Leo Beranek and Concert Hall Acoustics

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Concert hall acoustics owes an enormous debt of gratitude to Leo Beranek, not just for the science he advanced and not just for his professional accomplishments, but also for the inspiring manner with which he executed both simultaneously.

I was 22 years old the first time that I accompanied Leo Beranek to Boston's Symphony Hall, in 2002. Despite my relative youth, I had the three things needed for the task: a keen personal and professional interest in concert hall acoustics, availability on late notice, and a car. I had met Leo only once previously – he had visited Acentech's Cambridge office to present a dry-run of a presentation he was to give at an upcoming Acoustical Society meeting – but I knew opportunity when it came knocking and eagerly volunteered when the message went out to the acoustics group at Acentech: Leo Beranek's wife was out of town; he welcomed some company at that night's concert, and he needed a ride.

More than a decade later, I've come to appreciate how Leo's approach to his remarkable career in concert hall acoustics paralleled our approach to Symphony Hall that Sunday afternoon. When I picked him up from his Harvard Square condominium that day, it quickly became clear that Leo had made that drive many times before and knew exactly how to do it: he patiently but firmly instructed his driver on every lane change and maneuver, knew where to park, knew how much to tip the parking attendant. We visited the Beranek Room (imagine my awe!) at Symphony Hall for a pre-show cup of tea; Leo knew precisely when to make our way to his seats in the front row of the first balcony. Everything about our visit had been carefully examined during his many previous visits: alternatives were vetted and experiments conducted, so that Leo was able to efficiently and adeptly engineer our pre-concert experience and advise his eager companion on just what to do. And then the music began, and an altogether more important lesson became obvious: it's not just that Leo knew how best to make his way to his seat – he knew where to sit.

Concert hall acoustics owes an enormous debt of gratitude to Leo Beranek, not just for the science he advanced and not just for his professional accomplishments, but also for the inspiring manner with which he executed both simultaneously. Alongside his dozens of peer-reviewed papers, seminal textbooks, and outstanding buildings for music credited to Leo Beranek, his enduring legacy is also his remarkable ability to serve our community as both scientist and practitioner, theorist and engineer.

Leo Beranek – The Scientist

In August of 2010, Leo Beranek gave a public lecture organized by the Faculty of Architecture, Design, and Planning at the University of Sydney (transcribed 2011a). It was the latest in a long line of papers, talks, and books that succinctly

distill the most fundamental aspects of concert hall acoustics and room design. With his trademark clarity, Leo outlined a brief history of concert hall acoustics, introduced the principal acoustical attributes of a concert hall, described four basic concert hall shapes, illustrated his points by describing examples of the world's concert halls, and concluded by presenting a step-by-step process for designing concert halls. Leo is uniquely qualified to present such a comprehensive paper given his contributions to the field as an historian of concert hall acoustics, his scientific and analytical papers on key concert hall parameters, and as the individual most responsible for establishing the framework for how most acoustical consultants understand concert halls.

A Framework for Understanding Concert Halls and Opera Houses

Leo has followed this outline before, in prior papers (Beranek, 1975 and 1994, for examples) and in his seminal books on concert hall acoustics, beginning with his landmark book, *Music, Acoustics, and Architecture* (Beranek, 1962) and continuing up through *Concert Halls and Opera Houses: How They Sound* (Beranek, 1996), and *Concert Halls and Opera Houses: Music Acoustics, and Architecture* (Beranek, 2004). The emphasis and a few of the details have evolved in various papers over the decades, but key themes are consistent. The analytical framework hinges around key acoustical attributes of a concert hall: liveness, loudness, clarity, intimacy, spatial impression and diffusion, warmth, hearing conditions for the musicians, and the absence of deficiencies such as echoes or noise. Each attribute is associated with certain metrics or parameters – for example:

- reverberation time (RT) and early decay time (EDT) relate to liveness – both parameters indicate the time it takes for an impulsive sound source to decay in a room (RT is an overall measure of the time it takes a sound to decay 60 decibels, and EDT focuses on the first 10 decibels);
- loudness in a concert hall is characterized by the sound strength parameter G: the ratio (in decibels) of sound pressure level of a reference sound source measured in a concert hall to the sound pressure level measured in a free field 10 meters from that same reference source;
- clarity is associated with the ratio of early to late arriving sound – for example the clarity index C_{80}, which is a ratio of sound energy arriving in the first 80ms of an impulse response to the energy arriving thereafter;

Leo Beranek's prolific contributions to concert hall acoustics theory and science would not have been possible were it not for the sweeping portfolio of concert halls that he and his colleagues helped to design.

