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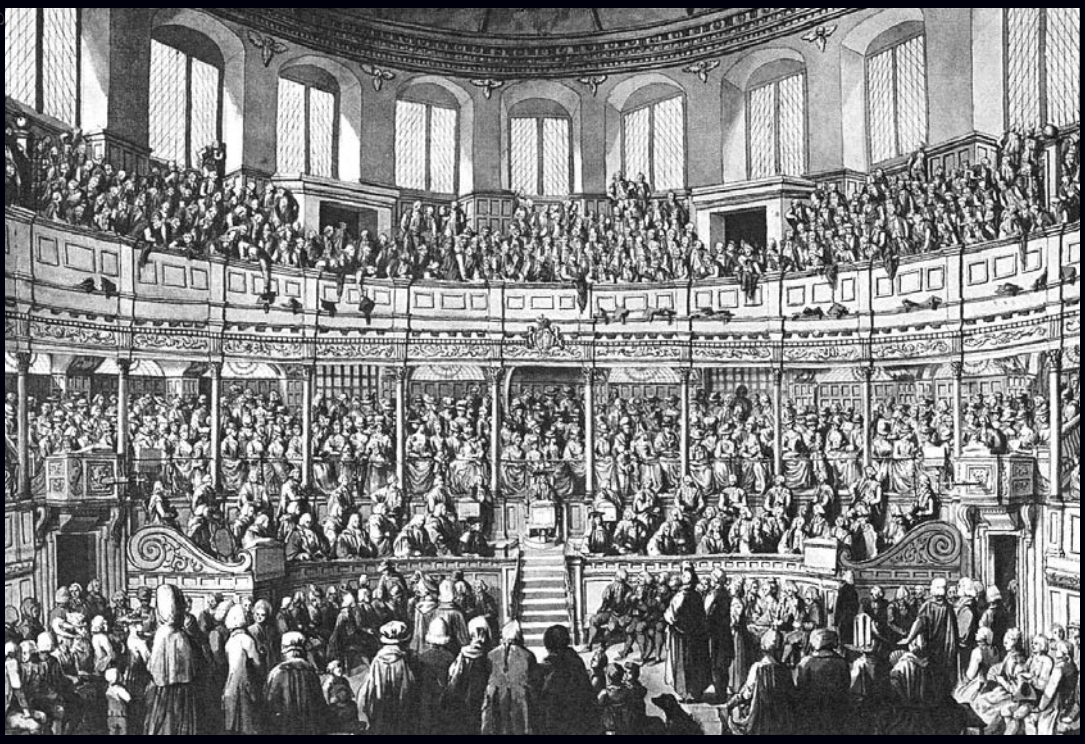

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Dorothea Baumann

Music and Space

A systematic and historical investigation into the impact of architectural acoustics on performance practice followed by a study of Handel's Messiah

This book explores a paradox: how can a musical work that was written specifically for a certain architectural space "survive" dramatic changes in performance conditions, as in the case of Handel's *Messiah?* From the chamber music hall in Dublin where it was first performed in 1742, small baroque theaters, and the chapel of London's Foundling Hospital, performances of *Messiah* after Handel's death moved to cathedrals, to new and large 19th-century concert halls, and finally to the immense Crystal Palace in Sydenham. Are there boundaries determining an adequate performance? How can we define the quality of room acoustics and how does this quality affect the performance as actual sonorous presentation of a musical work? In short, how do different acoustical conditions affect basic aesthetic premises?

There are no simple answers to these complex questions, which elicit different responses according to varying points of view. This aspect of cultural history necessarily calls for an investigation based on systematic, historical, and psychological methods. In the first part of this book, which draws from an extensive database of documents on halls, theatres, and churches, essential concepts from the main disciplines involved are introduced in order to define quality of room acoustics in relation to different performance situations. This background then serves as framework to investigate the performance history of Handel's *Messiah* in the second part.

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Music and Space

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Abbreviations

a	absorption
A. D.	Anno domini
AIM	American Institute of Musicology
Aml	Acta Musicologica
AMZ	Allgemeine Musikalische Zeitung
B. C.	before Christ
bc	basso continuo
bn	basson
cf.	cited from
cl	clarinet
dB	decibel
db	double bass
ed.	edited, edition, editor(s)
EDT	Early Decay Time
enl.	enlarged
EM	Early Music
EMH	Early Music History
et al.	*et alii*, and others
f.	folio
f.	following
facs.	facsimile
fl	flute
Fs.	Festschrift
GdM	Gesellschaft der Musikfreunde Wien
GS	Gesammelte Schriften
GW	Gesammelte Werke
HG	Händel Gesellschaft; Ausgabe der Deutschen Händel Gesellschaft
HHA	Hallische Händel-Ausgabe
HHdb.	Händel Handbuch
HJb.	Händel-Jahrbuch
hn	horn
HWV	Händel Werkverzeichnis
Hz	Herz
ibid.	*ibidem*, cited work, same page
instr.	instruments
IRASM	International Review of the Aesthetics and Sociology of Music
IRT	Initial Reverberation Time
ISO	International Standard Organisation
JASA	Journal of the Acoustical Society of America
JAES	Journal of the Audio Engineering Society
Jb.	Jahrbuch
JAMS	Journal of the American Musicological Society
NMA	Neue Mozart Ausgabe
m	meter
m3	cubic meter
MGG	Die Musik in Geschichte und Gegenwart
MJb.	Mozart Jahrbuch
ML	Music and Letters
mm	millimeter
ms	millisecond
ms.	manuscript
mss.	manuscripts
MQ	Musical Quarterly
MT	Musical Times
n.d.	no date
n.p.	no place
NG	New Grove Dictionary of Music and Musicians
ob	oboe
ÖMZ	Österreichische Musikzeitschrift
op. cit.	cited work
or.	orchestra
orig.	original
P.	Palais, Palazzo
perf.	performance
PRMA	Proceedings of the Royal Music Association
publ.	publication, published
r. p. m.	rotations per minute
repr.	reprint
rev.	revised
RAA	Répertoire d'Art et Archéologie

RIBA	Royal Institute of British Architects
RILM	Répertoire International de Littérature Musicale
RIM	Rivista Italiana di Musicologia
RIPM	Répertoire International de Presse Musicale
RISM	Répertoire International des Sources Musicales
RMA	Royal Music Association
RTM	Rundfunktechnische Mitteilungen
s	second(s)
s.a.	sine anno
SIMG	Sammelbände der Internationalen Musikgesellschaft
s.l.	sine loco
SMG	Schweizerische Musikforschende Gesellschaft
SS	Sämtliche Schriften
suppl.	supplement
T	Reverberation Time
tpt	trumpet
transl.	translated, translation
trbn	trombone
UP	University Press
v	violin
v.	voices
va	viola
vc	violoncello
vn	violin
vol.	volume
Zs.	Zeitschrift

Preface

The idea for this long term study on architectural acoustics in relation to music and music history arose from the author's experience as a performing musician, during sound recording and while teaching music acoustics at the University of Zurich, other universities and on the Swiss Radio and Television's education program.

