacted the previous auditory localization experiment's locational relationships among sound source and listeners/receivers for our survey points (soundmaking and sensing locations), performing auralizations via replica *Strombus pututus* to collect multiple forms of data from distributed sound sensors, simultaneously.

For Chavín, *Strombus pututu* and human voice are the only archaeologically certain soundmakers during site use in the Andean Formative period, though other Andean sound-producing instruments could be representative, especially bone and ceramic flutes and whistles. A human-generated impulsive sound from a "percussion instrument" (in western musical terms) is archaeologically arguable via ethnographical analogy and referential materials. Though such soundmakers are not known at Chavín, elaborately carved staffs appear in Chavín iconography, and are known throughout Andean prehistory. Therefore, for Chavín, *pututus* serve as archaeologically established soundmakers, and wooden clappers approximate the acoustical impulse standard while demonstrating a contrasting and archaeologically plausible form of sound production: hand-held percussion (shown in Fig. 3, below).[33]

<<INSERT FIG 3 NEAR HERE {FORMERLY FIG 2 image}>>

Figure 3. Collaborative distributed sound-sensing at the Plaza Mayor at Chavín, where sound-receiving researchers located around the plaza, terraces, and surrounding buildings make various forms of measurements and documentations of contextual factors and human-performed sound sources with ecological validity (contextual realism) for Chavín. Gestural wooden clappers, as shown, provide an approximation to the idealized impulsive sound sources used in standard spatial acoustical measurements, while providing a proxy for human percussive soundmaking.

We chose Chavín's largest public gathering space, the Plaza Mayor, as the focus of our outdoor experiments, a site area not well-studied in previous archaeoacoustics fieldwork. Our collaborative sound-sensing fieldwork began outdoors on 2 July 2018 with an on-site meeting on the terrace overlooking the countersunk 49-meter-wide plaza (Fig. 1, above). Because fieldwork team members had not previously participated in archaeoacoustics research at Chavín, our group discussions for experiment planning were prefaced by Kolar's overview of prior site archaeoacoustics research, including an explanation of the comparative method for "human-centered" archaeoacoustical fieldwork, and rationales for aural heritage research.[34]

Documenting aural heritage relates measurable material culture to its human experiential potential. A key technical concern of our study was to prototype and document the challenges and efficacies of a mixed variety of measurement and documentation tools, distributed spatially across sound surveyors. In this experimental construct, all sound sensors, humans and equipment, together constitute a reception system whose elements can be mapped to coordinates. In the case of our outdoor work at Chavín, survey positions can be aligned with site GIS data, despite the inaccuracy of taking GPS readings at Chavín (and we took them, with various devices, anyway): approximate sound-sensing locations can be geometrically honed by extrapolating source-receiver distance relationships from acoustical events documented in the experiment audio recordings. From temperature and humidity data taken during each test, the speed of sound in air can be calculated and used for accurate determination of distances between sound sources and audio recorders. This analytical technique can also be used to identify acoustical reflections from architectural features whose distances relate to timing, to map sound-sensor positions relative to the built environment. At the same time that audio recordings and sound-level metering enabled us to metrically document acoustics, researchers' observations through handwritten/typed notes and in audio-recorded group discussion produced individualized assessments of the experiential aspects of setting contextual sound-sensing. Objectively measured dynamical data was thus relatable to simultaneous human experiences, producing realistic examples about sound-sensing within Chavín's built environment. Cross-comparing these individual observations highlighted perceptible environmental features, such as the intensification of wind interference in outdoor settings from mid-late morning into the afternoon, or the visual-aural disjuncture for sonic events in and around the Plaza Mayor.

Our use of distributed sound-sensing equipment (for sound-level metering and audio recording) provided an objective means of documenting performed auralizations across site spaces. We used a combination of different audio recording setups to test the efficacy of a coordinated use of a variety of digital audio recording devices, ranging from consumer electronics to professional audio and acoustical measurement equipment. For cross-comparison with previous Chavín archaeoacoustics research, we included tools previously used at the site and productively employed in fieldwork elsewhere.[35] Some equipment, such as portable audio recorders on tripods (we used a Zoom H2N digital audio recorder) set at 159 cm above ground to approximate the ear-height of one of the researchers, were electromechanical sensors that produced digital data, either independently located or co-located with human perceiver-documenters of sound. Other audio recorders were associated with specific researchers who wore their attached microphones to approximate ear-position reception of sound in human listeners. We had two binaural microphone systems worn by researchers: the first was a custom set of Sennheiser in-ear microphones through a Grace Lunatec preamp/converter whose digital output fed a Sony PCM-D50 portable digital audio recorder, and the second was a set of Core Sound Binuaral Microphones, which were clipped on to different researchers' hats and fed a small Sony voice recorder (as shown in Fig. 4 and Fig. 10). Measurements of ambient climate conditions included temperature and humidity metering, and the metering wind speed and direction using the WeatherFlow WINDmeter attached to a mobile phone (an iPhone 6) with its corresponding app.

<<INSERT FIG 4 NEAR HERE {FORMERLY FIG 3 image}>>

Figure 4. Collaborative distributed sound sensing in the Laberintos Gallery at Chavín, showing researchers using mobile sound level metering and three different audio recording systems that include 1) hat-mounted binaural microphones (*left, foreground*); 2) stand-mounted microphones attached to a portable audio recorder (*left, background*); and 3) a stand-mounted audio recorder with onboard microphones (*right*).

Sound-level metering is a real-world calibration measure to accompany audio recordings and subjective perceptions that grounds those data with an objective, absolute metric. In our study, we used two digital sound-level meters (RadioShack and BAFX) and took the opportunity to field-test the use of consumer mobile devices (in our case, cellphones) for sound-level metering. One of the technical complications in using mobile phones, tablets, and laptop computers for audio recording or sound metering is the variability in configuration of their embedded microphones, as well as the audio signal processing in the hardware-software systems that mediate between the microphone electromechanics and any software application that records and/or analyzes the incoming signal. However, the use of an attached microphone, such as the Dayton Audio iMM-6 calibrated measurement microphone, provides a physical extension of an omnidirectional microphone as used in standalone sound-level meters, increasing the accuracy of metering.[36] We had seven iMM-6 microphones (each with its own calibration data) available for our study, which we employed, with the exception of cellphones that lacked adapters permitting mic plug-in. Researchers used both the DecibelX Pro and NIOSH audio metering mobile apps, depending on their device platform. Attention to such technical details, with built-in methods for estimating error (calibration data and cross-comparative analyses, with reference measures), ensured that despite the variety of equipment used, our sound-level measures could be assumed to vary within a perceptibly small range, and any outliers were readily identifiable.

In summary, key methodological principles of our case-study fieldwork included:

1) A site-situated, "human-centered" approach to data collection and documentation, in which audio recorders/microphones were placed at locations that

humans could occupy, at approximate human ear-heights.

2) Survey points that represented plausible locations for humans to produce and sense sound, with respect to architectural and landform features and/or archaeological evidence and hypotheses about spatial use.

