



Research Article

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Listening in Sacred Spaces: The Sanctuary of Poseidonia and Selinunte's Main Urban Sanctuary

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Abstract: The aim of this work is to analyse recent studies which have raised new hypotheses concerning aural architecture as an emerging trend in humanities research, with a particular focus on the intersection of sacred space, rituals, and sound in the past. These studies have highlighted how sacred buildings not only defined a sacred place as a physical and symbolic expression of a specific form of worship but also established the setting for performative and multisensorial ceremonies in which music, dance, and other sonic events played an important role. In this contribution, we investigate studies on aural architecture to explore if the location of sacred spaces indicates whether ancient people reacted to ritual and musical developments by modifying sanctuaries or by designing and constructing new buildings and spaces for performances. In addition, this article explores studies on aural architecture to obtain an overview of how specific sonic features could have influenced the soundscape of sacred spaces, which consisted not only of songs, music, prayers, recitations and religious sonic and vocal utterances but also of natural elements, such as animals, water, and wind. This overview also takes into consideration how digital technologies and virtual acoustics can help shape our understanding of the architecture-sound nexus.

Keywords: aural architecture, experienced ancient religious sound (studies), acoustic space, audible spaces

1 Introduction

Given that sound does not leave discoverable traces, it is rarely considered in archaeological studies. However, sound was an important aspect of ancient life, and it can be investigated using a new approach to the study of archaeological remains and evidence of acoustic properties in the archaeological record (Betts, 2017, pp. 1–12; Day, 2013; Mills, 2014, pp. 74–101). Previously, important sacred spaces and sanctuaries of the ancient Greek world were investigated almost exclusively with a focus on their visual function as spaces and architectural structures in which individuals or groups displayed and experienced their collective or personal identities and status (Jordan, 2020, pp. 9–11; Yioutsos, 2019, pp. 113–115). However, it was the interconnection of sacred spaces, rituals, and sound which characterised religious practices and the perception of the divine in Greek sacred buildings, thereby establishing the importance of acoustics in determining the volume, shape, and architectural features of these buildings. Greek sanctuaries and other sacred buildings not only served to define a

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sacred place as a physical and symbolic expression of specific forms of worship, but also provided the setting for performative and multisensory ceremonies in which music, dance, and other sonic events played an important role. As Mattern (2019, p. 225) has argued, “opening the ears during archaeological investigation allows for a recognition that human experience is, and always has been, multisensory and that ancient spaces have long functioned, either by accident or by intention, as resonance chambers and transmission media for sonic activity – for public address, interpersonal communication, ritual or musical performance.”

Current research on archaeoacoustics, soundscapes, and archaeomusicology highlights how varied hypotheses on the acoustics of ancient spaces can be. Given its intrinsic multidisciplinary nature, the study of sound in sacred contexts includes many subject areas ranging from sound studies and historical acoustemology (Mansell, 2021) to archaeology and aural architecture, as well as physics and acoustics (Díaz-Andreu et al., 2022; Santos da Rosa, Alvarez Morales, Martorell Briz, Fernández Macías, & Díaz-Andreu García, 2022). As Primeau (2021) has argued, each of these areas raises a significant number of challenges concerning the choice of the methodology and the approaches to be adopted; this occurs in archaeoacoustics, where the variation in results is derived from how the data have been collected.

In this regard, the fields of archaeoacoustics and aural architecture share similar points of focus, and perhaps common methodological points (Suárez, Alonso, & Sendra, 2016). Archaeoacoustics has often featured computational approaches and modelling; however, under a soundscape framing, it “can be considered as a contextual experience of spaces, and auditory perception as one of the ways in which people made sense of their world” (Primeau, 2021). Archaeoacoustics certainly does not only intend to re-enact ancient sounds or listening experiences, or merely claim to be able to approximate auditory perception in the past but also aim to carry out investigations on a wide variety of places and historical periods, shedding light on sound in antiquity, and providing data for re-evaluation of archaeological sites and architectural structures through the study of their sonic features (Suárez et al., 2016, pp. 567–572; Till, 2019). Regarding aural architecture, Blesser and Salter (2007, pp. 2–5) have pointed out that the field focuses on how listeners experience space. Moreover, aural architecture aims to explore the sonic design of ancient buildings and what this could reveal.

It is worth noting that any environment, natural or built, generates an aural architecture, and every space has an aural architecture, given that the acoustic features of a space are the result of its surface, shape, and materiality. Its aural characteristics are defined by the human experience of sensory stimuli provided by acoustic cues; the cues orientate the navigation of an aural space by influencing and enhancing the sensorial experience (Martinho, 2018, pp. 127–128).