The revival of Early Music since the 1950s, and even more so since the 1980s, paid special attention to the reconstruction of musical instruments, playing technique, and scores. Astonishingly, this interest very rarely included investigations of the original space of performance and even of subsequent acoustical conditions, although the impact of room acoustics on performance practice is generally acknowledged. Among others, this study explores methods that describe and qualify the acoustics of rooms, whether extant or not, in relation to the music performed.

The book consists of two parts. Following the methodology, the first part introduces the basic theoretical concepts of the related historical and exact disciplines: theoretical and applied acoustics, the history of acoustics, music history and music perception, sound recording technique and its historical development, architectural acoustics and the definition of quality factors, and, finally, the relation between room acoustics and the different types of music and performance situations.

The methods developed to describe and qualify the acoustics of historical rooms (including those no longer extant) in relation to the performed music rely on an extensive database of collected pictures, plans, dimensions of halls, theaters and churches of historical importance for music performance, as well as literary documentation related to these spaces. Where not yet published, dimensions of spaces were extracted from plans and, where necessary and possible, measured on site. Information on all elements relevant to room acoustics was added whenever possible. From this database several groups of spaces were selected and classified by certain criteria in order to present the whole spectrum of architectural space used for musical performance and to define characteristic types of architectural space in relation to music history, music genre, and performance situation.

The second part traces the performance history of one musical work from its first performance to the early 20th century. Handel's oratorio *Messiah* was selected with its uninterrupted performance tradition in Great Britain, which brought this famous work from the chamber music hall in Dublin where it was

first performed in 1742, small baroque theaters, and the chapel of London's *Foundling Hospital,* after Handel's death from the choir of large cathedrals to "amphitheatrical" stages in the nave of these cathedrals, to the new and large 19th-century concert halls, and finally to the immense *Crystal Palace* in Sydenham and the *Royal Albert Hall* in London. Within this period the number of performers increased from roughly two dozen to nearly four thousand, while the audience grew from a few hundred to a maximum of nearly ninety thousand.

This book, furthermore, explores a paradox: how can a musical work that was written specifically for a certain architectural space "survive" such dramatic changes in performance conditions? Are there boundaries determining an adequate performance? How can we define the quality of room acoustics and how does this quality affect the performance as well as the presentation of a musical work? In short, how do different acoustical conditions affect basic aesthetic premises? There are no simple answers to these complex questions, which elicit different responses according to varying points of view. This aspect of cultural history necessarily calls for an investigation based on systematic, historical, and psychological methods.

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Winckel † (Berlin), Jürg Jecklin (Universität für Musik und darstellende Kunst, Vienna, earlier Swiss Radio, Studio Basel), Kurt Eggenschwiler (Swiss Federal Laboratories for Materials, Science and Technology EMPA, Dübendorf), Russell Johnson † (ARTEC, New York), Jürgen Meyer (Technische Bundesanstalt, Braunschweig), Deborah Howard and Laura Moretti (Cambridge and Venice), Isabel Rucki (Zürich), Beate Schnitter (Küsnacht), and Ellen Taller (Küsnacht). Special thanks go to Thomas Baer-Loy † (Dübendorf) and Christina Niederstätter (architect Bolzano, Italy) for geometrical analyses, Beatrice Smedley (Tel Aviv) for the control of the English text, Elena Abramov-van Rijk (Jerusalem) for the layout and her help with the index, and Rosmarie Niggli (Männedorf) for her help with corrections.

Part 1

Music performance and architectural space: Theoretical and historical fundamentals

1.1 Introduction

1.1.1 Room acoustics and related disciplines

With the establishment of academic disciplines in the nineteenth century room acoustics became part of several scientific and humanistic fields, such as physical acoustics, medicine, psychology, sociology, history of architecture, musicology and others. This is one of the reasons why no comprehensive history of acoustics nor a history of room acoustics has been written thus far. Furthermore, the difficulty of measuring acoustic phenomena delayed the development of acoustics as part of physics and related exact disciplines. Despite the progress during the past hundred and mainly during the past thirty years, important questions in room acoustics still remain open. Nevertheless, the scientific knowledge available in all the involved disciplines provides a solid ground for a basic survey of the history of room acoustics and current theoretical concepts. The first part of this study will present such a survey from the different points of view of the main disciplines relevant to this research.[1]

Information on the history of room acoustics had to be compiled mostly from special studies, which are listed in the bibliography at the end of this book. Only very few larger historical surveys have been published so far, such as Frederick H. Hunt's *Origins in Acoustics*, printed posthumously in 1978 from an unfinished manuscript, and Robert B. Lindsay's history of acoustics, written as an introduction to the 1945 reprint of the 1877 edition of Lord Rayleigh's *Theory of Sound.*

The following publications were important to theoretical and applied room acoustics: *Planning for Good Acoustics* (1931) by the architect Hope Bagenal and the physicist Alexander Wood, which features plans of historical buildings and geometrical analyses that address also the point of view of musicians and listeners; Leo L. Beranek's *Music, Acoustics and Architecture* (1962) and *Concert and Opera Halls: How They Sound* (1997), both with an invaluable collection of plans, documents and acoustic analyses, though later research has rendered some assessments in the first book obsolete; Lothar Cremer's *Principles and Applications of Room Acoustics: Geometrical, Statistical and Psychological Room Acoustics*, published with Helmut A. Müller and Theodore J. Schultz (1982), based on Cremer's former German edition *Die wissenschaftlichen*

1 For more on the role of the various disciplines and the structure of this study, see 1.1.4.

Grundlagen der Raumakustik (1976–1978); *Bau- und Raumakustik* (1987) by Fasold, Sonntag and Winkler, a handbook on applied acoustics and engineering based on experience gained during the reconstruction of such famous historical buildings as Semper's Opera of Dresden destroyed during the Second World War.

