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Soundscape and sound experience:
an overview of the approaches and methods for the
study of sonic materiality of the past

Abstract

As something ephemeral that does not leave direct material traces, sound is not often considered in archaeological work. However, sound was an important aspect of ancient life, which can be investigated using a new approach to the archaeological remains and the evidence of sonic aspects in the archaeological record. By analysing the main recent research on these fields, we will discuss in this contribution the relationship between the intangible aspects and the spatial configuration of archaeological spaces.

Riassunto

In quanto qualcosa di effimero che non lascia tracce materiali dirette, il suono spesso non viene considerato nel lavoro archeologico. Tuttavia, il suono era un aspetto importante della vita antica, che può essere studiato utilizzando un nuovo approccio ai resti archeologici e alle testimonianze degli aspetti sonori nella documentazione archeologica. Analizzando le principali ricerche recenti su questi ambiti, in questo contributo si discuterà il rapporto tra gli aspetti immateriali e la configurazione spaziale degli spazi archeologici.

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SOUNDSCAPE AND SOUND EXPERIENCE: AN OVERVIEW OF THE APPROACHES AND METHODS FOR THE STUDY OF SONIC MATERIALITY OF THE PAST

Exploring sound dimension in the past

Identifying the role of sound and auditory aspects in historical and archaeological settings, as well as intentional acoustics, is challenging. Nonetheless, considering the pervasive nature of sound throughout human history, modern archaeological research is increasingly focusing on the importance of acoustics, musical instruments, and the auditory experiences of ancient peoples. This involves giving cultural significance to auditory experiences and recognising the crucial role sound played in everyday ancient life.¹

Recent studies have focused on exploring the sensory experiences of ancient people, using new methods to investigate how sound influenced their lives. Sound and auditory perception provide an important perspective for understanding social interactions in the past, and how individuals understood and navigated their surroundings. This concept is in line with the changing landscape of archaeology in recent years, which now seeks also to recreate the sensory experiences of ancient civilizations.²

By analysing the sounds that would have been heard within a specific natural and built environment and landscape, acoustic setting, and spaces for performances, we can enhance our understanding of how sounds events resonated with those who witnessed them.³ Shannon Mattern has suggested that paying attention to the auditory aspects in archaeological explorations can lead to the realisation of the inherently multisensory nature of human experience.⁴ She points out that historical sites have frequently acted, whether intentionally or unintentionally, as ‘echo chambers’ and pathways for sound, playing roles in public events, personal interactions, and ritual and musical activities. Employing sensory experiences to understand a site or artefact also involves acknowledging the importance of senses other than sight.⁵ It is important to remember that musical performances and

¹ Eleanor BETTS, “Introduction: Senses of Empire”, in: Eleanor BETTS (ed.), *Senses of the Empire: Multisensory Approaches to Roman Culture*, London and New York, Routledge, 2017, 1–12.

² Jo DAY, “Introduction: Making Senses of the Past”, in: Jo DAY (ed.), *Making Senses of the Past: Toward a Sensory Archaeology*, Carbondale (IL), Southern Illinois University Press, 2013, 1–31; Yannis HAMILAKIS, *Archaeology and the Senses: Human Experience, Memory, and Affect*, New York, Cambridge University Press, 2013, 48–55; Robin SKEATES and Jo DAY, “Sensory Archaeology: Key Concepts and Debates”, in: Robin SKEATES and Jo DAY (eds.), *The Routledge Handbook of Sensory Archaeology*, London and New York, Routledge, 2019, 1–17.

³ Margaret M. MILES, “Birds around the Temple: Constructing a Sacred Environment”, in: Jeremy MCINERNEY and Ineke SLUTTER (eds.), *Valuing Landscape in Classical Antiquity: Natural Environment and Cultural Imagination*, Leiden and Boston, Brill, 2016, 151–195; Erika HOLTER, Susanne MUTH and Sebastian SCHWESINGER, “Sounding Out Public Space in Late Republican Rome”, in: Shane BUTLER and Sarah NOOTER (eds.), *Sound and the Ancient Senses*, London and New York, Routledge, 2019, 44–60.

⁴ Shannon MATTERN, “Sonic Archaeologies”, in: Michael BULL (ed.), *The Routledge Companion to Sound Studies*, London and New York, Routledge, 2019, 222–230: 225.

⁵ Raquel JEMÉNEZ PASALADOS, “A ‘Phenomenology of Soundscape’: Archaeoacoustics, Landscape and Environment in Music Archaeology”, in: João CASCALHEIRA and Célia GONÇALVES (eds.), *Actas das IV Jornadas de Jovens em Investigação Arqueológica I*, Faro, Universidade do Algarve, 2012, 443–446.

sounds produced during sacred actions were more than just ways of communication. They held religious and authoritative meaning and helped shape personal and social identities, particularly because of their essential role in ceremonies and performances that involved worshippers and an audience.⁶

Sound and the experience of listening are universal phenomena that have manifested across all periods and cultures. The concept of a ‘soundscape’ incorporates both the anthropological context – human influences and activities – and its manifestation within audible space and acoustic space. Recognising the role of sound in sacred sites, performance areas, architecture, and even the creation and use of sound objects is essential, as it has impacted societies in myriad ways.⁷

When archaeological studies include the analysis of soundscapes, they bring material remains to life by using sensory-based approaches to investigate deeper anthropological questions related to cultural heritage. By studying human experiences, perceptions, and interactions with the world, new research perspectives can be uncovered in the study of the human past. By closely examining our shared physical senses, which are common to all humans, we can better understand the experiences of ancient peoples. Despite differences in interpretation, our shared biological heritage allows us to somewhat connect with the historical experiences of the past material world.

