
The second edition of *Acoustics and Psychoacoustics* by David Howard and James Angus is a welcome addition to the library of books on these subjects. It is appropriate that acoustics and psychoacoustics are treated together in one volume, since they are necessarily complementary in determining what we perceive as sound.

The book begins with introductions to sound and to hearing. The introduction to sound looks at the characteristics and behaviour of sound waveforms, singly and together, and how these characteristics determine what we hear. The introduction to hearing considers the structure and functioning of our hearing mechanisms. These comprehensive introductions very effectively set the scene for the rest of the book. As well as providing an essential prologue for the less experienced reader, they will almost certainly deliver some surprises to those of us who thought we had a thorough knowledge of the basics of sound technology.

The book goes on to deal with the waveform structure of musical notes, and pitch perception which is discussed at some length. This leads to a look at harmony, hearing musical intervals and tuning systems. Creation of musical sound is covered next in a chapter describing the mechanisms by which musical instruments, including the human voice, create musical sound.

In the next chapter the subject matter moves to timbre and how it is perceived. First the relationship between waveform characteristics and timbre is explored. This is followed by an examination of some of the psychological aspects of timbre perception and recognition, and the chapter ends with a description of some of the ways in which the ear can be deceived. These include masking, which is widely exploited to compress recorded musical waveforms.

The emphasis in the next chapter moves to the effect of environment on perceived sound. Early reflections and reverberation are covered in some detail, as are room modes and their effect on our satisfaction with particular environments. The chapter concludes with a look at absorption and diffusion materials, and the related areas of sound isolation and effective criteria for listening to recorded sound.

The last chapter is about electronic processing of sound and covers a variety of ways in which sound can be modified to change its spectral balance, to introduce artificial reverberation, to create effects such as chorus, phasing, flanging, pitch shifting, sound morphing, and vocoding, and to implement dynamic range compression and expansion. Spatial processing is treated in a short section of the chapter. In view of the growing importance of the techniques involved, both in the home and the public auditorium, this section might usefully be expanded in any future edition of the book. Finally, four appendices provide mathematical material to supplement the main text.

This is a book written by two people who combine a sound theoretical knowledge of their subject with extensive experience of the practical outworking of their theory. It holds the reader’s interest from the start and, whether he be a professional acoustician or a layman looking for a not-too-demanding guide to the sciences of acoustics and psychoacoustics, he will find much of value here. He will also find that it is seldom he is left with fundamental questions unanswered, and if he needs a more detailed treatment of any subject matter, the useful set of references at the end of each chapter will probably be able to help him. A working knowledge of basic mathematics will help the reader to gain the most from the text.

In summary, this is an authoritative and enjoyable book providing a broad but adequately detailed treatment of its subjects. In my opinion, it would make a very good choice for a music technology course textbook.

Peter Comerford


Electroacoustic music has developed rapidly in recent years and the studios in which it is produced have changed almost beyond recognition. Little if any of the hardware and software that would have been important
in studios fifteen or twenty years ago still plays an important role today. An exception to this, however, is Csound, the modular software originating from MIT. This is a great tribute to Barry Vercoe’s conception and design of the program. I first used Csound (in fact Music11 as it was then, but essentially the same program) in the early 1980s, and if anything its importance is now increasing rather than diminishing. In part this is because, now based in C, it is easier for programmers to extend the code and a small army of people are contributing to its ongoing development (co-ordinated by the invaluable work of John ffitch). Csound is perhaps the Linux of the musical world, and benefits from the same advantages of shared development. In addition, the increasing speed of computers means that computer synthesis and processing is now coming of age; no longer must the musician wait hours for a few seconds of relatively simple processing.

Until recently, little existed to help Csound users investigate the potential of this software apart from a basic manual from MIT (with the addition, more recently, of one or two tutorials). Since Csound does not reveal its full potential easily and getting to know the program involves a steep learning curve, this has often been a problem for newcomers to the package. In the last twelve months, however, two books have become available in English which, in different ways, add significantly to the documentation on Csound. Virtual Sound (originally published in Italian as Il Suono Virtuale) is mostly the work of just two authors, Riccardo Bianchini and Alessandro Cipriani, and focuses primarily on providing an elementary introduction to Csound. This contrasts with The Csound Book (ed. Richard Boulanger, MIT Press, 2000), a larger multi-authored compendium of articles ranging from introductory tutorials to advanced research topics (I should declare an interest here as one of the contributors to this book). Both books come with CD-ROMs containing additional information and examples.

