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FOREWORD

Before you go any farther, read what Jim has written about me on page xiii in his Preface. There is an axiom in academia—"any book that cites my work in admiration is a fine publication worthy of worldwide distribution." So I must in all honesty ask that Jim Jerger's name be substituted for mine once again.

Why do I say "once again"? In December of 2002, Jim Jerger kindly came to LSU to applaud my career at a retirement party. To paraphrase this witty clever man, whom I have always admired from the beginning of our association, he said something like:

> It is a pleasure and an honor to speak in glowing terms about a man whose influence on our field has been immeasurable, whose leadership and originality have set the stage for the development of a strong and powerful profession . . .

And as he went on and on, I muttered in a barely audible fashion "Jim that sounds much more like you than me." At the end of his encomium, he smiled and said " . . . But enough about me, we are here to celebrate Chuck's retirement."

No one laughed louder or longer than I did. It is to Jim we owe the popular acceptance of much of our modern audiologic practice differentiating cochlear from retrocochlear disease, starting with Békésy types, SISI, SPAR, tone decay, and so on and, of course, the ubiquitous test battery principle which now is the cornerstone of good audiology.

My honor, respect, and admiration for both Jim and Susan have only grown over the years. But it should come as no surprise that my view of our profession's history would have a slightly different twist based on discoveries made in intellectual streams quite different from those that formed the basis of audiology as Jim lived it. Other members of our profession were more strongly influenced by NIH and its training and research programs. Jim and Susan both played strong roles in promoting Audiology and its scientific validity in halls of NINDB and ultimately NIDCD. I daresay, without his support, some of my own grant applications would never have been approved.

Sadly, only a few of our audiologic colleagues have held NIH grants, but those who have, are leaders in our field and have published in the most prestigious journals in the world, including *Science* and *Nature*. Brenda Ryals of James Madison University, for example, published some of the germinal papers on hair cell regeneration and, working with Ed Rubel, helped discover that chicks regrow hair cells after noise trauma. That opened a remarkable chapter in auditory science, which uncovers new findings almost weekly.

Through my personal early postdoctoral training, underwritten by NIH, my notion of the first audiologists included C. C. Bunch. But I must add his anatomist-colleague-mentor Stacy Guild Ph.D. who learned about the WE 1-A from Bunch (or perhaps the other way around—history is unclear) and then rolled the first Western Electric audiometer around the wards of the Johns Hopkins, doing bedside audiograms on dying patients. He then collected their temporal bones and showed that high-frequency hearing loss (measured albeit tenuously to 16,384 Hz with Bakelite headphones!) was associated with loss of hair cells and nerve fibers at the basal turn of the cochlea. That publication dovetailed with von Békésy's first publication on traveling wave theory, meshed with Wever and Bray's findings on cochlear electrical events, and spawned immediate attempts to record human action potentials and cochlear microphonics instead of audiograms. The search for the objective audiogram had already begun before there were even norms or very many official practitioners. Their attempts to record these events from human ears unfortunately were technically premature, despite von Békésy's and Lempert's best efforts. Merle Lawrence, and later Joe Hawkins, were among the leaders who ushered in a new era of correlating electrically extracted audition with physiology and anatomy. This was the slightly different stream into which I fell as part of my early NIH-supported postdoctoral training. Without NIH support, I feel our field would have taken a somewhat less scientific turn.

It was one of my responsibilities as a postdoctoral fellow at the Johns Hopkins to test terminal patients bedside, get permission to harvest their temporal bones, and get the bones and fix them for subsequent study. It was there I first realized that what Jim and his colleagues already knew, that the pure tone audiogram did not always mesh with what textbooks taught about the underlying cochlear anatomy and physiology. My audiologic brain was expanding and people like Wever, Lawrence, Schuknecht, Lempert, and Guild, not to mention Ira Hirsh (none of whom would ever qualify for ASHA certification—sigh) were really teaching us important things about our patients from an entirely nonclinical perspective.

And Jim is, of course, also responsible in part for that expansion because he introduced me to, and captivated me with, the writings of Edward de Bono. (*The Five Day Course in Thinking* and *Serious Creativity* are two of my personal favorites.) Let me explain. de Bono taught us ways of thinking to address both the "quite impossible" and the "incredibly mundane" as worthy of some attention. So, in much of my teaching of medical students, neuroscientists, audiologists, and colleagues I ask the rhetorical question "Why Is the Sky Dark at Night?" The common and expected answer is: "Because the sun's on the other side of the earth." Well, that explains why the *earth* is dark at night, but why don't we see the light of the sun bypassing the earth on its way out to space? Is the earth casting a huge shadow that blocks out everything but somehow manages to skip the moon, the stars, and any planes or satellites passing by way up in the sky? Obviously not. The (partially) correct answer is that the sky is brilliantly lit with *infrared* light visible to cats, rats, mice, and so on but not to humans. The sun's light is moving away from us at the speed of light and undergoes a Doppler shift, which causes it to appear as infrared instead of visible spectrum light.

Why is this an important thinking exercise? We don't mull over this dark sky paradox because we have a logical answer that satisfies us, even though it is wrong. Once we make up an answer that satisfies us, we stop looking. The nature of the human brain is that we make up stories to fit the facts that we observe (cf. Gazzaniga and the *Ethical Brain*), which in turn dampens our curiosity.

For example, why do we have a middle ear muscle reflex and what does it have to do with the audiogram? We were taught (or taught each other) that it is a protective mechanism for "loud noises" and we elicit it with a loud sound to the ear. But virtually all mammals and many other species have such a reflex. Why would Nature (my apologies to the Intelligent Design folks) anticipate the industrial revolution and introduce a protective device that attenuates *low* frequencies by virtue of its increase in stiffness of the ossicular chain. In humans the middle ear muscle reflex is invoked 50 msec *in anticipation of* the onset of the voice, and in part as a protective device for the almost 115 dB SPL *low* frequencies generated in the vocal tract. In many mammals (bats, for example), it is a tool to modulate echo returns and keep them from impinging on pinging sounds emitted from the vocal tract.

I include this homily in honor of Jim and his contribution to our profession. He makes us think, and come up with new answers. What's more, his own relentless attempts to separate cochlear from retrocochlear disorders has an orderly interlaced lattice-like structure, which allows its ultimate reconfiguration once new facts are discovered.

Let me clarify. Because of the history of our profession and its reliance on the pure tone audiogram as a gold standard, we now have one of our most critical problems facing us. "If your only tool is a hammer, the whole world looks like a nail." Our primary tool was the pure tone audiogram and we thought that, once we obtained it, "our job was done." As Jim quite rightly notes in the text, some of our otolaryngology colleagues would like to relegate us to that role, or automate us out of our work. We must revise much of our thinking about the audiogram and learn instead to interpret it through modern concepts of physiology which we didn't have even 15 years ago.

To amplify, most of the work published in our journals views the ABR and middle ear muscle reflexes through the prism of the "getting the audiogram" or diagnosing a tumor, rather than the underlying physiology. In the late 1960s and early 1970s. Henry Spoendlin showed that it was the *inner hair cell* that mediated virtually all the auditory nerve activity in mammals. So the audiogram, the middle ear muscle reflexes, the ABR, and all of our understanding of speech perception and the articulation index reviewed in this book that were championed by Harvey Fletcher et al. now have to be re-examined from the point of view of the integrity of the inner hair cell, its dynamic range of only 65 dB, and the synchrony of the nerve fibers which it subtends. People with nearly normal audiograms can in fact have no ABRs because they lack synchrony, and, similarly, people with very poor audiograms can have *normal emissions* because their inner hair cells and/or nerve fibers are not functioning well. These observations demand that we put the quest for the "objective audiogram" and "objective hearing measurement" in a different light.

David Kemp's discovery of otoacoustic emissions allows us to study the outer hair cell almost in isolation. We recognize the outer hair cell has a wide dynamic range cochlear amplifier and, therefore, in the presence of normal emissions, an additional hearing aid is certainly not physiologically called for in the selected frequency ranges. Thus, we as audiologists are the only profession that can noninvasively dissect the cochlea into inner and outer hair cell function in living humans, and manage them from a physiologic perspective rather than exclusively from their audiograms. Unfortunately, the two-stage test of emissions first, followed by ABR second, described here by Jim as a major achievement in our profession has to be re-examined in the light of recent findings. It should be ABR first, and emissions second, because almost 40% of NICU babies will have normal emissions and absent or abnormal EcochGs or ABRs. They will escape proper diagnosis and management (Rea & Gibson) if emissions are done first.

