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Music Archaeology of the Americas
Mundo Florido
Arqueomusicología de las Américas

vol. 6

Edited by / Editado por
Matthias Stöckli & Mark Howell

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General Editor / Editor general
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Situating Inca Sonics

Experimental Music Archaeology at Huánuco Pampa, Peru

Miriam A. Kolar

Site-contextualized, emplaced experimental music archaeology tests and demonstrates the interactive potentials of sound production in archaeological architecture and environmental settings. Our acoustical survey at the Inca site, Huánuco Pampa, Peru situated the performance of archaeologically appropriate sound-producing instruments on and around its large central platform or “*ushnu*/*ushno*”. We used a systematic comparison of different sound producers in an archaeoacoustical exploration of Inca sonic communication, administrative architecture, and musical performance. Beyond characterizing interdynamics of instruments and settings that influence performance practice and reception, empirical knowledge can inform interpretation of historical accounts contributing to Inca archaeology. This article details an acoustical analysis of musical performance and platform-top sonic affordances at Huánuco Pampa, drawing into conversation relevant texts from across disciplines, including discourse on soundscape, archaeological entanglement, ethnomusicology, and Inca studies. In addition to contributing acoustical methodologies to ethnoarchaeomusicology, we pose our research as work towards a new form of “performative soundscape science” that explores the multi-relational interdependencies of sonic performance by emplaced sound makers.

Estudios de arqueomusicología experimental realizados *in situ* evalúan y demuestran el potencial interactivo de la producción sonora en estructuras arquitectónicas arqueológicas y el medio ambiente. En nuestro estudio acústico en el sitio incaico Huánuco Pampa (Perú) la ejecución de instrumentos sonoros considerados arqueológicamente apropiados se llevó a cabo encima y alrededor de su gran plataforma central (“*ushnu*/*ushno*”). Para explorar la arqueoacústica de la comunicación sonora, la arquitectura administrativa y la ejecución musical incaicas hicimos una comparación sistemática entre distintos productores sonoros. Más allá de la caracterización de la dinámica entre los instrumentos y el entorno, que influye sobre la ejecución y recepción sonoras, los conocimientos empíricos pueden inspirar la interpretación de fuentes históricas y también así contribuir a la arqueología incaica. En el presente artículo pormenorizamos el análisis acústico de la ejecución musical en, y las potenciales acústicas de la parte superior de la plataforma central de Huánuco Pampa, entablando una conversación con textos pertinentes de varias disciplinas, entre ellos discursos sobre el paisaje sonoro, el enlazamiento arqueológico, la etnomusicología y los estudios incaicos. Además de contribuir metodologías acústicas para la etnoarqueomusicología, planteamos nuestro modelo de investigación como un paso hacia una forma novedosa de una “ciencia del paisaje sonoro performativo” que se propone explorar las interdependencias multirelacionales entre los creadores de sonidos y sus entornos.

An experimental approach to archaeology raises epistemic questions: why reconstruct rather than conceptualize? In what ways can materially engaged music archaeology inform about past music making? What can we learn from performance reconstructions in archaeological settings? Moving from the real-world spaces of archaeological site settings, through theoretical and empirical considerations of acoustical spaces, across disciplinary delineations, into historical texts and the

Fig. 1 *The central plaza platform (32.5 x 48 m; 4.5 m high) at the Inca administrative center Huánuco Pampa (Peru) served as locus for an experimental acoustical survey of sonic communication and musical instruments conducted in July 2015. In the foreground is the tripod-mounted digital audio recorder with GPS device, approximately 133 m away from the sound-producing performer located centrally at the platform-top's eastern-most wall. Photo (looking west) by Miriam A. Kolar.*

thought-architecture of their discursive spaces, I interconnect distinct research frameworks with material performance to enliven the possibility space of Inca music archaeology, seeking to stimulate new interactions and discourse through a case-study exploration.

Empirically testing and documenting sonic communication potential motivated our 2015 acoustical field survey at the Inca administrative center, Huánuco Pampa, located in the central Peruvian highlands. This survey on and around the 19-hectare central plaza's 4.5m-high platform (Kolar *et al.* 2018) (Fig. 1), followed research precedents from integrative archaeoacoustics research at Chavín de Huántar, Peru (e.g., Kolar *et al.* 2012; Kolar 2013, 2017), a monumental Andean center active two thousand years earlier. Site-responsive and "human-centered" integrative archaeoacoustics adapts acoustical and auditory science techniques to specific archaeological settings and with respect to archaeological evidence.

Our methodology at Huánuco Pampa leveraged experimental performance as a contextually appropriate means for exploring sonic communication across commonly constructed musical-cultural divisions. Ecological validity (contextual realism) in acoustical experimentation requires culturally appropriate sound makers, whereas the use of standard acoustical measurement tools might be preferred for studies seeking to produce more generalizable findings. Our field study experimentally tested archaeologically salient interrelationships between soundmaking and the built environment with respect to site setting, activating concerns relevant to landscape and environmental archaeology. Fieldwork experiments reflect physically emplaced humans and document local conditions, such as weather and effects of human activity, among other factors that influence acoustical dynamics and the experience of sound. Post-survey data analyses enabled detailed archaeoacoustical evaluation, characterization of site acoustics, and data-driven acous-

Fig. 2 Atop the central plaza platform at Huánuco Pampa, researcher Miriam A. Kolar photographs to document the view from an acoustical survey measurement position. Photo (looking north) by José L. Cruzado Coronel.

tical models. Text and audio notes of researchers' survey observations, along with digitally recorded audio, photos (Fig. 2), and video of experiments provided additional records of dynamics. These research materials offer re-experiential potential from fieldwork products, via analytical review and through other media-rich representations of the research context. The archaeological interpretation of our survey data is an ongoing process that combines anthropological interrogation and re-situation of these experimental products with respect to other forms of archaeological and experiential knowledge. Broader archaeological engagements invite diverse forms of interaction with research products that may involve abstracted data, such as auralization demonstrations of specific acoustical effects, or creative explorations that incorporate responses of individuals, for example.

Despite the reconstructive realism of performance setting provided by an archaeological site with intact architecture, *in-situ* experimental explorations such as the Huánuco Pampa acoustical survey require further integration with archaeological knowledge to interpret musicologically. Experimental music archaeology pioneer Dale Olsen re-framed interdisciplinary, performative explorations as "ethnoarchaeomusicology, the cultural and interpretative study of music from archaeological sources" (2002: 22). Olsen's methodological model engages four modes of inquiry to produce musical knowledge: "music archaeology, iconology, history, and ethnographic analogy", and Olsen notes that, "in some instances, my specific objective will be knowledge of musical instruments while in others it will be musical-cultural knowledge" (*ibid.*, 23-24), in reference to dominant models of musical scholarship. Missing from Olsen's integrative model is the examination of acoustical dynamics of performance contexts: an exploration of the interaction between instruments and settings that influences performance practice and musical reception. In an interpretative exploration of the music archaeological knowledge produced in our experimental fieldwork at Huánuco Pampa, and as groundwork towards future interpretative and engagement applications, this article draws together ideas from disparate but relevant fields to initiate a new epistemological conversation about experimental music archaeology and spatial performance in Inca settings, and beyond.

Sonic Performance as Exploration of Archaeological Possibility Space

Is sound essential to music archaeology? Many examples have demonstrated it is not. Theoretical and abstract dimensions of musical discourse suggested by fragmented and indirect archaeomusicological evidence frequently subsume sonic expressions. Some music archaeology might exclude sonic considerations; however, all living humans produce and respond to sound, with diverse cultural implications. Enlivening music by bringing *musical performance* into archaeological discussion requires investigatory attention to sound, which can be approached from many perspectives.

Archaeoacoustically framed experimental music archaeology (e.g., Kolar 2013, 2014a, b) leverages acoustical and auditory science to explore musical sounding and performance practice. My research takes an archaeometric approach to evaluating the physical characteristics of archaeological materials, in which analyses of dynamics enable exploration of experiential implications. Descriptive experimental science – systematic testing and observation of dynamical processes – does not preclude simultaneous alternate understandings, such as the intuitive or indigenous perspectives often discussed in opposition to archaeological scholarship. I propone an archaeoacoustical knowledge production framework in which multiple perspectives realistically coincide within a possibility space of archaeological engagement, where the incorporation of additional voices enriches discourse; where diverse perspectives reflect the breadth of human experience with respect to materials from a particular archaeological context. My fieldwork and analytical approaches have produced archaeoacoustical knowledge towards applications in collaborative and open discourse, based on physical and performance dynamics of material culture. In this article, I explore scholarly intersections with my 2015 Inca fieldwork that suggest the importance of environmental considerations in framing such an archaeological possibility space. Our study at Huánuco Pampa demonstrates how *in-situ*, setting-responsive experimental performance contributes a viable research area to the framework for ethnoarchaeomusicological research proposed by Olsen (2002). The following discussion interconnects cross-disciplinary perspectives with our experimental performance study, and in the process, exposes several areas for further research.

Performing sound in archaeological settings, playing artifact or reconstructed replica instruments, and perceiving musical potential are interrelated activities in connecting past and present sensing, feeling, being (see related discussion in Kolar 2017). Engaging these sonic activities with other forms of archaeological knowledge more realistically situates the archaeological experiment and its experiential products. Paralleling human sensing with acoustical tools and recording media – and correlating their temporal documentations – produces simultaneous contrasting forms of information that can be compared and drawn into relational understandings. Metrical data are useful in estimating human experiential implications of acoustical phenomena, and to extend some findings to other research contexts. For example, in the acoustical survey at Huánuco Pampa (and in numerous examples from our fieldwork at Chavín), human voice and instrument-performed sounds were audible and specifically intelligible despite having signal levels around or below that of measured or recorded background noise. The perceptual effect of background noise is contextually dependent, on both the character of noise in the setting and the acoustical signal of interest within the noise. Performance experiments enact specific ways in which auditory perception (and listener cognition) of acoustical signal in noise depends on contextual factors that might only be identified via emplaced observation, with testing of different attention-directing mechanisms that facilitate sonic communication (Kolar *et al.* 2018: 19). Difficult to estimate without emplaced testing, such locationally contingent “attentional affordances” aid in evaluating the plausibility of archaeological scenarios.

Experimental archaeology re-creates material interaction dynamics, produces descriptive knowledge, and enables hypothesis testing. Music archaeology experimentation offers the opportunity to consider and evaluate how musical performance works archaeologically, both as science and cultural reproduction. Beyond physical engagement with archaeological questions and materials, sonic reconstructions enable dynamical tests of spatial and instrumental “affordances” (or “action potentialities,” following psychologist James Gibson). How affordances work archaeologically is a topic of considerable debate that benefits from examination in both archaeoacoustical and music archaeological terms.

Archaeologist Ian Hodder's discussion of "mutual affordances" (2012: 50), exemplified in a potter's responsive melding of clay (referencing cognitive archaeologist Lambros Malafouris), highlights the agential interplay between humans and materials, explores the idea of limiting and constraining "dependencies" (how the affordances of things make them work together but also lead to their inability to function), and ultimately champions key factors (*ibid.*, 51). In advocating experimental archaeology to explore and parse such mutual dependencies in the relations between humans and things, Hodder observes that "the study of performance characteristics concerns the interactions and affordance between things in relation to a task or goal. […] Things are bound together functionally, in relation to goals." (*ibid.*, 55). Hodder explores the relevance of "behavioral chain analysis" (following American archaeologist Michael Brian Schiffer) for its sequential understanding of dependencies, which Hodder reduces to "a dialectical relationship between dependence, often productive and enabling, and dependency, often constraining and limiting" (*ibid.*, 88). The physicality of Hodder's perspective on "entanglement," a "focus on the ways in which entanglements between people that involve things create specific practical entrapments" (*ibid.*, 95) serves well in conceptualizing how acoustical dynamics influence human responses to the sonic tools we design and leverage to interconnect with each other.

Experimental music archaeology re-instantiates, in our present physical world, an entangled interplay of human performers, sound-producing instruments, and environmental constituents that create acoustical context via a process whose archaeological goal is to re-produce, resound, and observe material interdependencies that would have been relevant in past life. From a physical standpoint, the possibility space of musical choices depends on acoustical functionalities among instrument, setting, and performer ability; therefore, such archaeologically informed reconstructions can be considered physically demonstrative of material sound-production potential. Archaeoacoustical music archaeology thus physicalizes performance in a contextually circumscribed potentiality space. Although physical contingencies drive agential dynamics, an individual performer's idiosyncrasies might interfere with objectively weighted, functional models of influence as discussed above. Can we account for human interpretative factors and other cultural unknowns, and at the same time, claim contextual realism in our reconstructions? We might annotate archaeological interpretation to highlight contrasting factors yet emphasize converging evidence, a tactic frequently employed in reconstructions. From a functional perspective, musical performance is expressly interdependent on a set of affordances that dynamically influence goals and behaviors of each individual who makes music. Instrument and spatial acoustics, performer skill and attention, social context and ambient conditions together create an entangled multivariate space of potentiality where key factors drive human decisions and thus push musical results in particular directions. These directions can be tested experimentally.

