

# CLASSICAL AUDITORIA IN THE MEDITERRANEAN OF UNIVERSALLY ACKNOWLEDGED ACOUSTICS: EVALUATING ELECTROACOUSTIC AMPLIFICATION

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## 1 INTRODUCTION

Mediterranean architectural heritage comprises classical auditoria of universally acknowledged acoustics, such as Hellenic ancient theatres, Byzantine temples, etc. Despite their natural sound been widely acclaimed, recently there has been a trend for such spaces to employ electronic amplification of their natural sound. The present work is a pilot study; this aims to investigate experimentally, whether natural acoustic properties of such auditoria can be enhanced by the use of electroacoustic amplification or, on the contrary, the latter will result in degradation of the overall acoustic experience. This study involves two subjective acoustic evaluation experiments in which two distinct monuments were used respectively; namely, the ancient theatre of Epidauros, and a typical Hellenic Christian Orthodox church.

## 2 EVALUATION OF ELECTROACOUSTIC AMPLIFICATION OF DRAMA PERFORMANCES, AT THE ANCIENT THEATRE OF EPIDAUROS

### 2.1 Introduction

The ancient theatre of Epidauros is regarded as the finest theatre of classical antiquity in the Mediterranean in terms of acoustics and architectural design, being the most critically acclaimed monument of this kind<sup>1</sup>. Since 1954 this theatre has been hosting annually the famous 'Epidauria' festival; this is one of the most important theatre events in the world presenting performances of ancient drama, and attracts thousands of visitors and aficionados who wish to enjoy the outstanding acoustics of the theatre. Nevertheless, over the last two decades the use of microphones, electroacoustic amplification and reproduction systems, has been established in the theatre for drama performances. This is a rather controversial innovation in terms of aesthetics and acoustics, since the acclaimed physical sound is questioned.

### 2.2 Background

The need for sound amplification of drama performances dates back to the nascent drama theatre in classical antiquity. Apart from the architectural design per se and the low environmental noise which contributed enormously to loudness of sound, other techniques were for instance the 'face masks'; those were employed during drama performances and boosted the directivity of the actor's voice<sup>2</sup>. Furthermore, unlike contemporary performances, drama in antiquity took place behind the *orchestra* (Figure 1); the latter allowed for early sound reflections from its own floor to reach the audience, amplifying so the actors voice. Additional early sound was also projected to the audience thanks to the *skene*, i.e. a solid barrier behind the actors<sup>3</sup>. Last it is not unlikely that the actors voice benefited from the increased sound energy per syllable, which was associated with long pronounced vowels of the classical Hellenic language.

In present days, the resumption of ancient drama performances in classical antiquity theatres, made the question of actor's voice amplification timely again. For this purpose, contemporary trends in drama performing, 'mise en scene', scenography, etc. had to adapt to the ancient theatrical space.

As an example reference is made to the established mode of reciting ancient drama on stage as well as backward body bending of actors, so as their own voice could become louder and more distinct in the audience area.

Sparing use of electroacoustic amplification initially, contributed to the actor's ease and comfort on stage, while artistic vocabulary was also broadened, allowing for a wider gamut of artistic interpretations and stage arrangements. In present days, electroacoustic amplification of drama performances has already been widely adopted in ancient theatres.



Figure 1: Parts of the ancient Hellenic theatre. 1. *Skene*, 2. *Orchestra*, 3. Lower Stalls, 4. Upper Stalls

## 2.3 Experimental Design, -Procedure, Results

Experimental subjects were asked to fill in a questionnaire, online. Two subject groups were employed, namely Sample A and B respectively. Sample A comprised two hundred thirty six (236) spectators, and theatre experts i.e. actors, stage directors etc., all of which were familiar with the ancient theatre of Epidauros. They had to evaluate the acoustic quality of the theatre on the nominal scale shown in Figure 2, twice i.e. with and without use of microphones respectively (Figures 2,3). Sample B comprised forty eight (48) actors who were familiar with performing in the test theatre, and were compiled from sample A above. These subjects were asked to evaluate their interpretation on stage along with five criteria shown in Figure 4, respectively in relation to microphone use. For each of the two samples, subjects were asked to indicate flaws relating with acoustics during performances, and make additional comments if any (Figures 5,6). Results are shown in Figures 2–6. Apparently, spectators' perception of the acoustics in the theatre, varied significantly between upper stalls and lower stalls, when unamplified sound was used (Figure 2).