- Leo's papers relate intimacy to the initial time delay gap (ITDG, the time of the arrival of the earliest reflection minus the time of arrival of the direct sound);
- spatial impression and diffusivity in a concert hall are related to early and late portions (respectively) of the interaural cross-correlation coefficient (IACC) or the related metric (which Leo coined): the Binaural Quality Index (BQI), which are measures of the relative similarity (or dissimilarity in the case of BQI) of impulse response signals in the two ears;
- Leo's early papers relate "warmth" in a concert hall to bass ratio – the ratio of the reverberation time of lower frequencies to that of middle frequencies. In later papers (e.g. Beranek, 2011b), he proposes a Bass Index equal to the strength parameter G at 125 Hz minus the same value at mid-frequencies.

This framework has evolved over time. It began with a first-of-its-kind survey of 54 halls, 23 musicians, and 20 professional music critics (since expanded and updated). The study, begun in 1955 and extended in 1962, resulted in a rank-order categorization of the world's concert halls and spurred an investigation into what differentiated the most celebrated halls. Initially, it focused on initial time delay gap, reverberation time, bass ratio, the intensity of the direct sound in relation to the reverberant sound, loudness of the reverberant sound, balance and blend, diffusion in the hall, ensemble, freedom from echo, freedom from noise, freedom from tonal distortion, and uniformity. The survey and the ensuing analysis laid the groundwork for *Music, Acoustics, and Architecture* (Beranek, 1962), and thereafter the surveys and analyses have been extended many times by Beranek himself (e.g. Beranek, 1996, 2004) and others (Hidaka and Beranek, 2000; Lokki, 2014, for example). The books contain a wealth of information about these concert halls of great import to working acoustics researchers, designers and consultants throughout the world– drawings to scale, detailed and cited room acoustics measurements, basic room dimensions and architectural data, and detailed descriptions of each space.

To his credit, Beranek has been careful to point out the limitations of his rankings of concert halls: the most-liked halls have the finest orchestras playing in them, irrespective of the

acoustics of the room; excessive noise or distracting echoes can render the rest of the room acoustics parameters moot; many listeners attend their local concert hall almost exclusively and are often quite pleased with its acoustics, whether or not it is highly "ranked." Nonetheless, the analytical framework that began in the 1950s and 1960s remains the backdrop for most ongoing concert hall research (Lokki, 2014).

In addition to the analytical framework outlined above, Beranek's survey papers and books on concert halls also categorize halls into four types:

1. The shoebox hall, with its parallel sidewalls, illustrated in most of Beranek's survey papers by Boston Symphony Hall. In his Sydney paper (Beranek, 2011a), he makes no secret of his preferences in terms of concert hall shape: "Choosing the shoebox shape literally ensures good acoustics."

2. The fan-shaped hall, which deprives the middle seats of early lateral sound reflections and is thus not preferred for halls larger than about 1000 seats.

3. The surround or "terrace" hall, often illustrated by Berlin Philharmonie and the Disney Concert Hall in Los Angeles, is sometimes called a "vineyard" or "terrace" shaped room because the audience is seated in trays of varying heights. Beranek has stated that its principal drawback is the lack of seat-to-seat uniformity in terrace-shaped rooms: "A third of the seats will not have the sound quality of a shoebox-shaped hall" (Beranek, 2011a).

4. The lateral-directed reflection sequence hall, typically exemplified by the Town Hall in Christchurch, New Zealand, is sometimes described as having a "hi-fi" sound because the emphasis on direct and early sound energy relative to reverberant energy is similar to many recordings of symphonic music.

Here again, Beranek's categorization provides a framework for an understanding of the concert hall form, and the benefits and detriments of basic formal designs. This is not to say that the framework is immutable or that the categories are rigid – indeed, improvisation will only further our understanding of and appreciation for concert hall acoustics. Just as music has a rich tradition of theme and variation, concert halls will continue to be built with myriad variety – and Beranek has helped to define the themes.