Outer hair cells can be tested with otoacoustic emissions and cochlear microphonics.

Inner hair cell integrity can be inferred from five test results: A synchronous N1 in the EcochG, a similarly synchronous Wave I in the ABR, recordable Summating potentials, brief cochlear microphonics (again because they come from *any* hair cell) and robust middle ear muscle reflexes at or less than 95 dB HL *regardless* of the audiogram. An absent reflex in the presence of normal emissions, or an absent ABR in the presence of normal emissions are cardinal signs of auditory neuropathy/dys-synchrony, a set of conditions that apply in at least 15% of our hearing-impaired children and many of our adults who are inexplicably poor hearing aid users or who have "dead zones" (Brian C. J. Moore).

With this armamentarium, why do we still fit hearing aids based on the audiogram without testing the underlying physiology? Because we think we know why the sky is dark at night and don't think beyond the pure tone audiogram the way Jim has always exhorted us to do. This is the core of a new way to look at audiology. It complements and plays a reprise to all of our audiologic forebearers, and ties together many loose ends which, at the time of original report, had only limited physiologic explanations.

By applying the Jerger and Hayes cross-check principle, we can study each new patient physiologically with tympanometry, reflexes, and emissions. This trio predicts what the audiologic results *should* be but prevents us from viewing the audiogram as the gold standard of hearing. The same audiogram can lead to entirely different auditory perceptions when and if inner hair cells and/or nerve fibers are disabled. Therefore, "fixing or compensating for the audiogram," as suggested by many of our forebearers is appropriate only if the outer hair cells and, in part, the cochlear battery (endocochlear potential) are the culprits.

When inner hair cells and/or nerve fibers underlie the poor audiogram (and sometimes their accompanying audiograms can be nearly normal!), we have an entirely new way to classify their problems. What looks like auditory processing disorder (APD) may really be cases of auditory neuropathy/auditory dys-synchrony (AN/AD), with nearly normal audiograms, poor hearing in noise, and poor performance on the SCAN or any of the dichotic procedures commonly applied to make the APD diagnosis. It is here that assistive technologies, which essentially enhance the signal-to-noise ratio become our strongest weapons. Inner hair cell and nerve fiber losses, often revealed by extraordinarily poor hearing in noise scores, ultimately will yield to FM enhancement, assistive listening devices (ALDs), or cochlear implants, provided the impairment does not stem from thalamic, cerebellar, or cortical impairment. C.C. Bunch's patient, whom Jim thought might have Ménière's disease, could just as easily have had temperature-sensitive auditory neuropathy/dys-synchrony. But the advent of anything that enhances signal-to-noise ratio can just as easily be viewed in the context of ameliorating inner hair cell and nerve fiber loss.

So the six streams of audiology that Jim has so elegantly outlined in this book all will converge in the future on the underlying physiology and genetics of our patients.

Why genetics?

Within the next few years, chips will be available that can sample droplets of blood from our patients and tell us whether they are homozygous or heterozygous for many different genetic forms of deafness. (See http://webh01.ua.ac.be/hhh/ for almost daily updates on the status of genes and deafness.) Knowing the underlying genetic causes of various types of hearing loss will liberate us from categorizing hearing loss as simply "conductive or sensorineural." We will certainly be able to understand and better manage the underlying mechanisms of various hearing losses and both apply and develop new tools for assessment. The most important tools of the future will be both genetic and physiologic, especially if we can develop a noninvasive or nondestructive method for evaluating the endocochlear potential in humans. Knowing the status of the cochlear battery will open new vistas for both diagnosis and management.

So, in summary, my favorite audiologist of all time, the man in our field I hold in the greatest of respect, has brought us to a place where we can liberate ourselves from the search for the all elusive Holy Grail of the *audiogram*. We can now amend all of our practices with physiologic and mechanistic underpinnings to better treat our patients and work with our professional colleagues to better understand some of the mysteries we encounter.

We certainly cannot say that once we "get the pure tone audiogram," we now know all there is to know about Why the (audiologic) Sky Is Dark at Night, Jim Jerger has helped us reach a new place, a new promised land, where we have all the "hallmarks of a robust and growing profession with a remarkable history."

Charles Berlin, Ph.D.

Reference

Rea, P. A., & Gibson, W. P. (2003). Evidence for surviving inner hair cell function in congenitally cleat ears. *Laryngoscope, 113*(11), 2030–2034.

1

The Pioneers

Harvey Fletcher (Figure 1–1) was one of the true pioneers of research in speech communication. After teaching physics for five years at Brigham Young University in Provo, Utah, Fletcher moved to New York to carry out research in sound at the Western Electric Company. Here he participated in the development of the Western Electric hearing aid, the first to employ vacuum tubes; the initial model was delivered to none other than Thomas A. Edison. Harvey Fletcher's book *Speech and Hearing* for many years was the accepted standard guiding research in speech communication. As director of physical research at the Bell Telephone Laboratories in New Jersey, Fletcher set the stage for what later became the concept of the articulation index, and, more recently, the speech intelligibility index. He helped to found, and served as first president of, the Acoustical Society of America.

Figure 1–1. Harvey Fletcher.

The Western Electric 1-A audiometer was quite large by today's standards and fairly expensive ($1500.00). As Figure 1–2 shows, it was hardly portable, but a later model, the WE 2-A, was smaller and lighter. It was sold mainly for use in otolaryngology practices. Within two years the Sonotone Jones-Knudson Model 1, became commercially available. Otolaryngologists were the primary users of audiometers in the 1920s and 1930s. Their enthusiasm was tempered, however, by the fact that there was no common standard for calibrating the devices. Each manufacturer relied on its own laboratory data, usually based on results from a few people available around the laboratory. Thus, the same patient might show somewhat different losses on two different audiometers. The problem was that no one was quite sure what were the SPL levels corresponding to average normal hearing in the population.

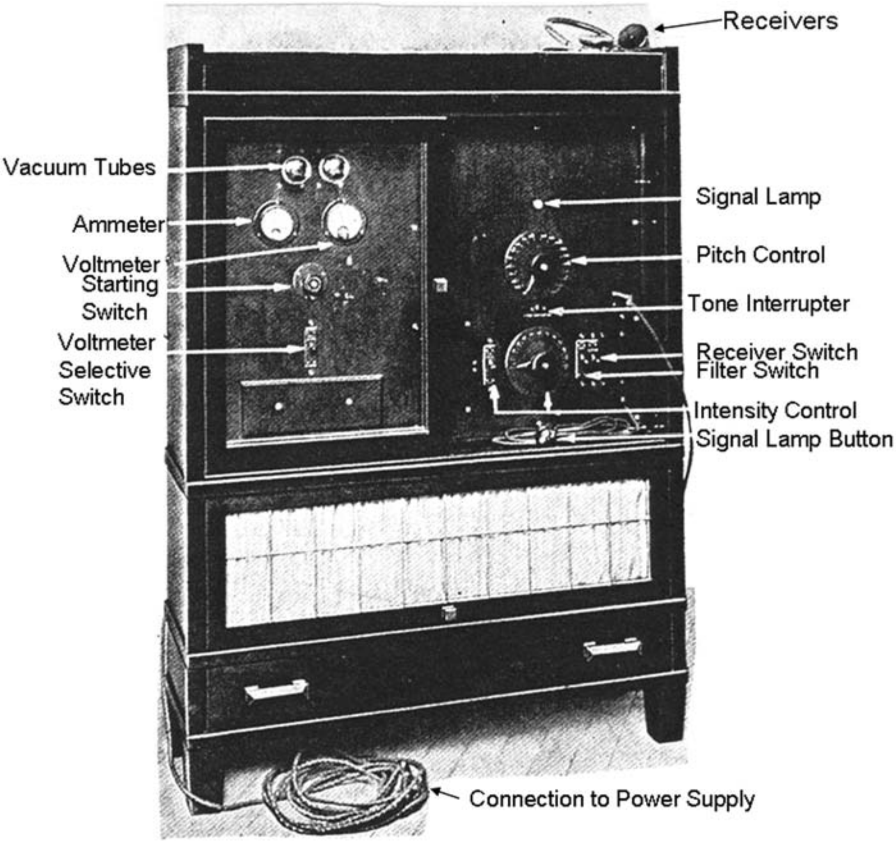


Figure 1–2. The Western Electric Model 1-A audiometer.