## 2.4 Discussion, Conclusions

It was demonstrated that the majority of respondents prefer performances without microphones (Figures 2,4). Of course, judgements are likely to have been biased by ideological stress that is normally associated with the theatre of Epidauros and its acclaimed acoustics.

Furthermore, faint voices of actors on stage and audience noise, emerged as significant flaws during performances, whilst low environmental noise levels were also acknowledged (Figures 5,6); the latter confirmed results from earlier acoustic measurements in situ<sup>4,5,6</sup>. It could be argued therefore, that

the use of microphones in the ancient theatre, to a certain extent at least, may be adopted in order to stop audience noise from masking faint voices on stage. This however, might result in the 'adverse effect'; in particular, on the one hand, the culture of 'least effort' could possibly be bred amongst those actors who disregard natural ways for amplifying their voice, and on the other hand a new generation of audience could emerge amongst those who do not hesitate to make noise, relying on the boosted loudness of performers voice.

Part of the acclaimed acoustics of the ancient theatre of Epidauros has been associated till present days with the extremely low levels of environmental noise. The use of electroacoustic amplification which tacitly supports noise making audience, impregnates the risk of devaluing the importance of silence as prerequisite for drama performance. In the near vicinity of a number of Mediterranean ancient theatres today, construction projects have already been implemented, for instance opening road connections, with deleterious effects on the environment and the acoustics of nearby theatres.

After years of contemporary performances without electroacoustic amplification in the ancient theatre of Epidauros, the need to project loud sound to the rearmost rows has given rise to a distinct genre of theatrical interpretation. Location of actors on stage, body posture, slow and long pronounced syllables, exploiting all possible ways for natural sound amplification, are only part of this genre; the latter expresses contemporary views about ancient drama and exploits the entire physiological gamut of human speech and hearing. Nevertheless, the use of electroacoustic amplification allows for wider range of artistic interpretation, broadens the possibilities and arrangements of actors in space, being so an important artistic tool in the hands of stage directors.

Based on present findings, it could be argued that electroacoustic amplification in ancient theatres could not be rejected *a priori*. However as with any other tool, electronic amplification of sound in drama performances needs be approached with care, since it may impregnate hazardous irreversible situations.

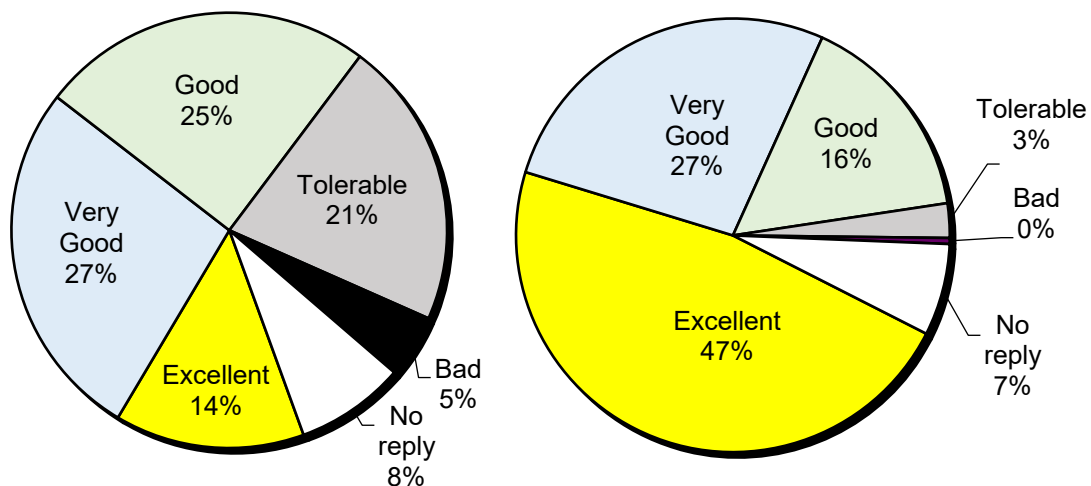


Figure 2: Percentage distribution of responses to question: Please evaluate the acoustic quality of **unamplified sound** in the theatre, on the following nominal scale

Bad	Tolerable	Good	Very Good	Excellent	No Reply
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Left: Upper stalls, Right: lower stalls