Towards evaluating the factors in play for individual instrument performers, it is conceptually useful to consider non-archaeological discussions of affordances. Human movement scientist Rob Withagen and colleagues, for instance, pose that affordances or action possibilities not only "invite behavior" (Withagen *et al.* 2012), but, important to a dynamical and materially based archaeological investigation, emphasize the agential role of human mechanics. Individual choices, from the perspective of performance physics, are both determinant and simultaneously driven by materials and their dynamical potential. Humans may wish to do one thing, but are practically able to do something else, as permitted by their skill with a particular soundmaking tool in an acoustical context; what is in the mind is not necessarily expressed in action (the implications, here, regarding intentionality, deserve treatment in another scholarly discussion). Because of the relative determinism of the dynamical agency of physical materials and human physiology, experimentation is necessary to understand more about the particular dynamical interplay of specific music-making tools and settings. Through exploring archaeologically specific interdynamics in reconstructive experiments, idiosyncratic performance characteristics emerge empirically, distinct from key material factors. A performed music archaeology experiment thus reflects a particular instance of a combination of materials and interactive factors, including those of an individual performer. Together, in dynamic relationship, these elements inform an archaeological

Fig. 3 *Atop the central plaza platform at Huánuco Pampa, researcher José L. Cruzado Coronel performs a pututu, a Strombus Lobatus galeatus conch shell horn, as a proxy for similar instruments carried by "chasquis/chaskis" (Inca messengers), as depicted in historical documents. Photo by Miriam A. Kolar.*

possibility space in which multiple simultaneous ways of understanding coexist towards interpretation, and agential relationships are functionally exemplified. Comparative studies in which one element is varied, such as different performers of one particular instrument in a setting, facilitate the systematic identification of characteristic interaction factors.

Performing Site Settings and Material Cultural Interdynamics

A music archaeology experiment based on human sonic performance might be framed in the following functional ways, with different observational goals. Comparing one performer's experience and practices across different instruments in a particular setting enables the testing of ideas about the sound production process as well as listener reception, "normalizing" that performer's individuality across instruments, as was our design at Huánuco Pampa (Figs. 3-4). An alternate experimental construct would be to have expert performers of each instrument type each perform their instrument across survey locations, to compare a reasonably "best-possible" sound production scenario for each instrument in the setting. The experimental design that would most comprehensively explore a range of sonic and gestural production techniques would employ several performers of a range of abilities who each play all the instruments, thereby producing data regarding the plausible range of performer potential given fixed measures of instrumental acoustical potential and an effectively static acoustical environment in a particular testing context. This third scenario best produces data for evaluating variation in individual performance technique and choices. However, if cultural context drives behavior, then epistemological questions about our present research imposition on presumed past realities hinge on cultural specificity; therefore, factors beyond performance practice must be part of archaeological and musicological discussion. Music is sonic culture, after all.

Physical, material factors do strongly influence cultural context by constraining and supporting performance potential. As argued from an archaeoacoustical, physical perspective, observational testing of instrument performance in an archaeological setting demonstrates the contextual affordances of a specific environment

Fig. 4 Performance gestures visually translate at distances in which their sound is de-synchronized, such as the percussion clapper performed by José L. Cruzado Coronel at the eastern edge of the central plaza platform at Huánuco Pampa. Photo by Miriam A. Kolar.

with respect to particular instruments, and permits the documentation of local environmental factors that likewise inform performance practice and its perceptual potential. Reconstructive performance produces acoustical and visual information, as well as haptic feedback from environmental interaction, in a demonstration of the influences that site materials have on the cultural practices they support. Further considering humans' sensory relationships with the material world can facilitate more nuanced understandings regarding interactions between humans: the social within the cultural. Questions of scale (temporal and physical) speak to presence, to emplaced human experience (as visually illustrated in Fig. 4); the idea of "reach" (temporal, physical, intentional) extends the idea of material scale into its social dimension.

Despite identifiable material dependencies, defining elements in an archaeological possibility space counters the unrealistic paradigm of strict determinism in archaeological interpretation. For music archaeology, this conceptual space I propose allows the interaction potentials of materials to be evaluated with respect to human agency, yet not unduly constrained by the specifics of individual biases. Different potentials can exist simultaneously, which permits the extension of archaeological interpretation over societal timescales, as well. Bauer and Kosiba have contributed a political argument to theories of entanglement put forth by Hodder (e.g., 2012), to a model of analysis "that concentrates on the situated processes and practices whereby people labored to resolve problems of social concern" (2016: 133). Redirecting archaeological research attention to understanding specific mechanisms for communication requires understanding how sound works to interconnect humans. Immediate sound-production dynamics scale up into communication modalities for a particular society, as in codified sonic production via particular instrument types, as I discuss later. Emplaced performance situates understandings of sonic affordances with respect to the environmental features of social settings. Cultural difference between past and present exists, yet retains a relationship to site materials, settings, and their functionality as dynamical agents.

Soundscape and Sonic Feedback in Archaeological Environments

Attention to performed sound in archaeological sites reasonably coincides with the breadth of their human occupation and consideration; for this reason, it should be assumed that sonic experiments in archaeological exploration are more common than their documented inclusion in field reports, formal archaeological discourse, or other research activities. People notice how actions on things create dynamical responses because moving objects produce sound. Sound in itself is as unremarkable to humans as, for example, the diurnal shift from day to night, yet in its role as perpetual messenger, abrupt changes or extreme inflections physically activate our attention. Considered a communicative substrate for interconnecting humans and informing us about the world, sound as anthropogenic medium becomes a powerful tool. Purposefully wielded sonic techniques facilitate diverse forms of human interactions and social functions: enticing, persuading, coercing, commanding, impelling, frightening, soothing – stimulating the extent of human emotions and behavioral responses. Throughout our lives, we learn contextually appropriate responses to particular sounds, and thus, our experience conditions our expectations. Yet sonic experience is not determinant of our responses to sound: new settings or situations for known sounds require attention and decision, and individual affective states likewise shift contextual parameters for sonic reception. Therefore, we notice our footstep sounds in new places; our architecturally induced vocal resonances in narrow spaces. Echoes demand our attention via repetition. Spectral transformations – shifts in sound quality – surprise, and prolonged sounds draw our cognition into their spatial implications. Often subtle, sometimes extreme, environmentally directed sound compels human attention to the environment and to how our actions influence our surroundings.

In archaeological practice, the term "soundscape" has until recently been used to indicate the specific sounds that characterize a particular physical environment, including the ways in which landscape and architecture influence sound. This material definition serves to describe environmental constituents in archaeological interpretation: what would be in a place to be heard in a particular temporal and social context. A comprehensive archaeological exploration of soundscape description, aligned with practices from the field of "soundscape ecology" (Pijanowski *et al.* 2011), Steve Mills' "auditory archaeology aims to investigate the role of everyday sounds and hearing in archaeological and landscape contexts that are diverse in space and time" (2014: 75). Mills' auditory archaeology at Çatalhöyük considered "the ways in which sound is entangled in activities, rhythms, and emplacement" (*ibid.*, 176); in part via "studies of contemporary sonic fabric [that] encourage thinking about the ways in which sound is implicated in habituation and in different modes of engagement with places" (*ibid.*, 177), through environmental audio recordings, experimental reconstructions, and surveys of the auditory experiences of visitors and researchers. Positioning the auditory environment as a place-based, materially connected constituent of life, Mills produced sonic data in visual displays such as spectrograms of audio recordings and maps of sound propagation.

Outside archaeology, a new, multidisciplinary "soundscape approach" has developed from research in noise control, architecture and urban design. Understanding human auditory perception of environmental sound motivates this new technical field that "distinguishes the perceptual construct (soundscape) from the physical phenomenon (acoustic environment), and clarifies that soundscape exists through human perception of the acoustic environment" (Brooks *et al.* 2014). In the "soundscape approach", methodological triangulation cross-verifies (1) surveys developed by investigators, (2) observations by local experts/users of a space, and (3) sonic data gathered via acoustical instrumentation that relates environmental sound to auditory science in place-relevant experiential studies (*ibid.*, 33). This technical method for soundscape characterization focuses on human perception by surveying individual responses to environmental sound. Framed as a tool for architectural and environmental design, a technical consensus by practitioners working across fields was detailed in the first International Standards Organization (ISO) *2014 Standard in Soundscape ISO 12913-1*. In its Definition and Conceptual Framework, Section 2, the technical document defines "soundscape" as "an acoustic environment as perceived or experienced and/or understood by a person or people, in context" (referenced in Brooks and Schulte-Fortkamp 2016: 2043). Brooks and Schulte-Fortkamp, researchers in the working group who began meeting in 2009 to develop the standard, observe that "the perceptions of those that are enveloped and engaged in their environment becomes a descriptor of that environment, as much as the physical attributes of the environment. Indeed, the perception of the sonic environment may be measured and analyzed just as the physical parameters can be." (*ibid.*, 2043). Leading advocates of this approach emphasizes contrasting modes or styles of listening, a framework that has developed through the multidisciplinary intersection of musicology, sound and media studies, with cognitive and auditory sciences. A multinational research collaboration published in 2016 differentiates between "attentive, analytic, descriptive listening", and "holistic listening" (Botteldooren *et al.* 2016: 19-22), discussing how dynamical factors for regulating auditory attention can be identified in the sensory environment.

Psychoacoustically based soundscape research draws on the "auditory scene analysis" research model pioneered by Albert Bregman (1990) in response to visually focused Gestalt psychology. Bregman's model for auditory representations is based on experimental psychology research that identified mechanisms by which humans parse complex sonic information. In archaeology, some practitioners, such as Steve Mills (2014), have drawn on Bregman's auditory scene framework, yet also incorporate philosophical considerations often unexplored by psychologists and experience designers. Cross-field applications of psychoacoustically oriented soundscape research pose exciting potential for archaeological engagements. In recent fieldwork at the Mt. Lykaion sanctuary to Zeus, architect and interdisciplinary soundscape researcher Pamela Jordan has applied a "soundscape approach" that leverages binaural recording technologies to estimate human perception in an outdoor context (2016).

Prior sensory approaches to sound in archaeology have tended towards either philosophical frameworks following phenomenological discourse, or archaeoacoustical approaches that emphasize material dynamics, in contrast to the fusing of auditory and environmental psychology that characterizes the soundscape approach to evaluating sound environments. Psychologically framed soundscape studies emphasize subjective sonic reception of environmental stimuli, a human-centered approach that shares considerations with experimental archaeology. In an article that frames soundscapes as architecture – thus as design considerations – Schulte-Fortkamp and Jordan discuss the interactive challenges of evaluating the complex interactions between humans and environmental acoustics:

> "Today, the Soundscape Approach combines perceptual and physical evaluations towards a holistic study of the sonic environment. Beyond merely the physical conditions at a particular location—what has previously been termed the 'shallow soundscape' a soundscape also necessarily includes any contributions by an individual, incorporating physical inputs (e.g. footsteps) as well as perceptual ones (e.g. how one experiences a condition based on previous experience, social conditioning, etc.). […] Because of this surfeit of influences on any soundscape, evaluation must be dedicated to a combination of acoustical factors and other sensory, aesthetic, geographic, social, psychological and cultural modalities relevant to human activity across space, time, and society. Taken together, these factors comprise a 'deep soundscape' that poses quite a challenge to comprehensive study; the continued refinement of investigative soundscape procedures is critical to advancing our understanding of sound and noise in our built environment." (2016: 217-18)

These soundscape researchers' acknowledgement that an individual's "physical inputs" influence both the soundscape experience and the underlying sonic environment parallels a concern fundamental to my environmentally interactive experimental music archaeology in the Andes. Purposeful sound production that is responsive to environmental acoustics and the sound environment has been the basis for my experimental archaeoacoustics and music archaeology research since I began fieldwork at Chavín de Huántar in 2008. Experimental music archaeology foregrounds the interactivity of performers with environmental settings and known cultural contexts, drawing attention to place-based interdynamics of sound production. In contrast, concerns about the sonic agency and sound production choices of people within contemporary soundscape research are typically given cursory mention, if even considered. Sonic performance – whether musical, otherwise intentionally communicative, or as artifact of other human activities – creates acoustical feedback intrinsic to the soundscape that is thus

Fig. 5 Performance context contingencies create acoustical feedback: in the Laberintos Gallery inside monumental buildings at the Andean Formative site Chavín de Huántar (Peru), José L. Cruzado Coronel (left) and Miriam A. Kolar (right) perform Strombus pututus similar to instruments excavated at the site. In this performance experiment, architectural acoustical resonances and the interaction of instruments compel vibrational synchrony between the air columns of the two pututus. Photo from the 2012 video by Cruzado and Kolar (Kolar 2014a, b).

integral to the anthropogenic constituents of the sound environment in a cultural context.