Researching historical sound environments provides more than just acoustic knowledge. It influences our understanding of sound-related artefacts in the archaeological record. This relationship works both ways: studying soundscapes and archaeoacoustics helps us interpret archaeomusicology, organology, and acoustics, and these disciplines can also help us define and understand ancient landscapes and boundaries.⁸ Steven Feld has proposed an innovative method to further explore the correlation between culture, space, and sound. He distinguishes between ‘acoustic space’ and ‘audible space’, providing a unique perspective for examining archaeological sites and structures. Through the concept of ‘Acoustemology’, he introduces a sound-focused epistemology, asserting that sound plays a vital role in acquiring knowledge. The act of generating sound and being aware of its existence can lead to a transformative understanding of human experiences.⁹ Studying ancient environmental sounds or analysing the exact acoustic properties at archaeological sites can provide valuable insights into the significance and purpose of sound in those environments. This approach combines the study of sound with heritage conservation and management, providing a fresh perspective on historical analysis. By examining sound in specific archaeological contexts, we gain a better understanding of how sound affects various aspects such as spaces, social interactions, architectural designs, and even relationships between humans and

⁶ Takeshi INOMATA and Lawrence S. COBEN, “Overture: An Invitation to the Archaeological”, in: Takeshi INOMATA and Lawrence S. COBEN (eds.), *Archaeology of Performance: Theatres of Power, Community, and Politics*, Lanham (MD), AltaMira Press, 2006, 11–12.

⁷ Barry BLESSER and Linda-Ruth SALTER, *Spaces Speak, Are You Listening? Experiencing Aural Architecture*, Cambridge (MA) and London, Massachusetts Institute of Technology Press, 2007, 67–78; Gian Franco CHIAI and Ralph HÄUSSLER (eds.), *Sacred Landscapes: Creation, Manipulation, Transformation*, Oxford and Philadelphia (PA), Oxbow Books, 2019, 40.

⁸ Raquel JEMÉNEZ PASALADOS, “A ‘Phenomenology of Soundscape’”, 445.

⁹ Steven FELD, “Acoustemology”, in: Davis NOVAK and Matt SAKAKEENY (eds.), *Keywords in Sound*, Durham and London, Duke University Press, 2015, 12–21.

animals. It is only by recognising and exploring the importance of sound that we can truly comprehend the complex relationships between space, society, and the natural and built environment.

Redefining the role of sound in archaeological field

In the field of archaeological research, sound has received little attention primarily because of its intangible nature: it leaves no tangible remnants for uncovering. Nevertheless, sound played a pivotal role in ancient life and human existence; modern methodologies¹⁰ in archaeology encourage us to explore this aspect by examining the auditory evidence in archaeological studies.¹¹ Humans have always been surrounded by a lively auditory environment that has influenced how they perceive the world. As Kristy E. Primeau argued,¹² the concept of “soundscapes” involves the dynamic interaction between humans and their environments, shaped by the combination of sounds and their interplay in any given space. These soundscapes are more than just noise; they reflect cultural practices, embody symbolism and aesthetics, mediate social dynamics, create religious experiences, hold memories, and evoke emotions. They establish cultural identities, mark temporal milestones, shape ritualistic practices, define territorial boundaries, and can even represent ideas of the sacred and status.

Despite the evident significance of aural experiences in performative contexts, traditional excavation of archaeological sites has been predominantly visual-centric, especially of theatres and of spaces for performances. Looking further back in history, we can see that sound, movement, and spatial design were closely connected, influencing the acoustic qualities that were crucial to the structure and purpose of venues for performances. Archaeological findings indicate that the architectural elements of these spaces may have developed in response to artistic developments of music and dance performances, which consequently influenced the design of these spaces. The sound environment in performance spaces was not only determined by the acoustics, but also by the combined impact of music, speech, and vocal sounds. These spaces were not just stages, but multi-sensory environments where sound was a crucial element. By viewing theatres as spaces that are ‘embodied’, we can explore how sound physically interacts with the architecture, revealing its influence on the design of the space and its role in social interactions. The acoustic characteristics of a space were closely linked to its social function, and studying this connection could provide new insights into the mutually beneficial relationship between sound and architectural design.¹³

The main focus of this evaluation is the size and scope of studying auditory experiences. This can include exploring sound perception in small areas or

¹⁰ Steve MILLS, *Auditory Archeology. Understanding Sound and Hearing in the Past*, Walnut Creek, California Left Coast Press, 2014, 53–74.

¹¹ Gjermund KOLLTVEIT and Riitta RAINIO (eds.), *The Archaeology of Sound, Acoustics & Music: Studies in Honour of Cajsa S. Lund*, Berlin, Ekho Verlag, 2020.

¹² Kristy E. PRIMEAU, “Current Trends in Archaeoacoustics”, Paper presented at the 86th Annual Meeting of the Society for American Archaeology, 2021, [online], <https://www.academia.edu/46920574/Current_Trends_in_Archaeoacoustics>.