The Saga of Average Normal Hearing

In 1935 The United States Public Health Service (USPHS) undertook a fairly massive effort for the time, a survey of hearing sensitivity in the United States. Willis Beasley, a public health officer, was appointed to carry out the survey during the years 1935-1936; in subsequent years it became known as the "Beasley survey." Considering that no one had ever undertaken such a study before, the planning, execution, and reporting were remarkably sophisticated. The SPL levels obtained by the Beasley survey provided, for the first time, large-sample data defining average normal hearing over the frequency range from 128 Hz to 8192 Hz.

The first standard for the calibration of audiometers in the United States was published in 1951 by the American Standards Association, a voluntary group of consumers, manufacturers, engineers, and specialists. The sound pressure levels (SPL) values from the Beasley survey corresponding to average normal hearing at each test frequency (the zero HTL line on the audiogram) became, in 1951, the basis for the calibration of all audiometers in the United States. And, because no other country had undertaken a similar survey, the ASA-1951 standard (which came to be known as the "American standard") was adopted by many other countries as the basis for calibrating their audiometers. But in the early 1950s two other hearing surveys were carried out, one in the United Kingdom (UK), the other in Japan. The two surveys were in agreement: both found average normal hearing to be about 10 dB better than the American standard. In an effort to understand what might account for the approximately 10-dB discrepancy between the ASA-51 and the UK findings, the Research Center of the Subcommittee on Noise in Industry, in Los Angeles, authorized Aram Glorig to plan and execute another survey of average normal hearing in which the exact methods and procedures employed in the Beasley survey would be carefully repeated. Audiometers and audiometric booths were set up at the Wisconsin State Fair in 1954, and 3500 fairgoers were tested audiometrically. Results essentially replicated the Beasley findings. This prompted Glorig to go back to the Wisconsin State Fair, in 1955, and carry out another survey, but using what he termed "laboratory methodology," in which threshold was crossed at least three times in each direction. This time results were about 10 dB better, and in agreement with the UK/Japan results. Glorig concluded that the difference lay in the technique of threshold determination. Apparently, the difference between, on the one hand, the Beasley and 1954 Wisconsin State Fair results, and on the other hand the UK/Japan and the 1955 Wisconsin State Fair results, could best be attributed to better audiometric testing technique. It seemed that experience over the period from the 1930s to the 1950s, especially as a result of World War II military programs, had improved threshold seeking technique, resulting in more accurate threshold estimates.

After a good many international meetings, checks, and counterchecks on possible procedural and/or calibration microphone, earphone, and coupler differences, and many other possible reasons for the discrepancy, all finally agreed, in an international meeting at Rapallo, Italy, that the International Standards Organization (ISO) should issue, in 1964, a new standard that all could agree on. This became known as the ISO-64 standard. It was essentially based on the findings of the UK and Japan surveys. From that point on, audiometers worldwide could be calibrated to the same standard.

This change in the basis for calibrating the zero HTL line on the audiogram had a major impact on a number of agencies in this country, particularly the military and the Veterans Administration. Because compensation for service-induced hearing loss was based on audiometric hearing threshold levels, a change of the zero loss level of 10 dB, had the potential to increase compensation benefits nationwide to a financially alarming degree. There was a long transition period during which reporting degree of hearing loss in the United States required that the calibration standard of the particular audiometer used for the measurement (ASA-51 or ISO-64) be reported as well. Eventually, however, all of these problems were resolved. Later, in 1969, the ASA (newly renamed the American National Standards Institute [ANSI]), made some minor adjustment to the ISO-64 standard, resulting in the ANSI-69 standard, and still later the ANSI-96 standard, which is now the basis for the calibration of audiometers in the United States. Although other details of these standards have changed slightly over the years, the ISO-64 SPL levels have remained virtually unchanged.

The Audiogram Recording Form

The year 1922 also saw the design of what we now know as the pure-tone audiogram recording form. It was conceived jointly by

Figure 1–3. Edmund Prince Fowler.

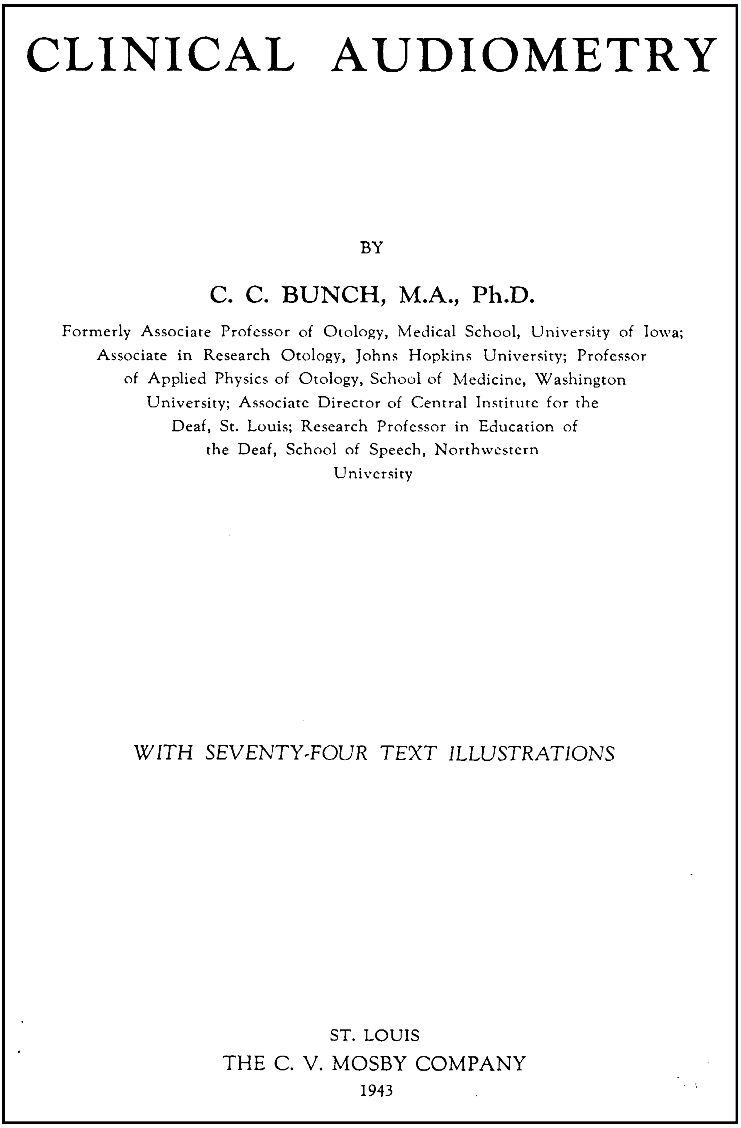
scientists Fletcher and Wegel and by an otolaryngologist, Edmund Prince Fowler (Figure 1–3) of Columbia University, the latter one of the great pioneers of otologic medicine. Unfortunately, they made two decisions that have continued to haunt us for the past 50 years. First, they proposed that "hearing loss" at each test frequency be expressed relative to "average normal hearing," a sound pressure level (SPL) that varies with frequency. Second, they thought that degree of loss ought to be plotted downward on the graph. All of this probably seemed like a good idea at the time, but it has caused unremitting problems in relating the audiogram to the performance of amplification devices, where performance at each frequency is expressed relative to a common SPL reference and is plotted upward on the graph in conformity with standard scientific practice. But at this point the practice is so ingrained that all efforts to bring reason to the situation have failed utterly.

The First Audiologist

The first genuine audiologist in the United States was undoubtedly Cordia C. Bunch. As a graduate student at the University of Iowa, late in the World War I, Bunch came under the influence of Carl Seashore, a psychologist who was studying the measurement of musical aptitude, and Lee Wallace Dean, an otolaryngologist. Together they convinced Bunch to undertake a five-year project on the practical application of methods for testing hearing. Because audiometers were not yet available commercially, Bunch developed his own instrument, called the "pitch range audiometer." It covered the frequency range from 30 to 10,000 Hz and intensities capable of reaching threshold in one direction and pain in the other. With this audiometer, Bunch plotted what he called the "hearing fields" of Dean's patients, from thresholds of hearing to thresholds of discomfort.