Scientific Investigations and Analyses

Having established a framework for our understanding of concert hall acoustics, Beranek focused on developing and refining our understanding of particular design features and acoustical metrics.

Panel Arrays

Following investigations at Philharmonic Hall in New York (more on that later) and Tanglewood (Johnson et al., 1961), Beranek and his colleagues analyzed the acoustics of six other halls with arrays of overhead reflector panels (Beranek and Shultz, 1965; Watters et al., 1963). This analysis pioneered the use of early-to-late ratios – already in use in the design of rooms for speech – as a tool to understand what the authors termed "running liveness" and "fullness-of-tone" in rooms for music. (The concept of running liveness has since been extended, in Beranek, 2008a, for example.) Beranek and Shultz also analyzed the relative frequency content of early and late energy, and conducted listening tests to extend our understanding of the importance and desirability of this spectral balance. They also extolled the virtues of variable acoustics and "tunability" in rooms that rely on overhead panel arrays.

Audience Absorption

Both early (Beranek, 1960) and late in his career (Hidakaet al.,2000; Nishiharaet al., 2001; Beranek, 2006), Beranek analyzed audience and seat absorption in concert halls. The early paper focuses on the important conclusion that absorption of audiences in large concert halls is better understood as a function of the area the audience covers rather than the earlier method of determining absorption on a per-person basis. This work allowed Beranek and others to draw conclusions about the relationship between acoustical parameters (reverberation time especially) measured in empty versus occupied halls. The collaborations with Nishihara and Hidaka focused on relating acoustical parameters (RT, EDT, clarity index C_{80}, strength G, and IACC) in empty versus occupied rooms, and on predicting occupied room acoustics parameters based on an analysis of four different methods for predicting or measuring audience absorption. The 2006 paper compares Eyring and Sabine RT formulations to derive a relationship between absorption coefficients determined using the two well-known equations, and goes on to determine Sabine and Eyring audience absorption coefficients for some twenty rectangular and non-rectangular concert halls.

IACC and Lateral Fraction

Beranek has collaborated with Hidaka on a number of papers, including two with Okano involving IACC and Lateral Fraction (Hidaka et al., 1995; Okano et al., 1998). The 1995 paper uses subjective ratings of concert halls to determine (1) that low-frequency sound levels (G-low) and the late part of IACC at three middle-frequency octave bands ($IACC_{L3}$)

Figure 1: *Leo on stage at Symphony Hall with students from RPI.*

are predictive of apparent source width (ASW), and (2) the early part of IACC in the same frequencies ($IACC_{E3}$) better correlates to subjective ratings of acoustical quality than does lateral fraction (LF). (LF is simply a ratio between lateral-arriving energy measured with a figure-8 microphone to the overall energy in an impulse response measured with an omnidirectional microphone.) The 1998 paper extends and reinforces the first point.

Sound Strength (G)

Beranek extols the virtues of the sound strength parameter G as a tool in evaluating and planning concert halls in a more recent paper (Beranek, 2011b). He describes its use not only as a descriptor of loudness, but also (if analyzed spectrally) as a predictor of low-frequency loudness (the G-derived "Bass Index"), listener envelopment, and – with BQI – of ASW (this last point an extension of his 1995 paper with Hidaka and Okano). His most recent article in JASA (Beranek and Nishihara, 2014) utilizes measured values of G and RT to derive mean-free paths of concert and chamber music halls and verify the validity of the well-known assumption that the average mean free path is equal to 4V/S where V is room volume and S is total surface area.

Histories and Survey Papers

Beranek is an accomplished historian of concert hall acoustics. He has published extensively on the contributions of Hunt and Sabine to architectural acoustics, including their work relevant to concert halls. He has a special personal interest in beloved Symphony Hall in Boston, and he has delved into the history and acoustical characteristics of the hall in great detail. He frequently shares this detailed knowledge with visitors and students (**Figure 1**).

In addition, Beranek has authored several comprehensive "survey" style papers, summarizing the concert hall acoustics research of others for significant periods of time: "Concert Hall Acoustics – 1989" was the first of these (Beranek, 1990), followed by similarly comprehensive installments in 1992 and 2008 (Beranek, 1992, 2008b). These are in addition to his more general papers on then-current thinking about concert hall acoustics cited previously (e.g. Beranek, 1975, 1994).