¹³ Zühre SÜ GÜL, “Acoustical Impact of Architectonics and Material Features in the Lifespan of Two Monumental Sacred Structures”, in: *Acoustics*, 2019, 1, 493–516: 493–495.

examining interactions in larger auditory environments and acoustic landscapes. This approach is especially important in the field of auditory archaeology, emphasising the significance of taking into account current sounds in research areas to encourage new insights into how we engage with and comprehend the relationships between locations, people, and the built and natural surroundings.¹⁴

Soundscapes, archaeoacoustics, and archaeomusicology

Research in the fields of soundscapes, archaeoacoustics, and archaeomusicology (or music archaeology) has been progressing, shedding light on the complex auditory dimensions of historical sites. These disciplines also concentrate on the acoustic features of ancient theatres and performance spaces, revealing that there is no one-size-fits-all approach to understanding acoustic behaviour and auditory experiences. Various techniques and goals have emerged within these research fields, particularly in probing the sounds of performance locales from different ages and locations.¹⁵ When combined with heritage conservation, studies of acoustics offer a deeper understanding of history, prompting us to think about sound not only as a sonic quality, but also as a fundamental aspect of social and cultural customs.

Although the theoretical discussion regarding soundscapes is well-established and provides a basis for archaeoacoustical research, studies focusing on historical acoustics within Greek architectural venues have been somewhat overlooked. The inconsistency in how soundscapes are defined across various disciplines, such as archaeology and sound studies, hinders a cohesive approach.¹⁶ Archaeomusicology and archaeoacoustics provide frameworks for investigating sound environments and analysing the auditory activities within ancient public spaces such as agoras and assemblies, theatres, *bouleuteria* (council houses), stadia, and *odeia* (music halls).

It is important to highlight that acoustical research often focuses on the physical properties of sound. However, to fully understand the sound environment of the past, we must also explore the cultural and performative aspects. An anthropological approach will greatly help in interpreting the significance of sound in archaeological contexts.¹⁷ The study of sound within ancient spaces, architectural structures, and historical buildings is inherently interdisciplinary.¹⁸ It includes perspectives from archaeology to aural architecture and acoustics, each presenting unique methodological challenges.¹⁹ Despite the diversity, a uniting factor is the use of both acoustic measurements and simulations, enabling a thorough analysis that

¹⁴ Stephen Francis MILLS, "Sensing the Place: Sounds and Landscape Archaeology", in: Douglass BAILEY, Alasdair WHITTLE and Vicki CUMMINGS (eds.), *(Un)setting the Neolithic*, Oxbow, Oxford, 2005, 79–89.

¹⁵ Francesco ALETTA and Jian KANG, "Historical Acoustics: Relationships between People and Sound over Time", in: *Acoustics*, 2020, 2, 128–130.

¹⁶ Chris SCARRE and Graeme LAWSON (eds.), *Archaeoacoustics*, Cambridge, McDonald Institute for Archaeological Research, 2006; John SCHOFIELD, "The Archaeology of Sound and Music", in: *World Archaeology*, 2014, 46, 33, 289–291.

¹⁷ Elizabeth C. BLAKE and Ian CROSS, "The Acoustic and Auditory Contexts of Human Behavior", in: *Current Anthropology*, 2015, 56, 1, 81–103.

¹⁸ Steve MILLS, *Auditory Archaeology*, 18–26.

¹⁹ Rupert TILL, "Sound Archaeology: A Study of the Acoustics of Three World Heritage Sites, Spanish Prehistoric Painted Caves, Stonehenge, and Paphos Theatre", in: *Acoustics*, 2019, 1, 3, 661–692.

blends ancient techniques with modern technology. Researchers in this field should be commended for their diligence and perseverance in carrying out precise measurements in challenging conditions.²⁰ They use both qualitative and quantitative methods to gain a comprehensive understanding of both ancient and current soundscapes. This comprehensive investigation is supported by technologies such as binaural recordings, giving us a window into historical performances and sonic events in the past.

Investigating sounds in performances venues of the past: a case study

The complex relationship between sound and performance in ancient spaces has been a research area that has evolved over time. Our understanding of how acoustics were considered and used in ancient performance venues has grown, revealing a detailed process of development closely linked to architectural advancements and the needs of expanding audiences. The project *Stesichoros: The Archaeology of Sound in a Greek City*, carried out in Italy at the National Research Council, Institute of Heritage Sciences, has provided insightful revelations in this field, focusing on the acoustic features of spaces for performances and employing sophisticated auralisation techniques to examine the sound quality in sacred areas of Selinunte.

Archaeoacoustic research involves a wide range of methods, which are influenced by differences in how data is collected and analysed.²¹ This field goes beyond using computational and modelling methods and instead adopts a perspective that views soundscapes as experiential contexts that are closely linked to how ancient societies understood their surroundings.²² By investigating the relationship between architectural design and acoustics, researchers aim to do more than just recreate ancient sounds or simulate past auditory experiences. Archaeoacoustics aims to shed light on the sounds of different locations and time periods, providing new insights into archaeological sites by focusing on their sonic qualities.²³

Recent research has become more diverse in both approach and results, focusing specifically on how advancements in digital technology, such as 3D modeling and sound simulations, can improve our understanding of historical sounds and aid in the preservation of sound-related heritage. For example, the *Stesichoros* project examined the way sounds interacted within an ancient theatre during the Archaic period, using experimental 3D reconstructions paired with acoustic modelling and auralisation technology in the field of archaeology. This project highlighted the significant role that sound played in enhancing the

²⁰ Nikos BARKAS, “The Contribution of the Stage Design to the Acoustics of Ancient Greek Theatres”, in: *Acoustics*, 2019, 1, 1, 337–353.

²¹ Rupert TILL, “Sound Archaeology: Terminology, Palaeolithic Cave Art and the Soundscape”, in: *World Archaeology*, 2014, 46, 3, 292–304; Rupert TILL, “Sound Archaeology”, 661–692.

²² Kristy E. PRIMEAU and David E. WITT, “Soundscape in the Past: Investigating Sound at the Landscape Level”, in: *Journal of Archaeology Science*, 2018, 19, 875–885: 875.