Performing experimental music archaeology reconstructs soundmaking in places, which, combined with archaeoacoustical methods can produce metrical data for evaluating the role of auditory feedback from site environments on performance practice. Experimental performance research as we have engaged at Chavín de Huántar and Huánuco Pampa is particularly concerned with identifying and evaluating interdynamics among performer, instrument, and environmental acoustics (e.g., Kolar 2014a, b). I pose here that archaeologically situated exploration of these multi-relational interdependencies of sonic performance by emplaced sound makers produces a new kind of "performative soundscape science", as we have engaged in our Andean archaeoacoustical fieldwork. Recent work towards multidisciplinary standardization of "soundscape" terminologies and evaluation practices by acoustical and auditory scientists provides useful tools for the materially situated but anthropologically oriented sonic inquiry within archaeology, but overlooks the importance of auditory feedback in influencing sonic performance. Anthropological archaeology valorizes multi-relational understandings of human-environmental interactions, emphasizing agential framings of materiality. Experimental music archaeology activates this contingent relationship, highlighting performers of sound as responsive listeners or receivers, whose performance choices relate to environmental contingencies, as studied specifically with *pututus* in the Laberintos gallery at Chavín (e.g., Kolar 2014a, b) (Fig. 5). Situating sound in real places via archaeoacoustical music archaeology, therefore, is as much about considering the ways in which setting shapes performance choices, as it is about understanding the physical contexts for those who hear and feel the sonic performance. Consequently, use potentials of the built and occupied environment require consideration as entangled factors in a complex narrative of human-material interactions, agency, and intentionality around the dynamism of acoustical expression.

Though operating via ethnographic research paradigms, methods employed in anthropologically based soundscape studies often intersect with those used in design-motivated research that follows the metrical "soundscape approach". Ethnographic techniques and philosophical framings produce similar and contrasting forms of evidence from survey participants and soundscape locations. Christine Guillebaud's introduction to an edited volume on the anthropology of ambient sound underscores the importance of place to perspective:

> "The study of the sensory environment is predominantly interdisciplinary, to the point that previous academic limits are being redefined in favor of more overarching fields of study […] this volume […] aims to ethnographically decipher everyday ways of living and doing, which a particular interest in how ambient sound produces social relations, how sound productions are invested with meaning locally, and how ways of listening are forged and oriented differently depending on the ethnographic context being considered." (2017: 1)

Ethnographic analogy, an important archaeological tool, can inform ecological psychoacoustics in the exploration of behavioral interconnections between sonic environments and human sound makers. Returning to re-consider Olsen's framing of ethnoarchaeomusicology as producing musical knowledge from "music archaeology, iconology, history, and ethnographic analogy" (2002: 22), I propose an updated model for ethnoarchaeomusicology that augments these modes of inquiry with expressly archaeoacoustical "performative soundscape science," which, by definition, incorporates theory and methods from both acoustical and auditory sciences. However, following my previous discussion regarding the interoperability of methods within music archaeology, these three research areas might alternately be subsumed under a new, more thematically ample definition of music archaeology. The interchangeability of associations among these sonic research areas indicates how interdependently entangled are their premises and research topics, paralleling the mutual dependencies of dynamical factors under investigation in experimental music archaeology. Ethnomusicology and archaeoacoustical experimental music archaeology both situate and contextualize musical practice in terms of human emplacement in real-world settings, because performers relate to their environments.

Translating Sonic Practices Across Time: Ethnographic, Historical, and Archaeological Intersections

Ethnomusicological analogy comparing present and recent Andean musical practices can provide plausible scenarios regarding music-making under the influence of the sierran environment. Highland emplacement and its climatic elements are operational to Andean cosmologies which, though complicated to trace backwards and across the many polities under Inca rule, arguably reflect expressive cultural production even predating Inca society. Andean ethnomusicologist Henry Stobart's contributions to Inca music archaeology exemplify dialectical interconnection of living musical culture and historical materials, considering practices with respect to local elements of the Andean environment. Stobart's work details how present-day musical expression encodes social communication, noting that, "during fieldwork in the rural Andes I discovered that music was generally presented in terms of an interface or bridge between people or realms of being, where individual musical creativity and knowledge were subsumed within broader notions of knowledge, dialogue and community" (2002: 80). Multi-disciplinary scholar and musicologist Gary Tomlinson's persuasive exploration of Inca *taki*, performative ceremonies with "song extending its inherent dynamic designs out to intersect with the cosmic rhythm" (2012: 64), demonstrates how such performance constitutes a kind of existential intensification, in which, as I re-interpret here, there would be no distinction between performer and music, music maker and music making. The role of music in Andean settings, therefore, not only serves to interconnect humans, but works as a mode of ontological transformation between music makers and their environments, real and spiritual. Music, understood in these terms, is a spiritual-social-cosmological engagement, an entanglement of performer, environment, and cosmos.

Ethnomusicologist Thomas Turino's research in Peru highlights Andean music "as a prime articulation of identity and worldview", with case-study examples that demonstrate "the complex interplay of social groups at the local, community, regional, state, and trans-state levels and between rural and urban environments" (2008: xiii). To develop a framework for understanding music as social practice, Turino has drawn on his fieldwork in the Andes, Africa, and North America, and references diverse musical cultures worldwide to characterize modes of musical engagement. Turino writes:

> "[…] *participatory music* is defined by contexts where everyone is invited, and often expected, to participate musically or by dancing, and where there are no clear-cut artist-audience distinctions, only participants and potential participants. Musical styles and practices are shaped in special ways when a primary goal is to involve as many people in performing as possible. In contrast, presentational music is defined here as an ideal type where one group of actors, the musicians or performers, prepare and present music/dance to another group, the audience, who are not primarily involved in producing the sound and motion of the performance." (2008: xiii-xiv)

Turino's elision of "sound and motion" in musical performance, as well as the use of the and/or structure to signify music/dance in discussion of Peruvian highland music in the 1980s closely tracks Tomlinson's historiographical exploration of Inca expressive culture in the early years of Spanish occupation. In these Andean performances, sound and movement are inseparable constituents of environmental engagement, social and spiritual interaction. These functional studies produce sociological knowledge that intersects with musicology – interpretative narratives regarding human-environmental relationships that underlie emplaced musical performance. Missing in such discussions is an investigation of the ways in which the acoustical interactivity of a place influences musical performance there: an examination of the entangled interdependencies of physical dynamics afforded by the materials in play.

Musical performance by living humans occupies and articulates space, moving through physical locations in particular gestural manners that convey meaning. Musicians' movements during and circumscribing sonics might entrain rhythmically with their soundings, or provide contrasting temporal markers. Performers' movements might be constrained to a specific performance locus, or enact a moving spatial journey that serves to integrate ritual locations and/or groups of specifically involved participants or less engaged observers. Physical gestures and bodily movements articulate space in both relational engagement and symbolic structures. Andean ethnomusicologist Rosalía Martínez's work on the multisensoriality of cultural production in the Bolivian Andes demonstrates formal parallels between the physical paths musicians trace during performances and patterns woven into local textiles (2014: 93-100). Spatial production is culturally consistent, reflected across forms of expressive production and physical media. Martínez observes that "the forms of culturally elaborated intersections that occur in the body of the musician lead to new perceptive configurations" (*ibid.*, 88) and a kind of spatial production via gesture and movement (*ibid.*, 89). The identification of cross-material spatial encoding as a form of cultural production, when extended to acoustical-perceptual modalities, suggests that the built environment contributes specific patterns of feedback whose structures are transposed in other expressive materials. The conceptualization of musical performance as dynamical spatial production involving acoustical feedback points to the necessity of experimental activation of archaeological settings to understand these interdynamics. Place-based experiments can re-activate spatially driven – and thus, locationally significant – patterns of production.

The physical, material basis of our experimental investigation at Huánuco Pampa – and its intersections with ethnomusicological perspectives – offers an empirical complement to the detailed interpretative work of music archaeologists who have comprehensively studied historical intersections with archaeological objects of sound production, such as Anna Gruszczyńska-Ziółkowska and Mónica Gudemos. Gruszczyńska-Ziółkowska (1995) compiled historical accounts to produce detailed characterizations of instrument use and performance conventions across Inca social and political contexts. Gudemos' (2004) study of iconographical depictions of musical performance on Inca *queros*, *copas*, and *pajchas* (ceremonial vessels) focused on pictorial conventions for demarcating physical and social space, both in visual-spatial patterns, and in representational categories, such as gender and social role. These two renowned musicological studies give multifaceted structural readings on cultural conventions around musical performance, by probing historical texts in the study of material cultural objects and associated iconography. The research of Andean music archaeologist Daniela La Chioma Silvestre Villalva draws together cross-temporal accounts of Andean musical practice from historical sources and contemporary ethnography to suggest that, in the case of colonial Inca chronicler Guamán Poma's depictions of conch shell horns, "for Andean thought, sound instruments were not differentiated from weapons within the context of a battle" (transl. Kolar) and points out that those conquered in Inca battle might have their body parts transformed into musical instruments (2012: 102). This ontological re-conceptualization of musical instruments and performers parallels my reading of Tomlinson's discussion of *taki*, where performers and music are perhaps one and the same (though conversely, in a life-affirming embodiment in this example). However compelling or frightening a narrative we might extract from these readings, exegesis on the basis of polemical historical texts and fragmented artifact-instruments far removed from their ancient use-lives runs its course back to hypotheticals, as music archaeologist Ellen Hickmann reminds us: "music archaeology takes us so far, but we cannot learn more" (2012: 53). Yet, rather than serving as a facile dismissal, Hickmann's assertion follows her existential questions about the makers and performers of archaeological instruments, and ends with a statement regarding the problem of objects without provenance. I pose here that performance experiments provide an investigatory alternative, an opportunity to engage an additional field of music archaeological knowledge beyond Olsen's list (2002: 22): we reconstruct plausible relationships between artifact instruments and settings in which they may have been used, to learn about realistically emplaced music making. Empirical testing in our present, though temporally distant and culturally contrasting, elucidates archaeological potential via interdependent material activations.

Translating Performance Functionality from Textual Interpretation

As Olsen's (2002) research model proposes, multiple investigatory areas considered together constitute a holistic approach to ethnoarchaeomusicological research. In our discussion of Inca music making, putting into conversation a diversity of scholarly approaches to object representations and historical accounts compels us to re-approach these "readable" cultural products, and cross-compare interpretations with respect to a particular investigatory lens. In the case of our experimental music archaeological research situated physically at Huánuco Pampa, our lens is performance functionality as it reflects environmental-acoustical interdynamics within Inca architecture.

The most commonly cited historical document describing Inca sonic performance is likely Felipe Guamán Poma de Ayala's 1,200-page autograph manuscript *El primer nueva corónica y buen gobierno* (1936 [ca. 1615]; from here referred to as the Nueva Corónica), a polemical appeal to the Spanish king to return governance to Andeans, poised as an objective history of Andean life that moralized the indigenous past and emphasized colonial abuses (Andrien 2001). Americanist Rolena Adorno, an expert on Spanish colonialism and Guamán Poma, characterizes its representational strategy as deliberately fragmented and combinatory:

> "[...] in all but the political category, Guamán Poma has created a pictorial structure in which Andean and foreign experience converge and blend into a continuous stream of symbolic values. This is accomplished by the systematic placement of certain classes of image-signs in sequence. The structures of theology, morality, and patriarchal society transcend both ancient and modern times and Western and Andean experience." (1979: 86)

If the Nueva Corónica problematizes such deliberate cultural fusions – with representations of Andean experience directed towards a European political audience – yet simultaneously transcends its position, from what privileged historical vantage do we now sit/act as its audience? What is known about Guamán Poma, especially via such historiographical analyses, might aid in evaluating his depictions of sound-producing instruments and their performance. Following Adorno's reading, the contextual framing of musical image-signs within the chronicle may be more important than the specificity of their depictions. Graphical depictions of musical practice inform, but regarding which aspects of musical practice? Does the text itself suggest methods of disentangling its systems of codes?

Consider musical representations common across fields with intersecting interests: Inca archaeology, music archaeology, ethnography, and cultural heritage, to name key constituents in the discourse about Inca sound producers. The sound-signaling device most commonly evoked to denote Inca communication is the *pututu*, or conch shell horn, ubiquitously referenced to

Fig. 6 Performance of pututu shown in the early 17th-century autograph manuscript by Guamán Poma [G.P. figure labeled 352].