Leo Beranek – The Practitioner

Leo Beranek's prolific contributions to concert hall acoustics theory and science would not have been possible were it not for the sweeping portfolio of concert halls that he and his colleagues helped to design. This project work gave purpose

Figure 2: *Overhead panels at the Shed at Tanglewood, Lenox, MA.*

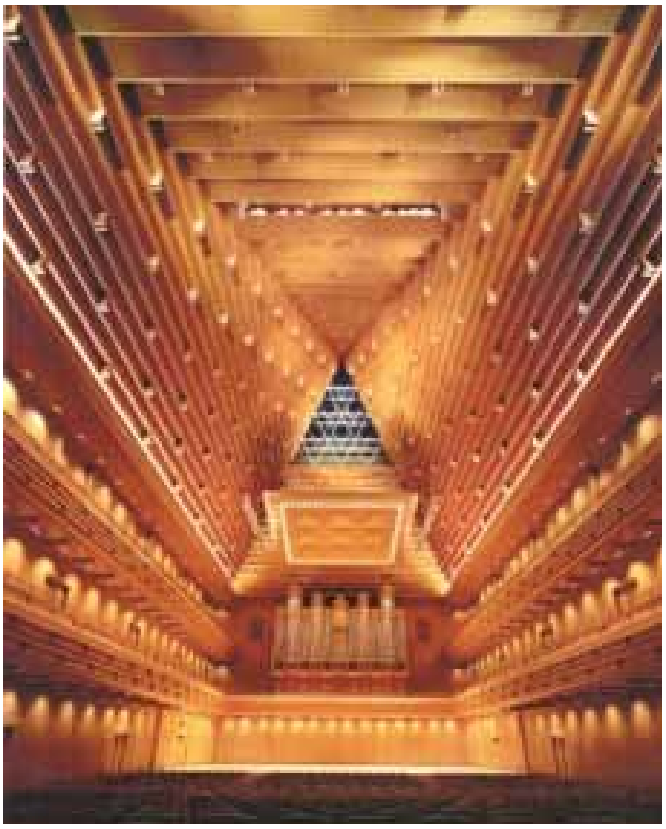

Figure 3. *Tokyo Opera City Concert Hall*

Figure 4. *Leo working with colleagues reviewing a working model of the Tokyo Opera City Concert Hall.*

to Beranek's body of acoustics research and grounded it in practical application. Beranek has consistently shared lessons from this body of consulting work in published papers. The literature includes Beranek's detailed accounts of the acoustics of the Mann Concert Hall in Tel Aviv (1959), the orchestra enclosure and canopy at the Tanglewood Music Shed (1961), BinyaneiHa'Oomah Jerusalem Congress Hall (1961), several accounts of the acoustics of Philharmonic Hall in New York City, and more recently, the Tokyo Opera City Concert Hall (2000) and the opera house at the New National Theater in Tokyo (2000). The acoustics at Tanglewood and at the concert hall at Tokyo Opera City, built nearly 40 years apart, have been widely praised and are among Leo's proudest accomplishments (**Figures 2, 3 and 4**).

The story of Philharmonic Hall has been recounted many times. The academic literature includes Beranek's contemporaneous accounts (e.g. Beranek et al., 1964), and Leo also recalls the events from his personal perspective in his biography, *Riding the Waves* (2008b). The experience significantly influenced not only Leo Beranek's career, but the arc of concert hall acoustics research and practice more broadly. Renewed analysis of reflected panel arrays was one of the results, but more fundamentally it changed the role of the acoustical consultant and society's general perception of the field.

Beranek also wrote about the evolving role of the acoustical consultant. He gave a plenary address at the 89th meeting of the Acoustical Society of America which was later published in JASA (Beranek, 1975b) called the "Changing role of the 'expert'." Much of the paper focused on the role of acousticians in national noise regulation, but he also discussed Philharmonic Hall from BBN's perspective: because access to the Lincoln Center board and the public was limited and because the board and the architect altered the design of the room without the consultants or orchestra knowing it, the room's acoustical design suffered considerably. He also wrote that the replacement committee of acoustical experts, hired to address problems after the opening, did not consult with the original team, to Lincoln Center's detriment; in the paper, Beranek calls for acousticians "to raise their level of professionalism, not only to their clients but also to each other."