²³ Linda C. ENEIX (ed.), *Archaeoacoustics II. The Archaeology of Sound*, Myakka, Florida OTS Foundation, 2016; Linda C. ENEIX and Michael RAGUSSA (eds.), *Archaeoacoustics III. The Archaeology of Sound*, Myakka, Florida, OTS Foundation, 2018.

functionality of architectural spaces, not only as places for interaction and communication, but also as environments that combined visual, auditory, and other sensory experiences. This research offers new insights into the relationship between ancient audiences and the sounds around them. The idea of reimagining and studying ancient performance spaces through their soundscapes is an innovative approach to archaeological research, one that aims to replicate and understand the auditory experiences of the past.

This approach is exemplified in the evaluation of sonic characteristics within the theatre area in ancient Selinus (odiern Selinunte), an ancient city recognised today as one of the most important archaeological sites of the Greek period in Italy (Fig. 1): from its foundation as a colony around the second half of the 7th c. through to the middle of the 3rd c. BCE, Selinus enjoyed a prosperous existence as reflected in its notable sanctuaries and temples. The theatrical area of Selinus was chosen as a case study for the *Stesichoros* project survey not only due to the various notable aspects of this performative space, but also because of its natural surroundings located in the Acropolis of this Greek city.²⁴ Moreover, there is a notable connection between the structure known as the ‘South Building’ and nearby sacred sites dedicated to worship practices of a public nature, specifically those related to the deities Demeter and Apollo. Various artefacts, such as musical instruments and sonic tools, were found in the theatrical area, indicating their use during performances and ceremonies held in the theatre.²⁵ One noteworthy discovery at Temple R. was an *aulos*, a type of wind instrument. Thanks to the excavation reports released by the American Archaeological Mission of the Institute of Fine Arts at New York University, directed by Clemente Marconi, it is possible to conduct in-depth analysis of this theatre and its immediate surroundings, given that there are no restrictions in the access to this monument.

²⁴ Clemente MARCONI, “Nuovi dati sui culti del settore meridionale del grande santuario urbano di Selinunte”, in: *Sicilia Antiqua*, 2013, 10, 263–272: 263–264; Angela BELLIA, “Towards a New Approach in the Study of Ancient Greek Music: Virtual Reconstruction of an Ancient Musical Instrument from Greek Sicily”, in: *Digital Scholarship in the Humanities*, 2018, 34, 2, 233–243.

²⁵ Clemente MARCONI and David SCAHILL, “The ‘South Building’ in the Main Urban Sanctuary of Selinus: A Theatral Structure?”, in: Rune FREDERIKSEN, Elizabeth R. GEBHARD and Alexander SOKOLICEK (eds.), *The Architecture of the Ancient Greek Theatre*, Aarhus, Aarhus University Press, 2015, 281–294; Luigi POLACCO, *Il teatro di Dioniso Eleutereo ad Atene*, Rome, L’Erma di Bretschneider, 1990; Inge NIELSEN, *Cultic Theatres and Ritual Drama: A Study in Regional Development and Religious Interchange between East and West in Antiquity*, Aarhus, Aarhus University Press, 2002; Mary B. HOLLINSHEAD, “Monumental Steps and the Shaping of Ceremony”, in: Bonna D. WESCOAT and Robert G. OUSTERHOUT (eds.), *Architecture of the Sacred: Space, Ritual, and Experience from Classical Greece to Byzantium*, Cambridge, Cambridge University Press, 2012, 27–65; Alexander SOKOLICEK, “Form and Function of the Earliest Greek Theatres”, in: Rune FREDERIKSEN, Elizabeth R. GEBHARD and Alexander SOKOLICEK (eds.), *The Architecture of the Ancient Greek Theatre*, Aarhus, Aarhus University Press, 2015, 97–104.