Fig. 7 Performance of pututu shown in the early 17th-century autograph manuscript by Guamán Poma [G.P. figure labeled 284].

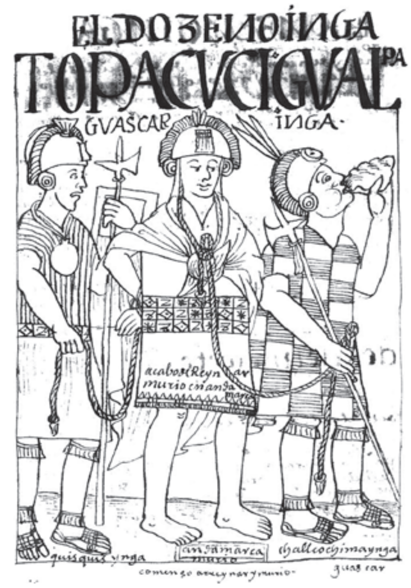


Fig. 8 Performance of pututu shown in the early 17th-century autograph manuscript by Guamán Poma [G.P. figure labeled 115].

Guamán Poma's depictions. Often called a trumpet, this instrument is organologically and acoustically a natural horn, created by removing the spire from the marine gastropod's shell to open a mouthpiece into its coiled conical interior ("bore," in organological terms). In the 400 drawings included in the Nueva Corónica, *pututus* are shown in several contexts. Most commonly cited as a signaling accessory of the runner-messenger "*correon major e menor – Hatun Chasqui Churu – mullo • chasqi • curaca*" [G.P. figure labeled 352] (Fig. 6), the *pututu* also appears enigmatically as an instrument in a religious penitence procession [G.P. figure labeled 284] (Fig. 7). *Pututu* ethnographer Martha Paola Acosta-Díaz, who has engaged an innovative and comprehensive study of conch horn use, performance, and musical materiality in Hatun Q'ero (a present-day rural community in the Paucartambo province of the Cusco region of Peru), relates the current practices she documented with two of Guamán Poma's bell-upward depictions, noting contrasting handedness in the performers (2015: 22-23). Although the *chasqi* messenger holds the shell with the bell/opening angled upwards, the processing performer highlighted in a study by Hickmann (2011: 71) (Fig. 7) appears to hold the shell with the ridged mantle up, and the bell/opening angled down. I pose that this orientation detail might not be descriptive of performance practice as many assert, because yet another *pututu* drawn by Guamán Poma seems to be in an ambiguous orientation [G.P. figure labeled 115] (Fig. 8), where graphical lines that might be read as contours in the outer shell could instead serve as reference to the dynamism of sound production, similar to the evocation of tears/crying on the faces of the processional penitents (see Fig. 7). Does depiction setting in the Nueva Corónica trope imagerial specificity, or, as Adorno details, require re-interpretation within the larger scope of the manuscript's argument and with respect to representational strategies for addressing its intended audience? What kind of knowledge are we producing via literal readings of performance practices – or any cultural activities – from Guamán Poma's "graphical dismantling of the chief symbol" of the Andean world (Adorno 1979: 95)?

The lure of interpreting musical practices from iconography and historical texts entices musicologically: performance depictions and instructions have accompanied music for thousands of years. There is good reason for people to record musical knowledge in contexts that valorize temporal translatability of music, though conversely, in some cultural contexts, the value of music is in its ephemerality, its resistance to physical permanence. In the case of Guamán Poma's Nueva Corónica, musical depictions might represent real practices, and/or function within a complex system of symbols, codes, and polemics. Considering music as a communication technology, we might for example, extend Andean art historian Tom Cummins' observation regarding Guamán Poma's representation of a non-sonic Inca communication device:

> "In Guamán Poma's drawings the *quipu* is displayed by a man in order to signify his office as a *quipucamayoc* (the accountant who reads the *quipu*) […] Guamán Poma never attempts a depiction of the *quipu* as a sign capable of signifying its content. […] the first time the *quipu* appears in Guamán Poma's drawings it is identified by a placard displaying the Spanish word *carta*. The word on the placard is turned toward the viewer and held in the same hand as the *quipu*. *Carta* refers to both the *quipu* itself and the fact that the youth carrying the *quipu* is serving as a messenger. These images of the *quipu* and *quipucamayoc* are to be contrasted with Guamán Poma's image of the native scribe who replaces the *quipucamayoc* in the colonial period [folio image 814]. Here, instead of displaying the objects of his craft in an iconic fashion, the scribe is shown engaged in the act of writing, with a legible, partially written text on the page before him. The scribe's pen is joined to the last letter so that he is literally in the act of communicating." (1994: 195-196)

Transposing Cummins' observation regarding written communication to that of sonic communication (and perhaps, musical performance, though there may be functional reasons to differentiate between these modalities of cultural sound production), we could question whether such distinctions are made between "native" and "colonial" representations of sonic communication in the Nueva Corónica. Following the pre-/post-colonial model for non-sonic communication that Cummins suggests, could we identify corresponding figural constructs regarding sonic/musical communication? Perhaps *pututus*, like the *quipu*, serve in the pre-colonial depictions to illustrate the social role of those who perform them, rather than illustrating specific practices with these tools. To parallel the paradigm of Cummins' scribe: the pen, a graphical communication tool, writes what the scribe pens; therefore, does the conch horn, a sonic communication tool, sound what the colonial-period performer blows? Such a representation strategy might serve to indicate (or normalize, with respect to its contemporary European worldview) a shift from non-textual communication modalities to literary culture. Or, would written communication be represented differently than communication via sound and music, and if so, why?

If Guamán Poma's manuscript aligns specific sound-producing instruments with social roles rather than simply depicting sound producers in use across sound-making contexts, how we interpret those depictions should be less literal as examples of performance practice. Might sonic communication actions signify conceptual categories for sound production modalities that differentiate musical expression from other forms of encoded communication? If so, whose conceptual categories are being represented? Is sound signaling, for Guamán Poma, considered a different acoustical technology than sonic performance to express or evoke emotions as part of affective displays? Does this reflect Inca conceptualizations, or a European cultural imposition? We should take care in reproducing a false (or Euro-historical) dichotomy between sound signaling and musical sonics, which are both forms of sonic expression and therefore communication modalities.

The musicological literature has set precedents for conceptualizing Inca performance practice. If we are to follow Gruszczyńska-Ziółkowska's classification that in Inca use, *pututus* are "*instrumentos de toque*", instruments that call attention rather than serving expressive musical roles (1995: 128-136), *pututu* depictions in the Nueva Corónica might be construed as a functionally specific class of sonic communication device. However, Guamán Poma has depicted a tearful *pututu* performer along with singers in a procession (see Fig. 7): if a sound-signaling role for conch horns is differentiated from affective musical communication, why is the *pututu* performer shown accompanying tearful singers following a somber procession rather than in a leadership figuration as in other "announcing" depictions (see Figs. 6 and 8)? Is the transformation of the *pututu* performer's role from anticipatory *chasqui* to accompanying processional performer one of the cultural mutations of Inca life under Spanish domination that Guamán Poma's work articulates? Such observations provoke a more detailed future study to parse when and where which instruments are depicted, in what performance associations under which political contexts, and how textual descriptions provide contexts or relate to graphical depictions. Better understandings could be gained from an examination of the representational strategies of Guamán Poma – cross-contextualized with other historical examples – that explores how musical/sound-producing instruments (including depictions of vocal production) are indicated and entangled symbolically.

Before departing from the use of historical references in reconstructing Inca sonic communication, it is important to note that beyond *pututus*, many other instruments and sonic performances are depicted and discussed by Guamán Poma. Hickmann directs our attention to musical instruments with continued Andean presence: frame drums played with sticks, and end-blown flutes (2011: 72) in the "*Fiesta de los Collasuyos*" [G.P. figure labeled 324], and another performance of frame drums and blown instruments (*ibid.*, 75) in the "*Fiesta de los Chinchasuyos*" [G.P. figure labeled 320], featuring a flute performance that Guamán Poma describes as "soplando la cauesa del uenado" ("blowing [on] head of deer"), or "trumpets" from dried heads of cervids, per Gruszczyńska-Ziółkowska's discussion (1995: 128). Not only using animals as sound makers, but imitating their sonics has been hypothesized as an Inca practice by Tomlinson, who has examined Guamán Poma's textual discussion of song-acts that give voice to animals, the animate environment, and responses by gendered human characters: llama sounds, river sounds, and queens and princesses who "sing very sweetly with a high voice" in response to the male Inca singing "to the tone of the llama" (2012: 63; 57, reprints G.P. figure 318). Ethnographic fieldwork in Bolivia by Henry Stobart highlights the importance of sonic mimesis in rural highland life, but frames it as distinct from musical performance practice:

> "I spent several days recording imitations of sounds from the local environment and discussing their categorization with my host and his elder brother. [...] These recordings and discussion revealed that the majority of the local names for wild species are onomatopoeic and directly associated with the semi-verbal mimicry of their call or other characteristic sounds. [...] I did not encounter descriptions of any direct correlations between the sounds of wild fauna and those used in musical performance. However, a direct link was made between the cries of llamas and the sound of *pinkillu* flutes. The vibrant flute timbre *tara* was associated with mating noises, whereas the thin, clear flute timbre *q'iwa* appears to be linked with the high-pitched wailing of hungry llamas." (2006:103)

Similar to Stobart's ethnographical account, environmental interaction has been identified by many scholars as a key element in both current Andean music making and Inca musical performance. A depiction of the Inca singing with the sun inspires Tomlinson to propose "a song fully divorced from the spoken language around it – a vocalization whose inevitable *phonocentrism* in no way involved it in a customarily kindred *logocentrism*. [...] The prospect is of an Andean expressive mode [...] with no basis in speech; but in this case, startlingly, it is the voice itself, the Inca's voice, that rises up in this non-grammatical, non-semantic space" (2012: 63). *Vocables*, nonverbal vocalizations, may have served to convey expressive meaning in Inca ceremony, used by the Inca himself in concert or coincidence with mimetic singing "as if communing in non-linguistic song with the extra-human world of natural forces were his special predilection" (*ibid.*). Both Stobart's and Tomlinson's discussions point to the ethnomusicological and archaeological problem of how to categorize sonic expression, and if any distinction of music versus other forms of communicative sonic expression is even culturally relevant. I offer that human expression via sound – whether vocal/verbal, vocable, mimetic, tonal, percussive, or by any other articulatory means – constitutes sonic communication appropriate for the potentiality space of experimental music archaeology.

The decision about what sounds to perform circumscribes the design of music archaeoacoustical experiments. The conch horn is as iconic to the present Andes as to Inca society. Inspired by its mechanical affordances, functional description, and analogical performance experiments by Andean musician Tito La Rosa at Chavín de Huántar (Kolar *et al.* 2012), I propose that we conceptualize the *pututu* as a proxy for human breath and voice, a channel for specific acoustical affordances. The conch horn is physically an extension of its performer's vocal cavity, where the performer's lips serve as a valve that opens and close to produce a "sounding tone" from the base resonance frequency of the instrument, with another strong resonance and therefore readily playable tone around a doubling of the fundamental frequency, a musical octave higher (*pututu* performance mechanics are detailed in Kolar 2014a, b; other discussions of Chavín *pututu* acoustics in Cook *et al.* 2010a, b; Kolar *et al.* 2012). The extensive survey of conch shell horns in Andean archaeology by Herrera and colleagues (2014) focused their acoustical study on characterizing these instruments' tonality. However, as archaeologist John Rick demonstrated in preliminary music archaeological experiments at Chavín in 2008, *pututus* readily serve as megaphones for enhancing mimesis, such as feigning feline roars to enliven relief-carved lithic depictions at that site. Mimesis via conch horns is known ethnographically across cultures; for example, in an organological discussion by pre-Columbian specialist and music archaeologist Arnd Adje Both, who corroborates Rick's suggestion, citing organologist Sachs' 1940 discussion: "While wind sounds can be produced by breathing through the trumpet and gurgling sounds by shaking a shell filled with water, the instrument can also be used as a megaphone and voice distorter by breathing, speaking or singing through the blowing hole, supposedly one of the oldest techniques of using the shell" (2004: 267). Mimicry as musical device, whether using conch shells that amplify and alter the human voice, via other sound-producing instruments, or through singing, whistling, or other vocal techniques, has been noted textually since the beginning of Andean history.