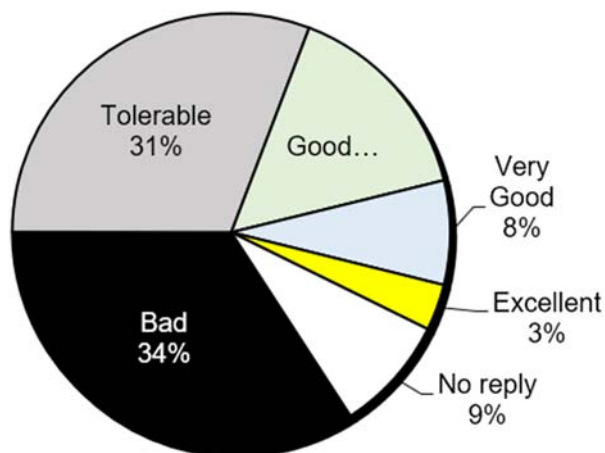


Figure 3: Percentage distribution of responses to question: Please evaluate the acoustic quality of **amplified sound** in the theatre, on the nominal scale of Figure 2

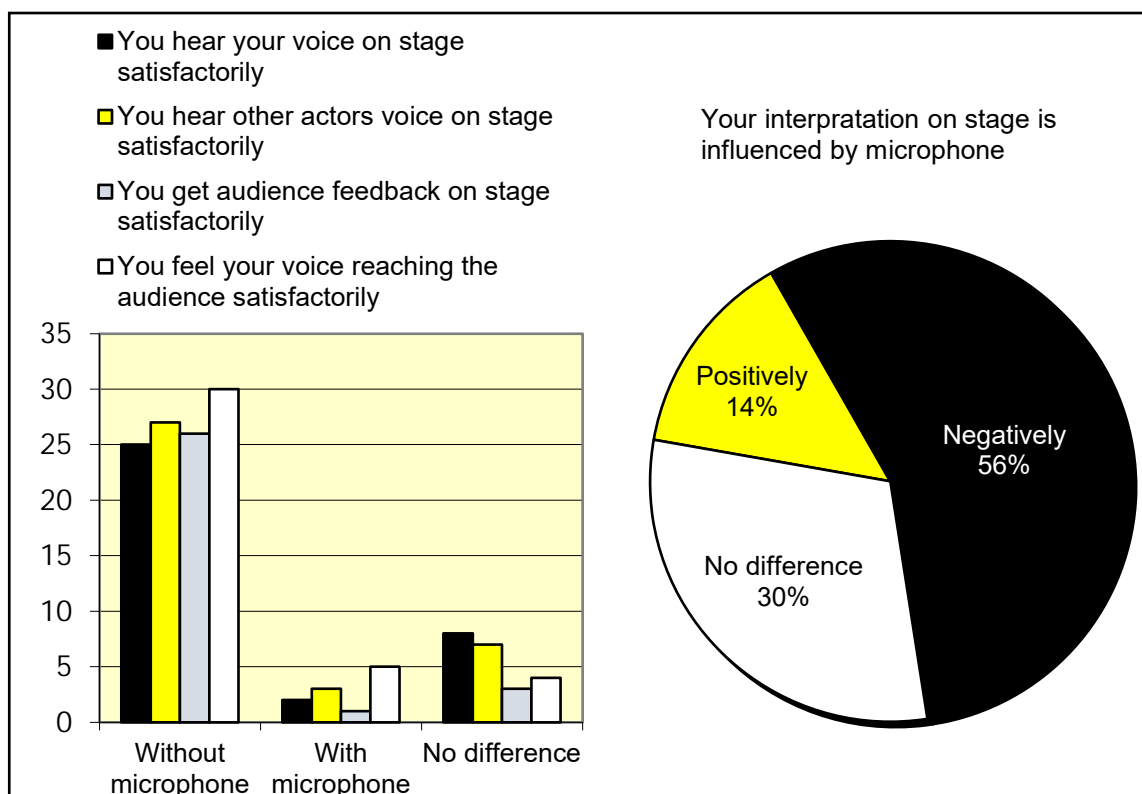


Figure 4: Subjective acoustic criteria concerning the interpretation of actors, in relation to microphone use

