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ECHOES

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Ultrasonic Eyeglasses for the Blind

by Leslie Kay

Vision substitution has been long-sought-after as a means for enabling blind persons to be more effectively rehabilitated, and for young blind children to develop more naturally like sighted children. Animals such as the bat have developed sonar methods for very effectively finding their way in the dark and catching food. The same is true for dolphins who use their sonar system underwater. These skills have often been quoted as good reasons to think that an "air-sonar" device might greatly help the blind, but for many years no one had the thought of developing an air-sonar as a "vision substitute." But the development of sonic eyeglasses in the early 1970's changed our thinking.

For the next 20 years a sensor system was under development to further improve the ability of users to perceive their surroundings. In the meantime, the sonic eyeglasses became widely used. The stage has now been reached when blind persons can walk about like sighted persons in a busy shopping area going in and out of shops, and be able to recognize their location relative to the many landmarks on the way. We are calling the new process "sonocular perception" - or seeing with sound. Blind persons appear to look at where they are going, and they can focus their attention on specific objects like sighted persons fixate on objects so as better to recognize them.

An example of sonar eyeglasses is illustrated in the background figure. These were specially developed for a blind child. There are three sensing elements: one radiates ultrasonic waves, and the other two act as receivers. Figure 1 shows a newer sensor (known as KASPA) fitted in a head band that has, in addition, a central field of view modeling the function of the eye's fovea. The fovea is a retinal area producing focused vision and containing the photoreceptors that enable color vision. The sensor has greater spatial resolution by a factor of 6 than is available with the eyeglasses.

The vision substitution method produces ultrasonic wave transmission into a wide field of view, from which a multiplicity of echoes is produced by each object in this field. An object such as a bush will produce tiny echoes from the leaves and the branches. These scattered echoes are then received by the sonar sensing elements and are each converted into tones that have a pitch (or frequency) representing the distance to each leaf.

We call these multiple tones a 'tone complex,' and the sound that is heard through miniature earphones by a user is called a 'sound signature.' With the sensor mounted on the forehead and moved about in a looking action, a blind user senses in a stereophonic form, the multiple object space that makes up the environment in which movement takes place.

The remarkable auditory experience one gets when first trying the vision substitute is the real-time change in sound that takes place as the head moves. This is because of the resulting change in view of the objects. This is like normal sight, but we pay no attention to the constant change. Indeed, the brain converts optical images at the eye, as they change with view, into invariant objects as seen from a different angle.

An experienced blind user of sonocular perception finds that the brain does similar things to the sound signatures. Each object is located and recognized as a separate entity. But this of course is not with the clarity of optical vision. Only those blind users who have developed the ability over time come to say that this is their experience.

Sighted persons have not had a need to spend the time learning to see with sound. For those blind persons who have, some quite remarkable skills have been developed. For example, some blind persons have learned to cycle in slalom fashion between a row of poles spaced 2 meters apart just as in snow skiing. A totally blind young man using a softball bat has shown that he can hit, with a good whack, a softball that is thrown at him. These examples were thought to be "not possible." This is especially so in

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We hear that...

• **Leo Beranek** was named as an Eta Kappa Nu Eminent Member during the IEEE Honors Ceremony in Vancouver, B.C. for technical contributions that have signifcantly benefited mankind.

• The request for the **Signal Processing** Interdisciplinary Technical Group to convert to a Technical Committee was recommended by the Technical Council and approved by the Executive Council.

• **Susan Blaeser** has been named Standards Manager for the Acoustical Society. She will be attending a meeting on TC108 in Vienna in March on behalf of ASA.

• **Steve Brown**, senior principal engineer at Steelcase, has been appointed chair of ASTM Committee E33 on Environmental Acoustics.

Student News

by Micheal Dent

The new Student Council is in full swing and ready to make an impact on the ASA in the new year. Hopefully, you met your technical committee's student council representative at the Newport Beach conference. Please inundate them with ways to help enhance student involvement in the ASA—that is why they are there. Also at the meeting for the first time, the student council hosted a reception for students only. This will, with any luck, become a "must attend" event in the coming years.

Congratulations to the winners of the Loudspeaker Design Competition: Shawn Devantier was awarded the $1000 first prize, and Ara Baghdassarian, Geoff Christopherson, and Dave Tremblay all received $500 commendations. The Best Student Paper Award winners are as follows: (AB) 1 - Kelly Benoit-Bird, 2 - Brian Branstetter; (AO) 1 - Kelly Benoit-Bird, 2 - Alex DeRobertis, 3 - Joshua Wilson; (EA) 1 - Julien Bernard; (MU) 1 - Jeffrey Moffitt; (SA) 1 - Jonathan Kemp, 2 - Nassif Rayess; (SC) 1 - Angelique Grosgeorges; (SP) 1 - Michael Versluis; (UW) 1 - Purnima Ratilal, 2 - Allen H. Reed, 3 - Karim G. Sabra.

In other news, the student section of the ASA website is almost ready to be posted. It will be full of useful information including room-sharing options for upcoming meetings, student awards, and job information and advice. Look for it in the upcoming months.

Micheal Dent is a PhD. student in Integrative Neuroscience at the University of Maryland studying the Precedence Effect in budgerigars.