After obtaining his Ph.D. degree, Bunch stayed on briefly at Iowa, then moved for a short time to Johns Hopkins University, as Associate in Research Otology. In the meantime, L. W. Dean had moved from the University of Iowa to Washington University in St. Louis and invited Bunch to rejoin him there. Bunch accepted and was appointed Professor of Applied Physics of Otology at the Washington University School of Medicine. For the next two decades Bunch gathered a massive number of air-conduction audiograms on Dean's patients, analyzed them, and wrote up his findings. Over the years from 1919 to 1943, Bunch published papers covering an astonishing range of topics. He wrote on the use of the audiometer, the importance of measuring sensitivity in the range of frequencies above the conventional audiometric range, the effect of age on audiometric thresholds, occupational and traumatic deafness, traumatic loss from firecracker explosion, progression of loss in otosclerosis, deafness in aviators, conservation of hearing in industry, hearing aids, race and sex variations in hearing thresholds, otitis media, effect of removal of one entire cerebral hemisphere, calculating percentage of loss for medicolegal purposes, and the effect of absence of the organ of Corti on the audiogram.

Bunch carried out the first systematic studies of the relation between types of hearing loss and audiometric patterns. These pioneering efforts were published in 1943 in a slender volume entitled *Clinical Audiometry*, which is now a classic in the field. The title page is shown in Figure 1–4. One case study from the book illustrates how his insights



CLINICAL AUDIOMETRY

BY

C. C. BUNCH, M.A., Ph.D.

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Associate in Research Otology, Johns Hopkins University; Professor
of Applied Physics of Otology, School of Medicine, Washington
University; Associate Director of Central Institute for the
Deaf, St. Louis; Research Professor in Education of
the Deaf, School of Speech, Northwestern
University

WITH SEVENTY-FOUR TEXT ILLUSTRATIONS

ST. LOUIS
THE C. V. MOSBY COMPANY
1943

Figure 1–4. The title page of C. C. Bunch's classic volume, *Clinical Audiometry*, published by C. V. Mosby in 1943.

foreshadowed ideas that did not come to fruition until many years later. In the book he presents the audiogram of a 42-year-old man with what may very well have been Ménière's disease (Figure 1–5).

Bunch noted that the audiogram may not always help in the selection of a hearing aid and, indeed, may even lead to the wrong recommendation. In this case, he advised an aid with uniform frequency response, but subsequent evaluation showed that the patient understood very little in spite of the amplification afforded by the aid. Then he tried a Y-cord arrangement to both ears, but the patient could still understand very little. At this point, he began to suspect that something was out of order. He returned to the audiometer, presented tones at suprathreshold levels, and simply asked the patient to make pitch comparisons of the tones. Using this procedure he discovered that tones at 128, 256, and 512 Hz all were heard at the appropriate pitch and in the proper order, but that tones at frequencies of 1024, 1448, 2048, and 2896 Hz "all sounded alike and lacked tonal quality." Bunch speculated that the hearing aid was useful only in the low frequency range below 512 Hz, but of little value in the frequency region important for understanding speech. Bunch then made the prescient observation that, if it had been possible to administer simple speech audiometric testing, then the discrepancy between the audiogram and the patient's actual ability to understand speech could have been detected and the patient would not have had to go to the expense of purchasing a hearing aid that was not very helpful.

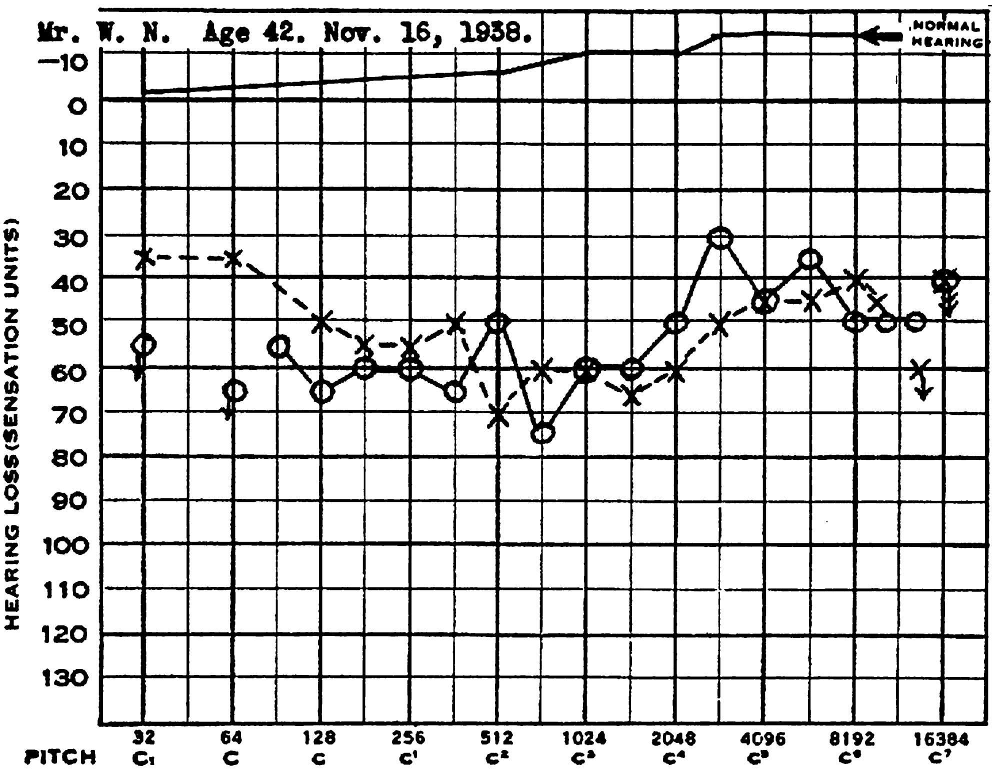

Figure 1–5. Audiogram of a Bunch patient who fared poorly with hearing aids.

Here, we can almost see the thinking of the consummate clinician/investigator at work. With only the pure-tone, air-conduction audiometer as test equipment, he senses a puzzling disagreement between his test results and the patient's ability to function with amplification. Determined to explore the matter, he does rudimentary pitch comparisons and discovers that all tones above 512 Hz have lost tonal pitch quality. He speculates that this may be the result of a unique aural pathology of which he is apparently unaware. He speculates that standardized speech audiometric tests, which, of course, were not available in 1938, would have been helpful in identifying the problem and thereby avoiding an inappropriate hearing aid fitting.

Bunch was probably the first to suggest that, in seeking threshold, the tonal stimulus should be keyed on and off rather than left on continuously, the first to suggest that testing should begin at 1000 Hz, and the first to suggest that total unilateral malingering would be revealed by the absence of an appropriate "shadow curve" on the presumably deaf ear.

After Dean's retirement, Bunch briefly became Associate Director of the Central Institute for the Deaf in St. Louis. In 1941 he accepted an offer from the School of Speech at Northwestern University to come to Evanston as Research Professor in Education of the Deaf, and to teach courses in hearing testing and hearing disorders. There he met and did a bit of mentoring of a young faculty member in speech science, Raymond Carhart. In June of 1942 Bunch unexpectedly died at the age of 57. In order to proceed with the course, the NU administration tapped Carhart to teach Bunch's courses. And the rest, as they say, is history. Carhart told me, years later, that no single person had had more influence on his career than C. C. Bunch.

6

Rehabilitation

Throughout much of the history of modern audiology the principal rehabilitative weapons have been wearable hearing aids, assistive devices, cochlear implants, and auditory training. Their paths have become interestingly intertwined.

Hearing Aids

Leland Watson, president of the Maico Company, and Thomas Tolan, an otolaryngologist, traced, in their volume, *Hearing Tests and Hearing Instruments*, the early history of the development of the wearable hearing aid. The following is based on their comprehensive review.

Alexander Graham Bell played a significant role in the invention of the first electrical hearing aid. In an effort to help his hearing-impaired wife, he experimented with the electrical properties of carbon granules. Bell failed to succeed with the hearing aid project, but his work with carbon granules led directly to the invention of the telephone. The first viable hearing aid based on carbon granule technology was actually developed by a Viennese physician, Dr. Ferdinand Alt, in 1900. American versions were produced in 1902 by Miller Reese Hutchinson in Mobile, Alabama and C. W. Harper in Boston. Carbon-granule based hearing aids were widely available in the 1920s and 1930s, but they had many problems, not the least of which was fairly poor sound quality. Vacuum tube amplifiers were a giant step forward. The first vacuum tube-based aid in the United States was produced by Art Wengel in 1937. It was called the "Stanleyphone." But it remained for the Aurex company to make the technology widely available. These aids stretched the definition of portable to an extreme degree. They were powered by a separate battery pack. The amplifying unit was mounted somewhere on the upper body, the battery pack either strapped to the midsection or on one leg. How a contemporary woman might outfit herself in the 1930s is illustrated in Figure 6–1.