What we gain here, from this brief and cross-field historiographical review, is an appreciation of the complexity of evidence typically overlooked in characterizations of Inca *pututu* use and performance practice based on the over-simplified annunciatory paradigm linked to *chasqui* messaging. Experimentation to test the functional potential of conch shell horns in real-world Inca settings offers the opportunity to explore environmentally situated instrumental affordances, rather than assume and assign constraints to instruments on the basis of sparse and potentially contradicting historical representations. Unlike the unbending and generalizable laws of physical mechanics that acoustical science explicates, the portrayals within Guamán Poma's Nueva Corónica might be idiosyncratic and even unstable across the manuscript. Conversely, read with a clearer understanding of the autograph's symbolism, these depictions might reveal information about sonic and musical practices (or contemporary conceptualizations about them) when parsed according to nuanced understandings of contextual framings within the text, as Adorno (1979), Andrien (2001), and Cummins (1994) would have us do for non-musical topics. And, there are other historical accounts to put into conversation with Guamán Poma's work that might further elucidate its textual and expressive conventions and departures. We should take care in defining Inca "music" in present-day terms, and as experimentalists, test the functionality of Guamán Poma's performance representations.

Reconsidering Guamán Poma's depictions of sound-producing instruments and practices (1) demonstrates their presence, importance, and diversity in colonial Inca life, (2) suggests that the *pututu* was used for Inca music making beyond its iconic reputation as a long-distance signaling device, and (3) provokes an examination of the musicological frameworks that have been applied to sonic concerns in historical texts, that are replicated in new studies and the archaeological literature without reappraisal. Integrating these ideas within the real-world contexts of site settings – within the Andean environment fundamental to Inca life – re-situates disembodied scholarship in a functional exploration of musical potential. Acoustical affordances of the places for musical performance offer functional clues to flesh out an archaeological possibility space where we can apply and explore interpretations of historical depictions.

Performance, Presence and Authority: A Music Archaeology Experiment on Inca Architecture

Architecture articulates space; performance enacts space and articulates architecture. The built environment projects stasis, and music making stimulates environmental agency. Spatial activations direct attention to the authority or privilege that particular occupations of space demonstrate. Of the many architectural forms canonical to Inca administration, platforms literally elevate their occupants, distinguishing the humans atop from surrounding spaces and people. Delineating space and elevating humans, the central platform at the Inca administrative city Huánuco Pampa,

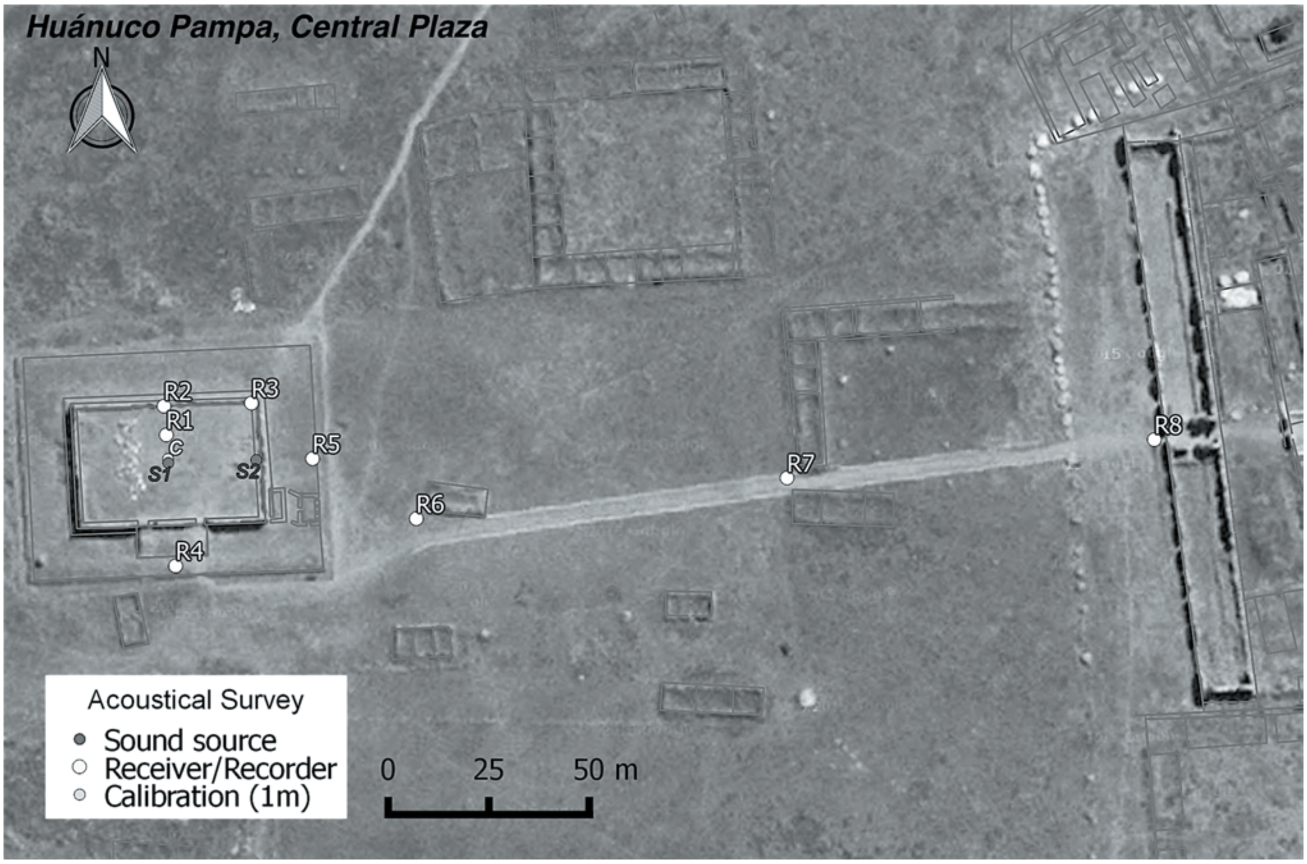


Fig. 9 Map showing survey points (sound source "S" and receiver "R" locations) in the Huánuco Pampa Acoustical Survey designed and conducted by Miriam A. Kolar (measurements) with José L. Cruzado Coronel (performance), in collaboration with a project led by archaeologist R. Alan Covey. Central Plaza (Sector 1) structures from the site digital map are superimposed over topographical photography from Google Earth. Point "C" approximates the signal calibration location at 1 m from the central source position. Map by José L. Cruzado Coronel.

in the central highlands of Peru, formally dominates both its landform setting and architectural context (Morris and Thompson 1985). Although many archaeologists and locals refer to that platform as an "*ushnu*" or "*ushno*," this term is complicated, and here I am not specifically seeking to apply this nomenclature. Our decision to use the central platform as locus for our 2015 acoustical survey follows diverse interpretative literature and historical accounts regarding the use of such platforms (e.g., Meddens *et al.* 2008; Stobart 2013), as well as the functional assumption of its locational vantage in the center of the administrative city. Whereas the fieldwork of Meddens and Frouin focused on the projection of sound from several Inca platforms (2011), our acoustical survey tested and documented interdynamics of sound sources and environmental constituents on and around the platform at Huánuco Pampa, with respect to multidirectional communication and especially to cross-compare the effects of different sound producers. We selected architecturally representative survey points at contrasting distances on and around the central plaza platform – locations for sound-source performances and sound-receiver audio recordings, level measurements, and researcher observations, as well as photo/video documentation, all GPS-located (Fig. 9).

Archaeoacoustical surveys and experimental music archaeology use a variety of test sounds to document the sonic responsiveness of archaeological settings. Our methodology compares different sound-production mechanics across the same survey points (locations for sound source and sound receivers, in acoustical measurement terms), and also produces *in-situ* observations of sound transmission, performance dynamics, and the site setting. Through comparing a sequence of human-performed instruments (repeated several times to account for variation in performance and environmental conditions), as well as a standard architectural acoustical test signal reproduced from a miniature loudspeaker, we identified acoustical features of the performance environment on and around the central plaza platform. We detailed the methodology, and presented fieldwork data with initial interpretations in a publication entitled "The Huánuco Pampa Acoustical Field Survey: An Efficient, Comparative Archaeoacoustical Method for Studying Sonic Communication Dynamics" (Kolar *et al.* 2018). In the present article, I discuss our survey as a demonstration of emplaced music archaeological experimentation that tests prior characterizations of Inca sonics as well as providing empirical data towards new interpretations, as archaeologist R. Alan Covey and I have initiated in our 2018 publication with José Cruzado Coronel. Activating site dynamics enlivens the theoretical construct of mutual affordances, reconstructing dependencies between performer and instrument, instrument and environment, performance and setting. Emplaced experimentation translates ideas into reality, reflective of previous realities.

In a detailed analysis of historical and archaeological references to Inca music making, Stobart (2013) considered the acoustics of plausible performance spaces in terms of their effects on musical communication. Environmental acoustical feedback is pivotal in Stobart's historically based interpretation that emphasizes the dynamical contrast between resonant indoor spaces and sound-dispersing outdoor locations for musical performance. Stobart argued that outdoor settings, which tend to offer less acoustical reinforcement, substantively constrain the roles of instruments and performance options (*ibid.*, 13-14, 22-24). Our observations on and around the platform at Huánuco Pampa (Kolar *et al.* 2018) contrast with some of Stobart's key assumptions about environmental acoustics that were made without empirical testing. Stobart's historical research and musicological perspective is detailed, illuminating, and thorough; however, experimental fieldwork can provide new insights and materially grounded metrics to better substantiate hypotheses about acoustical preferences for sound-making contexts, for example. I would like to engage with Stobart's discussion in order to provide some empirical contrasts that might enable a reconsideration of implied constraints for sound production and thus suggested parameters for musical performance preferences. Stobart's emphasis on architectural sound reinforcement as necessary to performance contexts does not align with findings from many outdoor acoustical studies, including my own Andean archaeoacoustics fieldwork over the past decade (e.g., Kolar *et al.* 2012; Kolar *et al.* 2018). Outdoor sound is important and functional beyond the scenarios tested by Meddens and Frouin (2011), who set limits of audibility that do not necessarily generalize, and in some cases contrast with our observations and measurements.

In acoustical fieldwork at Huánuco Pampa, our first observation on arriving atop the large central platform upended typical identifications of Inca platforms (elevated structures without roofs) as stages for outward pronouncements. This is not to say that the platform could not be used to address people below and around it (and our study demonstrated and quantified ways of doing that, out to the margins of the plaza, 225 meters from the platform-top edge); rather, the platform is architecturally functional in two other ways important to the re-conceptualization of Inca sonic communication and musical practice. Two functions beyond enabling plaza address were immediately evident from emplaced, empirical exploration. First, the platform provides a remarkable visual and sonic lookout, referred to in the Andes as a *mirador*. This large platform serves as a vantage for overhearing and even understanding conversations of people at the extents of the plaza, exceeding 200 meters away, as we discovered by observing colleagues and tourists (Kolar *et al.* 2018: 21). Second, the top of the 32.5 by 48 meter platform, semi-enclosed by waist/chest-high walls, constitutes a substantively private plaza with excellent acoustical reinforcement for sound production within. Human activities atop the plaza can largely be obscured from audibility and visibility by people in the main plaza 4.5 meters below, even at its base. The experience of being in a private, contained venue when one is located within the semi-enclosed platform top space contrasts public impressions of the platform's towering profile when viewed from the

Fig. 10 Atop the central plaza platform at Huánuco Pampa, researcher José L. Cruzado Coronel performs a Strombus Lobatus galeatus pututu. Photo by Miriam A. Kolar.