3) A comparative descriptive experimental method that held a constant while documenting variation among other aspects of the survey: for example, a cross-comparison of different sound sources evaluated through objective metrics and subjective observations together at one sound receiver location, or, cross-comparing spatial acoustics via objective metrics and subjective observations together at different receiver points for each source location.

4) Documentation of a range of sensing variables that relate context to individuals: a) researcher-observer perspectives and perceptions on sounding events and receiver positionality; and site temporality: b) observations of local temporal-contextual events and the changing climate conditions that affect sound speed, including temperature, humidity, wind speed and direction (data important to accurate estimations of distance relationships in audio recordings). Documentation modalities included written observations and photo/videography to capture visual perspectives and relationships among survey points, participants, and setting contingencies. Multiple, simultaneous forms of documentation enable cross-comparison during the analytical process and any future reconstructive applications of the data.

5) Distance, dimensional, locational, and acoustical calibration measures for real-world, extensible references; for example, repeated and averaged sound-level

measures at specified distances from sound sources to account for performance and testing variations.

In the following two sections, we describe implementations of our method for aural heritage fieldwork experiments in Chavín's well-preserved built environment.

Outdoor Collaborative Distributed Sound-Sensing at Chavín: Studies in the Plaza Mayor

Collaborative archaeoacoustical fieldwork, in the paradigm we propone here, involves more than just group on-site acoustical measurements: it incorporates iterative discussions (and documentation) of researchers' observations during fieldwork (regarding both research process and sound-sensing), and cross-comparisons of those experiences. This section highlights researchers' observations about sonic experiments in Chavín's Plaza Mayor to provide readers with specific examples from our on-site experimental process; we explain how these situational observations informed our investigation and strengthen the contextualization of acoustical survey data for future reconstructive applications. Interspersing experiments with group discussions about observations enabled us to generate and refine realistic research questions about experiential dynamics that we applied in systematic tests to document site sonic affordances with extensible metrics. This site-responsive, iterative research structure grounds the work materially and phenomenally, reflective of the site's architectural landform interventions engineered three millennia ago.

<<INSERT FIG 5 NEAR HERE>

Figure 5. Researchers served multiple roles in fieldwork experiments during which they documented their perceptual observations: not only as sound-sensors, but as sensing performers of *Strombus pututus* (conch shell horns), here shown in Chavín's Plaza Mayor. We used replica shell instruments to approximate the site-excavated *Strombus Lobatus galeatus pututus*, and we also compared the performance of large horns of that species with that of a smaller *Strombus Lobatus peruvianus* (*right-most* horn).

<<INSERT FIG 6 NEAR HERE>>

Figure 6. Distributed collaborative sound-sensing configurations for sound transmission measurements and documentation of stationary *pututu* performance, including simultaneous sound production from two *pututus* (left and right): "performed auralizations" from various locations including between staircases on opposite sides of Chavín's Plaza Mayor.

The following researcher observations exemplify how the fieldwork experience is itself an aural heritage engagement for those involved: they are experiencing the heritage site aurally as human sound-sensors, even while operating measurement equipment or producing sounds. Research immersion in various experimental scenarios and roles enabled us, a group of twelve researcher-participants, to generate new research questions and immediately test and discuss our sound-sensing exploration of those sonic scenarios. That is the productive potential of collaborative site-responsive research experimentation: site archaeology and methodological premises drive explorations, but the realistic contingencies of the built environment and its contextual affordances inform the discovery process.

In documenting one afternoon's survey of sound transmission across Chavín's Plaza Mayor,[37] three researchers who performed *pututu* sound sources (Fig. 5 and Fig. 6, above) offered both distinct and corroborative observations:

> 1) William Penniman, who performed the sound source of *Strombus Lobatus peruvianus pututu* especially noted perceptions about his own performance: "When playing with other people I could hear their resonance in my ears and it seemed louder when we were standing on top of the terrace, compared to standing inside the plaza."
>
> 2) Brian Morris, who performed the sound source of *Strombus Lobatus galeatus pututu* (with the resin smoothing of its mouthpiece), offered a suggestion for a workflow improvement related to multimodal communication across the plaza: "Vocal cues instead of hand signals would have been helpful for knowing when to

go [play], or one person signals the player."

3) H. E. Gálvez-Arango, who performed the *Strombus Lobatus galeatus pututu* "A" with a tube-modified mouthpiece, focused on observations about sound production qualities and implied mechanics, noting that "Will's *pututu* was the most consistent in terms of pitch and volume," and proposing that "it is highly likely that all of our pitches gradually lowered after the plaza was covered in shadow. Will's may have been more vulnerable to temperature changes due to its small size, but he may have adjusted for it."[38]

These observations, taken together, provide a multidimensional understanding of specific acoustical-performative interaction affordances of *Strombus pututus* within Chavín's 49-meter-wide Plaza Mayor that is flanked by broad terraces and tall buildings on three sides. Plaza architecture exists in a context of well-preserved landscape engineering including the diversion of a river around the plaza's perimeter.

Through our experiments in Chavín's largest extant plaza, we defined and explored the following research questions. These questions can be further addressed in data analyses and data-driven modeling to better characterize the architectural substrate of cross-plaza communication dynamics that would have affected human interactions in the Andean Formative period:

1) How do the acoustics of these stone walls, grassy terraces, and stone steps differently affect acoustics and thereby performance practices/decisions? For modeling estimations, what are the communication affordances of large architectural forms in their current conditions versus structural reconstructions and material variations?

2) What are the interaction effects between visual and sonic cues for perception of performative event timing (and source localization) around the plaza, such as rhythmic sound production or multimodal theatrical gestures?

3) How do diurnal cycles and weather conditions transform site acoustics, and what aspects of Chavín's built environment might have been structured in response to temporal-cyclical effects on its communication media and modalities (e.g, wind disruption of human vocal communication, versus the use of *pututus*, which are more robust to windshear)?

These collaboratively developed, site-responsive research questions bring a higher degree of contextual realism to the experiential scenarios we seek to simulate through analytical modeling and in virtual demonstrations of site acoustics. Measured and recorded acoustical data ensures a realistic basis for dynamical modeling of human experience at Chavín from materials, setting, and human sound-sensing perspectives. Such detailed and accurate information requires systematic fieldwork: comprehensive sound-sensing data cannot be abstracted from videos of human activities at the site, or extrapolated from maps, among other documents that are sometimes referenced as sensory data. Site-responsive experimental fieldwork generates the processes and positionality that together activate the aural heritage of Chavín's built environment.