The fields of archaeoacoustics and aural architecture are both multidisciplinary fields, and may require knowledge not only of archaeology, architecture, acoustics, and neuroscience, but also of history of religion, sound studies, musicology, and anthropology. Moreover, aural architecture studies the architectural soundscape and describes human behaviours in reaction to aural architecture throughout history (from prehistoric architecture to contemporary virtual auditory spaces) (Sabeti & Tafazzoli, 2022).

Taking into consideration that in the human body, ear and voice are the basic measures for designing architectural spaces and their sounds, many architectural structures from the ancient world appear to have been constructed “not so much to enclose space as to enshrine sound” (Mills, 2014, p. 29). Certain buildings and spaces were not designed specifically with sound properties in mind, while others most certainly were. Concerning the religious sphere, the aural architecture of a space is designed to create a space that induces such processes as ritual observance, communication, and memory, and to stimulate desired emotional states and aesthetic responses in worshippers. In this regard, Blesser and Salter (2012, p. 187) note that “the aural analogue of a visual icon, an *earcon* is a sonic event that contains special symbolic meaning not present in the sound wave.” They highlight how *earcons* acquire symbolic meanings by repeated exposure to a particular event in a corresponding context, which then “creates an associating linkage between the sound and its context. Subsequently, such sounds, even without the original context, trigger the thoughts, emotions, and memory associated with that context” (2012, p. 187).

The study of aural architecture of the past responds to new trends in humanities research, and is particularly informed by the emergence of sound studies. There are many competing systems of knowledge which can be used to grapple with the sonic (Sterne, 2012, pp. 1–17); by recognising sacred buildings as embodied spaces, based on how sound physically reacts to these architectural structures, it is not surprising

to find a correlation between acoustics and the architectural shape of sacred buildings in antiquity, including associations with performance, and consequently, social and sensorial interactions (Holter, Muth, & Schweisinger, 2019, pp. 44–60; Schulte-Fortkamp & Jordan, 2016, pp. 216–231).

2 Sacred Sounds in Sacred Contexts

Whether or not the perceptual approach to sound in the precise case of the built environment has been largely developed in the long-established discipline of architectural acoustics (Guillebaud & Lavandier, 2020), Blesser and Salter have detected a cultural dimension in the domain of aural architecture, where the study of the soundscapes and their acoustic traits is pivoted towards its many social, religious, and cultural referents. As Mills (2014, p. 42) has argued, spatial acoustics could concern the ways in which architectural spaces influence the physical properties of sound within the field of cultural acoustics. In this regard, spatial acoustics is related to how human beings interact and engage with architectural structures and spaces through listening, and the communicative power of sound within a clearly defined historical and cultural context. Moreover, the acoustic properties of buildings and spaces could have been designed to shape and alter sound; affecting audible spatial awareness, aural architecture enhances experience of sound and heightens sonic perception.

It is worth noting that physical and humanistic approaches consider the concept of “space” differently (Eisenberg, 2015, pp. 193–195; Solomos, 2018, p. 100). In acoustics, a space is merely considered a place’s physicality. In soundscape and aural architecture, space physicality creates an understandable and evaluable environment in combination with sounds. For this reason, “space” encompasses not only the place’s physicality but also significant life events that took place within those spaces, this is a fundamental context of human experience. Therefore, since the concept of space is entangled with everyday life in antiquity, and all aspects of life in general, it cannot merely be studied through quantitative or qualitative methods; rather, it should have its own specific research methods (Blesser & Salter, 2012). Comparing the subjects and methods from acoustic space with auditory space indicates a shift from quantity (in acoustics) to quality (in soundscape and aural architecture) and from quality to wholeness (in auditory space): it demonstrates how the study model of these approaches is based on the pivotal concepts of human interaction, sound, and place. This relationship provides results that are relevant to the study of antiquity (Holter et al., 2019). In this respect, exploring the foundational properties of sound in religious contexts allows acoustics to offer new insights into the social utility of ancient sacred spaces and to explore the connection between acoustic and auditory space as an intangible consequence of the space’s tangible construction.

Using the term “aural” in reference to the human experience of a sonic process, as well as the properties of a space that can be experienced through listening (Pentcheva, 2018), the analysis of “architecture of the sacred” seems to reveal that the ancient Greeks took sound into great consideration: it was seen as an important social resource for communities and an indispensable element of rituals and sacred actions (Wescot & Ousterhout, 2012). Although only a few sacred architectural structures from ancient Greece are preserved in their entirety, archaeological evidence provides commentaries on their design, ritual use, and in some cases, on the aural experience of these spaces (Jordan, 2020). In this regard, given their strong interest in all forms of aural activities, including music, oration, rhetoric, and religion, the ancient Greeks were likely to have been aware of how these activities were influenced by spatial acoustics (Blesser & Salter, 2007, p. 94).