The following publications pay special attention to the musicians' point of view: Fritz Winckel's *Music, Sound and Sensation* (1967), first published in German as *Phänomene des musikalischen Hörens* (1960);[2] Juan G. Roederer's *Introduction to the Physics and Psychophysics of Music* (1973); the two volumes on *Acoustique musicale* (1977, last reprint 1984) and *La machine à écouter* (1977) by the Paris physicist Emile Leipp; several publications by the German engineer Jürgen Meyer, mainly his *Acoustics and Performance of Music* (1972, 5th edition 2009) and *Kirchenakustik* (2003), which apply current theoretical knowledge and practice to music performance.

Basic introductions to psychoacoustics are provided by Jens Blauert in *Spatial Hearing, the Psychophysics of Human Sound Localization* (revised edition 1996), Eberhard Zwicker *Psychoacoustics, Facts and Models* (1999) and Stephen Handel *Listening, an Introduction to the Perception of Auditory Events* (1989).

In the cognitive neurosciences, which have developed rapidly in the last 30 years, the following publications were used, as they offer clear explanations of complex facts: *The Self and Its Brain* (1977) by John Eccles and Karl R. Popper; Richard F. Thompson's *The Brain* (1993); Manfred Spitzer's *Musik im Kopf: Hören, Musizieren, Verstehen und Erleben im neuronalen Netzwerk* (2002) and Lutz Jäncke's *Macht Musik schlau? Neue Erkenntnisse aus den Neurowissenschaften und der kognitiven Psychologie* (2008), a survey and bibliography on recent research on music in neurology.

Several publications on the history of rooms for music present the view of various disciplines. Michael Forsyth's *Buildings for Music* (1995, translated into German and French, unfortunately all out of print) is one of the best in the field of architectural history with a plethora of illustrations and a chronological survey of churches, opera houses and concert halls. Recent research has widely confirmed Forsyth's often independent acoustic assessments of spaces. Further important information is contained in publications on the history of theater construction, such as Manfred Semper's volume on theater building in the series *Handbuch der Architektur* (IV/6/5, 1904), Hammitzsch's dissertation *Der moderne Theaterbau* (1906) and Richard and Helen Leacroft's *Theatre and Playhouse: an Illustrated Survey of Theatre Building from Ancient Greece to*

2 A professional singer and engineer, Fritz Winckel (1907–2000) started to develop criteria for the assessment of room acoustics after the Second World War, during the reconstruction of so many famous destroyed halls and theaters.

the Present Day (1984). Information on the history of concert halls is featured in Hans-Ulrich Glogau's *Der Konzertsaal: Zur Struktur alter und neuer Konzerthäuser* (1989) and in several special studies, such as Heinrich Habel's *Das Odeon in München* (1967), with an important second part on early concert hall building; the excellent documentation on the *Gewandhaus Leipzig* by Rudolf Skoda (1984), which includes a historical survey on famous concert halls of the eighteenth and nineteenth century; and the two publications by Deborah Howard and Laura Moretti on architecture and music in Renaissance Venice published 2006 and 2009, with detailed analyses of several churches based on extensive tests and sound recordings in different churches, from small parish and *ospedali* churches to *San Marco*, *San Giorgio Maggiore* and *Il Redentore*.

The following bibliographic tools of architectural history were helpful: *Répertoire International de la Littérature d'Art (RILA), Répertoire d'Art et d'Archéologie (RAA), Bibliography of the History of Art (BHA,* since 1991), Edward H. Teague's *World Architecture Index* (1991, with an index of plans and pictures) and Terence Russel's *The Built Environment* (1989). Nikolaus Pevsner's *History of Building Types* (1976) and *The Penguin Dictionary of Architecture and Landscape Architecture* edited with Hugh Honour and John Fleming (2000) were consulted in order to define building types and to clarify terminological questions.

Many historical documents and pictures of rooms are published in Heinrich W. Schwab's *Das Konzert* in the series *Musikgeschichte in Bildern* (1971) and in Walter Salmen's book with the same title (1988). Howard M. Brown and Stanley Sadie present a wealth of information on the history of performance practice in the two volumes *Performance Practice* (1989) published in the series of the *New Grove Handbooks of Music.* Daniel J. Koury's dissertation *Orchestral Performance Practices in the Nineteenth Century: Size, Proportions, and Seating* (1986) offers a basic survey on this special field, as does Ottmar Schreiber's dissertation *Orchester und Orchesterpraxis in Deutschland zwischen 1780 und 1850* (1938), whose systematic evaluation of 30 music periodicals of the time underpins a survey on the development of the orchestra and orchestra seating in German-speaking countries. In *Musik und Raum: Gesellschaftliche und ästhetische Perspektiven zur Situation um 1800* (1989) Ernst Lichtenhahn presents important, thus far unknown, comments on room acoustics of the eighteenth and nineteenth century culled from writings on the sociology of music and aesthetics. More documents were found thanks to the indexes of nineteenth-century music periodicals indexed in *Répertoire International de la Presse Musicale (RIPM)* edited by Robert Cohen since 1980 (recent title: *Retrospective Music to Music Periodicals).* As a preliminary stage of this study, the author herself published several papers on acoustics and performance practice and their relation to room acoustics, sound recording and the building of musical instruments, theaters,

concert halls and churches. These papers are listed in the bibliography at the end of this book.[3]

1.1.2 Architectural space, room acoustics and music performance

An analysis of the relation between architectural space, room acoustics and music performance requires, first of all, a survey on the history of buildings and their architectural change over time. This information must be broad yet detailed enough to allow general assessments of the acoustic situation of a given performance at a given time. The descriptions and comments presented in this study draw on various sources, such as plans, designs, paintings, reports on buildings, halls and events, as well as material for musical performance, lists of musicians' payments, public reports, private letters from and diaries of listeners, performers, composers and critics. The available documents and publications contain more or less detailed information of variable reliability and significance for the event.