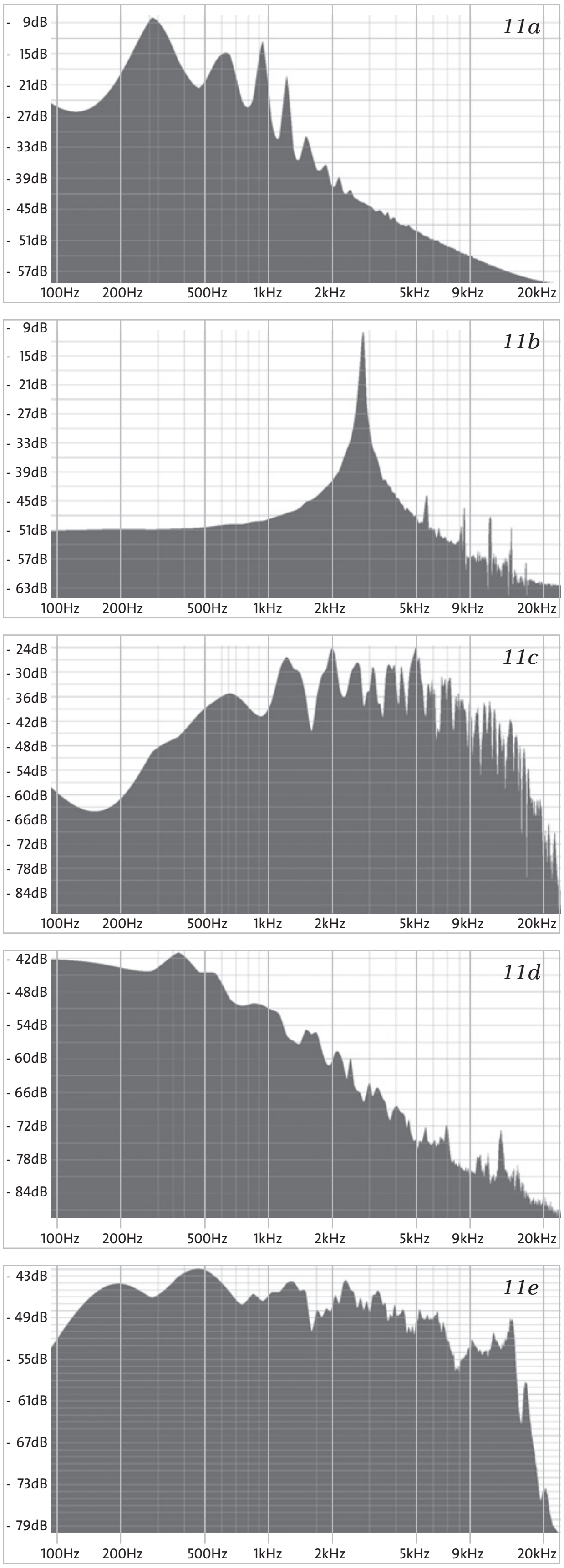
ground below, or seen from distances past the margins of the site, which extends 1.7 km. This is an important finding that suggests such spaces – the tops of large Inca platforms – might constitute private venues for elite activities, such as musical performance, which could involve patterned movements, among other forms of performative expression.

Given our novel consideration of the platform-top area as an isolated performance space, archaeologically appropriate acoustical testing is important for exploring, demonstrating, and characterizing how sound functions within the top area of the platform (Fig. 10). The interdependencies of instrumental affordances and platform-top acoustics set specific constraints on sonic communication potential, and therefore, systematic *in-situ* performance provides a kind of ground-truthing for assumed or hypothetical potentials. Physical situations of sonic and musical experiments in archaeological sites actualize the kind of relationships expressed in Hodder's discussion of mutual affordances and key dependencies, providing an empirical exploration of how material affordances drive behavior. For example, as demonstrated via experimentation at Huánuco Pampa: a musical performer who desired to be audible to a private gathering atop the platform would seek to perform an instrument whose sonic characteristics would be accentuated by that acoustical environment. If sonic isolation from the plaza were desired, instruments whose sound can be contained within the top-platform space would be used; the sounding of particular activities without visual correspondence could also be enacted strategically, as yet another communication strategy. Although such considerations may seem common sense, empirical testing in the form of an ecologically valid experiment (in a site setting, with realistic sound production) permits validation of such performance scenarios, and also the direct observation of unanticipated effects.

Archaeoacoustical Comparison of Performed Instruments in an Inca Setting

The sound production sources we selected for performance in the acoustical and music archaeology experiment at Huánuco Pampa were appropriate to its Inca context. In order to test, demonstrate, and gather empirical data on sonic communication within the platform top, as well as between the platform and its plaza surroundings, we identified specific survey points for sound source and sound receiver/listener positions that would enact contrasting proxemics, as well as provide specific architectural acoustical interactions. Performed sound producers included human voice, wooden percussion, and frequency-contrasting aerophones: a flute-like whistle designed for consistent sonics that produces frequencies within the range expected and potentially preferred (e.g., Stobart 2013: 25-26) for end-blown flutes associated with Inca performance – such as the flute fragment excavated at Huánuco Pampa by Morris (Morris and Covey 2003: 142; shown as Fig. 7 in that publication) – and a large conch shell horn made from a marine gastropod commonly used for *pututus* in the Andes. An electronically generated standard acoustical test signal (the repeated exponential sinusoidal sweep method) was reproduced via a directional miniature loudspeaker, to provide a consistent metric that could be related to human voice in terms of initial acoustical radiation pattern. Researcher José Cruzado Coronel performed all instruments, including vocal pronouncements of speech in announcement-level delivery, with phrases spoken in both Spanish and Quechua (an indigenous language known to be used by Inca). Each of the sound sources was documented in the near field, at one meter from the instrument, to provide calibration sound pressure levels and audio recordings, for reference comparison with measures across the survey points (listener/recorder locations). For each survey point (shown in Fig. 9), each instrument sounding test was repeated several times to provide averages across a range of production potentials, given our establishment of a specific performance technique for each instrument that would be representative of its idiomatic, readily-produced sounding. For example, we used a whistle designed to produce only one type of sound when directly blown, a distinct tone centered around 3 kHz (which corresponds to the frequencies of greatest sensitivity to adult humans, due to the dimensions of the ear canal). The percussion instrument – a wooden clapper – simultaneously provided a grand visual gesture along with its broad-band, acoustically impulsive signal (an instrumented version of human clapping, and simultaneously a performed analogue to the loudspeaker-generated impulsive signal preferred in architectural acoustical measurement). The *pututu,* iconic to Inca sound-signaling – and under-appreciated in its expressive potential as a musical instrument capable of diverse sounds – produces a "sounding tone" that represents the fundamental resonant frequency of its interior, conical bore (Kolar *et al.* 2012); this particular instrument's sounding tone measured around 300 Hz. Spectral graphs – charts of the acoustical frequencies present in the sound of each instrument, from Fourier analyses averaged over a typical production event – provide a visualization of each instrument's characteristic sound (Fig. 11).

The visual representation of the characteristic sound of each instrument performed in the survey aids in understanding the similarities and differences between the acoustical signals produced by each instrument. The frequencies produced, at what levels, determine how the instrument interacts acoustically with materials and structures in the environment. Here we show snapshots from 1m-reference audio recordings that give relative sound level on the vertical *Y-axis*, versus frequency on the horizontal *X-axis*, with frequency shown logarithmically to align with auditory perceptual scaling. The sound sources profiled visually are, from top left: the *Strombus Lobatus galeatus pututu* (Fig. 11a)*;* the metal whistle that was our experimental proxy for Inca flutes and whistles (Fig. 11b); wooden clapper percussion instrument (Fig. 11c); male human voice, announcement speech delivery (Fig. 11d); and the electronically reproduced exponential sinusoidal sweep, a standard for spatial acoustical measurements (Fig. 11e). Visually, it is apparent that the impulsive percussion and loudspeaker signals are most alike, in that they are broad-band, that is, covering a substantial portion of the audible frequency range. The air-produced, human-performed sound sources (including voice), by contrast, each cover a different part of the audible acoustical spectrum, and are all more specifically tonal, or restricted to prominent frequency peaks. The *pututu* and whistle each produce identifiable primary tones, with the *pututu*'s around 300 Hz (about D4, to provide a Common Practice (C.P.) reference, when A4 = 440 Hz), and the whistle around 3 kHz (in C.P. terms, in the G7 range). My reason for providing these Common Practice (C.P.) musical approximations is to translate frequency metrics for readers who are more fluent in conceptualizing the sonic implications of C.P.



note ranges. However, for its acoustical precision and phenomenological translatability across cultures, I advocate the use of the physical measure of acoustical vibratory cycles per second, specified in Hertz (Hz).

Zooming in on the power spectrum representation of each instrument's characteristic frequencies provides a detailed visualization of the key spectral components that distinguish one instrument from another; different frequencies contribute to contrasting effects with materials and architecture in performance settings. The five sound-producing instruments used in the survey at Huánuco Pampa are represented in five graphs (Fig. 12) whose level and frequency scaling do not correspond across instruments. In these graphs, acoustical power is indicated by vertical peaks, on the *Y-axis*, against frequency, shown horizontally, on the *X-axis*, in a linear scale (not exponential, as in the previous spectral graphs). Note that frequency range and zoom levels are not consistent across signals; rather, each graph is zoomed to best show the range of acoustical energy concentration of that instrument's characteristic sound. Each graph shows frequencies present and averaged over an entire sounding event for that instrument; for real-world calibration, sound pressure level was measured using the dBA scale at one meter from the instrument: from top, *Strombus Lobatus galeatus pututu* (96 dBA), whistle (105 dBA), percussion (95 dBA), voice (75 dBA), and at the bottom, the electro-acoustical test signal (90 dBA). The level readings were averaged over several performances of each instrument.

Fig. 11 Power spectrum graphs taken over the time of a representative sound event produced by each of the following: (a) Strombus Lobatus galeatus pututu with sounding tone around 300 Hz; (b) metal whistle as proxy for Inca flutes/whistles, with strong tonal peak around 3 kHz; (c) wooden clapper percussion instrument that produces an impulsive, broad-band signal; (d) male human voice at announcement-level speech in Spanish and Quechua; (e) exponential sinusoidal sweep (ESS) acoustical test signal reproduced via miniature-loudspeaker (iPhone 6 + JBL MicroII).

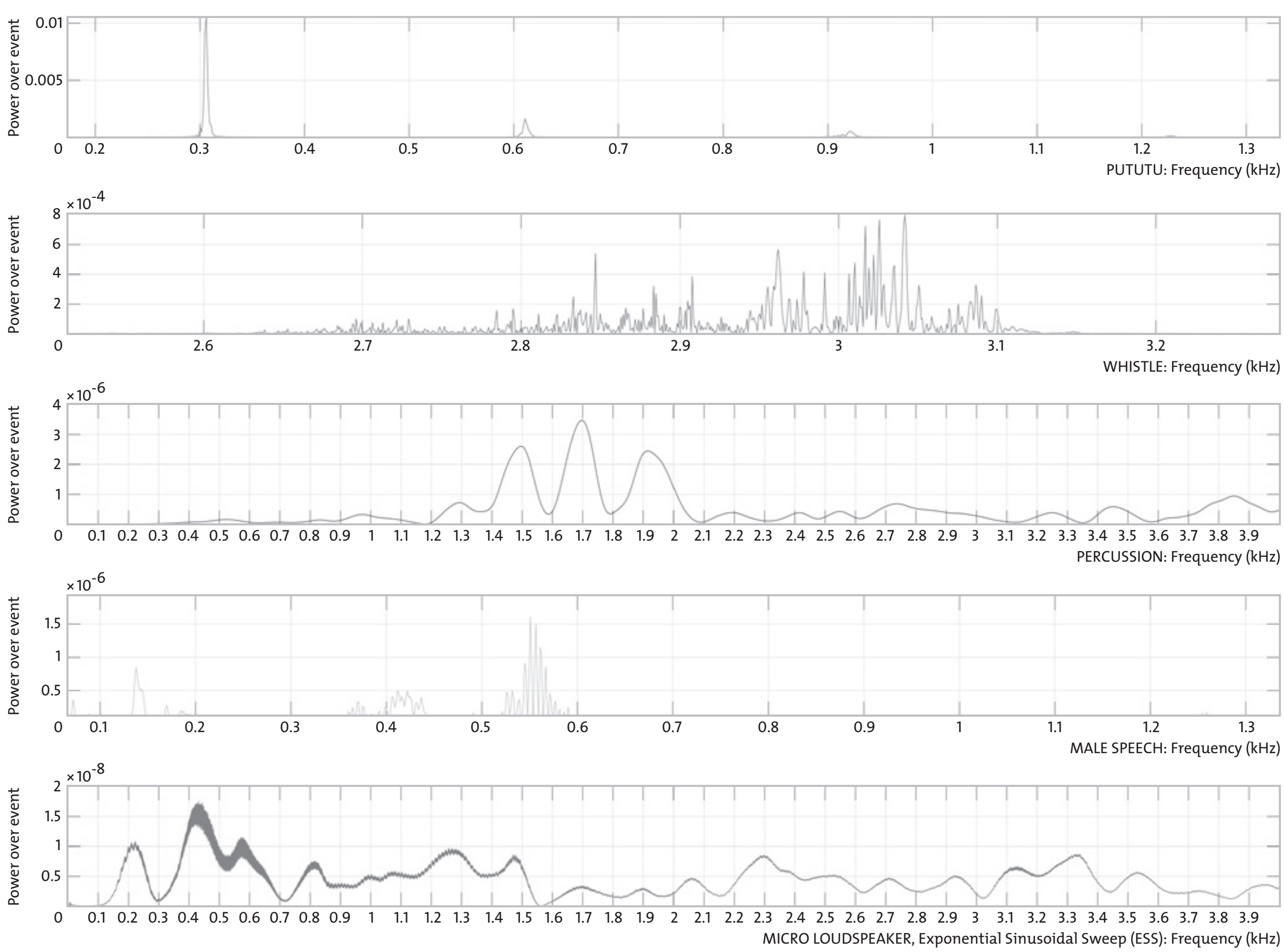


Fig. 12 Zoomed graphs of power spectra of instruments performed in the Huánuco Pampa Acoustical Survey and music archaeology experiment. From top: Strombus Lobatus galeatus pututu (96dBA); whistle (105dBA); percussion (95dBA); voice (75dBA); and, at the bottom, the electro-acoustical test signal (90dBA).