In response to our experiences of performing *pututus* and tracking their sound transmission and reception around the Plaza Mayor, collaborator and competitive marching band veteran Gálvez-Arango designed a performance experiment to explore spatial acoustical effects on sonic-gestural performance coordination. In the Plaza Mayor, the cross-modality of listening/sound-sensing and visual cueing, which de-synchronizes over distance, creates particular perceptual discrepancies. Strong acoustical reflections from surfaces around the plaza, including its terraces, staircases, and the larger buildings in the more distant surroundings, seem to complicate the coordination of human gestures and sonic performance timing within, across, and around the plaza. In order to gather data regarding this hypothesized setting affordance, we conducted a systematic multimodal performance experiment (Fig. 7, below) on the afternoon of July 4th. The following notes from Gálvez-Arango describe this experiment:

> This systematic study was meant to help move towards answering a larger question about potential musical/ceremonial uses of Chavín's Plaza Mayor. Does it seem plausible that this space was used for large-scale synchronized sonic activities (crowd clapping along with temple musicians, call-and-response singing, etc.) or would the timing of echoes around the plaza architecture make it too difficult for people to accurately respond to auditory cues? To mimic the experience of musical synchronization between human performers, I created a testing scenario with a human 'clapper' who provided the auditory-visual stimulus with which to coordinate, and a participant 'responder' who would try to synchronize their clapping with that of the clapper after a 10-clap demonstration for each stimulus (I created several different test scenarios, for different proximities of clapper and responder, separated by increasing distances across the plaza). Coordinating with click tracks that I prepared for my own listening through an earbud, I served as the clapper, and several research team members with varying levels of musical experience served as the responders. Each responder individually completed a set of twenty-four trials, differentiated by

tempo, distance between clapper and responder, and clapper position.[39]

<<INSERT FIG 7 NEAR HERE>>

Figure 7. Two testing conditions in the multimodal perceptual experiment to explore affordances for performance synchronization in Chavín's Plaza Mayor. In the experiment, a human 'clapper' (*right-most* researcher, in both photos) provided the auditory-visual stimulus (coordinated by listening to an earbud-delivered click track) for volunteer participant 'responders' from the research team (*left-most* researcher, in both photos) who tried to synchronize their clapping with the 'clapper.'

As these examples demonstrate, our experimental fieldwork positioned sound observers simultaneously or sequentially as sound producers. For real-world situations such as those we approximated for humans in various areas of Chavín's monumental architecture, the perception of a sound environment relates to being a soundmaker: how one plays a *pututu*, for example, depends on the particular acoustical feedback in the place where one is performing it. Therefore, when researchers engage in soundmaking-sensing, we form interactional relationships with the environments that we are studying, with extant aural heritage. The contextual realism of re-sounding archaeological spaces in this way is clear: through on-site sonic experiments in well-preserved heritage contexts, we can empirically document temporally persistent material-situational affordances that would have influenced prior human experiences in these settings.

Indoor Collaborative Distributed Sound-Sensing at Chavín: Multiple and Moving Sources in Chavín Galleries

The sessions during our 2018 collaborative fieldwork that took place inside Chavín galleries were designed to produce cross-comparable data with Kolar's previous auditory localization studies, by replicating her experiment's sound source and listener positions in Laberintos and Doble Ménsula Galleries with our distributed group of sound-sensing researchers, with measurement and documentation tools. For these tests, we produced sound via live *pututu* performers rather than the prior experiment's use of calibrated loudspeakers to play an audio recording of a Chavín *pututu* at each source position (for experimental consistency in the auditory localization study, it was important to have an identical sound stimulus for each testing condition) and we also incorporated moving sound sources, a contrasting and plausible scenario.[40] Using replica *Strombus pututus* as soundmakers that approximate the performative functionality of the site-excavated *pututus*, we were able to experiment on a range of perceptual correlates for documented acoustics in two indoor areas of Chavín's built environment.[41]

<<INSERT FIG 8 NEAR HERE>>

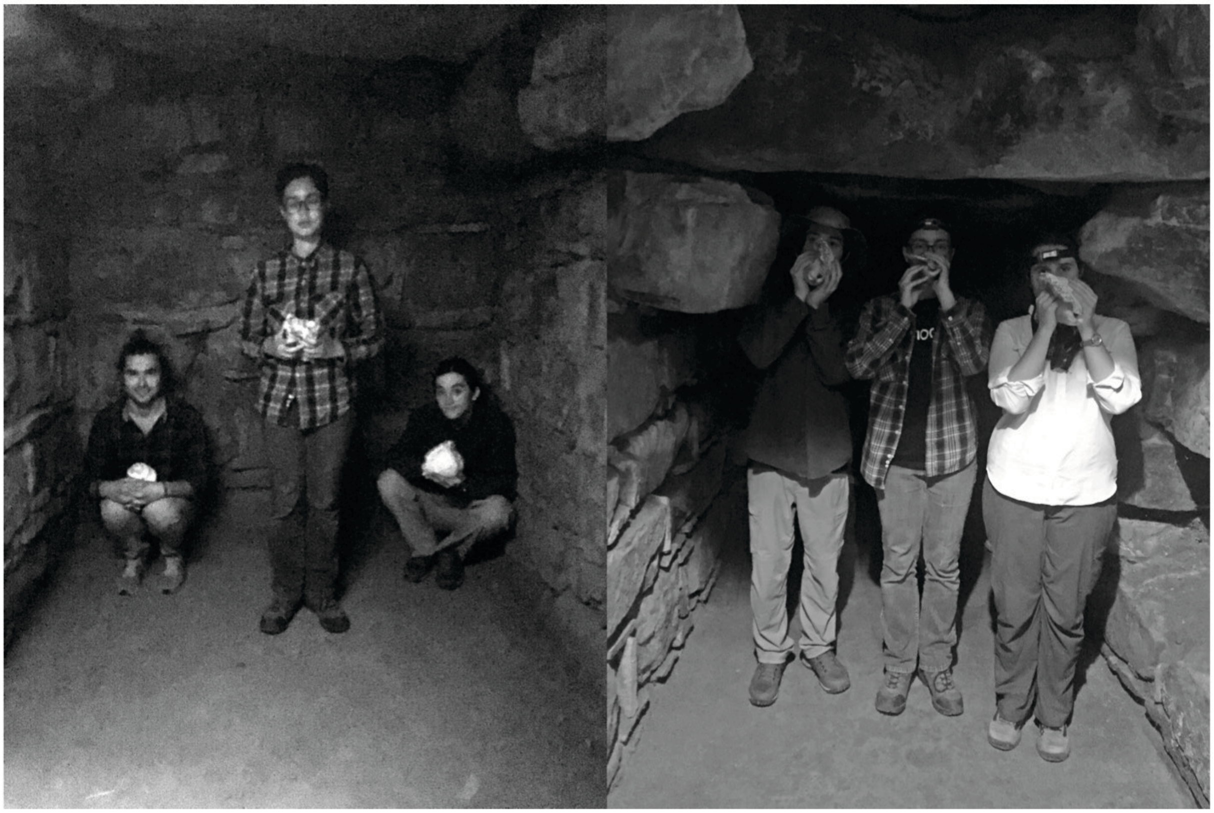

Figure 8. Distributed sound-sensing experiments included performed auralizations of *Strombus pututu*s within Chavín's Laberintos (*left*) and Doble Ménsula (right) Galleries, both stationary from survey points and in processional movement indoors to outdoors. We performed *pututus* individually and in groups of multiple instruments.

