Jürgen Meyer
Translated by Uwe Hansen

Acoustics and the Performance of Music

Manual for Acousticians, Audio Engineers, Musicians, Architects and Musical Instrument Makers

FIFTH EDITION

Modern Acoustics and Signal Processing

Springer

Acoustics and the Performance of Music

Modern Acoustics and Signal Processing

Jürgen Meyer

Acoustics and the Performance of Music

Manual for Acousticians, Audio Engineers, Musicians, Architects and Musical Instruments Makers

Fifth Edition
Originally published in German by PPV Medien, Edition Bochinsky

Springer

Jürgen Meyer
Bergiusstrasse 2A
D-38116 Braunschweig
Germany
juergen.meyer-bs@t-online.de

Translated by

Uwe Hansen
64 Heritage Drive
Terre Haute IN 47803
USA
uhansen@isugw.indstate.edu

ISBN 978-0-387-09516-5 e-ISBN 978-0-387-09517-2

Library of Congress Control Number: 2008944095

Translation of the latest (fifth) edition, originally published in German by PPVMedien GmbH, Edition Bochinsky, Bergkirchen.

Printed on acid-free paper.

9 8 7 6 5 4 3 2 1

springer.com

Preface

Since the middle of the twentieth century, concert performance developments have created raised, and to some extent, new demands on musicians and architects. Reasons for changes in performance conditions can be found on the one hand in the tendency for ever larger concert halls and on the other in the fact that listeners, educated by quality recordings are used to a high degree of precision and subtle tonal nuances. These circumstances lead to acoustic and performance technical problems for the interpreter unknown in previous generations. These tasks must largely be mastered by the musicians themselves, yet in some sense Tonmeister (sound recording engineers) and builders of concert halls can have an essential influence on the tonal results of a performance. Thus it is important for all participants to be knowledgeable of those acoustic processes which shape the tonal development beginning with the tonal perception of the performer down to the aural impression of the listener.

With this background, the first German edition of the book *Acoustics and Musical Performance* appeared in 1972, in which those aspects of musical instrument acoustics, and room acoustics, relevant to music in general were considered. An important element of this book was the consideration of the degree to which approaches to performance practice could be derived from those principals. The great demand for these themes made several new editions necessary, which in each case were revised to include current knowledge. Thus, this English edition of the book is based on the 5th German Edition of 2004. In addition to new experimental results in the physical, technical realm, many personal experiences by the author, as presenter and conductor of demonstration concerts with large orchestras, not only in Europe, but also in the USA and Japan, relating to questions of orchestral arrangements have added significant insights.

In order to make this complex subject matter accessible even for readers without special knowledge in the physical sciences, the principal chapters are introduced by brief explanations of the most important fundamental concepts of acoustics as well as a selection of some of the more important hearing principles essential for understanding. The detailed representation of directional characteristics in the fourth chapter was originally intended especially for audio engineers. Since then, the new area of room acoustical simulation auralization has been developed which

could not be anticipated in 1972. The sections concerned with room acoustics are deliberately limited to those aspects essential to musical performance. They are thus intended as an introduction for non-acousticians. On the other hand, it is likely more important for acousticians, when considering historic performance technical matters, to gain an insight relating to things which are routine for every musician.

Acoustic data which characterize tonal characteristics in sound radiation of musical instruments as well as room acoustics processes represent objective facts. In contrast, performance practical directions in many cases are only examples of subjective interpretations. They are intended merely to show the possibilities for utilizing acoustical facts for the realization of an artistic tonal perception. In this sense, the present volume occupies a position between the standard works of Fletcher/Rossing (*The Physics of Musical Instruments*) and Beranek (*Concert and Opera Halls – How They Sound*). They thus form a bridge between musical instrument acoustics and room acoustics, based on practical experience.

Scientific data obtained by the author are the result of continuing exchange between experimental investigations at the Physikalisch-Technische Bundesanstalt in Braunschweig and lectures in the framework of the audio engineering program (Tonmeister-Ausbildung) at the School of Music in Detmold (Music Academy). The author here again expresses gratitude to both institutions for decades of support. It is precisely the cooperation with generations of audio engineers that has significantly contributed to the fact that in recent years changes in attitude of conductors concerning the seating order of strings in the orchestra have been effected.

My personal thanks go to Professor Uwe Hansen of Indiana State University who has made enormous efforts to translate the voluminous text into English, while fine-tuning the formulation of numerous details in personal communications during several visits to Germany. Beyond that he has also taken it upon himself to interact with the publisher concerning production details. Special thanks also go to Springer-Verlag for the successful cooperation and the appealing final appearance of the volume.