These sound spectrum visualizations can be thought of as illustrating the sonic differences between instruments. Though these diagrams do not show the temporal changes over each sounding event, they show the frequencies produced during an entire short sound that is idiomatic to each instrument, sometimes called the "timbre" of that instrument. From a musical acoustics perspective, "timbre" refers to the perceptual result of a particular combination of frequencies, in specific proportions over time, that distinguishes the sound of one instrument from another, and consequently aligns produced sonics with instrument morphology (as in "families" of scaled instruments of different frequency ranges but similar "timbres"). However, in music perception literature, "timbre" is the technical term for a multidimensional percept of frequencies over time, more complex than a direct correlation with the spectral composition of sound.

Comparing the zoomed peak frequencies visualizations (Fig. 12) with the previous spectrum plots (see Fig. 11) is useful, because the zoomed power spectra (Fig. 12) give better precision in demonstrating the relative energy of strongest frequency components in each signal, which are most significant in terms of acoustical interaction potential with the environment in performance contexts. For example, in the top graph of Fig. 12, we can see how dominant is the just-over-300Hz fundamental tone of the *pututu* (the leftmost peak), and we can hone in on its first overtone, a strong doubling of frequency as would be expected for a natural horn, and also see the relatively lower third harmonic peak an octave higher, just over 900 Hz. The harmonicity of this specific *pututu* is near-perfect, but not uncommon to shell horns of its species (Cook *et al.* 2010a, b). The second graph in Fig, 12, of the whistle, is also strongly tonal, yet it appears noisier (there are more non-harmonically related frequencies) in the power spectra representation than in its previous spectrum plot (see Fig. 11b). However, in practical terms, the acoustical energy of the whistle sound is most concentrated around 3kHz, from 2.65kHz to 3.125kHz (for a C.P. reference, this is in the E7-G7 range, covering a spread of no more than 4 semitones). Such a spread of frequencies is not uncommon to small Andean flutes and whistles due to their complex noisy partials, despite the production of strong tones that can be identified perceptually as pitches. The third signal plot in Fig. 12, from the wooden percussion clapper, was taken from the shortest event duration (practically a click, less than a tenth of a second), and has its greatest concentration of acoustical energy between 1 and 2 kHz (for a C.P. reference, this spans the octave between B5-B6). But, its energy extends lower and higher, down to 450 Hz (close to “Concert A” in modern European art music) and well over 4 kHz, with a strong peak between 3.8 and 3.9KHz (which nears the top octave of a piano, to give readers another Western musical reference). Because of the distribution of energy across many frequencies, this percussion instrument can be considered broad-band. The human speech sample, shown in the fourth graph of Fig. 12, exhibits strong frequencies in both its fundamental resonance and formant ranges: substantial energy between 100 and 200 Hz, peaking around 150 Hz; with more energy distributed between 350 and 450 Hz, continuing to 600 Hz, with the strongest peaks from 525-550 Hz. There is an additional low-energy peak around 1.25 KHz, which is well below the whistle’s energetic range, and just under that of the percussion instrument. The particular combination of spectral components (i.e., “vocal formants”) provides contextual cueing for human listeners that indeed, this signal is human voice, whether or not words can be distinguished. The bottom graph is of the electro-acoustical test signal, whose energy is somewhat well-distributed across the audible spectrum, despite some distortion and notching (strong absences of certain frequencies) in the lower frequency range. Its known and consistantly repeatable content (an exponential sinusoidal sweep) provides a standard reference with respect to other acoustical research.

These spectral representations (see Figs. 11 and 12) illustrate the detail that can be explored via acoustical science tools and methods as one approach to characterizing sounding qualities of musical instruments. Pairing *in-situ* performance reconstructions with acoustical methods enables researchers to track how instruments’ sound is modified via acoustical interactions with site materials, architecture, and the larger site setting. Our acoustical-performative research model produces repeatable, physical dynamical data towards a comprehensive understanding of the interrelationships between instrumental and site acoustics. The field techniques of contextual sound-level measurements – including nearfield reference/calibration measurements, along with audio recordings – enable both metrical and perceptual ground-truthing and enable a breadth of post-fieldwork analytical techniques. Spectral analyses are just one method for characterizing acoustical potential of sound producers, which can be cross-compared to extrapolate the acoustical features of architecture and environment.

Sonic Performance Interdynamics with Spatial Acoustics: A Case-Study Example from Huánuco Pampa

Acoustical explorations of data from instruments performed in archaeological contexts contribute to functional descriptions of their interdynamical affordances with the architectural and environmental elements of a site setting. Towards sensory archaeological knowledge within an archaeological possibility space, archaeoacoustical data provide physical specificity in the discussion of the affordances of particular instrument-setting interdynamics. Physical dynamical data are useful in creating acoustical models and simulations, auralization demonstrations, and extending findings to other contexts with similar parameters. At Huánuco Pampa, our *in-situ* performance experiment enabled observations and produced measurements toward the empirical characterization of the central platform as a musical performance venue and locus of Inca communication.

Musical performance practice can be strongly influenced by environmental acoustics. In our study, the instrument that most specifically demonstrates this is the *pututu*. Large conch shell horns have figured prominently in our experimental music archaeology research, not only at Huánuco Pampa, but also in our ongoing work at Chavín de Huántar, an Andean Formative monumental center active in the first millennium B.C.E. (e.g., Kolar 2014a, b). In Andean archaeology, experimental research using *pututus* has been conducted as part of the comprehensive survey of Inca platforms as ritual space by Meddens and Frouin (2011), and also as a focal topic for a research team led by Alexander Herrera (2014), among other studies. Because of its powerful sonic potential – around 100 dBA at one meter, for the large conch shell horns made from *Strombus Lobatus galeatus*, commonly used in the Andes – performance practice with the *pututu* is exceptionally relational with its acoustical environment. The strong directionality of Strombus *pututus* (per my team's acoustical study of Chavín *pututus*, Cook *et al.* 2010a, b, and further detailed in Kolar *et al.* 2012) requires pointing the open bell towards surfaces or audiences for optimal interaction effects. For example, in our echo studies in outdoor spaces at Chavín, pointing the bell towards building surfaces or landforms produced stronger and clearer echoes. A bell-upward *pututu* orientation creates the greatest diffusion, because the highest proportion of full-spectrum sonic energy radiates outwards and upwards, bounded by ceiling or sky. A bell-downward position directs sonic interaction to the ground surface, which can dampen acoustical energy depending on the material and structural composition of the ground, and if it is angled inward toward the performer's body. The initial acoustical radiation of instruments is important to understanding how performance practice reveals and exploits the acoustical features of surroundings. A detailed analysis of *pututu* performance features was crucial to evaluating spatial acoustics in the following case-study example from our fieldwork at Huánuco Pampa.

The methodological advantage of cross-comparing acoustical affordances of settings with respect to different sound-producing instruments can be understood in the following discussion of acoustical data analysis from the Huánuco Pampa acoustical field survey (detailed in Kolar *et al.* 2018). Considering the frequency spectra of instrument sounds produced in experimental performance enables an acoustical description (with specific physical metrics) of site architecture and settings. In the case of our study at Huánuco Pampa, comparing the frequencies produced by instruments (from near-field reference measurements recorded at 1 m) with their responses to architectural acoustics (measured at survey locations) enabled a detailed assessment of the acoustical potential of a novel performance locus, the semi-enclosed top area of the central plaza platform. Among other observations about the platform's functional affordances, we documented the potential of its top space as an isolatable performance venue. By testing sound transmission and reception at different points, we confirmed that the waist/chest-high surrounding walls of the platform top provide substantial sound reinforcement, dependent on the sound producer. Our experiment demonstrated and provided metrics that characterize how the platform-top wall and its corners provide sound reinforcement of centrally produced sound for listeners located near the wall. Architectural sound reinforcement refers to sonic frequencies that are reflected by architectonic materials and thus continue propagating around the space. Atop the Huánuco Pampa platform, we measured acoustical reflections near the walls that, by continuation of sound transmission through the air, imply enhanced sound levels for listeners not located at the walls, including the instrument performer at the center of the platform who produced the sound. The walls reinforce sound for listeners anywhere within the platform-top area. Although I have called into question Stobart's assertion of an Inca preference for architectural sound reinforcement for musical performance (*ibid.*), sound reinforcement dynamics are useful in enhancing (and in some cases, isolating) any form of sonic communication, even if not a requisite condition for cultural sonics. Our finding is not insignificant: it means that any contextual preference for what has been presumed to be indoor, "resonant" sound, as proposed by Stobart (2013), would be effectively supported in this "outdoor" venue, high above the plaza at Huánuco Pampa. Table 1 provides data regarding these performance acoustics, which I discuss below.

Acoustical data from our performance study atop the Huánuco Pampa platform demonstrate that the platform-top area provides substantial sound reinforcement of performed instruments,

Difference between measured and estimated levels (architectural sound reinforcement, dB)				
	pututu: Strombus Lobatus galeatus 96 dBA @ 1m	**whistle:** (flute proxy) 105 dBA @ 1m	**percussion:** wooden clapper 95 dBA @ 1m	**voice:** male, speech (tenor/baritone) 75 dBA @ 1m
Survey Location				
Center-source to halfway to N wall (7m) (S1-R1):	2 dB	no difference	1 dB	11 dB
Center-source to N wall (14m) (S1-R2):	3 dB	4 dB	7 dB	11 dB
Center-source to NE corner (25m) (S1-R3):	10 dB	2 dB	13 dB	12 dB
principal FREQUENCIES cycles/second (Hz):	tonal: 300 Hz; low harmonics 600 Hz & 900 Hz	tonal: 3 kHz; noisy: 2.6 kHz to 3.2 kHz	broad-band 450 Hz to 4 kHz	150 Hz; 425 Hz; 500 to 600 Hz; 1.25kHz
corresponding WAVELENGTHS @ 340 m/s:	1.13 m; 57 cm; 28 cm	11 cm; 13 cm to 10 cm	76 cm to 8.5 cm	2.27 m; 80 cm; 69 cm to 57 cm; 27 cm

Table 1 Huánuco Pampa Acoustical Survey, platform-top analysis: Difference (in decibels) between measured sound levels (A-weighted) and free-field predictions for sounds performed from the center of the platform (as detailed in Kolar et al. 2018). These differences can be understood as the architectural sound reinforcement at each survey point. For each sound source (performed instruments, including voice), the principal frequencies of the characteristic sound and the associated physical wavelengths of these frequencies are listed below. Conceptualizing acoustical frequency in terms of corresponding wavelength dimensions can highlight potential architectural/material interaction dynamics. Coincident dimensions (and some proportions) suggest interaction effects with architectural materials and structures.

including human voice. Table 1 gives the difference between measured sound levels and predictions (from the free-field acoustical spreading loss calculation, as detailed in Kolar *et al.* 2018) for each of three survey points receiving sound from a centrally located human performer (shown in Fig. 10). Researcher Cruzado, located at the center of the plaza top, performed each of the above instruments in multiple repetitions, with metered sound level and audio recorded at survey points located halfway between the center and the northern wall (R1), at the northern wall (R2), and in the north-eastern corner (R3) (as shown in the survey map; see Fig. 9). A complete discussion of the experiment is provided in the acoustical survey article (Kolar *et al.* 2018), with measured and estimated sound levels given for all survey points in that article (*ibid.*, 15). The platform-top acoustical analysis, reveals specifics regarding the interdynamical relationships of instruments and this Inca architectonic setting.

Of all four sound producers listed in Table 1, the whistle, whose notable sonic frequencies are restricted to a narrow-band range of 2.6 kHz to 3.2 kHz, is the least reinforced by architectural reflections, significantly less effective as a sound producer in this setting compared to the other instruments tested. Although we used this whistle as a proxy for Inca flutes and whistles – we selected this particular instrument for its consistent sonics and its specific tonal center of heightened perceptual value – Inca flutes and whistles would be expected to produce many other tones, of significantly higher and lower frequencies. Other instruments in our survey covered those frequency ranges, so our choice to use a tonally restricted whistle/flute proxy provided a consistent sound-producing instrument without limiting our ability to test other frequencies important to flutes. Therefore, the interpretation to be drawn from this acoustical observation is not that flutes and whistles would not be reinforced architecturally in the platform-top setting, but rather, that the particular isolated frequency range of our test whistle is not supported substantially by this architecture. The likely reason can be explained mechanically, via acoustical physics: the approximately 11 cm acoustical wavelength of the whistle's predominant 3 kHz tone corresponds with similar dimensions/spatial openings in the material of the deeply grass-covered plaza floor, thereby absorbing sound energy at this frequency. Variations in size and spacing of the fitted stone-block walls may additionally have contributed to this effect. Acoustical dynamics tangibly relate physical structures and materials with acoustical effects (such as sound reinforcement or absorption); thus, tracking dimensional relationships between dominant frequencies in produced sounds and the environmental materials with which they interact can produce functional insights, as in this example. This observation highlights the acoustical importance of floor/ground-covering materials, prompting a follow-up study of what materials might have been used and preferred during Inca use of the platform.