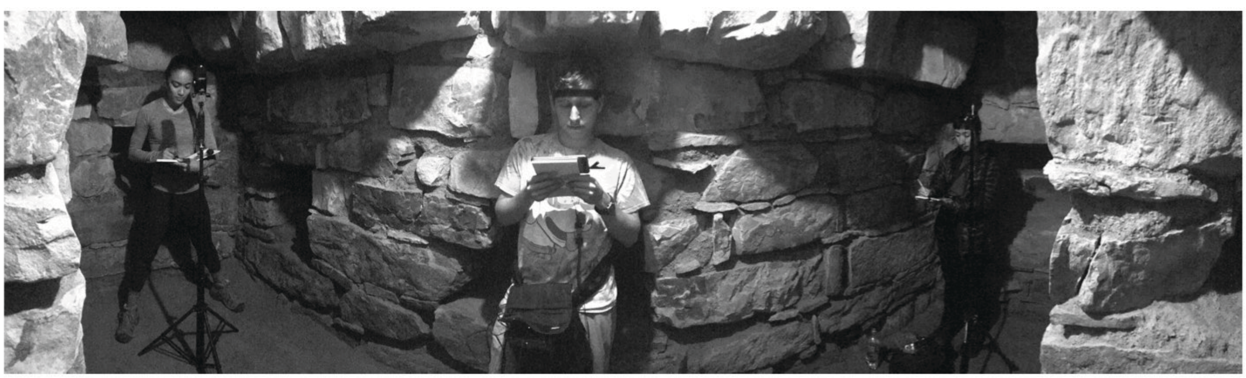

Figure 9. Collaborative distributed sound-sensing within one room in the Doble Ménsula Gallery at Chavín. Researchers documented their reception of *pututu* sound sources via handwritten notes and they made sound-level readings using a sound-level meter and sound-level metering apps on mobile devices, with simultaneous recorded audio for post-survey analysis, using a variety of devices, including: 1) a portable audio recorder with on-board microphones (*left*); 2) in-ear, binaural microphones into a professional preamplifier/converter and portable audio recorder (*center*); and 3) a portable audio recorder with an external, stand-mounted stereo microphone array (*right*).

<<INSERT FIG 9 NEAR HERE>>

Pututus as sound sources within the galleries (Fig. 8, above) create notable sound effects that researchers, participants, and visiting musicians have discussed in many contexts, as detailed in other Chavín archaeoacoustics publications.[42] During our two indoor research sessions to study *pututu* performance in Laberintos and Doble Ménsula Galleries, Goh, an artist and sound studies scholar who joined the team for her first archaeoacoustics fieldwork experience, observed the following:

> I and some of the other team members who were in the previously studied auditory localization listener locations in Doble Ménsula Gallery recording decibel levels (Fig. 9, above) began to discuss the experience of listening to the *pututu* horns in the spaces, isolated as we were visually from each other in the dark, rectilinear passages of the gallery. The idea emerged for us to request the three *pututu* performers play together in procession through the corridor of the inter-connected rooms which forms a pathway of some dozen metres from the furthermost point to its staircase and entrance. This impetus came from conversations of previous days where discussions had circled around Rick's theorisations of processions at Chavín, and ideas of experimental and performance archaeology, particularly during the time we spent doing tests outside on the Plaza Mayor. As a group we had discussed the performativity of such rituals and how a manipulation of sensory experience as theorized by Rick would perhaps have played on dynamics of presence and absence, disappearance and re-appearance with perhaps the

> movement of human bodies through the internal ducts from the open spaces of the Plaza Major and Plaza Minor for the purposes of creating a spectacle. . . . The result of the moving sonic improvisation[43] was an extremely powerful bodily experience. The volume of the three *pututus* sounded at once reached in excess of 110dB at places according to measurements. The players of the two larger *pututus* played long tones as they walked through the gallery, whilst the player of the smaller *pututu* played shorter, rhythmic bursts of sound. The long tones, similar in pitch, of the two larger *pututus* created an acoustic interference pattern known as a 'beating-tones effect,'[44] whilst the shorter tones aimed against different elements of the architecture had a disorientating effect, as the perceived direction of it was constantly shifting unusually in space. The drone-effect of the improvised procession of the three *pututus* created a thick, numbing intensity on my body and ears.[45]

Goh's field notes reflect aural heritage engagement as both a research process and archaeological knowledge production, and provide a descriptive documentation that can extend the accessibility of aural heritage documentation to those who may not hear audio or see video, for deaf or blind audiences, for example.

Our example of archaeologically situated group soundmaking, listening, and documentation enacts a material connection between ourselves as "site-present" humans with those of ancient Chavín. Aural heritage engagement is specifically about the awareness of human presence in places through sound. Although we cannot know specifically where or how *pututu* performers in ancient Chavín sounded these instruments, our reconstructive proxies have demonstrated plausibly experienced dynamics for both performers and sound-sensors, and provided metrics on spatial contingencies that shape human expressive decisions and sonic experience in the site's built environment. As exemplified in the performance and listening observations shared above, the collaborative, iterative research process we prototyped enables group interactions with aural heritage that simultaneously produce data for virtual preservation and access.

Site Visitors in Aural Heritage Research: Group Chanting in Chavín's Plaza Mayor

In addition to an aural heritage engagement for researchers and the production of site archaeological data, our fieldwork paradigm suggests opportunities to involve site visitors in performative experiments. While measuring sound transmission across the Plaza Mayor, we invited a guided group of site visitors (approximately 55 people) to produce a performed auralization of coordinated group chanting, in which the group was congregated along the west side of the plaza, facing inward (Fig. 10, *center*). We measured their produced sound levels at various locations and documented this impromptu experiment with video. Explorations such as these re-situate site visitors as active constituents of World Heritage—as participants in archaeological research and aural heritage documentation—and they demonstrate the relevance of present-day soundmaking-sensing to realistic understandings of past experiences at a site. This large-group soundmaking example is the recreation of a social condition that can produce metrics extensible to hypothetical past events or conditions; experimental *and* experiential archaeology.

<<INSERT FIG 10 NEAR HERE>>

Figure 10. Aural heritage fieldwork at Chavín involves performed auralizations, including archaeologically appropriate sound sources such as *Strombus pututu* (*left*) and tests of a group of human voices (here, about 55) via an impromptu visitor engagement (*center*), constituting a direct engagement of aural heritage through "re-sounding" site materials. Collaborative distributed sound-sensing research documentation in 2018 fieldwork took many forms, including audio recordings that produce human listening perspectives through the use of binaural microphones: shown here, hat-mounted (*right*), emphasizing "human-centered" archaeoacoustics.