Beranek's role as a consultant has been central throughout his work. In *Music, Acoustics, and Architecture* and in his subsequent books, he set out a vocabulary that has enabled fruitful conversation and discussion about architectural acoustics with those outside of the field – what acoustician Larry Kirkegaard has called the "Rosetta Stone for the languages of music, acoustics, and architecture" (dust jacket, Beranek, 2004). And it has grounded his scholarly work ever since.

Leo Beranek – The Inspiration

Leo Beranek has been thoughtfully engaged in concert hall acoustics research for decades – with published, peer-reviewed scholarly work on the subject from the 1950s through 2014. He has been a tireless contributor to the Acoustical Society and to many other related organizations – for example, he has been a leader of the Boston Symphony Orchestra since 1968, serving as Chairman of the Board of Overseers, Chairman of the BSO Board of Trustees, and currently holds the title of Life Trustee with that organization. His leadership in these and other organizations and his consistent commitment to advancing both the science and practice of architectural acoustics for such an extended period of time has inspired countless other researchers and practitioners. Throughout this time, he has also been a champion of the work of others in the profession, supporting younger scientists and consultants in their pursuits. Tapio Lokki, this year's Vern O. Knudsen Distinguished Lecturer at the Acoustical Society of America meeting, has said that Beranek has consistently encouraged his work: "Leo is always pushing me forward, without pushing his work on me or promoting his own work" (Lokki, 2014b). Beranek is an engaged presence at the Acoustical Society meetings, offering thoughtful questions and critiques, providing some historical context on occasion and encouraging further research where warranted.

Beranek's books, in particular, are themselves a source of inspiration for many in our field. For most of the acousticians with whom I spoke in preparation for this article, "Leo's book" is the first text on acoustics that they owned. (Which of his books was "Leo's book" depended only on the age of the person responding.) His books are accessible, presenting information in a way that is useful to consultants and researchers working in the field and always drawing basic conclusions regarding the design implications of his findings.

Conclusions and Next Steps

There is a great deal of ongoing work in concert hall acoustics that builds directly on Beranek's findings. Lokki, for example, has undertaken highly sophisticated research that has confirmed many of Beranek's assertions in a scientifi-

cally rigorous way (Lokki, 2014). "Even though [Beranek's] metrics aren't perfect, his numbers are good, his ideas are good, and the metrics are good" (Lokki, 2014b). With the possible exception of ITDG (which Lokki has called "misleading"), Lokki has described his work as scientifically proving or supporting Beranek's earlier findings. He compared his work to modern day physicists whose work basically supports Newtonian physics. There may be exceptions, some new information, some small changes, and significantly greater detail, but "Beranek was basically right about most things" (Lokki, 2014b).

Even so, there are many in the field who seek to work beyond the parameter-based framework that Beranek established decades ago. A 2011 article in *Acoustics Today* by Larry Kirkegaard and Tim Gulsrud, called "In search of a new paradigm: how do our parameters and measurement techniques constrain approaches to concert hall design?" eloquently makes the case not only for new metrics, but a new listening-based approach to concert hall design that isn't constrained by monaural microphones, omnidirectional sources, or the six or eight most commonly analyzed octave bands.

I know that Leo Beranek welcomes new research, new work, and even new approaches to concert hall design. It was careful listening, not parameters, that led Leo to select his excellent seats for his subscription to the Boston Symphony Orchestra concerts. And I also know that he would encourage disciplined engineering and scientific rigor to support this work – hallmarks of his career and his still-regular trips to Symphony Hall.

Biosketch

Benjamin Markham is the Director of the Architectural Acoustics Group at Acentech, the direct descendant of Bolt Beranek and Newman. Ben is active with Studio A, the performing arts studio at Acentech. He also teaches classes in architectural acoustics at the Schools of Architecture at MIT and Cornell University. He holds a BSE from Princeton University and an MS in architectural acoustics from RPI.

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Rear of the stage at Meyerhoff Hall, Baltimore, with diffuser panels.