Virtual Sound progresses through a succession of topics, ranging from the basics of how to operate the program to a variety of synthesis techniques, some quite advanced. Chapter 1 is an elementary introduction to how Csound works. It gives helpful information on how to run Csound both on a PC running Windows and on a Power Mac. It then goes on to an explanation of how to write Orchestra and Score files. This is intended for the total beginner and, for the most part, it is a clear and concise explanation. Some of the diagrams are particularly helpful in clarifying the flow of data. However, there are a number of places where I could imagine a beginner getting lost, especially one not used to programming languages. For example, it is not made clear that commas must be used to separate arguments in the orchestra and that spaces must be used to separate parameter fields in the score. Likewise, in the section ‘How to write notes’ (p. 10), the following statement appears: ‘An i statement turns on an instrument with the corresponding number in the orchestra file’. I am not convinced every beginner would realise this means the number immediately following the ‘i’. These may seem very pedantic points, but my own experience of teaching Csound indicates that it is precisely on these sort of fundamental issues that many beginners get stuck. In a situation where the reader might be studying without expert assistance, such details are of significance.

Later chapters cover a variety of synthesis and processing techniques, including: additive and subtractive synthesis, sampling and processing, analysis and resynthesis, various forms of modulation (amplitude, ring and frequency), waveshaping, granular and formant synthesis and, finally, physical modelling. Other chapters deal with control signals, spatialisation of sound, the use of MIDI files and real-time MIDI control of Csound. In addition, there are useful explanations of how flow charts can be used to represent Csound processes, of the principles of digital audio and of Csound as a programming language.

The chapters contain theoretical and practical descriptions as well as good examples (orchestra and score files) and many chapters also have ‘Extensions’, giving further details on certain topics. These extensions are an excellent idea providing both more advanced technical information for those interested and in some cases comparisons with earlier analog techniques and references to the musical repertoire produced using them. A good example of this is in the extension to Chapter 11 (p. 209ff). The first part (11.A.1) provides a brief introduction to the trigonometry of amplitude and frequency modulation for those with a mathematical interest. The second (11.B.1) provides ‘Historical Sketches on Ring Modulation’. This describes the analogue circuitry used for ring modulation in the Cologne studio of the 1950s. It also lists some of the works by Stockhausen that employ this technique and includes a quotation in which Stockhausen describes how he exploited features of this technique in composing Mantra. Although brief, this section makes important links between the past and present and between the technical and the creative.

The text of this book has been carefully ordered to follow a logical progression with beginners in mind although, perhaps inevitably with such a complex and interrelated topic, there are occasions where this does not quite work out. For example, the unit-generator ‘soundin’ is used in an orchestra on page 85, but not explained until page 141. Likewise, flow charts are used in advance of the very helpful chapter specifically dedicated to explaining them. In most cases these issues should not cause too many problems for the reader.

The final sections of the book, following the appendices, comprise ‘Readings’ by a variety of other authors extending the scope of the text in a number of directions. There is a chapter on using Csound with the Linux operating system (Nicola Bernardini), another on modifying
score files using general-purpose programming languages and readings on ‘Dyad Controlled Additive Synthesis’ (James Dashow) and ‘Granular Synthesis’ (Agostino Di Scipio). Perhaps most interestingly there is an account by Gabriel Maldonado of his realtime interactive front end for Csound on PCs. Although these sections cannot hope to cover the full range of advanced topics in Csound and some will be of more interest to certain readers than others, they do give some indication of further possibilities for working with Csound.

There are quite a number of typographical errors scattered throughout the book, sometimes involving single letters (e.g. ‘Itès’ for ‘It is’ on page 229), but on occasions whole words are either added (e.g. ‘in the shadow of after additive synthesis’, p. 91) or apparently missing (e.g. ‘whose functionality is identical an interconnected delay/delaypair’, p. 241). Although resulting at times in strange grammatical constructions they do not, for the most part, seriously impede the understanding of the text. The graphs and diagrams provided are often helpful, although the production of these is not especially refined by current standards and the axes are not always labelled. Although these are often explained in the text, there are a few places where I think a beginner could easily become confused. The most striking error is in Appendix 2 (pp. 341–8) where the grids of all but the first table are rather bizarrely misaligned and overlap some of the surrounding text.