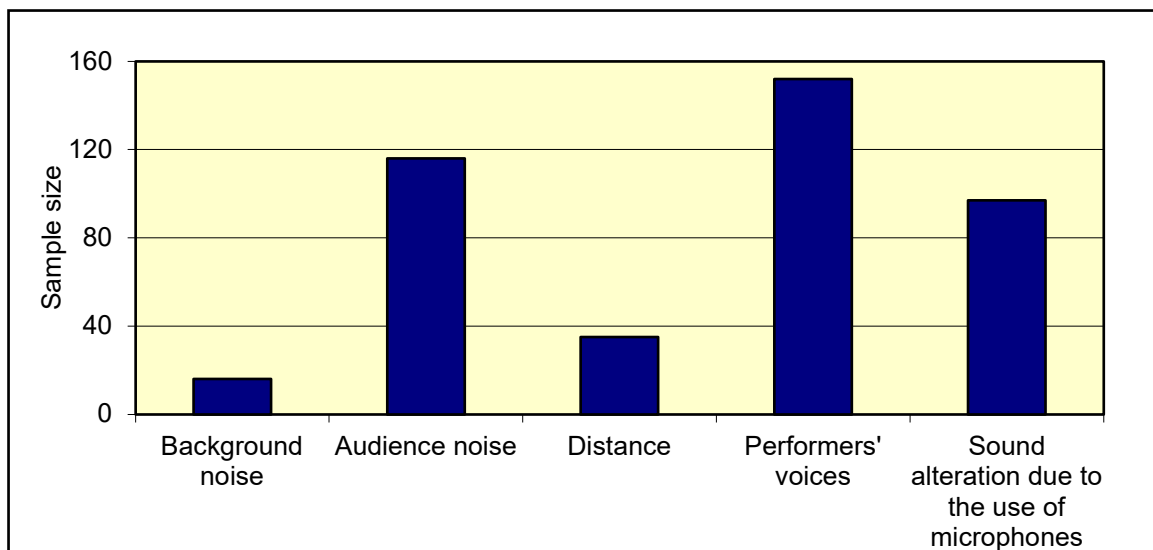


Figure 5: Histogram of important flaws associated with acoustics in the audience area, according to spectators

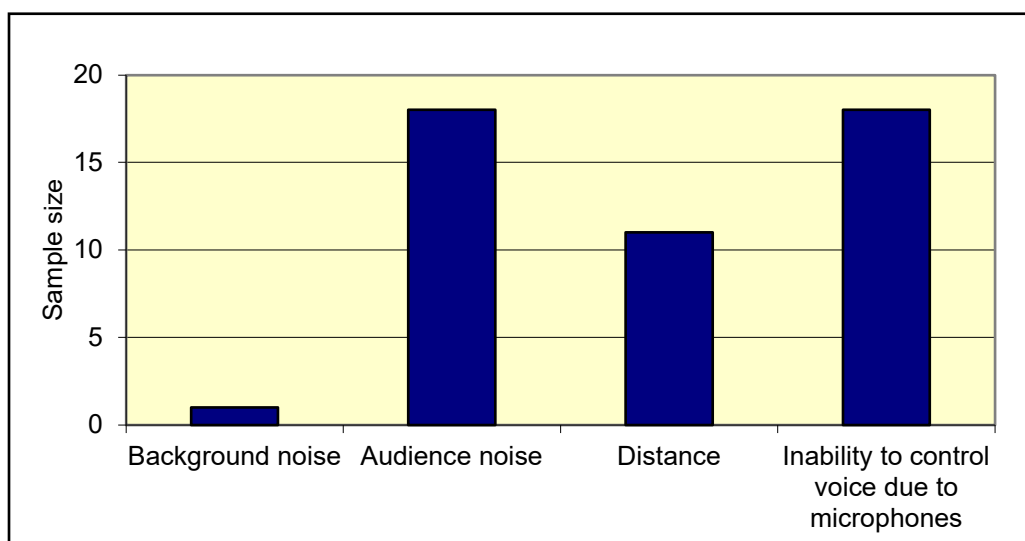


Figure 6: Histogram of important flaws associated with acoustics on stage, according to actors

### 3 SUBJECTIVE ACOUSTIC EVALUATIONS OF BYZANTINE LIVE LITURGY IN HELLENIC CHRISTIAN ORTHODOX CHURCH

#### 3.1 Introduction

Byzantine chant is a genre of religious music, which originated in the period of Byzantine Empire as a development of oriental and western musical influences. Byzantine chant ("melos") is sung solo or in chorus, and together with reciting ("logos") are major components of byzantine liturgy; the latter

was developed through centuries hand by hand with byzantine religious architecture and its inherent acoustical idiosyncrasy. The reverberant acoustics of Byzantine temples, has inspired composers to write great religious music and it has been widely acclaimed for uplifting the liturgy to a *metaxy* (a space between heaven and earth) bridging the physical and transcendental realms.