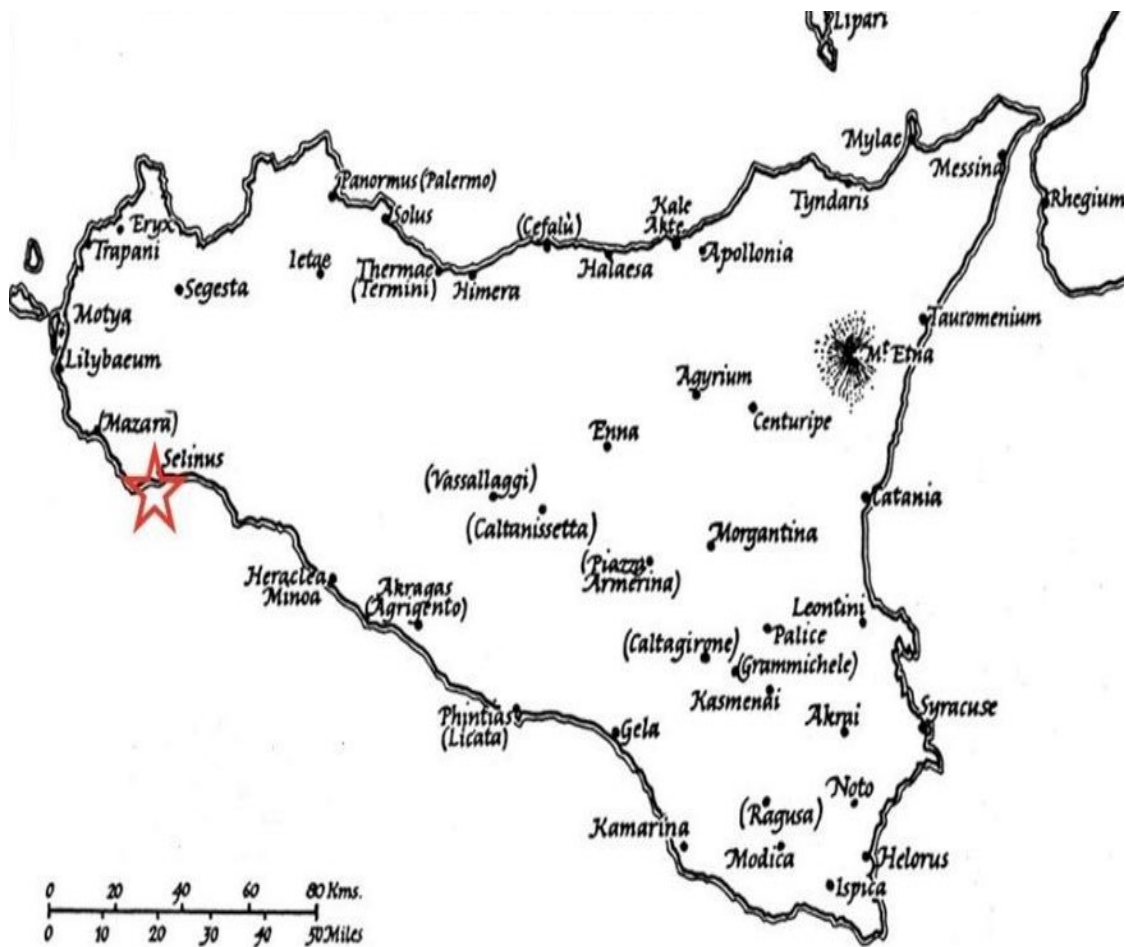


Fig. 1 - Allargare in orizzontale la Sicilia: è troppo schiacciata

The purpose of this study was to investigate if the location chosen for the construction of this building on the acropolis of the ancient Greek *polis* was strategically selected for its acoustical properties, with the goal of improving auditory experiences and public speaking. The research also aimed to explore how people engaged with this architectural design. This building, along with its associated open-air performance area, belongs to a fascinating cluster of structures found in various regions of the Greek world, such as the Peloponnese, Crete, Attica, East Greece, Magna Graecia, and Sicily. The seating arrangements predominantly faced the centre of the sanctuary, as did the temple of the deity, ensuring that both the audience and the ‘deity’ – be it a cultic statue or a priest/priestess – could observe and hear the events taking place in the *orchestra*, where the altar was typically located. These constructions were not conventional theatres in the modern sense but rather comprised of rows of seats (with linear and non-circular *theatra* and/or *orchestra*).²⁶

²⁶ Carlo ANTI and Luigi POLACCO, *Il teatro antico di Siracusa*, Rimini, Maggioli, 1981; Luigi POLACCO, *Il teatro di Dioniso Eleutereo ad Atene*, 119–159; Elizabeth R. GEBHARD, *The Theater at Isthmia*,

The stones chosen for the theatrical steps were carefully selected, considering their placement within the structure to improve not only the structural integrity and aesthetics but also, most likely, taking into account the acoustic properties of the space where these buildings were constructed. Although theatrical steps are a lesser-known category in the field of Greek drama, scholars like Carlo Anti²⁷ and Elisabeth Gebhard,²⁸ Inge Nielsen, in her research on cultic theatres and ritual drama in antiquity,²⁹ Alexander Sokolicek, in his exploration of the earliest Greek theatrical structures,³⁰ and Mary Hollinshead,³¹ in her examination of steps as integral elements of monumental constructions at Greek sites from as early as the sixth century, have shed light on their significance in religious and architectural contexts.

The theatrical structures discovered in sanctuaries are important for understanding the communicative and multisensory aspects of ritual performances. These structures do more than just enable observation of ritual actions at the altar – they are closely connected to enhancing the visual and auditory experiences during sacred representation and public events. Joannis Mylonopoulos³² has argued that theatrical steps are not necessarily dedicated to any specific deity, although they are commonly found in sanctuaries of Dionysos and Demeter: these buildings likely played a crucial role in the worship of Demeter, with several of her important sanctuaries in Corinth, Lykosoura, and Pergamon featuring monumental steps. To these buildings we can add the theatre steps in the south of the *Telesterion* in Eleusis – probably built in the time of Hadrian –,³³ and the ‘South Building’ in Selinus (Fig. 2).³⁴ There are multiple factors that indicate that this building served as a significant viewing area within the main urban sanctuary on the Acropolis. According to Clemente Marconi,³⁵ the structure was specifically designed to host audiences during sacred festivals, celebrations, cultic performances, and public assemblies associated primarily with Temple R, probably a temple dedicated to Demeter *Thesmophoros*.³⁶

Chicago and London University of Chicago Press, 1973; Eric CSAPO, “The Men who Built the Theatres: *Theatropolai*, *Theatronai*, and *Arkhitektones*”, in: Peter WILSON (ed.), *The Greek Theatre and Festivals: Documentary Studies*, Oxford, University Press, 2007, 87–121; Alexander SOKOLICEK, “Form and Function of the Earliest Greek Theatres”, 97–104.

²⁷ Carlo ANTI, *Teatri greci arcaici. Da Minosse a Pericle*, Rome, L’Erma di Bretschneider, 1947.

²⁸ Elisabeth R. GEBHARD, “The Form of the Orchestra in the Early Greek Theater”, in: *Hesperia*, 43, 4, 1974, 428–440.

²⁹ See Inge NIELSEN, *Cultic Theatres and Ritual Drama*.