The truly wearable hearing aid was made possible by the invention, and systematic improvement, of the miniature vacuum tube in the late 1930s. The filaments of the tubes were heated by a 1.5-volt "A" battery, the plate biased by a 22- to 30-volt "B" battery. These aids, about the size of a package of cigarettes, could be worn in a shirt pocket or in a cloth pocket suspended from the neck. They were connected by thin wire to a small transducer, curiously referred to as a "receiver," mounted in the ear canal by a totally occluding earmold. Such aids were made available to the aural rehabilitative

Figure 6–1. How a hearing aid was worn in the 1930s. The amplifying unit, mounted on the chest, was supplied by batteries strapped to one leg, and was connected by a long, flexible wire to the transducer mounted in a fully occluding earmold. (Reprinted from *Hearing and Deafness*, first edition, Murray Hill Books, 1947.)

programs of the various services during and after World War II and were widely distributed to returning servicemen. Examples of these "all-in-one" aids are shown in Figure 6–2.

Sound quality, in these aids, was still marginal. Figure 6–3 shows the frequency response of one such aid at various tone control settings. The wide-band, flat response was still a few years away.

The military programs generated a long-standing debate, which at times became quite contentious, over what might be called the "philosophy of fitting" an aid. On the one hand were the exponents of "hearing aid selection," a procedure promoted most notably by Raymond Carhart and his many students. The rationale here was that the audiologist must seek, through objective testing of speech understanding, the aid that best matches the unique shape and degree of the serviceman's loss. This was achieved by manipulation of gain and tone control of each of several candidate aids in search of optimal word intelligibility. As outcome measures of this approach Carhart adapted, for this purpose, the speech audiometric scores based on the spondee and PB word lists developed at the Harvard Psychoacoustic Laboratory during the war. The underlying assumption of the hearing aid selection procedure was that individuals differed in the unique details of their losses and that the best aid was the aid that complemented the shape of the loss, especially in terms of its frequency response. It was assumed that the speech audiometric scores would order the aids appropriately.

As early as 1946, however, an alternative philosophy emerged from two sources: (1) the British Medical Research Council (MEDRESCO) hearing aid, and (2) the Harvard Report. The MEDRESCO aid was developed by British engineers to meet the needs of the nascent British National Health Service. They were convinced that a single, relatively flat, frequency response was sufficient for most hearing-impaired individuals. Thus, they allowed for only minimal adjustment of the tone control of the aid.

The Harvard Report was generated by a group of scientists, including as noted earlier, Hallowell Davis, working on the National

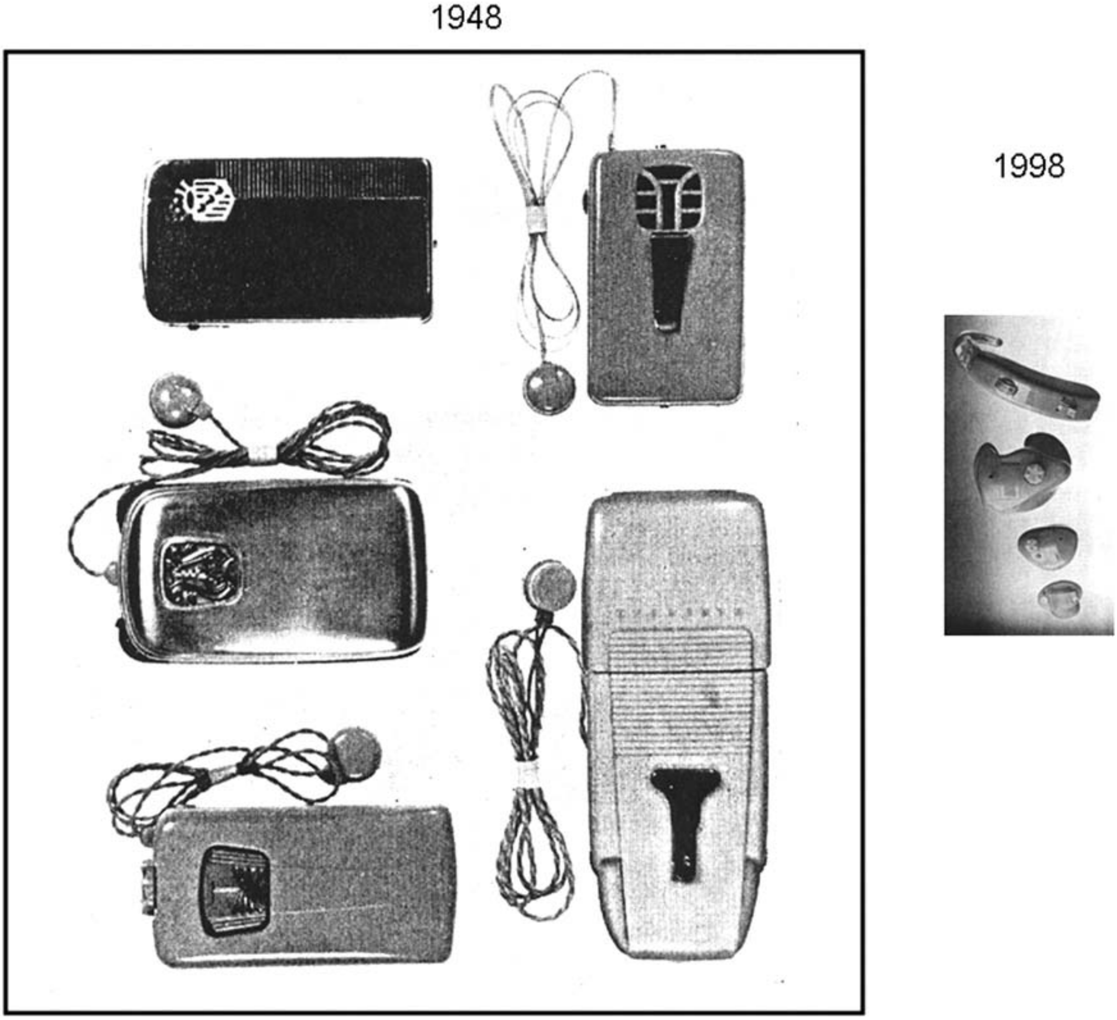

Figure 6–2. Five hearing aids popular in 1948, compared with four hearing aids popular in 1998. Fifty years of miniaturization.

Defense Research Council (NDRC) Aural Rehabilitation Project at Harvard University during the last years of World War II. They tested a number of hearing-impaired individuals with a master hearing aid, in which the frequency response could be manipulated over a wide range. Their report, published in 1946, reinforced the MEDRESCO philosophy in concluding that selective amplification was of little value. A uniform (flat) frequency response, or a response slightly tilted upward in the high frequencies, almost always yielded the best speech understanding scores. Thus, elaborate selection procedures were not warranted. For the next several decades, lively debate ensued between proponents of the two conflicting philosophies. Traditionalists continued to carry out hearing aid selection testing in the Carhart manner while young turks called for reform, but usually to little avail. It must be said, however, that the physical characteristics of the aids of that era