Our site-responsive, reflexive, and iterative research process was efficient and effective in producing data representative of simultaneous multiple sound-sensing perspectives, in order to create a more comprehensive understanding of sonic communication affordances in each site area we explored. Beyond its contribution to Chavín research, our collaboration was a proof-of-concept trial of a distributed sound-sensing method employing consumer mobile devices and portable sound recorders. The systematic use of readily available tools can lower logistical barriers to implementing acoustical fieldwork in heritage sites, yet produce robust data.

DISCUSSION: ENACTING AND CONSERVING AURAL HERITAGE AT CHAVÍN

Our collaborative case study prototyped a fieldwork method for direct, sensory engagement and dynamical documentation of archaeological materials through human-sonic interactions. On-site experiments that quantify material activations offer an informative complement to the static representations typical in the documentation of archaeological materials (e.g., diagnostic object descriptions and stratigraphy diagrams), to inform both site research and public interfacing. We demonstrated how site interactions might be re-imagined, if sensory research questions are explored collaboratively, iteratively, and inclusively. We also addressed the knowledge translation problem of involving constituencies beyond site researchers by engaging tourists in a sonic experiment; with that example we propone that heritage public programming can be coordinated with research activities to include site visitors in acoustical experiments as they pass through tour routes.

Central to the approach we present here is the idea that experimental archaeology is a heritage engagement, as much as its more tangible research products: data and interpretative interfaces. *Intangible culture*, as defined by UNESCO, includes many sound-related inter-human and human-environmental engagements.[46] The process of enacting experimental research is itself a form of intangible culture that activates material cultural heritage. Therefore, both our research process and produced data constitute *direct* sound-related engagements with the archaeology of Chavín. Any direct engagements—whether research or touristic—with Chavín architecture and preserved archaeological materials are only possible due to its history of site conservation.[47]

Knowledge of site reconstruction histories is important in evaluating and adequately contextualizing present interactivity, as in our experimental sonic activations of site spaces. Although Chavín's monumental architecture remains substantially intact, there are reconstructed elements that may not be obvious to visitors and even some researchers. During its several hundred years of monumental construction, Chavín's architecture changed, so knowledge of its construction sequence, as documented extensively by Silvia Kembel, and updated through subsequent site research, crucially informs research.[48] As we apply our fieldwork data to the development of virtual models and auralization simulations (that offer the opportunity to model reconstructed architecture and estimate the acoustics of prior structures) it will be useful to survey documentation about the mid-late 20th century architectural reconstructions by site caretaker Marino González and associates.[49] For any heritage site, its preservation record is relevant in the design and presentation of reconstructions, whether material or virtual, visual, sonic, or in combination.

Virtual acoustical reconstructions for demonstrative knowledge sharing are work-in-progress with our fieldwork data. As we design these sonic public interfaces, contextual contingencies and interpretative assumptions documented in fieldwork will inform these aural heritage exploration interfaces. Experiential simulations of any heritage site benefit from annotation regarding data sources for reconstructions and rationales for interpretations expressed in their presentation. Virtual sonic demonstrations of archaeological and heritage materials present novel research and development opportunities. Analogies with paradigms from the well-established field of visual reconstructive modeling that can inform conceptualizations of interactive aural heritage interfaces. In visual reconstructive modeling, one strategy used to differentiate extant from reconstructed architecture (or to parse its temporality) is to contrast colors and/or transparencies of forms. In auralization models, multimodal information delivery including narration over audio and through text are useful ways to inform listeners about the contingencies of reconstructions. In one archaeoacoustical demonstration paradigm we are developing for Chavín virtual auralizations, alternate scenarios are accompanied by a guide for listeners to compare specific features with graphical annotations and text transcriptions that enhance accessibility.

As we develop public interfaces about Chavín aural heritage, the reception of sonic engagements of cultural heritage is a point of particular concern. *Change Over Time's* current theme, "Sounding Heritage," indicates scholarly consensus that sound warrants consideration as a conservation topic. Why sonic heritage and sound-sensing concerns are not more broadly incorporated in heritage discourse is difficult to assess; over the past decade, archaeoacoustics has become increasingly visible through its inclusion in several major archaeological projects. One complication for any new field in archaeology is how it conforms to the workflow and timing of what is a multifaceted and logistically complicated collaboration process. In field archaeology, findings from one season's explorations often appear in research publications several years later, and depending on the specialization, might not be included in mainstream publications about a particular site, though all fieldwork must be documented in seasonal reports to site authorities. What is considered relevant to publication and for prioritization of program resources depends on contextual factors including the research agendas of program leadership, thematic prioritizations aligned with resource allocations, and the convergence of interests among influential stakeholders. Such are the politics of heritage programs whose output structures necessitate conformity, often at the expense of innovation, minimizing the contribution potential of new fields.

The politics of heritage profoundly influence how fieldwork and site research inform conservation.[50] Even at Chavín, where preservation is relevant both to experimental research evaluations as well as the experience of visitors to this World Heritage site, aural/sonic heritage has not been recognized as a conservation topic. With Chavín's reputation as a site with architectural acoustical design, and an archaeoacoustics component to its research and conservation program since 2008, why not? Pragmatics may be the answer: conservation resources are limited, so preservation work prioritizes structural integrity for the safety of tourists, researchers, and site staff. Novel research such as archaeoacoustics—even when integrated in site programs as in our work at Chavín—may be perceived as irrelevant to a site's physical preservation. From an acoustical preservation standpoint, material and structural accuracy in site preservation and reconstructions, as prioritized at Chavín, indirectly supports aural heritage conservation. Yet support as side effect of preservation for other purposes does not ensure aural heritage conservation. Valuing and conserving aural heritage requires explicit attention to what makes sound important to human experience and social interactions.

Aural heritage research enables human-centered—thus anthropologically relevant—characterization of the sonic communication substrate of any place, whether or not sound has been identified as specifically relevant to a site. Substantive contributions to aural heritage conservation begin with site explorations, especially systematic fieldwork documented in site reports and publications, with extensible metrics and details regarding researcher-observer decisions and perspectives. Aural heritage conservation includes experiential and analytical engagements such as our 2018 experiment that included both researchers and site visitors to reconstruct large group sound production in Chavín's largest public gathering area, its Plaza Mayor. In order to become relevant throughout the multifaceted chain of heritage knowledge production, conservation and access, sonic research must be shared via explanatory publications, in both heritage discourse and through experiential public interfaces. Establishing the value of the sensory in heritage and normalizing the inclusion of aural/sonic heritage as a conservation topic requires exemplary case-studies, documented with methodologies that can be repeated, evaluated, refined, and adapted for use in other sites.