However, the acoustic differences in the religious spaces of the ancient Greek world were not subtle. Based on archaeological discoveries, it can be assumed that the architectural components were adjusted based on musical developments, including vocal and dance practices that accompanied processions, sacrifices, and ritual acts, all of these contributed to the modification of the sacred architectural structures’ designs and therefore, how they were experienced.

3 Towards an Aural Architecture of the Sacred

The survey on sound in the sacred sphere has provided extensive documentation of human behaviour and commentary on the practices of ritual, relying on images, votive objects, inscriptions, and literary sources. Yet,

it rarely includes much information about the sacred architectural settings of the ancient Greeks. Indeed, the relation between hearing sounds and architecture has been neglected in the study of the embodied experience of Greek architecture and archaeological spaces.

The architectural structures, decoration, and surrounding landscapes of Greek sacred buildings created specific sonic features which influenced the soundscape of sacred spaces; these soundscapes consisted not only of natural elements, such as animals, water, and wind, but also of songs, music, prayers, recitations, and religious sonic and vocal utterances. Moreover, rituals such as sacrifices, processions, festivals, ritual plays or other ceremonies, which harnessed the potential of these sonic environments in specific ways. Additionally, Greek architecture reacted to ritual and musical developments, as well as to vocal and dance practices, by modifying sanctuaries or by designing and constructing new buildings and spaces for performances, processions, and sacrifices. Moreover, sound worked in tandem with sight and other sensory experiences in order to sustain the continuum between past and present ritual events.

Only by acknowledging, investigating, and recognising Greek sanctuaries as embodied sacred spaces (Betts, 2017, p. 27) based on shapes and physical structures, and the way sound reacts to architectural structures (Veitch, 2017, p. 28), can we begin to understand sound experiences in Greek architectural structures and their complex relationship with buildings, spaces, environment, and social and sensorial interactions. This is in line with the trend towards the area of study which Power (2022, p. 30) calls “experienced ancient religious sound (studies),” where “there is the rise of sound studies, both as an autonomous discipline and an interdisciplinary phenomenon that has made productive contributions in many fields.” This includes not only religious studies, musicology, and classics, but also soundscape archaeology, archaeoacoustics, and archaeology of musical performance. Within these research fields, soundscapes (broadly conceived) are specific to and characteristic of the identity of individual cults in sacred spaces, which take into consideration the physical spaces and structures of sanctuaries where sacred sounds were performed (Jordan, 2021).

It is worth noting that Greek sanctuaries were built to shelter visible or invisible divine entities in order to honour them or enter into communion with them, or manifest their presence, depending on the rituals directed towards them (Marconi, 2007, pp. 17–18). Large spaces of worship were usually designed to impress, which was often achieved through large – if not monumental – proportions. Moreover, Greek sacred places were meant to foster cohesion between members of the community and help transmit the message delivered by either the personnel of the cult or the whole group of members. While such a message was usually vocal, it could also draw on musical instruments, or deploy a mixture of both. Special sounds sacralised space and time: performed in sacred places, sounds heightened the sense of the numinous, and generated symbolic meanings that linked the material moment to a broader cultural and religious imaginary (Power, 2019, p. 20).

One may wonder whether sanctuaries were built in precise locations within distinctive landscapes and how a numinous ambience was created and enhanced through their setting in a natural sonic environment. The answers to these questions may not be fully recoverable, yet the interaction between numinosity and soundscape, as well as the viewing and listening of performances by worshippers, is worthy of exploration. This issue concerns the analysis of the concept of the sacred landscape, which is best understood as an entanglement (Hodder, 2012) and a dialogue between the built cultic environment and its natural surroundings (Vassilantonopoulos & Mourjopoulos, 2001; 2009, p. 293). This dialogue informs us about both sacred experiences and the formation of local identities in worship contexts in a process of communication and perception of religious actions; this process is dependent upon its performative context. One way of dealing with this is to study cultic archaeological sites with a focus on the rituals performed within them: processions, sacrifices, dance, music, sounds, and dramatic enactments of myths (Angliker & Bellia, 2021; Hamilakis, 2013, pp. 57–73).