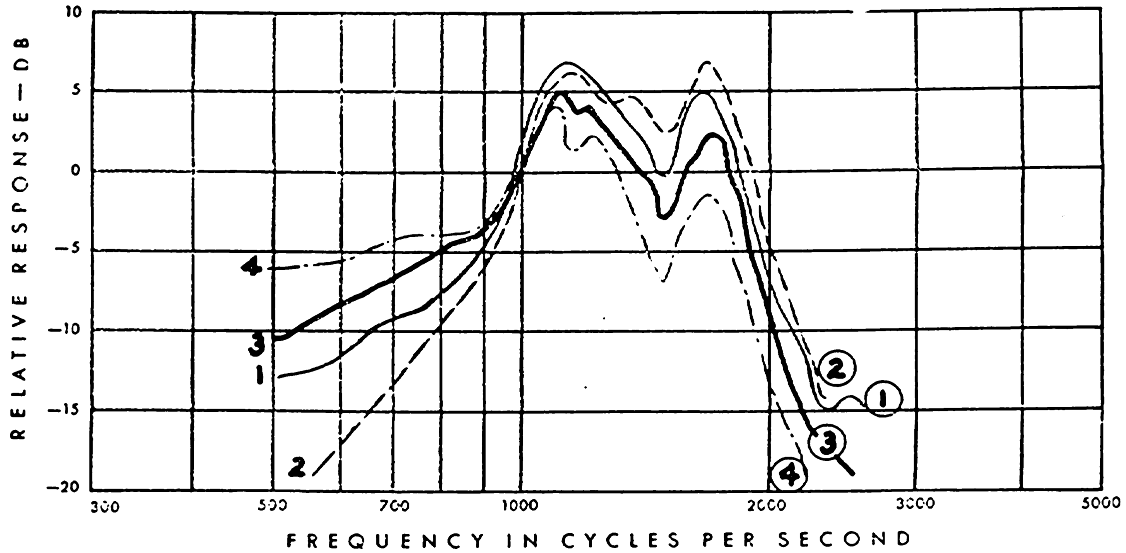

Figure 6–3. The frequency response of an inexpensive hearing aid popular in the 1940s at four positions of the tone control. (Reprinted from *Hearing Tests and Hearing Instruments*, Williams & Wilkins, 1949.)

did not permit very precise control over the frequency response of any aid. In retrospect, it is doubtful that either side could have amassed very much hard evidence in support of its position.

A similar conclusion was reached as early as 1949 by none other than Harvey Fletcher himself. He opined, at the Second Congress of the International Society of Audiology, that the appropriate frequency response of an aid ought to simply mirror the audiometric threshold levels, but that there would be little difference in word recognition scores between such an aid and one with a flat frequency response, so that, for all practical purposes the aid with a flat response should be suitable for everyone. He did concede, however, that if the audiogram sloped downward by more than 20 dB between 500 and 2000 Hz, then the response of the aid should slope upward at about one third the slope of the audiometric contour.

In the early 1950s the transistor was developed and its value in the design of wearable aids was immediately apparent. Transistors were certainly a good deal smaller than miniature vacuum tubes, but the main advantage was the elimination of the need for the bulky, high-voltage "B" battery. Transistors could manage the same amplification powered only by a small 1.5-volt "A" battery. This additional miniaturization made it possible to move the amplifier unit from the chest to a location over and behind the auricle, the behind-the-ear unit, and ultimately into the ear canal itself. Miniaturization also made bilateral fittings feasible, permitting for the first time the capability of exploiting the several advantages of two-eared hearing.

One of the early attempts in this direction was the development of the "eyeglass aid" in the 1960s. In this novel arrangement all of the components of an aid were built into the eyeglass frames, one aid on each side. It was a clever idea, but never really caught on, perhaps because it complicated the process of taking the glasses off and putting them back on. In those days, heavy frames were in vogue, but as that fad passed away, and only thin wire frames remained, there was no longer space for the hearing aids and the era of the eyeglass aid passed away with little fanfare.

An interesting innovation in hearing aid configuration was suggested by Earl Harford (Figure 6–4) and Joseph Barry in 1965. Persons with severe or profound unilateral loss were not considered suitable for hearing aid fitting because of the normal or near normal hearing on the better ear. But these individuals frequently complained of difficulty when the talker was on the side of the poorer hearing ear and difficulty in telling the direction from which a sound was coming. Harford and Barry reasoned that such a person might be helped by a fitting in which the aid and its microphone were mounted on the poorer hearing ear but the signal was actually routed to the better hearing ear. They called this arrangement CROS, standing for "contralateral routing of signal." Several innovative arrangements of the CROS principle were subsequently devised, including FM transmission of the signal from one side of the head to the other. In 1966 Harford further suggested that an individual with loss in both ears, but substantially more loss in one ear than the other, might benefit from a BICROS arrangement in which two aids are fitted but both signals are routed to the better ear.

Figure 6–4. Earl Harford.

The development of real-ear measurement of hearing aid performance was pioneered by Earl Harford. In the early 1970s, the advent of the miniature Knowles microphone raised the possibility of actually recording the sound pressure level of a signal within the human ear canal. Up to this time, hearing aid performance typically had been measured on a 2-cc coupler. But this approach failed to take into account the variations in response due to differences in real ear canals, transducer placement, and so forth. In 1973, William (Bill) Austin and David Preves of Starkey Laboratories brought samples of the new microphone to Harford's lab at Northwestern University and the trio ran numerous tests, using themselves as subjects, of what we now know as real-ear-measurement techniques. Austin and Preves continued to provide even smaller Knowles mikes as Harford continued his work testing hundreds of patients at the University of Minnesota. The first paper on the subject was presented by Harford at an International Symposium on Sensorineural Hearing Loss in Minneapolis in 1979. His first published paper, entitled "The Use of a Probe Microphone in the Ear Canal for the Measurement of Hearing Aid Performance," appeared a year later in *Ear and Hearing*. By 1985 clinically useful real-ear measurement systems were widely commercially available. In the almost 30 years since the original publications, real-ear measurement of hearing aid performance has become an essential element in the fitting of aids.

In addition to his seminal studies of bone conduction calibration and measurement, and his fundamental studies of speech recognition, the research of Donald Dirks (Figure 6–5), in particular, will be remembered for his development, with Sam Gilman, of a probe tube used to establish the effects of standing waves in the external ear canal over a wide range of frequencies. They were extremely useful in the subsequent development of clinical methods for real-ear measurement via probe microphones.

Figure 6–5. Donald Dirks. (Courtesy of Laraine Mestman.)

Auditory Deprivation and Acclimitization

In 1984 Shlomo Silman (Figure 6–6), Stanley Gelfand, and Carole Silverman published a seminal paper on auditory deprivation. When a person was aided monaurally, the aided ear maintained its speech-understanding capacity over time, whereas the unaided ear gradually declined. The late Stuart Gatehouse, in Scotland, later expanded the concept to include acclimatization, the tendency for the aided ear to improve slightly over time compared to the unaided ear. This important theoretical development has provided strong support for the fitting of aids to both ears whenever possible, even when there is a substantial difference between sensitivity levels on the two ears. It has also alerted researchers to take the initial period of acclimatization into account in hearing aid outcome research.

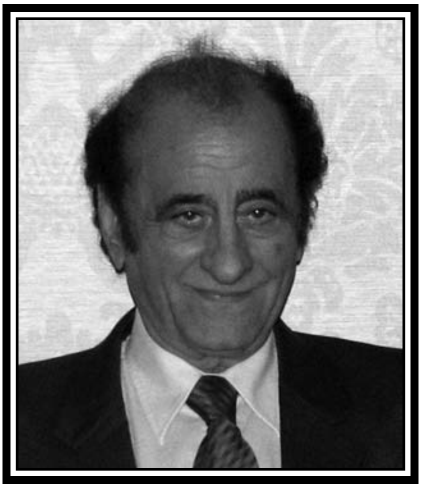

Figure 6–6. Shlomo Silman.

Binaural Aids

The fitting of independent bilateral aids, one to each ear, has had an interesting history. The idea that both ears ought to be aided in order to take advantage of the benefits of two-eared hearing was commonly asserted from the very earliest days of hearing aid fitting. But it was not until the advent of transistors that miniaturization made it practical to mount the aids, and their microphones in or near the two ears. Such fittings were originally called “binaural,” but the late Dennis

Bryne of the National Acoustic Laboratory in Sydney, Australia suggested that a more appropriate term would be "bilateral" in recognition of the fact that bilateral aids do not necessarily restore normal binaural function.

In spite of accumulating research evidence that bilateral hearing was, on average, superior to unilateral hearing in persons with normal two-eared hearing, for many years, there was considerable resistance in the marketplace to the fitting of an aid to each ear, probably for two principal reasons: (1) the additional cost of the second aid was a deterrent for many potential users, and (2) conventional speech audiometric test materials seldom reflected, in hearing-impaired individuals, the two-eared advantage so well documented in persons with normal hearing. As this situation improved, with the development of more sensitive tests; however, another problem surfaced. As more and more bilateral aids were fit, especially to elderly persons, it became evident that not all individuals benefited from bilateral fittings to the same degree. Indeed, in some individuals, the presence of the second aid seemed to actually make matters worse. The problem was noted as early as 1939 by Vern Knudsen of UCLA, and by Leland Watson and Thomas Tolan. Watson and Tolan reported that their observations led them to suspect some kind of conflict between the two ears.