Orthodox churches of the modern Hellenic period, i.e. since the Independence of Hellenic nation in early 19<sup>th</sup> century, are replicas of (historic) Byzantine temples, though normally of much larger scale than their archetypes, in order to accommodate the increasing population of church-goers in modern societies. Under such circumstances, issues of audience noise are raised; the situation becomes even worse considering the noise pollution originating in the fast expanding modern urban environment and the insufficient noise protection design of churches; current acoustic measurements in Christian Orthodox churches in the city of Athens <sup>7</sup>, confirm urban noise levels well exceeding the acceptable criterion value 30 dBA. The above have resulted, in present days, in massive use of electroacoustic amplification, in order that natural acoustics in modern churches is 'improved'. Yet, this trend has also been extended to (historic) Byzantine temples, many of which are architectural heritage monuments under the auspices of UNESCO; examples in Thessaloniki are Hagios Demetrius of the 7<sup>th</sup> century, the church of Panagia Chalkeon of the 11<sup>th</sup> century, etc.

With the above in mind it could be argued, that the use of microphones in Christian Orthodox churches, to a certain extent at least, may be adopted, to stop environmental noise from masking the liturgy. To gain an insight of the answer to this dilemma one might refer to the acoustic perception of Byzantine liturgy in Orthodox churches, with and without microphones respectively, and compare between the two situations. The present study investigates this subject, using semantic differentiation<sup>8</sup>.

### 3.2 Background

The need for intelligibility of sound in byzantine temples, dates back to the origins of byzantine liturgy and the associated religious architecture. Inherent in the nature of byzantine chant, has been the use of long pronounced vocables, so as they are audible and intelligible when coupled with the reverberant acoustics of the Christian church. This strategic use of the acoustics has been so effective, that it further inspired intercalations to the chant of even non semantic vocables (e.g. ti-re-rem) and melismas, giving so prominence to prosody even at the expense of semantics.

Other parameters contributing significantly to loudness of liturgy, were, low environmental noise and some architectural features of church. For instance, **a)** the pulpit, which is a stand, raised well above the surrounding floor for audibility and visibility of the reciting preacher, and the canopy above pulpit, which reflects the preacher's voice onto the congregation below (Figure 7), **b)** the *templon*, which is a solid barrier between sanctuary and the nave, and amplifies the priest's and chorus voices by reflecting these back onto the nave; this works in much the same way as the *scene* does behind the actors, in ancient Hellenic theatre (Figure 1). **c)** the *solea*, which is a raised part of the floor in front of the portal to the sanctuary, for the priest to stand on and **d)** the floor between the *templon* and the nave, that allows for early reflections to reach the nave, amplifying so the priest's and chorus voices; this floor works again in much the same way as the reflecting *orchestra* floor does, in ancient Hellenic theatre (Figure 1).

The question of amplification of Byzantine liturgy in Orthodox churches, becomes timely again in present days. Amongst the fewest studies investigating this subject using semantic differentiation and employing electronically amplified live liturgy, is the work of Sotiropoulou et al<sup>9</sup>. In that study, independent subjective acoustic Factors were identified indicating prominence of subjective sound STRENGTH (Table 1); Applicability of those results in the case of unamplified live Byzantine liturgy remains to be investigated.