Since historical sources are often lacking or have been lost, it is not always possible to gather complete architectural documentation on a specific hall, theater or church. For example, it is especially problematic to obtain full documentation on an opera house covering a longer period of time, as these buildings were often renovated, destroyed by fire, rebuilt or adapted to changing conditions.

Regarding music performance, information on musical instruments, orchestra size or such details as seating plans of musicians has rarely been preserved and, if extant, is often unreliable. Nevertheless, certain conditions permit a comparison between one performance and other, better documented performances. Such comparisons warrant conclusions about the expected or presumable number of instruments, the expected seating plan or the probable number of listeners.

Architectural spaces can be grouped by building type as theaters, halls and churches, and then classified according to shape, volume and other relevant criteria that enable comparisons between spaces of the same class or type used at the same time or even at different times. The information for this study had to

3 D. Baumann, "Performance Practice and Architectural Acoustics: Bibliographic Sources in Related Disciplines" (1991).

be collected systematically, with such comparisons in mind, and its amount and quality had to be defined.[4]

The documents were classified according to the following main categories:

1. Documents on architectural space: shape, dimension, interior decoration,
   a) chronologically, by building type (church, theater, hall);
   b) by musical centers, grouped by building type.
2. Documents on music performance:
   size of orchestra, orchestra seating, number of attendants,
   a) by musical genre;
   b) by city / musical centre;
   c) by building type.
3. Documents on musical composition in relation to architectural space,
   a) by social function of the event;
   b) by musical genre;
   c) by composer.
4. Documents on music performance practice:
   performance material (scores, parts and annotations), instrumentation, instrument construction and playing techniques, etc.
5. Documents on the reception of musical works:
   reports by composers, musicians, listeners and critics.

Each group is related to respective theoretical writings:

1. Theory of architecture;
2. Theory of orchestration and conducting;
3. Theory of composition;
4. Theory of instrumentation;
5. Music aesthetics, sociology of music, psychology of music.

An initial overview of documents shows multiple overlapping among data from different groups and partial completion of content among the groups and subgroups. Furthermore, this classification permits generalization of information only under certain conditions. For example, data from group 2 on performance practice provide a general chronological survey on the orchestration and specific number of instruments used in musical performances from the seventeenth to the twentieth century. This information grid can serve as a background for the interpretation of a certain event or its comparison with a similar event, such as another performance in the same hall or a performance in a hall of similar shape and size, but also for a comparison between performances in the same

4 See 1.1.4: Methodology.

category of architectural space. Across this grid different subgroups, such as documents on a specific musical work related to a certain building type, can be regrouped by the event's social function in order to gain a broader view on the social history of a music genre (subgroups 3a and b). Only if information is embedded in this complex network of relations can one avert the risk of incomplete reconstructions or speculations that would inevitably lead to a distorted view of the historical situation.

1.1.3 Music for rooms and rooms for music: two points of view and three levels of approach

Given such complex subject matter, how can one select and group the musical and music-related architectural aspects of room acoustics to develop clear definitions and allow for significant comparisons between related elements? Two central points of view command attention: one relies on the musical composition, the other is underpinned by the architectural space used for the performance of certain musical works. A brief examination is already sufficient to show that these two different approaches affect the interpretation of facts.

Let us take a well-known example: polychoral compositions, a genre that emerged in the fifteenth century with music for two small choirs and by the seventeenth century had developed into a complex musical event with several ensembles placed on different balconies, filling churches in Northern Italy and elsewhere with impressive, splendid sound. As Iain Fenlon said on the adoption of the *cori spezzati* style at *San Marco* in Venice, "any reconstruction of music and liturgical practice inside *San Marco* during the sixteenth and seventeenth centuries must take account of the three musical elements: chant, improvised polyphony, and composed polyphony. Throughout the period these three coexisted. […] While chant and improvised polyphony were sung by the canons of the Basilica, polyphony was performed by the professional singers of the Cappella Marciana. – Those charged with performing these different strands of the musical component of the liturgical rituals inside the Basilica were located in different places at different times."[5] Laura Moretti's research and the documents presented by Iain Fenlon reveal the following main positions for musicians in *San Marco* (figure 1 and 2):[6] a) the *pulpitum magnum cantorum* or *bigonzo* (dating from the first half of the thirteenth century), an octagonal

5 I. Fenlon, "The Performance of *cori spezzati* in San Marco" (2006), 94–5.

6 L. Moretti, "Architectural Spaces for Music: Jacopo Sansovino and Adrian Willaert at St Mark's" (2004).

structure located in the crossing in front of the iconostasis on the right-hand side; b) the two *pergoli* or balconies just behind the iconostasis within the main pier on either side of the choir, at about 2.10 meters above the floor level;[7] c) different positions on the upper level, mainly the two organ lofts on either side of the choir at 5.60 meters above floor level; d) the usual position for liturgy held at the floor level, with singers standing or sitting on benches in the choir.[8]

Figure 1: Venice, *San Marco,* view from the main nave toward the iconostasis with the presbyterium behind and the ocatagonal *bigonzo* on the right-hand side: the presentation of doge Alvise IV Mocenigo (Francesco Guardi, ca. 1763).

7 Measures taken by the author, who would like to thank Laura Moretti and Patrizia Lerco for their help and Monsignor Antonio Meneguolo for permission to enter the *presbyterium* of the basilica. For a detailed acoustic analysis, see D. Baumann: "Geometrical Analysis of Acoustical Conditions in San Marco and San Giorgio Maggiore in Venice" (2006).

8 See Moretti (2004), figures 2–7; Fenlon (2006), figures 4–8.

Singers and musicians in *San Marco*, the private chapel of the doge and the chapel of the Republic of Venice had to respect liturgical and ceremonial functions. Acoustic considerations were but one further element. As Iain Fenlon wrote, "the principal 'audience' for the civic and religious rituals which took place in *San Marco* consisted of the doge and senate who occupied [...] the space in front of the High Altar and within the central sacral area. [...] This was to create a private chapel within the context of the broader uses of the building as a whole. [...] Members of the general public [...] were confined to the areas west of the iconostasis."