The phenomenon of binaural interference, described by Jerger and by Shlomo Silman in the 1980s and 1990s seemed to be at fault. In 2005 the problem was highlighted in a landmark study by Therese Walden and Brian Walden at the Walter Reed Army Medical Center. They showed that some elderly hearing aid users did, indeed, perform better on a test of speech understanding in competition when only one ear was aided. Performance was often poorest when both ears were aided. We still await data on the prevalence of this binaural interference phenomenon in the entire population of hearing-impaired individuals. It is certainly the case that the majority of hearing aid users of all ages perform better with a bilateral fitting, but the lesson for audiologists has been that all potential users, but especially elderly users, must be evaluated under both unilateral and bilateral fitting conditions.

Digital Signal Processing and Microphone Technology

No engineering advance in the past half century has had greater impact on the wearable hearing aid than the advent of digital signal processing in the late 1980s and early 1990s. Now, for the first time, it was possible to actually manipulate the fine grain of the frequency response of an aid in order to match it to the shape of the audiometric contour. This capability, combined with digital compression/expansion and various adaptive algorithms fueled a resurgence in interest in selective amplification. At the same time, studies by David Pascoe and Margo Skinner, at Washington University in St. Louis, by Larry Humes (Figure 6–7) at Indiana University, and by many other investigators, have emphasized the critical impact of the exact degree and configuration of high-frequency sensitivity loss on speech understanding. These two forces have lent such strong support to the philosophy of selective amplification that it has become the virtual rule in hearing aid fitting. Additionally, the laborious testing characterizing Carhart's original concept of hearing aid evaluation have given way to emphasis on fine tuning a smaller number of aids, with heavy reliance on the real-ear measurement of their physical characteristics.

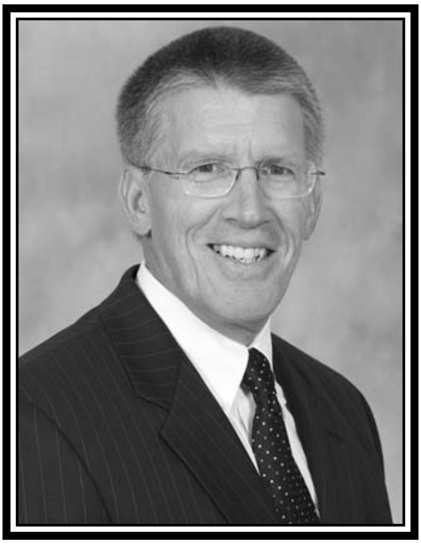

Figure 6–7. Larry Humes. (Courtesy of Indiana University Photo Services.)

Confluent with advances in digital signal processing, microphone technology has advanced to a point permitting the development of a truly directional microphone in which directivity patterns favoring input from a particular direction have been implemented. Although there have been voices of dissent, the available evidence seems to favor the use of directional microphones in most listening situations involving competing speech or noise.

In the months and years to come, it is certain that continuing advances in hearing aid technology will broaden our rehabilitative capabilities. Indeed, we are already seeing aids that learn a client's preferred volume setting, and switch among programs for quiet listening, music, listening to speech alone, and listening to speech in a noisy background. And there are aids that will automatically switch to the directional mode when background noise is detected, aids that can be recharged, and even aids that can be individually programmed to suit a particular lifestyle.

Accountability

As hearing aids and other amplification devices have become more sophisticated, there has been a growing sense that the field stands in need of better outcome measures to assess how well a particular intervention actually helps the hearing-impaired person. For many years, the only outcome measure available was the ubiquitous aided PB score. But Harvey Fletcher's prediction in 1949, that existing word recognition tests were not really capable of differentiating among aids, became ever more evident.

The efficacy of word discrimination testing, as it was then called, was challenged as early as 1960 by Irvin Shore, Robert Bilger, and Ira Hirsh at Central Institute for the Deaf. For the next two decades, there was growing unease about whether PB scores were acceptable as measures of accountability. Finally, in 1983, a study by Brian Walden and his colleagues at Walter Reed reinforced the growing feeling that word discrimination scores were just not up to the task.

Further development took three directions. First, there was a concerted effort to design more sophisticated measures of speech understanding such as the speech perception–in-noise (SPIN) test by Kalikow, Stevens, and Elliott in 1977 and its revised version by Bilger, Nuetzel, Rabinowitz, and Rzeczkowski in 1984, the hearing-in-noise test (HINT) by Nilson, Soli, and Sullivan in 1994, the BKB-speech-in-noise (BKB-SIN) test by Killion et al. in 1997, and its abbreviated version, the QUICKSin test in 2004. New tests will eventually replace the old PB lists, but progress is painfully slow.

A second major development has been the construction of assessment questionnaires such as the Hearing Handicap Inventory for the Elderly (HHIE) by Ira Ventry and Barbara

Weinstein in 1982, the Abbreviated Profile of Hearing Aid Benefit (APHAB) by Robyn Cox and Genevieve Alexander in 1995, the Client-Oriented Scale of Improvement (COSI) by Harvey Dillon in 1997, the Satisfaction with Amplification in Daily Life (SADL) scale by Cox and Alexander in 1999, and the International Outcome Inventory for Hearing Aids (IOI-HA) by Cox and Alexander in 2002. Researcher Robyn Cox (Figure 6–8), at the Memphis Speech and Hearing Center at the University of Memphis, has been one of the foremost supporters of accountability through evidence-based practice in audiology. Craig Newman (Figure 6–9), of the Cleveland Clinic, has been particularly active in the construction and evaluation of questionnaires in a number of areas including hearing handicap in the elderly, tinnitus evaluation, and quantifying hearing aid benefit.

A third development has been the application of cost-benefit analysis to aural intervention by Harvey Abrams and his colleagues at the VA Medical Center in Bay Pines, Florida.

Finally, there is the intriguing development of the concept of acceptable noise level as a predictor of a successful fitting by Anna Nabelek (Figure 6–10) and her colleagues and students at the University of Tennessee-Knoxville.

Figure 6–8. Robyn Cox. (University of Memphis, courtesy of L. Lissau.)

Many audiologists have made significant contributions to research on hearing aids over the years. Space limitations preclude an exhaustive list, but a sampling of entrants to

Figure 6–9. Craig Newman. (Courtesy of the Center for Medical Art and Photography, Cleveland Clinic.)

Figure 6–10. Anna Nabelek.

the hearing aid hall of fame would surely include Ruth Bentler, Donald Dirks, David Hawkins, Mead Killion, Sam Lybarger, David Pascoe, David Preves, Todd Ricketts, Margot Skinner, Wayne Staab, Pat Stelmachowicz, Gerald Studebaker, Tom Tillman, Michael Valente, and Laura Wilber.

The Saga of Barry Elpern

No history of audiologists and hearing aids would be complete without an account of the adventures and misadventures of Barry Elpern (Figure 6–11). Barry was an audiologist at the University of Chicago in the 1960s. One cold mid-winter evening in 1967, he was driving home from work on Chicago's south side in the midst of a record-setting midwestern blizzard. Snow and freezing wind swirled around his car as he made his way, slowly and stressfully, along the freeway. But it soon became impassable. After spending the night in his car, he had to walk the rest of the way home in cold, waist-deep snow. He describes a moment of epiphany, during this walk, in which he asked himself, "Is this any way for a reasonable person to live?" As soon as he reached home he instructed his family to pack up as they were moving to Arizona.

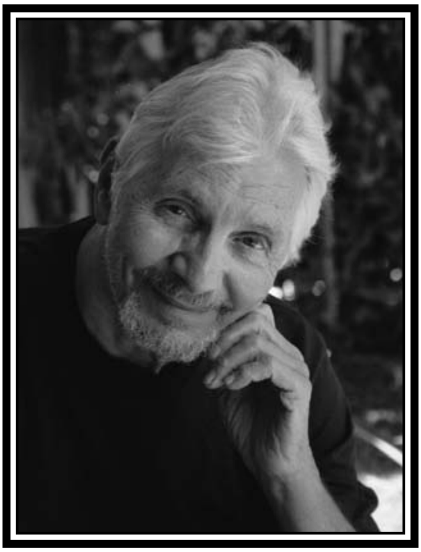

Figure 6–11. Barry Elpern.