Support of New Tools

Leo Beranek has touched and educated all of us throughout his illustrious career. One of my examples was in the early 1990s, My firm, RPG, was involved in acoustical testing and questionnaires with the Baltimore Symphony Orchestra (BSO) at the Joseph Meyerhoff Symphony Hall, with and without diffraction grating diffusers and absorbers on stage. The installation was intended to be temporary, but actually remained on stage for several years. So when Leo was compiling his 1996 book How they Sound: Concert Halls and Opera Houses, he included photos the stage treatments, and comments from the BSO Executive Director stating, in part "…The musicians have had some difficulty hearing each other on stage, and there have been some early reflections strong enough to be distracting to both the musicians and the conductor. A series of panels called QRD® Diffusors have been set up around the perimeter of the stage. These panels have had a very dramatic and positive effect of clearing up the sound on stage…… The musicians report improved ensemble playing."

On a lighter note, I always enjoyed running into Leo at the fitness center of the hotel that was hosting the ASA meeting for an early morning workout. His attention to fitness has apparently contributed to his longevity.

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Ten Things I Learned from Leo Beranek

Leo Beranek helped to form my basic thinking and approach to architectural acoustics in many ways. His writing, speaking and design work has been a continued inspiration and example to me since 1979 when Bert Kinzey, my professor at the University of Florida, introduced me first to his work and then to Leo himself. Here is my list of ten things I learned from Leo (though he may not know he taught me these).

1. The importance of theory. Once Bert Kinzey introduced me as a young student of architectural acoustics to Music, Acoustics and Architecture in 1979, the idea that one could develop an architectural theory based on something as intangible as the perception of musical sounds in architectural spaces yet rooted in science was both fascinating and challenging.

2. Think broadly about sound. In my first year of study with Bert we read Acoustics, Noise and Vibration Control, Music, Acoustics and Architecture, and Noise Reduction by Leo. These books which covered sound systems, noise control, sound transmission, HVAC system noise control, vibration, room acoustics and the perception and meaning of sounds among other topics introduced us to the breadth of acoustical thinking in architecture.

3. Always be a student. Leo remains an inspiration to me when I see him seated in paper sessions at ASA, CHRG and other meetings from early in the morning until the end of the session, listening intently and engaging in the discussion like a young graduate student. His enthusiasm and engagement with current research in acoustics is an example to us all.

4. Listen carefully and often. Leo sits and listens everywhere he goes. His writings convince all of us that this is the reason for the science.

5. The qualitative is important. A reading of Music Acoustics and Architecture and its subsequent derivations demonstrates the importance for dialogue among participants in the soundscape of concert rooms to develop a science of architectural acoustics about the shared experience of listening to music in world class venues.

6. Test, Design, Build, Listen, Test, Design Build, Listen, etc. Sharing the viewpoint that the science of architectural acoustics is rooted at once in science, acoustical testing with new metrics, analysis of data, designing, building, listening and then further testing, analysis, designing, building in iterative sequences is essential to the growth of the field. **Build may be the biggest distinguishing factor here.** Leo and his colleagues built the field of architectural and environmental acoustics building by building, project by project, year by year in amazingly creative and interesting ways. What a portfolio of work!

7. Work in the "in-betweens." The interdisciplinary gaps between the fields of music, acoustics and architecture are where much of Leo's work falls. He chose to dedicate his life to the exploration of the gaps between three traditional fields of knowledge to form a new discipline that he helped to raise to a sophisticated science and a high art.

8. Collaborate. To work or labor together. At Harvard, BBN and in later years with many others collaboration and sharing was at the heart of much of Leo's work. His colleagues in all of these endeavors are a who's who of those who shaped architectural acoustics from the middle of the 20th century to the present day in so many different ways, places and forms.

9. Ask Questions. Leo shows everyone around him that it is worthwhile to ask questions as a way to learn. He eagerly engages everyone he meets and the authors of the papers he listens to in active participation with the topics they have discussed.

10.It keeps getting better. Anyone who has been to one of the recent halls Leo has worked on or listened to one of his recent papers can attest to the fact that **it just keeps getting better.**

Best wishes on your 100th birthday with profound hope that it just keeps getting better.