Musicians knew that the elevated positions in the crossing and in the choir helped cope with acoustic difficulties in this complex space with its five domes and large pillars separating the main nave, side naves and transept. This was certainly one of the reasons why the medieval singer balcony on the south side behind the iconostasis was raised higher in 1536–37 and why in 1541–44, just at the time Adrian Willaert wrote his first double-choir compositions, a similar balcony had been built on the north side.[9] The two *pergoli* stand at a distance of about 10 meters, directly under the large arch connecting the two piers, which is about 17.30 meters above the singers' heads. The *pergoli* provide excellent acoustic conditions for the interplay of two four-voice choirs with one or two singers in each voice and for listeners within the central sacred area, especially for the doge, who sat in the choir, his back to the iconostasis, on a new throne made by Jacopo Sansovino.

Listeners outside the choir could hear the music as though it were coming from another space, not only because the iconostasis was closed by carpets during ceremonies, but also because sound coming from the *pergoli* reached the areas west of the iconostasis only through wave reflections directed upwards to the side walls and into the cupola (see figure 2). Astonishingly we read that around the 1560s psalms during vespers and most masses in *coro spezzato* technique were sung by the two choirs crowded into the octagonal *bigonzo* or *pulpitum magnum cantorum* (position a) located in the crossing in front of the iconostasis on the right-hand side, or, if it was occupied by the doge, in the *pulpitum novum lectionum* on the left hand side, "even if they had very little space there."[10] If singers faced the main nave, the sound projected directly to the public. If they faced towards the pier's west front, as shown in a

9 Moretti (2004); Fenlon (2006); D. Howard and L. Moretti, *Sound and Space in Renaissance Venice: Architecture, Music, Acoustics* (2009), 17–42, and 243–5.

10 In the *Ceremoniale* of 1564 we read: "In Vigilia vero Ascensionis cantore [...] cantant divisi in duobus choris alternatim. Sua Serenitas ascendit pulpitum magnum et ibi audit vesperas [...] cantores cantant in pulpito novo lectionum, licet anguste maneant in eo." Cf. D. Bryant, "The 'cori spezzati' of St Mark's: Myth and Reality" (1981), 172, footnote 27.

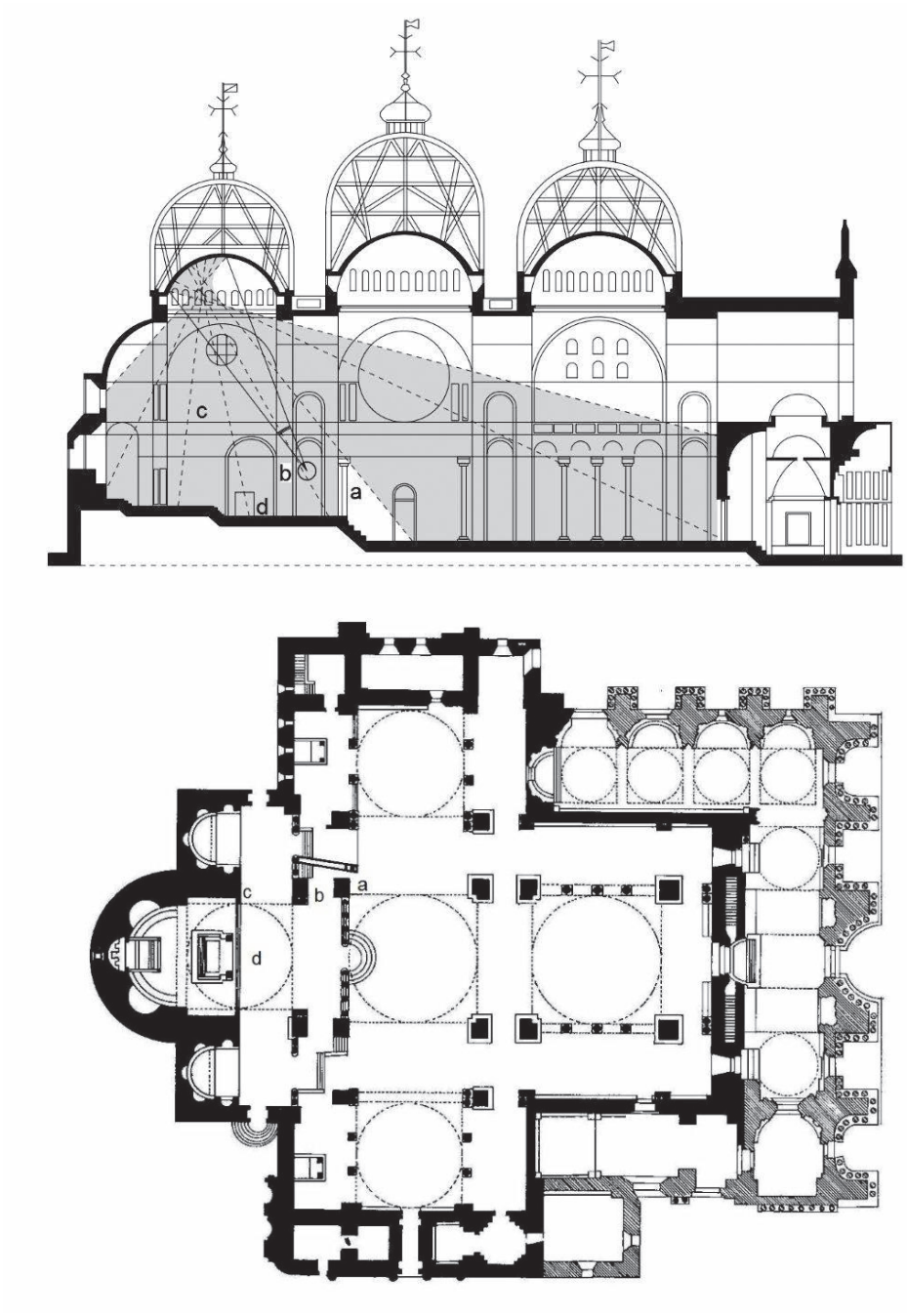

Figure 2: Venice, San Marco, section showing sound distribution from position b and ground plan.

drawing by Canaletto from 1766,[11] sound was reflected backwards to the main nave but also reached the choir, passing through the uppermost, open part of the iconostasis.