³⁰ Alexander SOKOLICEK, “Form and Function of the Earliest Greek Theatres”, 97–102.

³¹ Mary B. HOLLINSHEAD, “Monumental Steps and the Shaping of Ceremony”, 46–56; Mary B. HOLLINSHEAD, *Shaping Ceremony: Monumental Steps and Greek Architecture*, Madison, The University of Wisconsin Press, 2015.

³² Joannis MYLONOPOULOS, “Greek Sanctuaries as Places of Communication through Rituals: An Archaeological Perspective”, in: Eftychia STAVRIANOPOULOU (ed.), *Ritual and Communication in the Graeco-Roman World*, Liège, Presses universitaires de Liège, 2006, 69–110.

³³ Mary B. HOLLINSHEAD, “Monumental Steps and the Shaping of Ceremony”, 32–48; Mary B. HOLLINSHEAD, *Shaping Ceremony: Monumental Steps and Greek Architecture*, 41–50.

³⁴ Clemente MARCONI and David SCAHILL, “The ‘South Building’ in the Main Urban Sanctuary of Selinus”, 279–292.

³⁵ *Ibid.*, 289–290.

³⁶ *Ibid.*, 288.

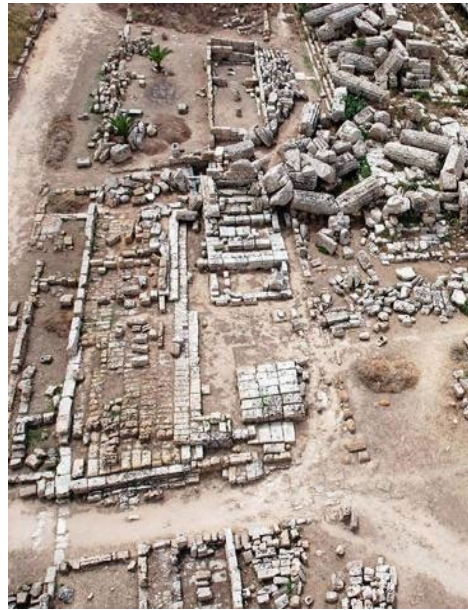


Fig. 2 - Aerial view of the area of investigation. © Institute of Fine Arts, NYU.

Choral dancing and musical activities performed at this part of the main urban sanctuary of Selinus are suggested by the discovery of fragments of Corinthian vases in the sacred area of Temple R. These fragments depict chains of dancing women in a ‘style’ that aligns with *Frauenfest* iconography.³⁷ Moreover, two parts of a bone *aulos*, dating back to 570 BCE, were found in the same area.³⁸ These findings highlight the importance of music and dance in the sacred setting of Selinus, dating back to its Early Archaic period when the *polis* was founded.³⁹ The choral and musical material evidence discovered at Selinus sheds light on the importance of sonic events and ritual dancing in this place, particularly in relation to the activities around Temple R. Considering the ‘South Building’ as a possible stop for processions, including dramatised rituals related to the Demeter myth, parallels can be drawn to Megara Nisea, the city from which Selinus originated. Pausanias⁴⁰ mentioned how a sacred drama honoring Demeter and her daughter was performed in Megara Nisea, involving female worshippers who participated in lamentations. These performances likely mirrored the myth of Demeter and were staged along a route connecting different sacred sites. It remains uncertain whether a similar sacred drama was staged at Selinus, and whether music and dance activities were performed. However, the enactment of music and dance performances during

³⁷ Clemente MARCONI, “Nuovi dati sui culti del settore meridionale del grande santuario urbano di Selinunte”, 263–272.

³⁸ Clemente MARCONI, “A New Bone *Aulos* from Selinus: Music and Spectacle in the Main Urban Sanctuary of a Greek Colony in the West”, in: Angela BELLIA (ed.), *Musica, culti e riti dei Greci d'Occidente*, Pisa-Rome, Istituti Editoriali e Poligrafici Internazionali, 2014, 105–116; Angela BELLIA, “Towards a New Approach in the Study of Ancient Greek Music”, 233–243.

³⁹ Angela BELLIA, “Performative Aspects of Music in Sacred Contexts of the Western Greeks”, in: Agnès GARCIA-VENTURA, Claudia TAVOLIERI, and Lorenzo VERDERAME (eds), *The Study of Musical Performance in Antiquity: Archaeology and Written Sources*, Newcastle upon Tyne, Cambridge Scholars Publishing, 2018, 155–173.

⁴⁰ PAUSANIA, *Guida della Grecia, Libro I. L'Attica*, a cura di Luigi BESCHI e Domenico MUSTI, Milano, Fondazione Lorenzo Valla, Arnoldo Mondadori, 2013, I, 43, 2.

rituals was common and we can take into consideration the *aulos* was the instrument best suited for female lamentation and ritual movements. The *aulos* provided intonation to the lament and was easily portable for non-professional performers in processions. The presence of the *aulos* in the sacred area of Selinus suggests that it was used during rituals in the area, helping to shape the auditory space of the performance and establishing a distinctive sound environment for participants. Moreover, the sound of the *aulos* added to the overall sonic atmosphere of the ritual space, mixing with natural sounds to enrich the ritual experience.

