

Listening to Loudspeakers

By: Alan Hardiman

Sound Reproduction: Loudspeakers and Rooms

By Floyd E. Toole
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The title of Floyd Toole's new book, *Sound Reproduction: Loudspeakers and Rooms*, embodies its central theme, which is that, together, loudspeakers and rooms comprise a system that, along with listeners, must be approached as a whole by those of us who undertake to design listening experiences. In this 550-page work, Toole brings together—much of it in one place for the first time—a wealth of research, experience, and practice from scores of investigators like himself working over many decades, and distills from it a number of empirically substantiated recommendations for practice. In the process, he examines some beliefs and rituals long held sacred in some quarters, and finds many to be not merely irrelevant, but in some cases counterproductive.

Sound Reproduction represents the summation of Toole's life's work. Starting in 1965, he spent 26 years at the National Research Council of Canada, where he attained the position of senior research officer in the acoustics and signal processing group. From 1991 until his retirement last year, he served as corporate vice president—acoustical engineering, at Harman International Industries, Inc., where he directed the Harman research and development group, a central resource for technology development and subjective measurements. He is a fellow and past president of the AES and a fellow of the Acoustical Society of America. In September 2008, he was awarded a lifetime achievement award by the Custom Electronic Design and Installation Association (CEDIA).

Ever the scientist, Toole focused his research on the acoustics and psychoacoustics of sound reproduction in small rooms, and directed it to improving engineering measurements, objectives for loudspeaker design and evaluation, and techniques for reducing variability at the loudspeaker-room-listener interface. Accordingly, the book is divided into two equal parts. Part One: Understanding the Principles lays the theoretical groundwork, while Part Two: Designing Listening Experiences leans toward practical matters relating to test methodologies, loudspeaker design, and system installation. The book is richly illustrated with an abundance of graphs, tables, and drawings, along with a few photographs, but readers can rest assured that an engineering degree is not required to understand any of it.

This is a very important book. It should be required reading for everyone in the sound business. In a review such as this, it's

impossible to do justice to the sweep of Toole's work, but I'll risk it in an effort to entice as many people as possible to read it.

Pointing out the obvious fact that typical listening rooms and home theatres, where reproduced sound is enjoyed, cannot be compared in either size or purpose to concert halls, where sound is originally produced, Toole suggests that the weight given to calculating and engineering optimum reverberation time and room dimensions for concert halls does not apply in the same way in designing listening rooms. There is no way to replicate the original sound field in a room designed for sound reproduction through loudspeakers; indeed, in most multitracked pop music recordings there is no "original sound field" to begin with. Instead, several key perceptual cues must be provided to stimulate the listener into a suspension of disbelief, providing a credible sense that the sound stage is wider than the space occupied by the front loudspeakers ("apparent source width"), and a sense of spaciousness ("listener envelopment"). Toole shows how both senses, along with speech intelligibility and timbre identification, are increased by the presence of early lateral reflections, and suggests that in most cases, reflections from side walls should be encouraged, not suppressed.

It follows that constant directivity in a loudspeaker is very important: Off-axis frequency response should match as closely as possible the axial frequency response; otherwise, reflections of the off-axis sound from side walls will be colored, leading to a deterioration of the total sound field (direct sound plus reflections) at the listening position(s), and a drop in the sense of spaciousness.

Regarding room dimensions, Toole recommends that low frequencies, where room modes and standing waves become significant factors, should be handled by a separate sound system comprising at least one subwoofer and a bass management system. Such a system combines low frequencies in any or all of the front and surround channels with the low-frequency effects channel (LFE) in 5.1 surround formats, and delivers the combined signal to one or more subwoofers. He notes in passing that current crossover technology is inadequate to the task: "The idea that the normally supplied electronic high- and low-pass filters are sufficient is a dream...Only acoustical transfer-function measurements in the room, at the listeners' head positions, can provide the necessary data to permit good subwoofer-satellite transitions to be achieved using additional electronic filtering."

If a room is being designed for more than one optimum listening position, as in the case of home theatres, then more than one subwoofer is necessary. Toole spends considerable time comparing the benefits of different configurations of two or more subwoofers in evening out regions of high pressure caused by standing waves engendered by various room modes.

Part One concludes with an 18-page summary of its 13

chapters. Readers with limited time or who wish to take a concentrated dose of the book can start here.

Part Two: Designing Listening Experiences begins with a review of multichannel options for music and movies. Toole reiterates how surround loudspeakers can be useful not just for providing the illusions of direction and distance, but also for increasing the “feeling of space” (apparent source width plus listener envelopment), which turns up in the research as the single largest factor in listener perceptions of “naturalness” and “pleasantness,” two general measures of quality. He goes into great detail in describing the methodology underlying double-blind listening tests, the only reliable way to discover listener preferences that are free of biases relating to appearance, price, brand loyalty, and so on.