Larger-scale polychoral pieces, such as those by Andrea and Giovanni Gabrieli, many of which are not strictly liturgical and were probably written for special occasions, required special performance arrangements.[12] For such solemn feast days singers and musicians could be placed in the two organ lofts on either side of the *presbyterium* at 5.60 meters above floor level with a distance of about 12.50 meters between them (position c). This emplacement was probably also less frequent, as no stairs led directly from the church to the organ lofts.[13] Once up in the lofts, musicians and singers could not serve other functions down in the church. In case of two or more organs and groups of wind players, musicians were also placed in special balconies aside and below the organ lofts on both sides of the *presbyterium.* Sometimes musicians and singers were placed also on special *pulpiti* in the *presbyterium.* Canons always remained on floor level for liturgical and ceremonial tasks. The choir space functioned as a separate acoustic space connected to the rest of the church only via the dome and the vaulted ceiling above the apse (position d).

In all positions higher than the iconostasis musicians had to contend with a fuller acoustic reaction from the main volume of the church, especially at higher dynamic levels and with low bass instruments.

These examples from *San Marco* in Venice, which have been analyzed more deeply in other publications,[14] show that each point of view, the musical and the architectural, runs on three significant levels.

From the musical perspective, the relation between music and performance practice operates on the following levels:

1. the performance of a *specific piece of music* (for instance, a polychoral *symphonia sacra* by Giovanni Gabrieli);
2. the performance practice of a *specific musical genre* that demands certain acoustic conditions, as does polychoral church music in general which, for acoustic reasons, needs a full choir with bass for each group, if the choirs are placed apart;[15]

11 Baumann (2006), figure 8.
12 Fenlon (2006), 95.
13 Bryant (1981), 165–86.
14 See Moretti (2004); Fenlon (2006); Howard and Moretti (2009).
15 G. Zarlino, *Le istitutioni harmoniche,* Venezia 1558, III, cap. 66; see V. Ravizza, "Musikalischer Satz und räumliche Disposition – Zur frühen venezianischen Doppelchörigkeit" (1994), 177 and footnote 3; Bryant (1981), 167, footnote 7; Fenlon (2006), 89, footnote 23.

3. the most general level, that is, *church music in general* with its peculiarities related to the liturgical function, which in itself may have developed partly as a result of acoustic conditions of performance.

In acoustics-related architectural elements the following levels must be distinguished:

1. the analysis of a *specific space*, its specific shape, special decoration, arrangement of platforms and seats for a specific event and number of attendants at the moment of a certain performance, as, in this case, the church of *San Marco* in Venice with its organ lofts and special *palchetti;*
2. the *type of architectural space* with its typical construction properties according to style and function, as, in this case, a Byzantine-style church in the form of a Greek cross with side naves and several domes;
3. the *category of space*, that is, the *church in general*, which elicits in the listener the expectation of a long reverberation, regardless of its dimensions, construction and acoustics. The church then becomes an acoustic *topos* closely related to the symbol of the dome as *domus dei* (house of God),[16] even though churches of different shapes and dimensions, with various ceilings (flat and vaulted), ground plans and, therefore, very different acoustic properties, have been built throughout history.

1.1.4 Methodology: the study's two parts

The main subject of this musicological research is music as a sonorous art, the substance of music in its actual sounding presentation and perception. Its primary aim is to elucidate the spatial-acoustic properties of music and their relevance to performance practice.

Since the Middle Ages the volume of documents related to music, space and room acoustics has steadily grown in all fields of research. The relations among the disciplines involved are complex, as each discipline has its own terminology, often not easily accessible to non-specialists, but also because methods used in history, science and cultural studies must be applied. Whereas the exact or natural sciences (as in the present study physical room acoustics and the physiology of hearing) seek laws and principles, historical disciplines (such as the history of architecture, of music, of its performance and reception) ad-

16 E. Baldwin Smith, *The Dome* (1971), 4.

dress phenomena subject to change and investigate them using conventions of style and assumptions that shift over time.[17]

According to the Neo-Kantian Wilhelm Windelband (1848–1915) historical disciplines use the so-called *idiographic* procedure, which describes phenomena created by human thought and consciousness, whereas the exact or natural sciences proceed *nomothetically*, that is, by defining laws and principles. Natural sciences, which teach "what has always been", seek laws, whereas human sciences, which describe "what happened in former times", seek forms or "Gestalten". Still, as Windelband remarked in *History and Science*,[18] the same topics can be studied both nomothetically and idiographically.

Another Neo-Kantian, Wilhelm Dilthey (1833–1911), mainly in *Introduction to the Human Sciences* (1883), *Ideas for a descriptive and analytic psychology* (1894), *The Rise of Hermeneutics* (1900) and *The Formation of the Historical World in the Human Sciences* (1895 and 1907),[19] defined the humanities as an understanding informed by the "re-experience" of a historical or foreign existence expressed in writing, language, gestures, mimics, art and other human phenomena. These active processes are not based on rational thinking alone, as in these fields cognition cannot be proven in the sense of a definitive truth or falsehood as in natural science but is always a hermeneutic interpretation underpinned by a certain point of view within a certain context. Meaning cannot be constructed from single elements removed from their context. Rather, both the element and the whole can be understood only in reference to each other. This procedure, which Dilthey termed "hermeneutic circle", sets psychology as the foundation of humanities – though not the branch of psy-

17 D. Baumann, "Systematische Musikwissenschaft – eine Disziplin zwischen Kulturgeschichte und Naturwissenschaften" (2009), 40–51.

18 W. Windelband, *Geschichte und Naturwissenschaft* (1894): "Die einen sind Gesetzeswissenschaften, die anderen Ereignisswissenschaften; jene lehren, was immer ist, diese, was einmal war. Das wissenschaftliche Denken ist – wenn man neue Kunstausdrücke bilden darf – in dem einen Falle nomothetisch, in dem andern idiographisch. [...] die eine sucht Gesetze, die andere Gestalten. [...] Es bleibt möglich und zeigt sich in der Tat, dass dieselben Gegenstände zum Object einer nomothetischen und daneben auch einer idiographischen Untersuchung gemacht werden können." See also C. Dahlhaus, "Musikwissenschaft und Systematische Musikwissenschaft" (1982), 28 ff.

