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Bibliographical reference

The Acoustics of the Ancient Theatres, John Mourjopoulos and Patrizio Fausti, Acta Acustica **vol. 99** (Number 1), 2013, pp. iii-iv

DOI
https://doi.org/10.3813/AAA.918581

The Acoustics of the Ancient Theatres

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Dear Readers of Acta Acustica united with Acustica,

Ancient theatres were prominent public buildings of the Greek-Roman era. Although mostly located around the Mediterranean, such theatres were built in every major city of the ancient world in Europe, Middle East, North Africa and beyond, spreading from Alexandria on Oxus (now Ai Khanum) in Afghanistan to Lisbon along the east-west axis, and from the Roman sites in northern England to Ptolemais in southern Egypt, along the north-south axis. To date, 741 ancient theatre structures have been identified and documented, 194 being earlier Greek theatres, 425 theatres and 46 odeia being from the Roman period and another 76 recorded theatres not accurately categorised. The evolution of these theatres starts from 6th century BC and the transition from the Hellenistic to the Roman period is placed around the mid-1st century BC. These ancient theatres stand as the earliest testament to the close relationship between the architectural concepts, acoustic principles and theatrical act. The emergence and historical development of theatre as an art form from the beginnings of ancient drama to later forms of theatrical expression was affected by the structure and acoustic properties of the open-air amphitheatres. This simple structure consisting of the large cavity to seat spectators (the "koilon" or "cavea"), the mid-way stage area where the action took place (the "orchestra") and the backstage building (the "skene") is possibly the earliest example showing how proper architectural acoustics can support and enhance speech and music communication, over large public audiences. By allowing perfect speech reproduction for more than 10000 persons, these buildings allowed the transformation of age-old ritual ceremonies in honour of gods into great and timeless works of dramatic art performed by actors to their fellow citizens and the world. If well-preserved, such theatres still attract numerous audiences during modern-day performances fulfilling functions similar to those for which they were constructed more than two thousand years ago. Via their evolution to the roofed odea which were more appropriate for music performances and to the later-day theatrical spaces and concert halls, these ancient theatres represent the ancestry in architectural acoustics. In a broader sense, these theatres are also significant for the western civilisation and the universal cultural heritage. The acoustics of these ancient theatres, odeia and monuments keep impressing not only the casual visitors but also the experts in our field and present a long-standing challenge to our scientific understanding. Prominent acousticians of the past have devoted studies – a complete book for the case of François Canac – discussing and analysing their acoustic properties. Recently, the widespread use of acoustic simulation software methods has generated renewed interest by allowing the "acoustic reconstruction" and study of such structures; the availability of portable and flexible measurement systems has also assisted to detailed measurements and examination of some well-preserved theatres. Such results and studies are presented via selected papers in a Special Section in this issue of Acta Acustica united with Acustica covering a wide range of topics:

The first paper by Jens Blauert analyses the conceptual aspects of the qualitative acoustic experience in theatre spaces, examining processes from the areas of psychoacoustics, sensory psychology, physics, and communication science which contribute to the formation of aural quality.

In the second paper, Alessandro Cocchi discusses from a historical perspective the acoustics of ancient theatres examining the evidence for the relationship between acoustics and ancient theatre design.

Jens Holger Rindel then presents, in the third paper, extensive results of investigations and acoustic simulations for numerous Roman and Greek ancient theatres produced during the ERATO project.

The fourth paper by Soterios Psarras *et al.* and the fifth paper by Tapio Lokki *et al.*, concentrate specifically on the ancient Greek theatre of Epidaurus. Through the analysis of measurements (in the case of the former) or of acoustic modeling (in the latter), they both reaffirm the exceptional acoustic quality of this theatre particularly for the reproduction of speech.

The next two papers deal with specific aspects, such as sound diffraction and stage-set effects, using both measurements and simulations with computer or scale models. The paper by Panos Economou *et al.* presents results indicating the significance of diffraction in the edges of the multiple tiers in the theatre, whereas the sixth paper by Nicola Prodi *et al.* presents modelling principles for these open-air amphitheatric structures based on scale models.

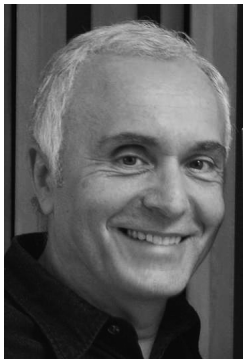
The next three papers discuss the issues of the use of resonators in ancient theatres and churches and the function of ancient theatrical masks. The paper by Spyros Polychronopoulos *et al.* examines the topic of the resonant vases (acoustic pots) in theatres, whereas the paper by Jean-Christophe Valiere *et al.* presents a study for such acoustic pots in medieval and modern day churches. A study of the acoustic function of theatrical masks used during ancient drama performances is presented in a paper by Alexandros Tsilfidis *et al.*

In the successive papers, other aspects linked to the use and characteristics of spaces for performance in different historical periods are presented. The acoustic properties of the 18th century Teatro Ideale based on the neoclassical architectural design of Francesco Milizia are presented in a paper by Lamberto Tronchin, the acoustics of a space for later day medieval drama performances in York, in a paper by Mariana Julieta Lopez *et al.*, and measurements and reconstruction of the acoustics of the Neolithic monument of Stonehenge in the paper by Bruno Fazenda *et al.*

Finally, the last paper by Angelo Farina *et al.* presents a visualization technique which clearly shows direction-of-arrival of the room reflections, a novel technique which can be applied to all architectural spaces, including ancient theatres.

We sincerely hope that these papers will help our readers to resolve some issues related to our heritage in the field of architectural acoustics and also to allow them to clarify and appreciate more clearly our current practices and aims. As guest editors, we would like to thank the reviewers who have generously contributed to this Special Section.

The Guest Editors,



John Mourjopoulos



Patrizio Fausti