Nevertheless, ritual practices may have been distinctive at the sacred spaces in Selinus. The placement of the altar in front of Temple R, reminiscent of the Sanctuary of Demeter at Pergamon (judging by inscriptions, finds, and architectural arrangements it served as a *Thesmophorion*), means that the ‘South Building’ would have served as a viewing area for any sort of ritual performances or public assemblies in the open space between the temple and the access to the sanctuary.⁴¹ It probably hosted processions, musical and dancing performances, sacrifices, festivals, and other public events. The theatrical steps at Temple R underscored the importance of audience participation in Greek religious rituals, highlighting viewing and listening as integral parts of the worship experience. Taking into account theatrical steps as material evidence within the lived sonic experience of cult – as 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, which would have included various acts of worship in the sacred and public space.

Acoustics and architectural reconstruction

Several methods were used to investigate the acoustic properties of this architectural space. These techniques included 3D modeling to simulate the acoustic properties of the site, the use of microphones, speakers, and musical performances to evaluate sounds and assess auditory perception within the theatrical area,⁴² as well as experiments involving replicas of musical instruments, sound tools, and voices to analyse the range of sounds produced and their acoustic impact. This investigation revealed unexpected sonic qualities within the theatrical area despite the incomplete preservation of this theatrical structure. A 3D model of the theatre building was created, and we used software capable of calculating acoustic values. Thanks to the development of a virtual application for Oculus Rift, we explored the 3D reconstruction of the theatrical area⁴³ in the Acropolis of Selinus (Fig. 3) and, at the same time, listened to the auralisation from different positions; audio files of the recorded musical performances were also used in our survey. The primary purpose

⁴¹ Clemente MARCONI and David SCAHILL, “The ‘South Building’ in the Main Urban Sanctuary of Selinus”, 290.

⁴² Stefan FICHNA, Thomas BIBERGER, Bernhard U. SEEGER and Stephan D. EWERT, “Effect of Acoustic Scene Complexity and Visual Scene Representation on Auditory Perception in Virtual Audio-Visual Environments”, in: *2021 Immersive and 3D Audio: from Architecture to Automotive (I3DA)*, Bologna, Italy, 2021, 1–9.

⁴³ Angelo FARINA and Lamberto TRONCHIN, “3D Sound Characterisation in Theatres Employing Microphone Arrays”, in: *Acta Acustica united with Acustica*, 2013, 1, 99, 118–125; Daniel PINARDI and Angelo FARINA, “Metrics for Evaluating the Spatial Accuracy of Microphone Arrays”, in: *2021 Immersive and 3D Audio: from Architecture to Automotive (I3DA)*, Bologna, Italy, 2021, 1–9.

of this virtual reality (VR) application, created using Unity, was to provide users with an experience of theatres from the perspective of an ancient listener. The development of the VR application involved two phases: first, the 3D modeling and texturing of the theatrical area; and second, the creation of audio simulations from different positions within the 3D model of the theatrical structure and its immediate surroundings by using anechoic musical performance files.



Fig. 3 - Temple R. Virtual reconstruction of Archaic phase (ca. 580). © Institute of Fine Arts, NYU.

To create and texture the 3D model shown (Fig. 4), we used the software 3D Studio Max 2016. Mental Ray materials were applied to the surfaces of the 3D models, and the renderer was configured to NVIDIA Mental Ray. This choice was made because Mental Ray materials come equipped with preset features tailored for specific materials such as stones, which were prominently used in the construction of ancient theatres. Once new images were mapped onto the 3D model, they were exported as .fbx files for easy integration into Unity. Additionally, when developing the 3D model, we considered not only the available documentation on ancient theatres acoustics, but also made comparisons with the acoustics of other theatres in the ancient world.



Fig. 4 - Virtual reconstruction of area of investigation in the Archaic period. © Institute of Fine Arts, NYU.

The process of auralisation was carried out by using the Odeon Room Acoustics software. Five to eight audio files were utilised and auralised from various positions within the theatrical structure and its associated space. The anechoic file was recorded in the sonic laboratory of the Institute of Heritage Science at the National Research Council of Italy, with the assistance of a music maker and professional musician. He played short melodies on his *aulos*, which was reconstructed using different materials and based on the measurements and shape characteristics of the ancient Greek instrument found in the area of the theatrical structure and the Temple R. Subsequently, the *aulos* melodies were recorded in the anechoic room of the laboratory, and the recorded files were imported into the theatrical 3D project in Odeon Room Acoustics. Additionally, audio files of recorded human voices and natural sounds from the Acropolis were used to recreate the ‘sonic fabric’ of the performing space in Selinus and to assess the complete sound experience in the theatrical structure. The Neumann KM 183 omnidirectional microphone was employed to capture impulse responses from nine different receivers placed along three directions of the orchestra. The microphone was positioned in the orchestra at a constant pitch, on the seats, and at a height of 0.8m. The audio files were convolved automatically with the impulse responses recorded by the receivers placed in the theatrical building and space. By exploiting the information contained in the impulse response related to the architectural characteristics of the theatrical structure, it was feasible to generate a corresponding audio file representing the actual sound in a specific position within the theatre.