19 W. Dilthey, "Einleitung in die Geisteswissenschaften: Versuch einer Grundlegung für das Studium der Gesellschaft und der Geschichte" (1883), *Gesammelte Schriften* vol. 1 (1973), xv–xx; "Ideen über eine beschreibende und zergliedernde Psychologie" (1894); "Beiträge zum Studium der Individualität" (1895/96), "Die Entstehung der Hermeneutik" (1900); "Die geistige Welt: Einleitung in die Philosophie des Lebens", *GS* vol. 5 (1968); "Der Aufbau der geschichtlichen Welt in den Geisteswissenschaften" (1895, 1907), *GS* vol. 7 (1973). English editions: W. Dilthey, *Selected Works* vol. 1 (1989), vol. 3 (2002), vol. 4 (1996); see also R. A. Makkreel, "Wilhelm Dilthey" (2008), and B. Ramber, G. Gjesdal, "Hermeneutics", *Stanford Encyclopedia of Philosophy* (2005).

chology informed by the natural sciences, but a primarily descriptive psychology that seeks to understand human expression within its context.

The philosopher Ernst Cassirer (1874–1945) explored these questions extensively in the 1940s in his five studies on cultural history and in *An Essay on Man* (1944).[20] According to him a discipline that investigates processes of human culture calls for a special methodology based on physics, history and psychology, as the concepts of these three fields are indispensable to the description of cultural objects. Yet we cannot understand these objects on the basis of their discrete elements but only through the latter's mutual, interpenetrating relations.[21] Such understanding relies on the formal and stylistic concepts of cultural studies, which differ from both scientific and historical concepts. Here the topic is not "dead" matter but human action.

Following this approach to cultural history, a study of the relationship between room acoustics and music performance requires a finely tuned combination of methods. Normative nomothetic models alone cannot point out why certain rooms are better or worse for certain kinds of music, nor would it be appropriate to use only historical idiographic descriptions to explain why music has been performed in certain rooms at certain times and why musicians and attendants qualified these performances as better or worse. A strictly idiographic procedure would also require a full survey of the history of performance practice of Western music and its social background, which would exceed by far the scope of this study.[22] This research aims, rather, to *combine* normative, idiographic and psychological methods in order to develop clear ideas about the relationship between music and room acoustics. As a result, criteria can be defined for a better understanding of the subjective process of qualification of the acoustic background of music performance then and now. However, the combination of history, exact sciences and cultural studies does not imply a fusion of methods. The different symbolic realms remain distinct, and their symbols preserve specific meanings. But we may follow Cassirer, who said in *Structuralism in modern linguistics*, his last lecture shortly before his death in 1945, about the relationship among various symbolic realms: "The dissimilarity of the objects of natural science [or acoustics] and linguistics [or music and musical performance practice] does not exclude a correspondence in the structure of

20 E. Cassirer: "Naturbegriffe und Kulturbegriffe" (1980; orig. publ. 1942), 56–86; *An Essay on Man: an Introduction to a Philosophy of Human Culture* (2006; orig. publ. 1944); see also R. A. Makkreel: "Cassirer zwischen Kant und Dilthey" (1997), 150–1.

21 Makkreel (1997), 57.

22 A wealth of new documents and studies has been published in the context of the European Research Project: *Musical Life in Europe 1600–1900. Circulation, Institutions, Representation* (2003 ff.). Important in the context of this study is vol. 9: *Espaces et lieux de concert en Europe, 1700–1920: architecture, musique, société* (2008).

the judgments that we find in both sciences." [23] Not only objects of natural sciences but also functions of the mind and sensorial perception have a clear logical structure. The concept of "Gestalt", a form of both objects and processes (according to Cassirer),[24] enables us to connect apparently very disparate things if their Gestalts show similarities. While physical processes and mental functions that generate human culture may share formal or logical analogies, such sharing does not prove that matter and meaning are identical for human beings. In the analysis of a process of change, physics investigates the cause of change, but cultural studies address the human meaning of that change. Still, with its detailed scientific description, the knowledge of physical processes can become a basis for the understanding of these processes of human existence.

Hence the two-part structure of this study: the first part presents a survey on the history of room acoustics and charts the current knowledge about room acoustics as viewed by the different disciplines involved and introduces, explains and compares their terminology. Using the general historical background and the basic systematic rules presented in the first part, the second part describes and assesses the performance history of one specific musical work from its first performance up to the early twentieth century.

The first part opens with a brief historical outline of basic acoustic knowledge applied to building construction from antiquity through the time acoustics developed as a science and up to the late nineteenth century. Follows a discussion on the changing relations between room acoustics and music since the beginning of public concerts up to the First World War. The various ways of perception are then addressed from the viewpoints of musicians, composers and listeners. The basic theories of acoustics, hearing, sound perception and room acoustics in physics and the disciplines dealing with auditory phenomena (physiology of hearing, cognitive neurology, psychology of perception) constitute the next section. Finally, a historical survey of sound recording techniques and their spatial aspects serves as a basis for the analyses of sound recordings used in the second part as both historical sources and a tool for the auditory analyses of room acoustics.

Based on the current knowledge on physical room acoustics and the disciplines related to auditory perception, architecture-related quality factors are defined to be used for extant and no longer extant historical rooms. Music-related quality factors of room acoustics are assessed next. The material from the five fields defined in 1.1.2 (documents on architectural space, music performance, musical composition in relation to architectural space, performance practice, and the reception of musical works) is then regrouped differently in order to elucidate the relationship between, on the one hand, the period a specific space

23 E. Cassirer, "Structuralism in Modern Linguistics" (2007; orig. publ. 1945), 313.
24 see 1.4.3

was used and, on the other hand, the three types of space (church, theater and music room or concert hall) and performance-related aspects. Musical genres are then examined in relation to the typical size of the space and the musical ensemble.