Our research has contributed to Chavín archaeology, and with the growth of a worldwide community of practice, we expect that archaeoacoustics and aural heritage research will gain traction as a theme both in archaeology and for heritage conservation, more broadly. Both processual and tangible products of our collaborative sound-sensing research have contributed to functional assessments of Chavín's built environment within its Andean highland setting. For example, we produced new data for key site areas regarding what can be heard from where, and how: data on built acoustical features with experiential correlates and setting contingencies. We generated new, cross-comparable data for three site areas regarding how architectural features distort sensory understandings of spatial relationships among people within, testing communication affordances of the built environment. Our metrical data and perceptual correlates on sonic dynamics at Chavín help "ground-truth" use-function hypotheses and narratives about site ritual.[51]

That Chavín's structural contours have persisted, though shifted over time, attests to their robust engineering, and also to the conservation efforts of several generations of Peruvians and their international associates. With attention to the contextual realism of site conservation strategies and reconstruction techniques (such as the use of equivalent materials and the replication of structural forms), Chavín's built environment will faithfully represent many of its acoustical affordances, to preserve extant aural heritage for future site visitors. However, structural additions, particularly posts and coverings, can dramatically alter sound transmission and reception around the site. Although such architectonic interventions are necessary for safety and conservation, if aural heritage is valued, the design of such preservation structures might, in some settings, interfere less with acoustics—or more accurately reconstruct damaged structures––to facilitate better visitor engagement and empirical research. From the standpoint of archaeological data interpretation, without attention to sonic and sensory concerns, it is impossible to construct plausible narratives that reflect realistic understandings of past human experiences at the site.

In summary, our contributions through this aural heritage study include:

1) archaeometric, dynamical-sensory data (in contrast to the typical static descriptions of archaeological materials) with attention to ecological validity (contextual realism) for Chavín, that documents sonic-experiential contingencies of its built environment and landscape-engineered highland setting;

2) innovation of collaborative methods for archaeological exploration and data collection, especially via performed auralizations constituting "performative soundscape science;"

3) documentation of a collaborative and iterative site-responsive discovery process that generates new research questions through experiential immersion;

4) expansion of Chavín knowledge and its archaeoacoustics research project;

5) preservation of Chavín aural heritage via data and fieldwork documentation;

6) promotion of sound-related archaeology;

7) exemplification of arguments for aural heritage conservation.

We are translating our fieldwork into experiential media demonstrations that auralize our arguments for the value of archaeoacoustics research and aural heritage conservation. If contextually structured sonic engagements continue in fieldwork at Chavín and in other heritage sites, visitors of these sites—and their virtual auralization interfaces—will be able to engage with realistic re-soundings of material culture, regardless of their temporal or physical contingency. Through a diversity of engagements with aural heritage, researchers, local constituencies, and a larger public may access realistic demonstrations of the sonic communication substrate of heritage sites.

ENDNOTES

[1] Extensive landscape engineering was integral to Chavín's built environment, as discussed in Daniel A. Contreras, "Landscape Setting as Medium of Communication at Chavín de Huántar, Peru," Cambridge Archaeological Journal, 25, no. 2 (May 2015): 513 - 530. doi: 10.1017/S095977431400081X.

[2] Archaeoacoustics at Chavín is part of the site's archaeological site research and conservation program, Programa de Investigación Arqueológica y Conservación Chavín de Huántar (PIACCdH – the Chavín de Huántar Archaeological Research and Conservation Program), directed by Dr. John W. Rick with various Peruvian co-directors, authorized by the Ministerio de Cultura del Perú (Peruvian Ministry of Culture). Initiated at Stanford University in 2007, the Chavín de Huántar Archaeological Acoustics Project was founded by archaeologist Rick and computer music/spatial audio expert John Chowning with project director Miriam Kolar and collaborators at the Center for Computer Research in Music and Acoustics (CCRMA). "Integrative archaeoacoustics" is a term proposed and detailed in two of that project's early publications: 1) Miriam A. Kolar, with John W. Rick, Perry R. Cook, and Jonathan S. Abel, "Ancient *Pututus* Contextualized: Integrative Archaeoacoustics at Chavín de Huántar, Perú," in *Flower World: Music Archeology of the Americas / Mundo Florido: Arqueomusicología De Las Américas*, *Vol.* 1, ed. Arnd Adje Both and Matthias Stöckli (Berlin: Ekho Verlag, 2012); hereafter referred to as Kolar et al. 2012. 2) Miriam A. Kolar, "Acoustics, Architecture, and Instruments in Ancient Chavín de Huántar, Perú: An Integrative, Anthropological Approach to Archaeoacoustics and Music Archaeology," in *Music & Ritual: Bridging Material & Living Cultures*, ed. Raquel Jiménez, Rupert Till and Mark Howell (Berlin: Ekho Verlag, 2013); hereafter referred to as Kolar 2013a.

[3] In the 1970's, Peruvian archaeologist Luis Lumbreras was the first to publish a hypothesis regarding the importance of architectural acoustics at Chavín, with colleagues: Luis G. Lumbreras, Chaco González, and Bernard Lietaer, "Acerca de la Función del Sistema Hidráulico de Chavín," in *Investigaciones de Campo, no. 2.* (Lima: Publicaciones del Museo Nacional de Antropología y Arqueología, 1976); hereafter referred to as Lumbreras et al. 1976. Current site research director John Rick developed socio-structural hypotheses that infer the use of sound in site ritual in several publications, notably: John W. Rick, "Context, Construction, and Ritual in the Development of Authority at Chavín de Huántar," in *Chavín: Art Architecture and Culture*, ed. William J. Conklin and Jeffrey Quilter. Monograph 61 (Los Angeles: Cotsen Institute of Archaeology, University of California, Los Angeles, 2008); hereafter referred to as Rick 2008. Kolar has given detailed background on the sonic investigatory history at Chavín in Kolar 2019: 34-35.

[4] Miriam A. Kolar, "Archaeoacoustics: Re-Sounding Material Culture," *Acoustics Today* 14/4 (2018): 28-37; hereafter referred to as Kolar 2018.

[5] Ibid., for discussion of archaeoacoustical fieldwork as experimental archaeology.

[6]A theoretical framing of archaeoacoustical methods towards an "archaeological possibility space" is detailed in 1) Miriam A. Kolar, "Situating Inca Sonics: Experimental Music Archaeology at Huánuco Pampa, Peru," in *Flower World of the Americas Vol. 6.*, ed. Matthias Stöckli and Mark Howell (Berlin: Ekho Verlag, 2020); hereafter referred to as Kolar 2020.

[7] Discussion of *Aural Heritage*, published on the NEH project website "Digital Preservation and Access to Aural Heritage Via A Scalable, Extensible Method," http://auralheritage.org/auralheritage.html, by Miriam A. Kolar, accessed February 16, 2020.

[8] Material archaeology contrasts with historical archaeology by the limitation of evidence of past human activities in physical materials, without corroborative written evidence. Prehistorical sites such as Chavín offer no texts to guide archaeological inferences, although graphical representations are sometimes interpreted semiotically.

[9] As per the international standard published by the International Organization for Standardization (IOS): International Organization for Standardization (IOS), "Soundscape: ISO 12913-1:2014 Acoustics – Soundscape – Part 1: Definition and conceptual framework," accessed November 14, 2018, https://www.iso.org/standard/52161.html.