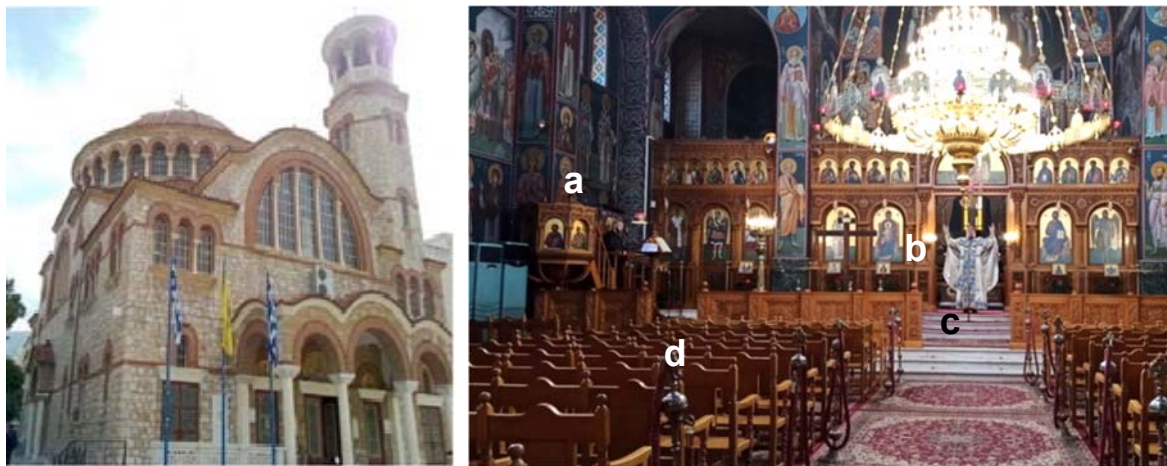


Figure 7: Hagios Therapon, Zografou, Athens. Left: Outside view, Right: Inside (front) view.  
a. Pulpit, b. *Templon*, c. *Solea*, d. Nave

Table 1: Results of Factor analysis of data obtained in Christian Orthodox churches with **amplified** live liturgy, according to <sup>9</sup>

Factor	Associated scales	Factor loadings	Variance (%)
I. STRENGTH	mighty - weak	-0,843	25
	full - empty	-0,766	
	poor - rich	0,717	
	restricted - wide	0,707	
	special - dull	-0,639	
	deep - shallow	-0,631	
II. CLARITY	dissonant- harmonious	0,744	17,7
	indistinct - distinct	0,700	
	blurred - clear	0,675	
	rough - soft	0,641	
	short - long	0,609	
III.TONAL QUALITY	calm - intense	0,766	16
	warm - cold	0,762	
	harmonious - toneless	0,554	
Cumulative percentage variance:			58,7

### 3.3 Experimental Design, Methods of Analysis, - Procedure, Results

The subjective evaluation experiment was carried out in a contemporary church in Athens, namely Hagios Therapon (Figure 7, Table 2), and employed the methods and procedure that had been previously used in <sup>9</sup>. In particular, subjective responses were measured by bipolar and continuous semantic rating scales. The scale judgements were analysed by Factor analysis<sup>10</sup>. Comments on the identity of Factors, their interpretation and their relative importance, can be found in <sup>11,12</sup>.

A common set of eighteen (18) rating scales (Table 3) were used in present evaluations and in <sup>9</sup> respectively. The rating scales were based on a list of opposite verbal labels that had been experimentally developed in an earlier study<sup>13</sup> to describe the acoustics of opera auditoria. The



assumption had been confirmed in <sup>9</sup> that there are acoustic qualities common amongst opera auditoria and Christian Orthodox churches. In same way as in <sup>9</sup> experimental subjects were self recruited, i.e. they offered to fill in a questionnaire when requested to do so. Subjects made their evaluations immediately after liturgy i.e. as soon as they stepped out of the sacred space. A total of twenty two (22) questionnaires in Hellenic, were filled in during the evaluations. Results of factor analysis of subjective judgements are shown in Table 4.

In order to compare the evaluations of the present study with those in which amplified sound was used<sup>9</sup>, raw data from the two studies were pooled together and were analysed according to Factor analysis. Then, for each subjective Factor an analysis of variance test was applied to the Factor scores (Table 5). Results showed that for Factor STRENGTH the subjective judgements were the effect of some systematic objective influence; identification of the latter in terms of the sound reinforcement system is obvious.

Table 2: Basic details of the test church

Hagios Theraon	
Year of Completion:	1952
Seating Capacity:	347 persons
Volume:	6150 m <sup>3</sup>
Reverberation Time (measured, unoccupied, mid freq.):	3.47 s
Background noise:	38.5 dB(A)

Table 3: List of opposite labels used in present evaluations. Translation in Hellenic is in parenthesis