In Phoenix, Barry joined a group of engineers who had formed a company to improve hearing aid performance. As part of the operation, they established a dispensary to test-market new products and to assist in corporate cash flow. Because of his audiologic background, Barry was chosen to operate the dispensary. But the American Speech and Hearing Association (ASHA) had long decreed that dispensing hearing aids, by a member, was unethical, and it roundly drummed Barry out of the organization (which in those days was tantamount to ejecting you from the profession). But Barry persisted, and soon other individuals holding a long pent-up concern that ASHA's ethical code was not helpful to the profession began to exert pressure on ASHA to change its ethical stance. It took some time, but in 1979 the ASHA Code of Ethics was finally modified to permit the dispensing of aids.

Nowadays the dispensing of hearing aids and other amplification devices is such a cornerstone of the profession that we have to be reminded of what it was like before the ASHA code was changed. After you had spent hours in audiometric testing and the evaluation of several aids, you could only send the client off to a hearing aid dealer whose code of ethics was less burdensome. It was very unlikely that you would ever see that client again. You never really knew whether they had even acquired an aid or whether they were successful users. There was very little feedback and no accountability. Only in the VA and the military clinics, where the audiologist was permitted to be the dispenser, did the audiologist have any sense of closure, any feel for the ultimate consequences of his or her work. It is fair to say that, today, audiology is a very different profession as a result of Barry's defection leading to that pivotal decision by ASHA in 1979. It provided a key part of the framework for the rise of private practice, a development so essential to the viability of an independent profession.

Assistive Devices

Audiologists have long been familiar with FM systems employing remote microphones, and tend to equate these with all assistive listening devices (ALDs). But Cynthia Compton Conley (Figure 6–12), of Gallaudet University, reminds us that there are a wide variety of devices designed to improve the communication skills, the well-being, and the quality of life of hearing- impaired and deafened persons, and that not all such devices involve "listening." Thus, although the term ALD is still being used, a more appropriate umbrella term, hearing assistance technology (HAT), refers to both auditory and nonauditory assistive technology. Historically, the first were alerting devices, designed to assist the individual to be aware of and identify environmental sounds and relevant or dangerous situations. These include systems that flash a light or vibrate a transducer when the doorbell rings, when the baby cries, and so forth.

Figure 6–12. Cynthia Compton Conley. (Courtesy of Gallaudet University.)

A second category of assistive devices includes systems to assist in telephone communication, for example, devices to amplify the telephone signal.

Third are devices to assist in the enjoyment of broadcast and other media. In these systems, the audio signal from the broadcast source is amplified and delivered to the hearing-impaired person either via a hardwired amplification system, such as coupling a portable music player to one's hearing aids or implant via direct audio input or induction, or via wireless transmission. The wireless, devices may be of three types: (1) Infrared (IR), (2) FM carrier, or (3) induction (audio loop). Each of these systems consists of a transmitter and a wireless receiver. Although the transmitter can be connected to the sound source via a microphone, usually the transmitter is simply plugged into the sound source directly.

The history of remote-microphone technology can be traced back to the availability of the very first commercially available vacuum tubes in the 1920s. In 1949 Leland Watson and Thomas Tolan, in their comprehensive volume, *Hearing Tests and Hearing Instruments*, noted that, in the early 1930s multiple vacuum tube hearing aids were widely installed in schools for the deaf, leagues for the hard of hearing, churches, and theaters. Foreshadowing the later development of the wireless remote microphone, a microphone was placed in close proximity to the source of sound (loudspeaker or live speaker) and hard wired to the multiple aids. To their amazement

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The Medical Connection

Throughout its history, audiology has been strongly influenced by related medical specialties, particularly otolaryngology. Early pioneers included Los Angeles otologist Isaac Jones who collaborated with legendary acoustician Vernon Knudsen, head of the physics department at UCLA in the 1920s, to develop the first audiometer with bone conduction testing capability; otolaryngologist L. W. Dean, who mentored the young C. C. Bunch; otolaryngologist Walter Hughson, who collaborated with speech pathologist Harold Westlake in the development of the well-known "Hughson-Westlake" protocol for obtained a pure-tone audiometric threshold; and, of course, physiologist Hallowell Davis, whose many contributions have already been discussed.

Many long-standing and fruitful collaborations between audiologists and otolaryngologists arose from a common interest in patients with medically treatable hearing disorders. The development of the fenestration operation, by Julius Lempert in 1938, and subsequent techniques of stapes mobilization pioneered by Sam Rosen in the early 1950s, created an unusual opportunity for a mutual collaboration between otologic surgeons and audiologists in documenting and quantifying the improvement in hearing provided by surgical intervention. One example was the collaboration between Raymond Carhart, head of the audiology program in Northwestern University's School of Speech, and George Shambaugh, chairman of the department of otolaryngology in Northwestern's School of Medicine. Shambaugh was one of the pioneers of the fenestration operation, in which a surgeon creates an opening in a semicircular canal to bypass the middle ear mechanism immobilized by otosclerosis. Throughout the decade of the 1950s, Carhart and Shambaugh jointly staffed a weekly otology/audiology clinic in which Carhart and his audiology students carried out audiologic assessments and Shambaugh and his residents carried out the medical evaluations of a small number of patients from Shambaugh's practice. Then the patients were jointly counseled by Carhart and Shambaugh. It was an excellent example of how the two disciplines could collaborate in an atmosphere of mutual respect, for the benefit of hearing-impaired persons: and, it was a teaching experience of unparalleled value to all who participated. It was this collaboration that resulted in the now famous "Carhart notch," the characteristic depression in the bone conduction threshold at 2000 Hz in persons with otosclerosis.

Another example of early collaboration between audiologists and otolaryngologists occurred at the Louisiana State University (LSU) Medical School in New Orleans. Here audiologist Charles Berlin and otolaryngologist Merv Trail collaborated on a research and clinical program of unusual productivity for over 20 years.

At the University of California at Los Angeles (UCLA), audiologist Donald Dirks collaborated, first with otolaryngologist Victor Goodhill and later with Goodhill's successor, Paul Ward, in the development of an audiologic research program of international renown.

The success of these early collaborations convinced many audiologists and otolaryngologists that they could take maximum advantage of each other's expertise by working together in the same medical department. Such collaborations continue to flourish today in many academic medical settings.

Unfortunately, the course of these interactions has not always been smooth: frictions have sometimes arisen. In his classic book, *Clinical Audiometry*, published in 1943, C. C. Bunch noted that an otologist had publicly stated that he had no confidence in audiometric tests because he had been sent three entirely different audiograms of the same patient by three different testers. Bunch suggested that a report of this sort would have been impossible if the tests had been carried out under proper conditions by trained examiners, using standardized audiometers and careful testing technique.

A particular point of contention in today's world has been the reaction of some otolaryngologists to audiology's attempts to upgrade the qualifications of its practitioners. Because a significant percentage of audiologists are employed in medical settings, and usually in departments headed by otolaryngologists, there is a persistent concern among our medical colleagues who view audiologists as valued but nonetheless technicians, and fear that upgrading to the Au.D. degree will both increase the cost of employing audiologists and result in overqualified personnel. Periodically, they have threatened to train their own audiometric technicians to fill the roles presently played by audiologists with master's and Au.D. degrees. Indeed, they have recently developed a program known as CPOP (Certificate Program for Otolaryngology Personnel) with an initial concentration on the training of audiometric technicians. The extent to which such activities among the medical ranks will impact audiology diminishes as our field moves more and more in the direction of private practice.

In general, collaboration between audiologists and otolaryngologists historically has been most successful when the audiologist held the Ph.D. degree, and least successful when the audiologist held only a master's degree. In the former case, mutual respect was more easily achieved than in the latter case. One of the theoretical benefits of upgrading from the master's degree to the Au.D. degree was the idea that this would help to foster an atmosphere of coequality in medical settings. Whether this hope will fall victim to the financial concerns noted above only time will reveal.

In summary, the strong relationships and good will built between audiology and otolaryngology in the early years remain in force in many medical settings, certainly to the advantage of both disciplines. But as our profession matures and moves in new directions there have been, and will undoubtedly continue to be, strains and frictions between the two arenas. Hopefully, the issues underlying any conflicts will be resolved amicably so that each discipline can continue to benefit from mutual interaction.