[10] Stanford-CCRMA audio digital signal processing researchers associated with the project developed two prototype

computational acoustical models of Chavín interior architecture, based on field measurements: 1) Miriam A. Kolar, Jonathan S. Abel, Patty Huang, John W. Rick, Julius O. Smith III, and Chris Chafe, "A Modular Computational Acoustic Model of Ancient Chavín de Huántar, Perú," in *The Journal of the Acoustical Society of America* 128 (2010): 2329, doi:10.1121/1.3508227. Presented at the 160th Meeting of the Acoustical Society of America (ASA), Cancún, Nov. 2010. Hereafter referred to as Kolar et al. 2010. 2) Regina Collecchia, Miriam A. Kolar, and Jonathan S. Abel, "A Physical, Modular Computational Acoustic Model of the Coupled Interior Architecture of Ancient Chavín." Presented at the 133rd Audio Engineering Society Convention, San Francisco, CA (2012). Hereafter referred to as Collecchia et al. 2012.

[11] We use the term "affordances" in an extension of psychologist Gibson's definition of the human interaction potential of materials; prominent archaeoacoustical usages of this term are discussed in Kolar 2020.

[12] An overview of Peruvian archaeology, with attention to contributions by Rick and Lumbreras, is given by Henry Tantaleán, *Peruvian Archaeology: A Critical History*, trans. Charles Stanish (Walnut Creek: Left Coast Press, Inc., 2014). Among Lumbreras' many Chavín publications, his two-volume work on Chavín excavations profiles his team's fieldwork discoveries, and offers comprehensive archaeological interpretations based on his 1960s-70s research: Luis Guillermo Lumbreras, *Chavín: Excavaciones Arqueológicas*. Vol. 1 & 2 (Lima: Universidad Alas Peruanas, 2007).

[13] Lumbreras et al. 1976.

[14] A detailed study of the Chavín *pututus* and their treatment in Andean archaeological literature is given in: Miriam A. Kolar, "Conch Calls into the Anthropocene: *Pututus* as Instruments of Human-Environmental Relations at Monumental Chavín," in *Yale Journal of Music and Religion* 5/2 (2019). doi:10.17132/2377-231X.1151. Hereafter referred to as Kolar 2019.

[15] A socio-structural interpretation is framed in Rick 2008. The first archaeological study on the Chavín *pututus* was non-acoustical study: Nathaniel Parker VanValkenburgh, "The Sound of Interregionalism in the Late Initial Period and Early Horizon: Twenty *Strombus Galeatus* Trumpets from Chavín de Huántar, Peru." (Honors thesis, Stanford University, 2003). Acoustician David Lubman analyzed Rick's recordings to estimate the loudness and transmission range of *Strombus pututus*: John W. Rick and David Lubman. "Characteristics and speculations on the uses of *Strombus* trumpets found at the ancient Peruvian center Chavín de Huántar." in *The Journal of the Acoustical Society of America* 112: 2366. doi:10.1121/1.4779586. Presented by Lubman at the First Pan-American/Iberian Meeting on Acoustics, Cancún, Mexico (2002).

[16] See 1) Mélanie Ferras, "Pratiques musicales et sonores des Andes centrales préhispaniques: Une contextualisation archéologique et sociale" (Ph.D. diss., Université Paris Sorbonne, 2019); and 2) Kolar 2019.

[17] Perry R. Cook, Jonathan S. Abel, Miriam A. Kolar, Patty Huang, Jyri Huopaniemi, John W. Rick, Chris Chafe, and John M. Chowning, "Acoustic Analysis of the Chavín *Pututus* (*Strombus galeatus* Marine Shell Trumpets," in *The Journal of the Acoustical Society of America* 128 (2010): 2359. doi:10.1121/1.3508370. Presented at the 160th Meeting of the Acoustical Society of America (ASA), Cancún, México, Nov. 2010.

[18] Chavín de Huántar Archaeological Acoustics Project website: https://ccrma.stanford.edu/groups/chavin/, last modified May 2020.

[19] Chavín archaeoacoustical research findings and methodological innovations were first detailed in Kolar et al. 2012, Kolar 2013a. In their first publication about site acoustics, the Stanford-based acoustics and audio engineering team related initial acoustical analyses to human auditory perception by way of the normalized echo density metric: Jonathan S. Abel, John W. Rick, Patty Huang, Miriam A. Kolar, Julius O. Smith III, and John M. Chowning, "On the Acoustics of the Underground Galleries of Ancient Chavín de Huántar, Peru," in *The Journal of the Acoustical Society of America* 123 (2008): 3605. doi:10.1121/1.2934780. Presented by Chowning, Huang, and Kolar at *Acoustics'08 Paris* (July 2008). See also Kolar et al. 2010 and Collecchia et al. 2012 for computational acoustical model prototypes based on Chavín interior architecture.

[20] Detailed in the discussion of on-site auditory localization experiments at Chavín, in Miriam A. Kolar, "Archaeological Psychoacoustics at Chavín de Huántar, Perú" (Ph.D. diss., Stanford University, 2013); hereafter referred to as Kolar 2013b.

[21] Explanations and examples of impulse response measurements in archaeoacoustics fieldwork are given in Kolar et al. 2012: 37-38, and Kolar 2018.

[22] See Kolar 2020 for a discussion of contrasting definitions of "soundscape" across fields and within archaeology, as well as the rationale for archaeoacoustical music archaeology fieldwork as "performative soundscape science."

[23] E.g., the overview by Michael Vorländer, *Auralization: Fundamentals of Acoustics, Modelling, Simulation, Algorithms and Acoustic Virtual Reality* (Berlin: Springer Verlag Berlin Heidelberg, 2008). Researchers in the Icons of Sound Project at Stanford University used computational auralizations to create choral music performances as if performed in the Hagia Sophia of Byzantium, for both audio recordings and public concerts, as detailed in Bissera V. Pentcheva and Jonathan S. Abel, "Icons of Sound: Auralizing the Lost Voice of Hagia Sophia," in *Speculum* 92/S1 (October 2017). Kolar, a founding collaborator on that project, worked with Abel to develop the prototype of their system, specifying the singers' virtual acoustics monitoring system and engineering the project's first virtual acoustics recording session of vocal ensemble Capella Romana in 2011.

[24]Miriam A. Kolar, "Archaeological Auralization as Fieldwork Methodology: Examples from Andean Archaeoacoustics," in *The Journal of the Acoustical Society of America* 141 (2017): 3936. doi.org/10.1121/1.4988908. Presented at *Acoustics'17 Boston* (July 2017).

[25] Kolar 2018: 32.

[26] Experimental fieldwork at Chavín is summarized in Kolar 2018. The comparative, site-contextualized acoustical survey method employed at Huánuco Pampa is detailed in Kolar et al. 2018 and Kolar 2020.

[27] See Kolar 2020 for conceptual framing of acoustical affordances in archaeological research.

[28] See Contreras 2015 for an overview of landscape engineering in Chavín's built environment.