There is much in this book of great value to the intermediate user of Csound and much helpful material for use in supporting of class teaching. Even the experienced user might learn something; I did: the authors of Virtual Sound clearly have an impressively thorough knowledge of Csound. As a text for total beginners to use in teaching themselves Csound unaided, I am not convinced that the book always succeeds. Although there are many useful sections, the clarity of explanation is not entirely consistent. For example, following an excellent chapter on amplitude and ring modulation, Chapter 12 on frequency modulation is less consistently clear. A total beginner might well find the way that the concept of the modulation index is introduced (p. 213) confusing. Only as the chapter progresses does its significance become a little clearer. Likewise, the description of convolution (p. 246ff) might well baffle newcomers to the subject. The first paragraph of section 13.6 is particularly opaque and unhelpful, especially to the beginner. Concise but much clearer introductions to both these topics can be found in a number of more general texts. In a much smaller way, the failure to distinguish clearly between ‘prime numbers’ and ‘numbers that are prime relative to one another’ on page 218 could well cause confusion for the non-mathematician. None of this undermines the value of this book as a support for class teaching or as a reference book for experienced users, and even the lone beginner will still find much here that is of great use. It is very much to be welcomed that there are now such books on Csound and indeed that there are different texts bringing different perspectives to the subject. It is to be hoped that they will inspire and enable further imaginative use of the software.

Michael Clarke
University of Huddersfield


The Art of Digital Audio first appeared in 1988 and was something of a landmark text. Comprehensive in its scope, and given more to explanation than mathematical equations it provided a reader-friendly approach to the subject through illustrated examples in practical equipment. However, as technology in music has moved on, and a glut of textbooks concerning the subject have flooded the market, the third edition of this book finds itself up against stiff competition, not least, superficially, against the Computer Music Tutorial by Curtis Roads.

As one would expect, Watkinson has thoroughly revised his text to include explanations of many of the latest technologies, including Internet audio, MPEG audio compression and digital audio broadcasting. He considers the book to be ‘essentially an introductory book, a theory book, an applications book and a reference book all in one’. As with any book that attempts to be a number of things, there will inevitably be some level of redundancy. Anyone but a novice will gloss over the diagrams of a DAT cassette, and yet, to someone coming new to the subject, such a level of detail on this, and many other aspects, helps to demystify many of the illusions that have arisen about such subjects. It is, however, this very quantity of information provided for each subject that has lead the previous editions of the book to become regarded as one of the standard reference books for the subject.

Unlike the Computer Music Tutorial, The Art of Digital Audio does not attempt to cover all aspects of sound production and reproduction. As one goes through the book it becomes obvious that its approach to digital audio is more towards a systems analysis and consideration of digital audio hardware applications, rather than digital sound itself. Considering digital audio to the extent that it does has both an advantage and a limitation. The advantage is obvious. So detailed is this book, that from a hardware and systems perspective, this is the only book you need. The disadvantage, however, is that to gain a broader understanding of how digital audio fits into the larger picture of sound production you will need further texts. One such example is the area of surround sound. There is an explanation of how a DVD player works in the chapter on digital audio in optical disks,
and of Dolby AC-3 in the chapter on compression formats. The two, however, are never combined in a discussion of the various surround sound formats and how we perceive them in 3D space. Similarly, you will find no explanation of sound synthesis techniques or what happens to a digital signal when you put it through a digital reverb, chorus or flange.

The book splits the subject of digital audio into bite-size pieces. Moving progressively from a basic introduction to audio and digital principles, to conversion and compression methods, error correction, types of digital audio tape recorders and magnetic disk drives, to editing and optical disks, each chapter starts with an introductory overview of the subject before moving into more depth. The opening chapters are particularly noteworthy for their direct and matter-of-fact treatment of digital and audio principles. While the former provides, amongst other things, a particularly detailed explanation of filters, the Fourier and wavelet transforms, the latter provides one of the best introductions to the concepts of audio that the reviewer has read. Essentially a chapter on acoustics and psychoacoustics, it is written in an extremely accessible language. Anyone wanting to understand the basics of digital audio simply must read this chapter. Similarly impressive are the chapters on digital conversion, compression, transmission principles and correction that make up the heart of the book. In every chapter there are well-labelled diagrams that amplify and clarify the more detailed parts of the text in a clear and coherent manner. What this book adds up to is a text that compliments the Computer Music Tutorial rather than being in direct competition with it.

What The Art of Digital Audio has over many other currently available texts on this subject is its degree of comprehensivity and approachability. It would make the ideal primer for any undergraduate grappling with digital audio in media production, multimedia, or in the sound studio. For those with a working knowledge of digital audio it is simply an essential reference book. For any musician interested in electronic music and its production I would strongly recommend that The Art of Digital Audio sit between the Road’s book and a good psychoacoustics text. You will rarely want to reach for something else.

Mathew Adkins