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Leo at ISRA 2013 conference

The Birth of CHRG

One of my earlier contacts with Leo Beranek started with informal discussions at the May, 1991 ASA meeting in Baltimore. This led to the later creation of the Concert Hall Research Group (CHRG), a lot of new concert hall measurements, and ultimately to improvements to the ISO 3382 standard. For the ASA meeting, I had organized three sessions on new measurements in concert halls, and Chris Jaffe was enthusiastic for such measurements to be made in an additional number of North American Halls. The key impediment was getting financial support for the researchers' travels costs. Chris Jaffe encouraged me to talk to Leo Beranek.

I wrote Leo a letter proposing a measurement tour of three research teams led by Anders Gade (Danish Technical University), Gary Siebein (University of Florida), and this author (NRC Canada). Measurements by all three teams would be made in halls in the northeastern US on the same occasions so as to allow for detailed comparisons of the results. The results would then be made available to others, and the sponsors would have some say in the halls that were included. Leo agreed that it would be a unique opportunity to transfer research knowledge into practice and it could help with his wish to include new measurement data in a new (1996) version of Music Acoustics and Architecture. He organized the contacting of key acoustical consultants and before long we were all sitting around Leo's dining room table making telephone calls.

Funds were found, measurements were made in nine halls in May 1992, and initial results reported at the May 1993 ASA meeting. It was a great success made possible by Leo Beranek and his enormous stature and respect throughout the acoustical community.

I have had many subsequent interactions with Leo including requests to review drafts of his papers. More recently I was disappointed to hear that he had turned down our invitation to present a paper at the recent International Society on Room Acoustics (ISRA) 2013 conference. He explained that as he was approaching his 98th birthday, he intended to cut back on his travel to conferences. This was disappointing but very understandable. So imagine our pleasant surprise to discover that Leo was the first person to submit an abstract to ISRA 2013, which he did indeed attend and present his paper. He is a very remarkable example to us all.

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Shared Respect

As a young student in architectural acoustics, I had, of course, read all of Leo's books, and I only learned much later that he had read my book too. How gratifying! I met him first in person in 1994 at the occasion of the Wallace Clement Sabine Centennial Symposium in Cambridge MA. He approached me and invited me for lunch, where we fiercely discussed our common research topic at that time, namely, the elements in spaces of which that spatial impression for musical performance are composed.

Although we did not agree on quite a number of details, I was impressed by Leo's openness and curiosity. And I felt awfully honored by the respect that he paid me and my research—and this, in effect, left me with a strong feeling of encouragement. And whenever I have met him since and talked to him, I always come away with a sense of being respected and supported in my scientific efforts. Indeed, I think that it is an outstanding attribute of Leo's character that he has the ability to provide respect and encouragement to younger colleagues and to his peers—and that he actually actively does so.

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The dedication page of the book In at the Beginnings: A Physicist's Life by Philip Morse, inscribed: "To my good friend Leo Beranek with regards." This book is one of many books that were given to Leo as presents from other scientists. The collection now resides at the Architectural Department library at RPI.

New Home for Leo's Books

On April 1, 2010, Dr. Leo Beranek presented his collection of professional acoustics books to RPI during a visit to the campus. Leo was very pleased to know his books would find a welcoming home at Rensselaer.

"I wanted to find a place that could use the collection," Beranek said. "I found that this would supplement what you have. Some of the older books are very difficult to find and the addition will make the collection more complete than what a modern library would have." Leo's gift acknowledges the significance of Rensselaer's Graduate Program in Architectural Acoustics and offers the acoustics students and faculty access to the rare books he has accumulated in a lifetime of work within the field. At the same time, it points to his expectation that the Rensselaer Graduate Program will educate the next generation of top architectural acousticians.

Leo Beranek's book collection now lives in the Architectural Library on the 3rd floor of the Greene building at Rensselaer where the Graduate Program in Architectural Acoustics students have their classes and research labs; every book has a dedicatory name plate inside. Student and faculty research has benefitted from the many books that have since been checked out from the collection. In one example, Cameron Fackler, one of the 2014 INCE-USA Leo Beranek Student Medalists, was able to read Zwikker and Costen's hard to find 1949 Sound Absorbing Materials used in his doctoral research on rigid-frame porous materials and micro-perforated panel absorbers.

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