4 The Aural Architecture of Poseidonia

The approach mentioned above could be particularly useful in the study of the *Heraion* on the River Sele in Poseidonia, a Greek *polis* in Magna Graecia founded at the end of the seventh century BCE in the southern half of an extended fertile plain near the bay of Salerno. The immediate natural and built environments in this sanctuary, which was devoted to Hera, provide an interesting example of how a sacred space can be

considered as specified loci for sound experiences and musical and choral performances, especially during processions: the implications of the landscapes and soundscapes of this sanctuary allow us to explore not only how sacred sounds interacted with the natural environment but also how sensory ambience could contribute to enhancing and heightening religious experiences in sacred places.

In the sanctuary in Poseidonia, the lush natural environment – of which Hera was the patroness – was closely connected to the River Sele (Figure 1). The watercourse enriched the city's surrounding countryside and its land, enabling both agricultural exploitation and husbandry, and especially the domestication of the horse. This seems to be the main activity in the sacred area and its surroundings, along with the cultivation of roses and fruit trees, such as pomegranates (Greco, 1998, pp. 179–180; 2016, pp. 404–406). Moreover, archaeological research has uncovered a large area between the architectural space and the surrounding landscape which was devoted to the sacred grove (Bowe, 2009); the sanctuary at Poseidonia – which was located in a natural environment and was immersed in a sacred grove – is comparable not only with the *Heraion* in Argos but also with the Hera sanctuaries in Corinth and Samos (Greco, 1998, pp. 45–47). The immediate green landscape around these sanctuaries supported a sacred environment, and their personnel supervised their care and regulation. In addition, these sanctuaries included both “cultivated” and “wild” elements of the landscape alongside human-made votives and buildings. Such an environment could have recalled or even evoked divine presence through the contrasting elements in these sanctuaries, since Hera herself was the goddess of both cultivated and wild landscapes.

If the sacred grove at the River Sele, along with other natural elements, contributed to the evocation of a numinous atmosphere (Larson, 2001, pp. 9–11), it is worth noting that the grove in sacred places was traditionally a space of sonic decorum, a *locus amoenus* (Leach, 1978, p. 543) suffused with the soft soundscape of nature (Power, 2019, p. 21). For example, in the sacred grove of the sanctuary at the River Sele, the sound of water from the numerous surrounding streams could be heard alongside the sound of leaves rustling in the wind: these sound impressions could have been harmonised with ceremonies and performances immediately recognisable by participants, shaping the *earcon* during rituals celebrated by worshippers (Power, 2022, pp. 7–10).

Whether or not the sacred space of the *Heraion* on the River Sele was particular to its soundscape and the specific story of the sanctuary in a special natural environment, its *earcons* as sacred soundmarks could be considered both functional and symbolic. As Power (2019, p. 22) has argued, in the “ancient cultic context, we



Figure 1: Aerial view of the area of the *Heraion* in Poseidonia and the River Sele. After Greco, 1998.

might designate a soundmark as any emotionally and symbolically charged sonic maker, usually extraordinary or even wondrous in nature, that was distinctive to the cult's locale, be it in features of the natural landscape, ritual practices or some combination thereof." The soundmarks in the *Heraia* in Poseidonia could be heard as real auditory phenomena, integral to the primary, on-site cult experience: inspiring in worshippers fascination and awe, these sounds could have created a sense of involvement in a numinous moment. The architecture, the shrine set on the River Sele, the greenery around the temple, which was redolent with delightful scents and surrounded with carved metopes representing lively young female dancers, all contributed to evoking a sense of the sacred. However, the most powerful key to the creation of a sacred environment was not only natural and human sounds, but also musical and dance performances in ceremonies (Figure 2) (Bellia, 2021c).