The analysis of the acoustic properties generated important data that was essential for determining the suitability of the theatrical area in Selinus for different types of performances such as talks, music and choral activities, and other sonic events. It also allowed for an evaluation of whether the acoustic characteristics of the performative space supported clear speech comprehension and enjoyable music

listening experiences. Moreover, studying the acoustic parameters provided valuable insights into how various sounds from the environment, including natural sounds (geophony), sounds produced by animals (biophony), and human-made sounds (anthrophony), interacted within the soundscape in the theatrical area.⁴⁴ An evaluation has been conducted from an ecological-historical and ecoarchaeological viewpoint on the sounds associated with geophonic origins (such as weather patterns and seasons) in the theatrical area. By investigating geophony in the location of the theatre, it was possible to explore the various sources of geophonic sounds that could have had a significant impact on auditory experiences (e.g. the sounds of the sea in Selinus). Moreover, sounds related to animals and plants, which create a 'sonic frame' and play a key role in rituals and performances, were examined. The analysis of fauna provided important insights into the crucial role animals played in the ecosystem in this area and how they contributed to the overall sound environment.⁴⁵ While the specific soundscape of the theatrical area in Selinus today likely differs from that of the past, the overall distribution of sound may have remained relatively consistent. By taking into account contemporary sounds such as those from nearby rivers and the sea that are audible at the Acropolis of Selinus, the research aimed to investigate the role and impact of sound in both ancient and modern settings. It is possible that while human-created sounds may have evolved over time, natural sounds such as wind may have remained in the area, as is still the case today at the Acropolis. (Fig. 5). Studying the relationship between natural and human sounds presents an interesting viewpoint when analysing the soundscape of public areas in ancient times and gives us a better understanding of how those spaces may have been perceived and experienced by ancient people.



Fig. 5. Acropolis of Selinus. © Institute of Fine Arts, NYU.

⁴⁴ Stephen Francis MILLS, "Sensing the Place Sounds and Landscape Archaeology", 79–89.

⁴⁵ See Bernie L. KRAUSE, *Wild Soundscapes: Discovering the Voice of the Natural World*, Berkley, Wilderness Press, 2002, 2–7.

Some final thoughts

Analysing the acoustic properties of the ancient performative space in Selinus using 3D models has led to the discovery of new insights and hypotheses. This space, which was crucial for communication and social interaction in this ancient Greek city in the West, reveals previously unexplored aspects of its architectural structure and the societal practices of the past.

One key finding of the research is that the acoustics of this archaeological site suggest a shift in its use during the transition from the Classic to the Hellenistic period. It is hypothesised that the abandonment of the theatrical area during this time may have been influenced by the need for a larger space to accommodate a growing audience, reflecting changes in historical events, religious practices, and public performances in this *polis*. This shift aligns with the construction of circular stone theatres in Sicily during the same period, where improved acoustics facilitated a better auditory experience for music, voices, and sounds. The evolution of these theatrical structures may have been intertwined with advancements in acoustics and musical practices, including changes in instruments and of the ‘spectacularization’ of music (and dance) from the 5th-4th c. BCE. Written sources suggest that the musical landscape during this period saw innovations in instrumental capabilities, melodic effects, and musical structures, as well as a heightened emphasis on musical storytelling through mimesis. This cultural shift towards a more dramatic and elaborate approach to music and dance likely required appropriate spaces for performances in order to enhance the overall sensory experience for the audience.⁴⁶

For this reason, the research on the theatrical steps in Selinus explored written and, where possible, figurative sources concerning past performative spaces to complement the material evidence and archaeological remains with their sonic aspects. Moreover, analyses of a substantial number of literary texts by orators, philosophers, and historians (e.g., Aristotle, Aristoxenus, Plutarch, and Vitruvius), which mention theatre acoustics issues more or less incidentally, provided valuable information on the acoustic principles guiding the construction of theatrical buildings and spaces in the past.

Another significant outcome of this research is the emergence of new research areas like sensory archaeology,⁴⁷ auditory archaeology,⁴⁸ and aural architecture in antiquity.⁴⁹ This study not only aimed to address queries on the types of performances, sonic events, or ritual activities held in the theatrical space in Selinus but also underlines the importance of acoustics in archaeology and architecture.⁵⁰

⁴⁶ Kathryn G. BOSHER, “Infinite Variety: Ancient Greek Drama in Sicily”, in: Claire L. LYONS, Michael BENNETT, and Clemente MARCONI (eds.), *Sicily: Art and Invention between Greece and Rome*, Los Angeles, The J. Paul Getty Museum, 2012, 110–121; Kathryn G. BOSHER, *Greek Theater in Ancient Sicily*, Cambridge, University Press, 2021.

⁴⁷ Eleanor BETTS, “Introduction”, 1–12.

⁴⁸ Steve MILLS, *Auditory Archeology*, 53–74.

⁴⁹ Barry BLESSER and Linda-Ruth SALTER, *Spaces Speak, Are You Listening?*, 67–97.

⁵⁰ Rebecca DOWD GEOFFROY-SCHWINDEN, “Digital Approaches to Historical Acoustemology”, in: Mary CATON LINGOLD, Darren MUELLER, and Whitney TRETTIEN (eds.), *Digital Sound Studies*, Durham, Duke University Press, 2018, 231–249; Shawn GRAHAM, Stuart EVE, Colleen MORGAN, and Alexis PANTOS, “Hearing the Past”, in: Kevin KLEE and Timothy COMPEAU (eds.), *Seeing the Past with Computers. Experiments with Augmented Reality and Computer Vision in History*, Ann Arbor, University of Michigan Press, 2019, 224–236.

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Discussions on Greek architectural acoustics, specifically, emphasise the complex connections between the physical environment and social and auditory factors. By connecting information and placing archaeological evidence in context alongside written and visual sources, these approaches, methodologies, and interdisciplinary connections can expand our comprehension of the significance of sound in ancient societies and its impact on the locations, areas, and buildings experienced by people in the past. An approach known as “soundscape archaeology” can enable the investigation of sensory auditory issues while also preserving and managing auditory heritage, providing new perspectives on antiquity.⁵¹ Due to the increasing amount of research, it is clear that future studies should use 3D reconstructions and virtual acoustics to understand the reasons behind the design of performance spaces in the past.

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⁵¹ Kristy E. PRIMEAU, “Current Trends in Archaeoacoustics”.