Branschweig,
Germany

Jürgen Meyer

Translator's Preface

A number of comments are in order. It has been a great pleasure to be associated with this work, which so admirably bridges the gap between science and performance. As I was translating, at times it was as though I could hear Jürgen's voice speaking from the pages. The translation has progressed in three stages. The initial attempt was to preserve the integrity of the German original. Readers who feel that the final version retains too much of the German convoluted grammar have my sympathy and my apologies. The second step attempted to transform the literal translation into readable English. The third approach included a thorough review with the Author, to insure scientific accuracy and preservation of the Author's intent. As in the earlier translation of the second edition by John Bowsher and Sibylle Westphal we are using the American notation for octave assignment of notes, except we prefer the standard American usage of subscripts. Thus, what follows is a comparison of notations

American	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8
German	C_1	C	c	c'	c''	c'''	c^4	c^5

Vowel association with formants in a spectral content occurs frequently throughout the book. The German edition uses the German letters a, o, u, e, i, and the modified "Umlaut" letters ä, ö, and ü for this purpose. Unfortunately English, and of course also American vowel usage frequently goes over into a double vowel or diphthong pronunciation. The use of international phonetic symbols was considered, but both the Author and I felt that easy access would be encumbered by that solution. We finally decided to retain the German vowel use and add the English pronunciation in parentheses such as a(ah) with the understanding that a detailed guide is included in this preface. This recognizes that English vowels, like a, o, and i are in fact pronounced as eh-ee, oh-oo, and ah-ee, where the second vowel generally is short. In this context the vowel relationship to the formant relates only to the first vowel of the otherwise colloquially used diphthong. Thus the sound represented by the o vowel should be sounded as only the "oh" sound with the usually short

following "oo" sound entirely dropped. The following represents a pronunciation guide for the German vowels as used in connection with formant representation

u	"oo" as in tool
o	"oh" as in old
å	"aw" as in fall
a	"ah" as in father
ö	as in her with pursed lips
ü	as in French rue
ä	as in air
e	"eh" as in late without the final short ee sound
i	"ee" as in fleet

My thanks go to the Indiana State University department of Languages Literature and Linguistics for the use of language laboratory facilities and the help of numerous students.

Innumerable discussions with Dr. Ramon Meyer, formerly music director of the Terre Haute Symphony, Professor Emeritus of Music, and director of the Choral Program at Indiana State University, have been a great help in clarifying current use of musical terminology.

Terre Haute, IN

Uwe Hansen

Contents

Chapter 1
Introduction to Acoustics

1.1 Fundamental Physical Principles

1.1.1 Sound Pressure

When we hear music, the perceived tonal impression is caused by sound carried to our ears by the air. Relevant in this context are the minute pressure variations which are superimposed on the stationary pressure of the air surrounding us. The pressure variations propagate as waves in space. These more or less periodic deviations from the stationary mean value, comprise the so called sound pressure variations, for which in practice the shorter term "sound pressure" is used.

Since our ear is capable of responding to a wide range of sound pressures, from a barely perceptible sound, to the intensity for which the hearing sensation becomes painful, generally a logarithmic scale is used to represent the range of sound pressure values of interest to the acoustician. This makes the scale accessible and inclusive. The relation of a certain sound pressure to a reference value is given in "decibels" (dB), and one speaks of the sound pressure level, where the concept "level" always refers to a logarithmic scale. To the unaccustomed reader this procedure may initially appear somewhat complicated, however, it has proven very advantageous in practice, particularly once a number of dB values are associated with their corresponding sounds as heard. Furthermore, the logarithmic dB-scale reflects hearing perception more closely than a linear representation.

So called "absolute" dB values for sound pressure levels are obtained when a reference value of 2×10^{-5} Pa (Pascal) is used. This value was chosen by international agreement. It corresponds approximately to the threshold of hearing in the frequency region where the ear is most sensitive. (Consideration of the reference value as well as the logarithmic calculations are carried out by the measuring instrument.) As an example, in a Bruckner Symphony, depending on concert hall size, and location in the hall, as well as the size of the orchestra, one can expect values between 90 and 100 dB for a *fortissimo*, on the other hand a *pianissimo* could result in 40–45 dB.

J. Meyer, *Acoustics and the Performance of Music*.
DOI: 10.1007/978-0-387-09517-2_1, © Springer Science + Business Media, LLC 2009