[29] Annie Goh, "Sounding Situated Knowledges: Echo in Archaeoacoustics," in *Paralax* 23/3 (Sounding/Thinking; 2017): 297.

[30] Chavín "ritualscape" was proposed in Miriam A. Kolar, "Sensing Sonically at Andean Formative Chavín de Huántar, Perú," in *Time and Mind: The Journal of Archaeology, Consciousness and Culture*, 10/1 (2017): 39-59. doi:10.1080/1751696X.2016.1272257. The concept is further explored in the discussion of the Chavín *pututus* as instruments of human-environmental relations in Kolar 2020.

[31] Ibid.

[32] Cook et al. 2010; Kolar et al. 2012.

[33] Kolar et al. 2018.

[34] For methodological details, see Kolar et al. 2018, Kolar 2018, and Kolar et al. 2012.

[35] In addition to their archaeoacoustical use at Chavín as detailed in Abel et al. 2008 and Kolar et al. 2012, many of these tools were also used by Kolar in fieldwork at Huánuco Pampa, detailed in Kolar et al. 2018.

[36] Kolar chose this microphone for group mobile use based on a review of audio engineering studies that concluded that mobile apps for sound-level metering and frequency analysis perform most accurately when used in conjunction with an external calibrated microphone, such as the iMM-6, specifically: 1) Chucri A. Kardous and Peter B. Shaw, "Evaluation of Smartphone Sound Measurement Applications," in *The Journal of the Acoustical Society of America* 135 (2014), EL186. doi:10.1121/1.4865269. 2) Chucri A. Kardous and Metod Celestina, "Use of Smartphone Sound Measurement Apps for Occupational Noise Assessment," in The Journal of the Acoustical Society of America 137 (2015), 2292. doi:10.1121/1.4920365. 3) Chucri A. Kardous and Peter B. Shaw, "Evaluation of smartphone sound measurement applications (apps) using external microphones—A follow-up study," in *The Journal of the Acoustical Society of America* 140, (2016), EL327. doi:10.1121/1.4964639.

[37] We include a research documentation video of one of our *pututu* sound transmission tests in the Plaza Mayor; it illustrates one experiment configuration and shows our workflow coordination strategy of arm-raising for visual cueing among spatially distributed sound-sensing collaborators: <<INSERT VIDEO 1 HERE: https://vimeo.com/424870236 - password CHAVSOUND!18>>.

[38] H. E. Gálvez-Arango's observations stem from personal experience in a competitive marching band, which employed strategies for sonic-visual performance coordination across large distances and in varying climate

conditions, which are known by some musicians to affect sonic production. See, for example, "Why does my horn go sharp when it gets hot and flat when it's cold?" in *The Horn Guys Blog: Why does pitch change with temperature?* https://www.hornguys.com/blogs/horn-guys-blog/15338265-why-does-pitch-change-with-temperature, written by "Neil," September 8, 2014, accessed May 17, 2019. From an acoustical-organological perspective, lip-reed aerophones, such as the European "brass" musical instruments featured on that website, are physically functional analogues to the three-thousand-year-old Chavín *pututus* and their replica proxies.

[39] We share here a research documentation video that shows an excerpt of the multimodal experiment designed by H. E. Gálvez-Arango to evaluate an acoustical setting's effects on performance coordination via tests of steady clapping in synchrony with a leader at different established rates. We hypothesized that in Chavín's Plaza Mayor, the temporal coordination of human activities is disrupted by visual-auditory perceptual discrepancies further complicated by echo sequences among architectural and landform surroundings. Experiment participants' precision in coordinating their clapping with that of the leader was recorded via audio and video to enable evaluation. Here, we show the best-case coordination scenario (for error measures) of a close configuration, though with increasing distances between clapper and responder, synchronization capabilities decreased as hypothesized: <<INSERT VIDEO 2 HERE: https://vimeo.com/424869948 - password CHAVSOUND!18>>.

[40] Maps of auditory localization experiment participant-listener and sound-source locations within Chavín galleries (that we replicated in 2018 fieldwork) are shown in Kolar 2013b: 23-24.

[41] Detailed in Kolar 2019 & Kolar 2020.

[42] An extensive discussion of the *pututu* as a versatile soundmaker and its specific sonic interaction effects with Chavín's built environment is given in Kolar 2019.

[43] We share here a research documentation video of our performed auralizations of three *pututus* in procession through Doble Ménsula Gallery, covering the extent of the gallery to include its access stairway: <<INSERT VIDEO 3 HERE: https://vimeo.com/424869415 - password CHAVSOUND!18>>.

[44] *Pututu*-gallery and intra-*pututu* acoustics are detailed with on-site performance examples by Cruzado and Kolar, in: Miriam A. Kolar, "*Pututus*, Resonance and Beats: Acoustic Wave Interference Effects at Ancient Chavín de Huántar, Perú," in *The Journal of the Acoustical Society of America* 136 (2014), 2270. doi:10.1121/1.4900202. Presented at the 168th Meeting of the Acoustical Society of America, Indianapolis (Nov. 2014). Popular version of paper 4pAAa2 is available online with video: https://ccrma.stanford.edu/groups/chavin/ASA2014.html.

[45] Excerpted from a draft of Annie Goh, "Sonic Knowledge Production in Archaeoacoustics: Echoes of Elsewhere?" (Ph.D. diss., Goldsmiths, University of London, 2020).

[46] The United Nations Educational, Scientific and Cultural Organization (UNESCO) provides descriptions of *Intangible Cultural Heritage (ICH)* on their website, accessed March 5, 2019: https://ich.unesco.org/en/what-is-intangible-heritage-00003.

[47] Site-appropriate conservation at Chavín has long been identified as a priority of the site research program, as discussed by John Rick, John Hurd, and Julio Vargas-Neumann, "Chavín de Huántar, a Past Challenge to Nature, a Current Challenge to Archaeological Conservation," paper presented at the 11th International Conference on the Study and Conservation of Earthen Architecture Heritage, Universidad Católica del Perú, 2012.

[48] See especially 1) Silvia Rodríguez Kembel, "Architectural Sequence and Chronology at Chavín de Huántar, Perú" (Ph.D. diss., Stanford University, 2001); and 2) John W. Rick, "The Nature of Religious Space at Chavín de Huántar," in *Rituals of the Past: Prehispanic and Colonial Case Studies in Andean Archaeology*, ed. Silvana A. Rosenfeld and Stefanie L. Bautista (Boulder: University Press of Colorado, 2017), 21–50. Hereafter referred to as Rick 2017.

[49] Rick 2017: 24.

[50] The politics of cultural heritage can be seen to define it, with great contextual specificity and contrasts across sites, as framed and detailed by the editors and contributors to *Heritage Keywords: Rhetoric and Redescription in Cultural Heritage*, ed. Kathryn Lafrenz Samuels and Trinidad Rico (Boulder: University Press of Colorado, 2015).

[51] See, for example, the socio-political interpretations about sonic communication at Chavín detailed in Kolar 2019.