1	Clear (καθαρός)	-Blurred (θαμπός)
2	Intense (έντονος)	-Calm (ήρεμος)
3	Toneless (άτονος)	-Harmonious (μελωδικός)
4	Live (ζωηρός)	-Dead (υποτονικός)
5	Empty (άδειος)	-Full (γεμάτος)
6	Pleasant (ευχάριστος)	-Unpleasant (δυσάρεστος)
7	Cold (ψυχρός)	-Warm (ζεστός)
8	Rich (πλούσιος)	-Poor (φτωχός)
9	Shallow (ρηχός)	-Deep (βαθύς)
10	Soft (απαλός)	-Rough (σκληρός)
11	Far (απόμακρος)	-Near (εγγύς)
12	Weak (αδύναμος)	-Mighty (ίσχυρος)
13	Distinct (ευκρινής)	-Indistinct (ασαφής)
14	Dull (αδιάφορος)	-Special (ξεχωριστός)
15	Harmonious (αρμονικός)	-Dissonant (παράφωνος)
16	Wide (ευρύς)	-Restricted (περιορισμένος)
17	Balanced (ισορροπημένος)	-Unstable (ασταθής)
18	Long (μακρύς)	-Short (σύντομος)

### 3.4 Discussion, Conclusions

In the case of Christian Orthodox churches, TONAL QUALITY and STRENGTH were found to be acoustic qualities common amongst unamplified and amplified live Byzantine liturgy (Tables 1,4). TONAL QUALITY dominated the evaluations when unamplified sound was used (Table 4), and liturgy induced 'pleasantness' was found to be associated with this quality. This finding confirms what has ever been widely considered, namely that TONAL QUALITY is an important concept inherent to the identity of Byzantine chant. By contrast, when amplified live liturgy was used in the evaluations,



STRENGTH turned out to be the dominant sound quality (Table 1). It was demonstrated in that case, that the evaluations were the effect of the sound reproduction system.

The above findings provide evidence that electroacoustic amplification, although it supports subjective sound strength, this is at the expense of the overall acoustic experience. It could be inferred, that to cope with the deleterious masking effect of environmental noise in churches, it may be far more appropriate to enhance the noise protection design of church rather than the electroacoustic properties of sound!

Table 4: Results of Factor analysis from present evaluations with unamplified live liturgy

Factor	Associated scales	Factor loadings	Variance (%)
I. TONAL QUALITY	harmonious - toneless	-0,861	22,71
	dissonant - harmonious	0,813	
	special - dull	-0,796	
	warm - cold	-0,768	
	unstable - balanced	0,746	
	unpleasant - pleasant	0,725	
	calm - intense	-0,674	
II. STRENGTH	mighty - weak	-0,896	18,54
	dead - live	0,840	
	poor - rich	0,770	
	short - long	0,745	
	near - far	-0,671	
	full - empty	-0,648	
	indistinct - distinct	0,614	
Cumulative percentage variance:			41,25

Table 5: Comparison of subjective factor scores between experiments of present study and of <sup>9</sup>

Factor	F-ratio	Significance
I. STRENGTH	45,41	<b>0,00</b>
II. TONAL QUALITY	2,82	0,10
III. CLARITY	0,92	0,34

## 4 OVERALL CONCLUSIONS

It is demonstrated in both experiments that the majority of respondents prefer performances without microphones. In one of the two experiments, namely in Christian Orthodox church it was made possible, further, to demonstrate that electroacoustic amplification, despite supporting subjective sound strength, this is at the expense of the overall acoustic experience.

Furthermore, there is evidence, that environmental noise pollution is significant drawback in both cases tested. It could be argued therefore that the use of microphones, to a certain extend at least, may be adopted in classical auditoria of universally acknowledged acoustics. This however, impregnates the risk of devaluing the importance of silence as prerequisite for performances in such auditoria, with the following deleterious consequences: i) breeding the culture of 'least effort' amongst,

on the one hand noise making audiences, and on the other hand performers who disregard natural ways for amplifying their voice, and ii) relegating noise protection design for such auditoria to a secondary place.

After centuries of performances without electroacoustic amplification, the need to project loud sound to rearmost seats of classical auditoria has given rise to distinct genres of interpretation. Nevertheless the use of electroacoustic amplification allows for wider range of interpretation, broadens the possibilities and arrangements of performers in space, being so an important artistic tool in the hands of sound engineers.

Based on present findings, it could be argued that electroacoustic amplification in classical auditoria of universally acknowledged acoustics, could not be rejected *a priori*. However, as with any other tool, electroacoustic amplification in such auditoria needs be approached with care, since this may impregnate hazardous irreversible situations.

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