ACOUSTICAL SOCIETY OF AMERICA
VON BÉKÉSY MEDAL

David Kemp

2018

The von Békésy Medal is presented to individuals, irrespective of nationality, age, or society affiliation, who have made outstanding contributions to the area of psychological or physiological acoustics as evidenced by publication of research results in professional journals or by other accomplishments in the fields.

PREVIOUS RECIPIENTS

Jozef J. Zwislocki	1985
Peter Dallos	1995
Murray B. Sachs	1998
William S. Rhode	2010
M. Charles Liberman	2012

CITATION FOR DAVID T. KEMP

. . . for the discovery of otoacoustic emissions and contributions to cochlear biophysics and the detection of hearing loss

MINNEAPOLIS, MINNESOTA • 9 MAY 2018

David Kemp trained as a geophysicist, earning his Ph.D. in physics from the University of London in 1970. His early research focused on the prominent series of peaks in the extreme low-frequency (ELF) region of the Earth's electromagnetic spectrum known as "Schumann resonances." Schumann resonances are global electromagnetic standing waves, excited by lightning discharges, that form in the "cavity" bounded by the Earth's surface and the ionosphere. With this background, David was well poised to grasp the significance of the curious, quasi-periodic pattern of spectral peaks and valleys ("microstructure") evident in the hearing threshold curve. David immediately understood this microstructure as the tell-tale signature of standing waves inside the "cavity" of the cochlea. These standing waves, he realized, should be detectable outside the cavity, in the external ear canal, if only one could listen hard enough. And thus, by listening to the ear, David's soon-to-be-illustrious career in auditory neuroscience was born.

By having the genius to do the simple and obvious—placing a miniature low-noise microphone in the human ear canal and carefully recording and interpreting the ear's response to sound—David Kemp sparked nothing short of a revolution in our understanding of the physical and physiological basis of hearing. David's discovery in the mid-1970s that the ear makes sound while listening to sound completely overturned the reigning dogma of the day that the cochlea was nothing but a linear, passive mechanical transducer.

Early on, many refused to believe it, regarding the "Kemp effect" as some sort of insidious artifact. But these critics overlooked David's brilliant series of well-controlled experiments establishing beyond doubt that the sounds he was recording originated within the inner ear. Others, although willing to credit the result, failed to appreciate the extraordinary theoretical and practical importance of these sounds, which are now known as otoacoustic emissions. For this reason, David experienced difficulty getting his results published. The manuscript announcing the discovery was rejected by *Nature* on the grounds that otoacoustic emissions would surely prove of little interest outside the community of clinicians concerned with the diagnosis of hearing impairment. Thus, thanks to the obtuseness of *Nature*'s editors, the Acoustical Society of America (ASA) received the honor of publishing David's seminal results. David's initial report is now the fourth most-cited paper in the history of the *Journal of the Acoustical Society of America* (and, according to the Science Citation Index, is the only one in the top nine concerned with auditory physiology).

David's discovery and his subsequent studies probing the physical and physiological mechanisms confirmed controversial hints of cochlear mechanical nonlinearity and revived a largely forgotten suggestion—by astrophysicist Thomas Gold in 1948—that the cochlea employs "regenerative action" powered by electrochemical potentials to enhance cochlear frequency selectivity by counteracting the viscous damping. Thus, David's work launched a flurry of experimental and theoretical activity, and within just a few short years the paradigm had shifted completely—the inner ear was now no mere passive transducer, but an active nonlinear amplifier controlled via neural feedback from the brain. Researchers soon found that the cochlea contains an array of cellular force generators (outer hair cells) that act in concert to amplify quiet sounds, thereby boosting the sensitivity and dynamic range of hearing.

Today, the quest to understand the mechanical, cellular, and molecular basis of the "cochlear amplifier" and its feedback control mechanisms dominates the study of the peripheral auditory system, and understanding the role of nonlinear amplification and compression in the analysis and perception of sound is a central theme in psychophysics. In the years since Kemp's discovery, the revolution has spread throughout the animal kingdom. Otoacoustic emissions (OAEs) almost identical to those first discovered by Kemp have been reported in animals as diverse as birds, lizards, frogs, and insects. The biological amplification of sound appears to be a universal theme in sensory physiology.

All of this is the direct result of David's singular contribution to basic science. But David had the further insight that OAEs had enormous translational potential. He realized

that the emitted sounds provide information about the health of the inner ear—because changes in emission magnitudes reflect changes in hearing sensitivity, OAEs can be used as an objective test for the presence of hearing impairment. David showed that OAEs could be recorded using a small probe—containing both an earphone to provide the stimulus sound and a microphone to detect the emission—inserted into the ear canal. Recording OAEs was therefore a simple, noninvasive procedure capable of detecting sound-evoked biological activity in the inner ear.

After validating this procedure as an objective test of auditory function—and having failed to obtain the necessary support, either from the hearing test industry or from government bodies—David established his own company, Otodynamics Ltd, to develop, manufacture, and refine the test equipment and its software. With the unwavering support of his wife, Gillian, David built the company while continuing his full-time academic commitments as a lecturer and then Professor of Auditory Biophysics at University College, London (UCL). The resulting "ILO88" instrument set the standard for what has become a vital piece of every audiologist's armamentarium. Today, OAE recording is an indispensable component of the battery of audiological tests used in hospitals and clinics around the world; literally thousands of ILO88s and its successors are testing hearing every day, in both advanced and developing countries. OAE recording has also become a routine procedure in basic science laboratories investigating the mechanisms underlying normal hearing and its pathologies.

As noninvasive tests that require no input from the patient, OAE measurements are particularly valuable for assessing the hearing of babies. David recognized this potential and saw the value of early hearing screening so that intervention for hearing impairment might be implemented early in life. He was at the forefront of the drive for screening all neonates for hearing impairment. Newborn screening was first implemented in the USA, later in Europe and the UK. The early identification of hearing impairment is, of course, of enormous significance for the social and educational development of affected children.

David has used resources from his company to help build a premier auditory research facility, the Centre for Auditory Research at the UCL Ear Institute. This facility now houses many of the world's top researchers devoted to the study of hearing in all its aspects, including auditory biophysics, psychophysics, neuro- and molecular biology, and genetics. Academically, David has led the development and teaching of undergraduate degree courses in Audiology and postgraduate degree programs in Audiological Science and Audiological Medicine, as well as training and mentoring the next generation of researchers in the field though his supervision of Ph.D. students and postdoctoral fellows. At hearing conferences, David is often sighted quietly haunting the poster aisles, patiently probing and encouraging those young researchers now following in his footsteps.

Over the years, David has received many honors and awards recognizing his outstanding contributions to basic and applied hearing science. These include the Association for Research in Otolaryngology's Award of Merit, the American Speech-Language-Hearing Association's Distinguished Service Award, and his election as a Fellow of the Royal Society. David is a supreme example of how science, technology, and innovation can combine for the betterment of society. He has played a leading role in developing the measurement and analysis of OAEs into a ubiquitous and invaluable tool for improving human health. We are very pleased to congratulate David Kemp for being awarded the Acoustical Society of America's von Békésy Medal.

CHRISTOPHER A. SHERA
ANDREW FORGE
BRENDA L. LONSBURY-MARTIN