In passing, he notes that for 30 years, Consumers Union (CU) has been rating loudspeakers in its *Consumer Reports* magazine without conducting listening tests, on the basis of 1/3-octave measurements of sound power only. Noting that CU’s “product ratings have a significant influence on the North American market,” Toole recounts an independent 2004 evaluation of 13 loudspeakers that had been recently reviewed by *Consumer Reports*. In a fully balanced, double-blind listening test—every loudspeaker is auditioned against all others the same number of times, and their identities are hidden from both test administrators and listeners—a group of trained listeners found no correlation at all with the magazine’s rankings. In fact, the loudspeaker that came first in the listening test was ranked dead last by Consumer Reports. Toole generously allows “that if the subjective data are correct, the CU method of evaluation is based on a faulty premise,” noting that “Consumers Union is in the process of revising its evaluation process for loudspeakers.”

He also shows how audible comb filtering is not the problem it is often thought to be (it doesn’t bother us because we hear through and around reflections), how two-channel stereo is simply faulty (among other things, phantom-center images between loudspeakers sound dull, because identical sounds from each speaker take a longer path to the listener’s far ear, resulting in substantial cancellation around 1.8kHz), and why the practice of walking around a hall making adjustments while listening to pink noise is irrelevant (seated listeners benefit from the phenomenon of adaptation, and concerts do not consist of steady-state pink noise). He also demonstrates why a popular center-channel loudspeaker design (midrange-tweeter-midrange) is inherently flawed, why dipole surround loudspeakers are worse than ineffective in current surround formats, and why bipoles are a better alternative.

He demonstrates why the resolution of 1/3-octave-band analyzers is insufficient in revealing high-Q resonances that may well be tamed with parametric equalization—but not the conventional 1/3-octave band graphic EQs of the past. “We

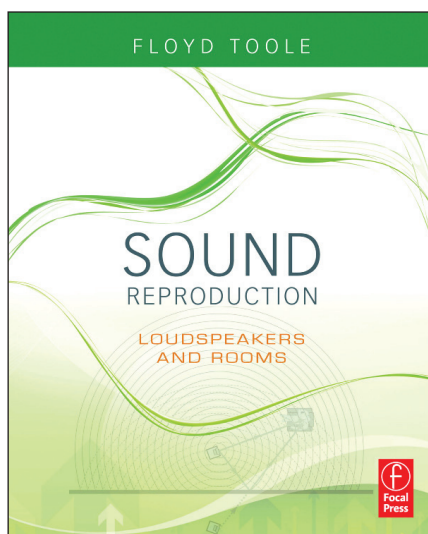
realize now that much of the problem with equalization was that the industry had been performing surgery with a blunt instrument.”

The book includes many practical recommendations, including several concerning video resolution, screen size, and viewing distance, and for dealing with the ensuing compromises involved in reconciling viewing distance with listening distance and loudspeaker placement.

Along the way, Toole takes an occasional poke at interior designers (“a lot of careful design, and the sound of the room, are degraded when the ‘finishing touch’ is added”), self-aggrandizing acousticians, and equipment reviewers, whose opinions are almost never based on double-blind listening tests, and are, therefore, worthless. “Why are these people in positions of such trust?” He also notes that, due to the normal deterioration of hearing with age, scientific listening is really a younger person’s pursuit. “When graybeards expound on the relative merits of audio products, they may or may not be relevant. But be polite—the egos are still intact.” In an astounding display of truth-for-the-sake-of-science, Toole includes a chart that graphically exposes the decline of his own hearing over three decades.

He repeatedly urges manufacturers “to provide comprehensive anechoic data on their products...reasonable description of how the product performs needs to be the ‘price of entry’ to this marketplace. It should not be up to the customer to discover information that should be publicly available. During the design of the product, this information was presumably available to the engineers who designed the product. If such data was not available to those engineers, then one is left to contemplate the competence of the source of the product. The descriptions of acoustical performance offered by many of the significant players in the loudspeaker business are simply insulting in their inadequacy.”

The book’s organization, type face, and layout make for a quick, easy read. It contains fewer typographical errors than most books in the genre, none of them seriously confusing the matter at hand. References in the text to the bibliographical apparatus do not interrupt the flow, and free the book from distracting footnotes. It is a breath of fresh air that all necessary references to the work of others are incorporated either into the running text or the captions accompanying illustrations. I enjoyed the book and learned a lot from it. You will, too. ☺



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