In contrast to the narrow-band whistle, all three other sound sources, which either have lower-frequency tonality, or more broad-band energy (and thus all produce frequencies of larger wavelengths), were substantially reinforced within the platform-top area via reflections from the walls, and would not be prone to absorption by the grassy floor. Both percussion and voice resulted in audible sonic enhancement: over 6 dB reinforcement at the wall, and in the corner, over 12 dB in the corner (10 dB is equal to a perceptual doubling of loudness, for reference). The overlapping frequency range of these two sound sources corresponds to acoustical wavelengths from approximately 75 cm down to 27 cm, which would be expected to reflect back from the fitted block wall surface. The comparison of the spatial dynamics of the longer-wavelength sounds of the percussion and vocal sources with the smaller-wavelength-producing whistle source supports my hypothesis that the grass-covered ground surface material absorbs the whistle sound, but not the lower frequencies present in the signals of voice and percussion, based on dimensional comparison (see Table 1 for wavelengths of sonic frequencies). The *pututu*, with its even lower-frequency tonal center around 300 Hz (which corresponds to a wavelength of over one meter; the instrument also produces a strong second-harmonic frequency corresponding to an approximately half-meter-wavelength), would likewise be expected to generate strong acoustical reflections from the wall surface, and not be absorbed by the grass. Why, then, are the measurements of the *pututu* contrary to this prediction?

At the wall position, the *pututu* sound measured less than half of the level of the percussion sound, and just over a quarter of the vocal sound level, although based on the wavelengths of its principal frequencies, similar levels would be expected. The dynamical explanation for this discrepancy relates to the directionality of the *pututu*'s acoustical radiation as performed: the direction in which the performer oriented the bell during the measured sound production tests. By facing north, towards the R1 and R2 receiver locations (it was the experimental convention for all central-sourced tests that the performer face north), the bell opening of the *pututu* was oriented towards the east (as shown in Fig. 10), rather than towards the north survey point. Held in the canonical position we specified for the survey, with the instrument's mouthpiece-apical axis aligned directly in front of its performer and its lip positioned up, the bell of a typical, "right-handed" *pututu* (the spiral direction in which these animals predominantly grow) opens towards the player's right hand, thereby directing the initial acoustical energy 90 degrees off-axis from the facing direction of the performer.

The initial radiation pattern of an instrument matters in settings on this scale, that is, in musical performance/sonic communication contexts that could be considered intimate. As a performance descriptor, it is worth noting that in such settings, the features of the performers' faces and thus their displays of emotional affect could be interpreted by observers, contributing as affective performance elements, though not necessarily affecting acoustics. Although the *pututu*, percussion clapper, and voice share key frequencies for architectural reinforcement, the directionality of the *pututu* can be seen to have affected level measurements for the R1 and R2 positions, when its distal end point (opposite the mouthpiece) rather than its bell was facing the receiver/measurement location. The *pututu* instrument is substantially directional (see the diagram from Kolar *et al.* 2012: 31, Fig. 7), and therefore, when the *Strombus pututu* in our experiment was performed with its distal end facing the wall point (R2), the acoustical energy was strongly radiating 90 degrees to the east. This acoustical effect of the directional instrument's angle can be seen in the relatively higher sound level measurement at the wall-corner position (R3), a location from where the shell opening/instrument's bell could be seen by the observing researcher. This visual observation provides an empirical confirmation that the angular relationship between the north-facing central performer with the NE wall-corner R3 measurement point produced a nearly direct path for receiving the initial acoustical radiation from the instrument. The measured sound levels for that testing configuration confirm strong acoustical reflections amounting to a gain of 10 dB, an effective doubling of loudness at the R3 corner listening position. Acoustics measurably affect performance practice; both a *pututu* performer and listeners would discern such architectural acoustical feedback resulting from this performance construct whose dynamics are created in relationship with the built environment.

By emplaced practice, instrument performers learn how to optimize performance technique with respect to location and desired effect. For directionality effects, a *pututu* performer can intentionally or intuitively adjust the direction of the bell of the instrument (the shell opening) for the desired effect of acoustical reinforcement (e.g., directing it towards highly reflective surfaces, such as a stone wall). If an acoustically dampened, muted sound, were desired, the performer might re-direct the bell towards materials that would create frictional losses (such as inwards toward the performer's body), or up into the air of the sky, a diffusive medium. This case-study example from a music archaeology experiment on the Inca architecture at Huánuco Pampa demonstrates how acoustical-performance features of *Strombus pututus* – specifically, their strong directionality and tonality (within a frequency range characteristic of a particular instrument and/or of horns made of similar shells) – can be considered dependencies of that instrument, and therefore primary contributors in their interdynamics with site settings. Experience with specific acoustical environments, including architecture and landforms, enables an instrument performer to learn how different materials and structures respond to performance techniques. Environmental feedback informs and constrains performance choices based on material features.

Our study shows that sonic communication and musical performance are acoustically facilitated by the central platform at Huánuco Pampa. Sonic projection from the platform outward could address audiences to the extents of the plaza, and even to the margins of the site, depending on both the sound source and reception conditions that could be cultivated via visual cues. We demonstrated and provided metrics for the functionality of the platform-top area as a selectively isolatable and sound-reinforcing acoustical venue, whose sound-reinforcement efficacy would increase given a floor surface more reflective than the present deep grass that was probably not its covering during Inca use. The central platform at Huánuco Pampa affords its occupants privacy as well as impressive public projection, with the additional functionality of an acoustical and visual vantage for surveying a vast highland plain and the Inca Road (Qhapaq Ñan). Situating Inca sonics through studying the interdynamics of site architecture and setting with archaeologically appropriate sound-producers injects empirical, metrical data with perceptual relevance into an archaeological conversation dominated by historically derived estimations and static understandings of material culture.

Site-Situated Performance Experiments as Archaeological Practice

Emplaced performance engages the interdynamical potentials of sounding materials and modalities, instruments and settings, on the timescales of human sensation and musical experience.

Through music archaeology experiments, we reproduce and observe interdependencies within an archaeologically circumscribed possibility space, whose materiality and its performance are connecting factors between past and present, known and unknown. My Inca case-study discussion, developed around fieldwork at Huánuco Pampa, Peru, has demonstrated how archaeoacoustically informed experimental music archaeology can be interrelated with other approaches to studying human-sonic interrelationships and developing archaeological knowledge. To inform fieldwork and expand archaeological discussion across relevant scholarship, I drew into consideration a cross-disciplinary selection of writings from the past and present. Re-situating historical and musicological premises with respect to material evidence involves parsing layers of history and colonialist representations of oral histories, in this case scrutinizing the intersection of 16th- and 17th-century Spanish knowledge production modalities with scholarly inferences regarding non-literary, Andean communication. Testing historical and scholarly assertions via archaeological reconstruction produces empirical knowledge. The site-situated and acoustically framed performance experiment at Huánuco Pampa enlivened our understanding of human experience in the site's built environment and landscape setting, revealing functional aspects of architecture and instruments previously overlooked. The immediacy of emplaced observation facilitates realistic understandings of architecture and setting between an estimated past and an observed present. Reconstruction versus conceptualization exploits the human-material interactions that produce tangible discoveries about archaeological materials and places, about human-environmental awareness and contingencies.

The importance of environmental acoustics to Inca communication and music making has been explored in detail by Stobart (2013) and by Tomlinson (2012). In closing a nuanced historiographical and musicological interpretation of Inca *taki*, Tomlinson emphasizes the importance of direct environmental interactions in shaping performance, but at the same time asserts that "[...] environmental affordance, if it is pervasive and formative, is nonetheless a general, weak determiner of human world-building, and the Incas were relatively free to elaborate as they chose (the ability to produce diversity is another universally human trait)" (*ibid.*, 65). Although human creativity can exceed expectations, Tomlinson seems to be defining "environmental affordances" in very different terms than I have here. I contend that if acoustics are "weak determiners" of sonic communication potential, then humans find ways to modify spatial acoustics, or invent the means to surpass their apparent limits via sound-producing instruments and sonic communication technologies, as our study at Huánuco Pampa has revealed. Clearly, there is no limit to human creativity in imagining and developing new technologies, but that technological "world-building," to re-position Tomlinson's use of the term, responsively addresses environmental affordances. Therefore, I assert that environmental acoustical affordances should be considered strong determinants of human communication strategies and technological innovation. Acoustical affordances are driving factors, and experimentally performed explorations of them produce empirical knowledge towards understanding their function and importance.

The archaeoacoustical music archaeology fieldwork that I have detailed here comprises interrelated forms of investigation across the four modalities for ethnoarchaeomusicological inquiry suggested by Olsen (2002), and also incorporates acoustical and auditory science, performance reconstruction, and site-responsive interpretation (as part of experimental reconstruction). Our performance-based acoustical survey at Huánuco Pampa sought to explore the archaeological possibility space around sonic communication and emplaced musical performance. We designed the study based on material and environmental concerns relevant to Inca contexts, seeking to provide empirical knowledge to inform interpretations of the limited and politically circumscribed historical accounts contributing to Inca archaeology. Thus, our study is material, historical, and referential, asking "what if" from a functional and place-contextualized research perspective. Materials influence performance, human performers enliven the acoustical potential of materials, and human observers/listeners sense and respond to these relationships to construct meaning. The work we have discussed so far could be extended in a deeper consideration of performance dynamics that would include additional acoustical analyses of the study data along with psychoacoustical experimentation to explore other aspects of the interdependencies of material acoustics and performance choices. Continued archaeological engagement with this data, analytical products, and the development of novel experiential modalities via digital models will permit further explorations. This is the entangled archaeological possibility space newly broadened yet better defined by in-situ reconstructions of musical performance, in which mutual affordances and interdependencies can be identified and parsed by enacting and observing emplaced dynamics.

Beyond archaeology, this research contributes to the growing discourse around soundscape studies, in our emphasis on testing human-environmental interrelationships through responsive interaction with sound environments. A "soundscape approach" to archaeological engagement has the potential to provide temporally translatable information when certain factors are explored or evaluated, when the research is designed with attention to assumptions about cultural knowledge that might not pertain archaeologically. Present-day listeners' observations of acoustical phenomena and acoustical features of an archaeological site, such as perception of discrete echoes, measures of auditory localization, or audibility studies, can provide extensible estimations of material potentialities to inform archaeological interpretation. In contrast, design-motivated soundscape research about present-day sites is particularly interested in how emplaced experiences make listeners feel (their affective responses), in attentional attributes, and other personalized responses to sound environments that can be extrapolated socially and used in planning spatial interventions as well as new applications in known cultural settings. Our aims differ in the archaeological quest for definition of cultural unknowns, whereby produced knowledge tends towards explication, rather than the generation of new tangible products, as in soundscape design. However, due to the growing interest in creative archaeological engagements – such as heritage exploration interfaces – experiential applications of archaeological knowledge should be assumed viable research extensions. Therefore, archaeological characterization of the interdynamical affordances of human-environmental acoustical interactions is both relevatory of cultural frameworks under investigation, and simultaneously generative of demonstrable experiential products. Experiential interpretation gains realism from the systematic study of acoustical-performance feedback relationships, typically not explored in soundscape research about present-day contexts. Thus, I reiterate my previous point that our experimental musical-acoustical research approach, demonstrated at Huánuco Pampa, is work towards a new form of "performative soundscape science" that calls to attention the multi-relational interdependencies of sonic performance by emplaced sound makers. In archaeological research, soundscape should be considered a bidirectional construct with respect to the agency of each soundscape observer in producing and responding to the constituents of the acoustical environment that emplaced-engaged observers simultaneously evaluate and create through producing sound.

An acoustically informed approach to experimental music archaeology fieldwork produces contextually specific, functional information about sound transmission and its reception potential. As shown in research at Huánuco Pampa, reconstructing emplaced performance using archaeologically relevant sound sources that produce contrasting as well as overlapping sonic information enables the observation and detailed analysis of site-responsive performance practice. Acoustically framed, site-contextualized experimental music archaeology demonstrates the interactive potentials of archaeological sound makers with their related architecture and environmental settings, activating dynamical forms of understanding towards an evidentially situated, expansive archaeological possibility space.

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