The study of the architectural structures of the sanctuary on the River Sele provides the overall framework of its spaces suitable for rituals and festivals. The *Heraion* was the place of arrival of solemn processions related to the hecatomb devoted to the goddess (Mertens, 2006, pp. 166–168), like the one celebrated at Prosymna in Argos: taking into consideration that a wide sacred path crosses the sanctuary, processions could be performed in the *Heraion* at Poseidonia, which, as it is well known, were amongst the most important events in celebrations. The festival celebrated in Argos is described as a "great procession" (*Scholium* to Pindar, *Olympian Odes*, 7, 152), during which 100 oxen were paraded and led to be sacrificed (Torelli, 2013, p. 44). These processions were not only occasions for young boys to compete in races, but also for young girls to perform ritual dances, exposing themselves to the admiration of young boys during the processions and under the goddess's protection. It is worth noting that in the *Heraion* at the River Sele, five bone *auloi* fragments were discovered (Bellia, 2021d, p. 73, Figure 7; Greco, 1998, p. 57). The *aulos*, the instrument that embodied the true festival spirit, accompanied the processional approach to the shrine since it was the instrument of the *prosodion*, a choral lyric sung for the procession which often reinforced the celebratory solidarity of the *pompe*: the singing of hymns or paeans was a customary part of the sacrificial ceremony. Indeed, the instrument was played during the different stages of this ritual and it accompanied the dances performed in other sacred spaces devoted to Hera (Moustaka, 2001, pp. 131–132). We do not know if the *aulos* was played at the festivals celebrated in Poseidonia; however, we can assume that the *aulos* soundmarking served to bond the worshipping group closely together in a precise place as well as accompany dances, deepening perceptual sympathies between members and heightening collective feelings of euphoria and enthusiasm (Papadopoulou, 2004, pp. 347–365). Tracing the pathway for the participants involved in the ceremony, music announced the events at hand and was an invitation to the worshippers to engage with the rituals within a well-defined sonic space. Moreover, the *aulos* was played not only to accompany the dancing groups, but also to accompany songs, they were sung in processions and around altars, before and after sacrifices (Bundrick, 2005, pp. 34–42; Bellia, 2012, pp. 91–98). It is worth noting that, as previously highlighted, figures of young girls are depicted on



Figure 2: Area of the sacred structures and performative spaces in the *Heraion* in Poseidonia. After Greco, 1998.

the metopes of the sanctuary on the River Sele; dating to the end of the sixth century BCE, these figures move metaphorically in an uninterrupted flow of dancers around the temple (Bellia, 2021c). Therefore, as a space for choral performance under the protection of Hera, this sanctuary can be considered a dancescape, a ritual space used as a dance venue during sonic events that can be mapped across the sacred place (Naerebout, 2017, pp. 39–40).

5 Exploring the Performative Context in Theatres

While acoustical research methods typically focus on the physical aspects of sound (Kolltveit & Rainio, 2020), cultural and performative contexts should also be investigated; this is crucial in forming an anthropological approach to the study of sound in archaeology (Blake & Cross, 2015, pp. 81–103). Given that a “soundscape” is influenced by a combination of anthropological data framed within an audible and acoustic space (Pasalados, 2011), it must be remembered that sound associated with particular sacred places, performative spaces, animals, architecture, as well as the production and use of material culture, influenced people in a variety of ways (Blessner & Salter, 2007, pp. 67–78). Furthermore, we must keep in mind that sounds, performances, and music were more than a mere channel of communication: they gave meanings of sacredness and power, given that they were important aspects of sacred activities and ritual practices of individuals and groups (Inomata & Coben, 2006, pp. 11–12).

Studying Greek architectural buildings inevitably directs attention towards interactions between behaviour and the built environment. As Betts (2017, p. 4) has pointed out, architecture has agency, acting upon and influencing human perception, experience, behaviour and memory, since it has particular, measurable physical properties. In this respect, several spaces designed for sonic events and musical performances related to religious and social occasions were a common feature of all sanctuaries and their immediate surroundings in Greek *poleis*, and architectural structures for these public gatherings were provided accordingly.

Observing these sacred places, we can make the assumption that any open-air areas which are relatively levelled and free of obstacles or terracing may have functioned as sacred sonic event settings. Indeed, we can find structures such as monumental steps or theatral facilities enclosed in sacred areas that look as though they were used for sitting, standing, and walking: their functions as sacred spaces for ritual activities need not be doubted when they are close to a building with a known religious purpose, like a temple. According to Hollinshead (2012, pp. 27–65; 2015, pp. 3–15), these buildings, some of which imply movement while others suggest static behaviour, were used from at least the sixth century BCE in Greek sanctuaries at Lindos, Athens, Corinth, and Aegina, as well as at Perachora, Eleusis, and at Selinus in Sicily as pathways for processions and as grandstands for observing events: as pathways, steps shaped processional routes towards and within cities and sacred areas; as destinations, they served as grandstands for viewing and taking part in public events and performances. An example is the theatral structure in front of the Artemis Orthia temple in Sparta, where worshippers took part in the annual festival devoted to the goddess (Dawkins, 1929, pp. 4–7; Nielsen, 2002, pp. 88–93). Images of grandstands are represented on four black-figure vase fragments, the best of which is a fragment of an Athenian dinos signed by Sophilos and dated to 570 BCE (National Archaeological Museum, Athens, no. 15499): rows of seats with audience attending the funerary games for Patroklos are depicted, as in *Iliad* Book 23 (Hollinshead, 2015, p. 10).