Although a room's acoustic quality must always be evaluated in relation to a specific musical work, these general definitions produce a grid that allows to describe the general background of acoustic experience for a certain group of listeners at a certain period in a certain room category. This approach permits, among others, a better understanding of the new definition of chamber music in relation to hall size, which emerged around 1800, well before the widespread use of large concert halls for symphony orchestras and the even later preference for small halls for chamber music.[25]

The second part of this study called for a musical composition with an uninterrupted performance tradition from its first performance to the twentieth century, well documented in all five fields and performed already during the composer's lifetime in all three room categories. Of the main music genres – opera, oratorio and symphony – only the oratorio was performed in all three room categories, namely, in theaters, churches and small halls called "oratorios" or music rooms. The history of the oratorio is well documented from the seventeenth to the twentieth century.[26] A bibliographic survey of documents indicates that Handel, an oratorio composer with a vast contemporary documentation, is an appropriate object for such an investigation. Handel discovered the Italian *oratorio volgare* around 1708 in Rome and consequently developed the genre of the English oratorio which, from 1732 onward, played an important role in the development of the public concert in England. From 1770 a selection of his oratorios was performed in various music centers on the continent in translated versions.[27] Among Handel's oratorios we chose *Messiah*, as many contemporary documents on music performance and reports on the reception of musical works are extant. Furthermore, this oratorio has enjoyed a nearly uninterrupted performance tradition from 1742 to our time in many different spaces of all three categories, some of which are still extant. The inclusion of other selected compositions (some by other composers) enables documentation of the main aspects of the research matter. The choice of Handel's *Messiah* set down the main research lines of the second part, presented in detail at its beginning.[28]

In the first, mainly systematic, part as well as in the second, mainly historical, part on Handel's *Messiah* questions emerged that could not be answered, as they need further special research or broader research in music history, the

25 See 1.3.3: New definition of chamber music.

26 See H. Smither, *A history of the Oratorio* (1977–1987), and many special studies.

27 See appendix 3.5.2, table B.

28 See 2.1: Handel's *Messiah*, the change of performance practice and room acoustics.

history of composition and reception and its sociological and aesthetic aspects, but also because further interdisciplinary research must involve scholars from several related disciplines in order to apply their methodologies. Further research on the history of architecture and art would fill lacunae in the history of rooms used for music. Psychological tests would answer questions on the psychological process of perception, and more exact acoustic measurements and calculations carried out by engineers in conjunction with musicians and instrument makers would hone our understanding about the significance of room acoustics for both musical production and perception. Nevertheless, the systematic and historical overview presented in the first part provides a solid ground for the analysis of the performance tradition and the interpretation of the music examples in the second part.

The first part lists examples of halls, theaters and churches that are important for music history. Some readers may know many of them well from personal experience. Whenever possible, the main room dimensions are indicated. Many of those partial or not yet published were completed from scaled plans or measured on site. With the exception of some famous twentieth-century concert halls and opera houses, the study is limited to spaces erected before the end of the First World War, mainly because new construction techniques have introduced important changes in architectural design, and modern scientific acoustics have been applied on the basis of measurements of absorption factors and the calculation of reverberation time according to the formula defined by Wallace C. Sabine around 1900.[29] New shapes and interior design styles of halls and theaters were developed, and large-scale spaces were built, mainly in the United States. Moreover, the invention of sound recording and reproduction and, later, of sound amplification affected the perception of music and its spatial aspects.[30] The reconstruction of old and the construction of new opera houses and concert halls after the devastation of the Second World War has accelerated the disappearance of old spaces. Some famous old buildings have been reconstructed, many of them with slightly or considerably different acoustics. Yet all these changes in the exterior aspects of music performance and perception in the twentieth century require further research that is beyond the scope of this study.[31]

29 For the development of acoustics as a science, see 1.2.5.

30 1.3.5: Electro acoustic reproduction of space; 1.7: Spatial impression in sound recording.

31 See also D. Baumann, "Konzertsäle und Opernhäuser des 20. Jahrhunderts im Spannungsfeld zwischen Umbruch und Tradition" (2002); M. Forsyth, *Buildings for Music* (1985): "Science and the Auditorium", "The Hi-Fi Concert Hall" and "Toward the Future: A New Context for Music"; L. L. Beranek, *Music, Acoustics, and Architecture* (1979) and *Concert and Opera Halls, How They Sound* (1996).

1.2 Acoustic knowledge applied to the construction and use of rooms

Understanding the relation between the history of architecture and music performance requires, first of all, an examination of the acoustic knowledge available to those who built or chose rooms for music performance.

1.2.1 Acoustic knowledge in ancient Greece and Rome

One of the few physical laws known in the ancient world was the law of reflection, according to which light rays reflect off a mirror at the incident angle.[1] Since Aristotle (fourth century B.C.) this law was also known to be valid for sound. Aristotle himself refers several times to the analogy between light and sound, mainly in his explanation of the echo heard when a voice hits a hard surface without being shattered: "The whole remains intact or the two parts are separated because reflection occurs at the same angle. That is why the voice of the echo is similar to the original voice."[2] This law was also important for the understanding of sound in ancient theaters and closed spaces. *De architectura libri decem* by the Roman architect and engineer Marcus Vitruvius Pollio (active around 30 B.C.) contains important knowledge in room acoustics. From the Middle Ages to the seventeenth century this treatise was widely transmitted to the Arab and Christian cultures.[3] Vitruvius not only describes the ancient theater but also gives a detailed account of sound propagation and distinguishes between helpful reflections (*reflexiones consonantes* – sounding together and reinforcing sound) and disturbing reflections (*reflexiones resonantes* – resounding like an echo; *reflexiones dissonantes* – coming from above, impeding the free distribution of the following sound waves; *reflexiones circumsonantes* –

1 C. B. Boyer, "Aristotelian References to the Law of Reflection" (1945), 92–5.

2 Aristotle, *Problemata*, XI, 23, 901/b, cf. Boyer (1945), 93.

3 Vitruvius, *De architectura libri X*, ed. and translated by M. H. Morgan (1960); on acoustics see book V, chapter 3–9; on the transmission of Vitruvius, *ibid.*, introduction, 10 ff.; on the transmission of general acoustic knowledge of the ancient Greeks in Arabic and Greek translations, see D. Baumann, "Musical Acoustics in the Middle Ages" (1990), 199–210. An adequate critical edition of Vitruvius' treatise is still lacking.