Taking into consideration theatral steps as architectural structures built to accommodate audiences of worshippers, it is interesting to note that a fourth century BCE inscription from the sanctuary of Amphiaraios at Oropos in Attica refers to “the viewing area next to the altar” (*IG VII 4255.29-30*; Schultz, Wickkiser, Hinge, Kanellopoulos, & Franklin, 2017, p. 68). This inscription suggests how worshippers convened in a stepped *theatron* to observe sacrifices and associated ceremonies in the performative spaces around the altar. Long ranks of steps beside an altar framed the ritual while providing a better viewing and listening experience for worshippers. So, it is quite possible that monumental steps could also have served a theatral purpose for viewing and listening to rituals at the altar and, perhaps, in purpose-built spaces in the forecourts of the sanctuaries (Csapo, 2007, pp. 87–121). However, these steps were not proper theatres in the modern sense of the

word, but rather rows of seats (with linear and non-circular theatre and/or *orchestra*) (Marconi & Scahill, 2015).

These theatral steps in sanctuaries seem to be important for understanding the communicative and multisensorial possibilities of ritual performances, as they do not only appertain to the observation of ritual procedure at the altar but are perhaps connected even more intensely with the visual and aural experience in a framework of sacred representation (Mylonopoulos, 2006, pp. 59–97). Inge Nielsen (2002, pp. 142–148) assumes that theatral steps were meant for spectators watching and listening to sacred actions and ritual dramas carried out in front of the temple, often with active participation from the worshippers: sonic events were related to the re-enactments of the myths of the gods, as it were, in their presence (Bellia, 2020). Moreover, as an important part of many cults, music, sounds, and ritualised movements were essential elements of these sacred representations. In this respect, music and dance performances also contributed to the enactment of rituals in these sacred contexts: sound and hearing made contributions to the holistic experience of these theatral spaces as significant as those made by image and sight.

As Mylonopoulos (2006, pp. 76–77) has argued, theatral steps can by no means be connected to any particular divinity, although they are especially prevalent not only in sanctuaries of Dionysos but also of Demeter: these buildings appear to have played an essential role in the latter's cult. At least three of her most important sanctuaries, in Corinth, in Lykosoura, and in Pergamon, possess monumental steps. To these buildings, we can add the theatre stairs in the south of the Telesterion in Eleusis (Avgerinou & Dreni, 2014) – probably built in the time of Hadrian – and the “South Building” in Selinus (Figure 3) (Hollinshead, 2012, pp. 32–48; 2015, 41–50; Marconi & Scahill, 2015, pp. 279–292).

Several elements suggest that this structure was an impressive viewing area and an important space for rituals and performances in the main urban sanctuary on the Acropolis. According to Clemente Marconi (2014), this structure was built to accommodate audiences during sacred festivals and celebrations, as well as spectators of cultic performances associated primarily with Temple R, probably a temple of Demeter *Thesmophoros*. The performance of choral dancing and musical performances in this part of Selinunte's main urban sanctuary is also suggested by several discoveries in the area of Temple R: a series of Corinthian vase fragments, which feature chains of dancing women that conform to the so-called *Frauenfest* iconography; two elements of an *aulos*; and a statuette of a singing siren. Similar to this figurine, the bone wind instrument can be dated to 570 BCE (Bellia, 2017, pp. 17–22; Marconi, 2014, pp. 105–116). Material evidence of musical and choral performances at Selinus is very significant, particularly with regard to sonic events performed in the

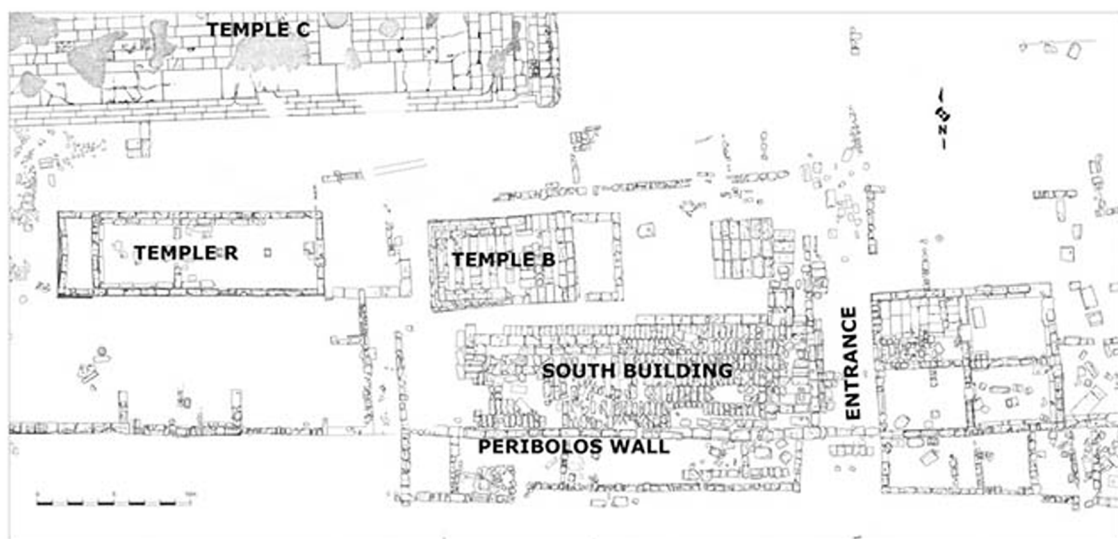


Figure 3: Selinus, plan of the “South Building.” Southern sector of the main urban sanctuary on the Acropolis. After Marconi, 2014, p. 113, Figure 1.

Temple R: the scale and placement of the theatral steps at Selinus's Temple R provide emphatic architectural codification of viewing and listening as participation, a fundamental premise of Greek religious ritual.

Taking into consideration theatral steps as material evidence within the lived sonic experience of cult – ritualised sound and movements, which, alongside other, non-musical sounds and gestures, make certain physical impressions upon the worshippers who listen to and perform them – these buildings contributed to the effort of ritual performance. According to Sokolicek (2015, p. 104), the quality of the stones was carefully selected in relation to their placement in the theatral steps; this selection was based on structural, aesthetic and, in all likelihood, acoustic considerations. In this regard, a range of techniques – including 3D modelling to simulate site acoustics, as well as using microphones, speakers, and musical performances to assess sounds and evaluate auditory perception within the theatral area – have been used to investigate the various acoustic properties of this architectural space. A 2021 survey revealed surprising sonic qualities in this theatral area. Given that the theatral structure is not fully preserved, the study used a 3D model of the theatral building and incorporated software that is able to calculate acoustic values. Thanks to the development of a virtual application for Oculus Rift, the study explored the 3D reconstruction of the theatral area in the Acropolis of Selinus and, at the same time, listened to the auralisation from different positions; audio files of the recorded musical performances were also used in the survey. The main aim of this VR application, developed through unity, was to experience theatres as an ancient listener. Therefore, the VR application was developed through two phases: the first was the 3D modelling and texturing of the theatral area; and the second was the auralisation of an anechoic file of a musical performance from different positions in the 3D model of the theatral structure and its immediate surroundings (Bellia, 2021a, pp. 2475–2478).

The resulting values obtained through acoustics analysis undertaken by the research members at the National Research Council of Italy Sonic Heritage Laboratory were useful in exploring whether, for example, the theatral area was more suited to talks or music (and choral) performances and/or sonic events, and in analysing if the acoustics in the theatres and the immediate surroundings met the criteria for good comprehension of speech or for enjoying music (Diaz-Andreu & Garcia-Benito, 2014). Moreover, acoustic parameters were helpful in understanding the interaction with surrounding sounds from the sonic environment (Figure 4) (Bellia, 2021a). The experimental research setup enabled the research team to take advantage of the fact that sound quality changes dramatically when various parameters of the space are altered. Simulating different configurations of these parameters allowed the team to compare the functional capacity of these spaces: by analysing the differences in sound quality, the influence of various parameters on auditory comprehension was assessed (e.g. how softly an instrument player has to play so that he can no longer be heard; when addressing a noisy crowd, the distance at which it no longer matters how loudly the speaker can project his/

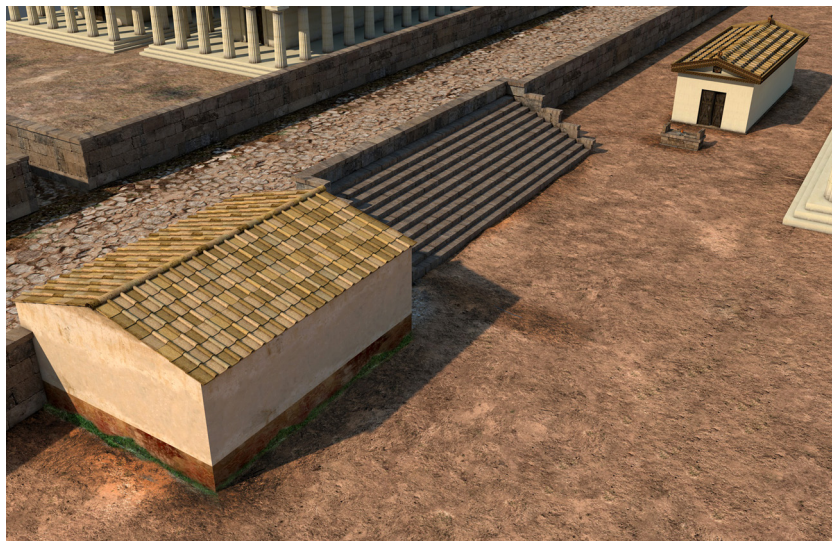


Figure 4: Theatral structure and Temple R in Selinunte (digital reconstruction by Massimo Limoncelli © Institute of Fine Arts, NYU).

her voice), as well as which configuration of parameters optimised auditory comprehension (Graham et al., 2019).

6 Conclusion

Taking into consideration two case studies, this article has aimed to expand our knowledge of the role of sounds in archaeological contexts. This research is in line with recent developments in archaeology over the past few decades, particularly the interest in new approaches to understand how ancient people experienced their surroundings (Hamilakis, 2013; Skeates & Day, 2020). Given that sound has always been an omnipresent component of human experience, recent trends in the archaeological inquiry have encouraged an exploration of the role of acoustics, instruments, and of what was heard in the past. The starting point of this exercise is the idea that it is possible to ascribe cultural meanings to sonic experiences, and that sounds have played important functions in quotidian life and in worship.

Sacred spaces and architectural structures help establish specified loci for sonic events and define the viewing and listening space for worshippers. The sheer capacity of spaces and structures is a testament to their importance in accommodating and even fostering social and religious activity for large number of peoples (Jordan, 2020). The spaces are in themselves representations of large-scale participation; they give form to the stages of ceremony, which would have included various acts of worship in religious contexts, such as processions, performances of hymns, sacrifices, and ritual dramas (Connelly, 2011, p. 330). Sound builds a relationship to the built and natural environment and organises space, while at the same time organises worshippers through the arrangement of social events and performances. Therefore, sacred sounds, as well as music and dancing, can play an instrumental role in shaping the forces of social interactions.

Architectural structures, which may have been auxiliary manifestations of festival proceedings intended as a setting for social events, give formal expression to the location and scope of celebration in and of themselves; thus, their design not only produced specific visual and aural effects, but their very construction was influenced by the display behaviours enacted during sonic events.

In sacred spaces, worshippers may enjoy a sense of festivity provided by the constructed setting and a shared group sonic experience; this experience is concentrated in prescribed pathways and captured by architectural structures for assembled crowds. The embodiment in sacred spaces (Hollinshead, 2015, p. 87) is a form of social energy, the collective enthusiasm and solidarity of large festive groups performing and actively observing familiar yet immediate rites, in which sacred sounds embody the festival's true spirit, strengthen the relationship between believers and their beliefs. Sacred sounds were intended to maximise the effects of the ceremony, and reinforce the solidarity engendered by practices in a worship context.

In this respect, architectural structures were not simply settings for ritual, but a tangible expression of community behaviours. Active participation in processing, listening, and viewing created *communitas* of shared experience. The essential “energy” of a crowd in motion was intensified by sounds and music. Enhanced by sensory cues – visual, aural, tactile, olfactory – sonic events at the heart of sanctuaries and the related spaces and structures heightened the religious experience in a built and natural environment. Such connection of body and place, of behaviour and built form, gave frame and shape to sonic events and to shared multisensory experiences in sacred spaces across a range of locations and time periods.

Some of the acoustic effects identified in sacred spaces have been considered in previous research (Bellia, 2021b). However, how various types of architectural remains were perceived and used has generally been studied through the analysis of one sense (usually sight). This has resulted in the exclusion of the full set of human senses and in a limited understanding of how sound interacted with the sacred sphere and built and natural environments. It is worth noting that acoustic effects are a result of the extent to which surfaces reflect and/or absorb sound, and are dependent on the dimensions, shape, and properties of the space in which any given sound was produced, as well as the objects encountered when travelling through it. These acoustic features are critical for auditory spatial awareness and can be incorporated into our understanding of the aural architecture of the sacred. How sound and listening contributed to the appreciation of the properties and

dimensions of the sacred spaces may tell us more about sound and auditory culture in antiquity. For this reason, cutting-edge acoustics methods and auralisation techniques are pivotal in interpreting sacred spaces and architectural structures. Evaluating their acoustics through digital technology, we could shed light on their unexplored sonic features and effects, ultimately opening the door to a deeper knowledge of sound phenomena in the sacred sphere and of the architecture-sound nexus in producing aural spaces of the past (Down Geoffroy-Schwinden, 2018).

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