ECHOES ECHOES

Newsletter of the Acoustical Society of America

Provided as a benefit of membership to ASA members

The Acoustical Society of America was organized in 1929 to increase and diffuse the knowledge of acoustics and to promote its practical applications.

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From the Education in Acoustics Committee

by Uwe J. Hansen

Much is happening in Acoustics Education, including several activities at Newport Beach and a heavy involvement in the Chicago meeting. The December meeting coincided with open heart surgery for Uwe Hansen, so Dan Russell served as chair for the meeting of the On-Line Education Committee, and Vic Sparrow filled his familiar role as chair of the Education Committee. As part of the session on informal education, organized by Tom Rossing, Dean Ayers arranged for the California State University, Long Beach, Mobile Science Museum to make their displays available to conference participants. Many acousticians availed themselves of the opportunity to do science hands-on.

The ad hoc Committee on On-line Education is attempting to follow the spirit of the original "Tokyo String Quartet" Committee which was charged with the task of producing exciting visual material for use in high schools. With recent advances in technology it was deemed better to prepare on-line material, rather than a free standing video. The speed with which streaming video can be downloaded by high school users generally limits the image size and the length of individual video clips which can be accessed at one time. We expect to have preliminary material available for viewing at the time of the Chicago meeting. It will take the format of introducing a concept using a still image and written text, followed by a short video section which can be spooled during the time the still image is presented. The length of each video section will be determined by optimizing the spooling time. For his paper in the informal education session, Tom Rossing assembled an impressive list of Internet sites for teaching acoustics.

At the Chicago ASA meeting in June, Tom Rossing and I will present a tutorial on Demonstration Experiments, in which we will be assisted by a team of Chicago-area physics teachers. In addition we will have a session of hands-on experiments for high school students and their teachers. These outreach sessions are a lot of fun, but they are also a lot of work. If you would like to participate in that session (and share in the excitement of interacting with the next generation of acousticians), please contact me at u-hansen@indstate.edu.

Echoes from Newport Beach

A total of 1352 acousticians attended the 140th meeting of the Acoustical Society of America and Noise-Con 2000 in Newport Beach, California. The weather was as warm as promised, and in addition to a rich program of events, some attendees enjoyed Fashion Island with its many shops and the tallest decorated Christmas tree in the United States.

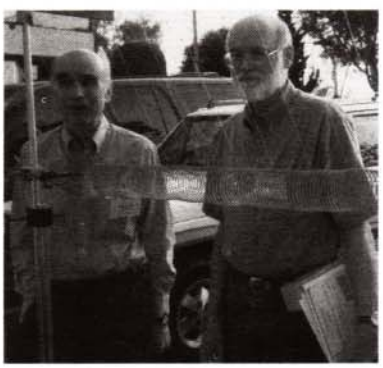
The varied program included 873 papers arranged into 108 sessions, a joint instrument and equipment exposition, several plenary and special lectures, a tutorial on Virtual Musical Instruments, a short course on Applied Digital Signal Processing in Acoustics, technical tours, a gallery of acoustics, buffet socials, receptions, an awards ceremony, and a concert by the Americus Brass Band.

At the Awards Ceremony, Distinguished Service Citations were presented to John Bouyoucos and Avril Brenig. The Pioneers of Underwater Acoustics Medal went to Darrell Jackson (University of Washington) and the Silver Medal in Physical Acoustics to Gregory Swift (Los Alamos National Laboratory). Science writing awards in acoustics went to Kathryn Brown, Roland Pease, and Radek Boschetty (journalists) and to William Hartmann (professional in acoustics).

In conjunction with the special session on informal education in acoustics, the California State University (Long Beach) Mobile Science Museum was available in the parking lot, and many acousticians viewed (and played with) the hands-on exhibits on acoustics.

At left, Eric Ungar listens to a focussed message.

At right, Jim McKibben explains sound to Bill Hartmann.



Robert Pyle (L) and Dean Ayers (R) visit the Mobile Science Museum.

Above left, Gregory Swift, recipient of the Silver Medal in Physical Acoustics is congratulated by ASA President Katherine Harris. In photo right, an after-hours sing-a-long of Handel's "Messiah."

New ASA Fellows with ASA officers: ASA Vice President Gilles Daigle, Richard Love, Charles Thompson, W. Jack Hughes, Dennis Jones, Donald Hall, Ji-qing Wang, R. Dean Ayers, Oleg Godin, ASA President Katherine Harris.

Proceedings of Noise-Con 2000, held jointly with the 140th meeting of the Acoustical Society in Newport Beach in December, can be purchased on a CD-ROM. Also included on the disc are proceedings of Noise-Con 96, Noise-Con 97, Noise-Con 98, and the 1998 Sound Quality Symposium (SQS 98). The CD-ROM may be ordered from Bookmasters International, Distribution Services Division, 30 Amberwood Parkway, Ashland, OH 44805 (<order@bookmaster.com>). The price is $75 and credit card orders are accepted.

Cochlear Wave Reflections, Otoacoustic Emissions, and the Microstructure of the Hearing Threshold

by Arnold Tubis, Glenis R. Long, and Carrick L. Talmadge

In 1979, David Kemp of England discovered the capacity of the healthy ear to generate sounds known as *otoacoustic emissions* that are of cochlear origin and may be detected in the ear canal with a sensitive microphone. He suggested that the mechanisms for producing these so-called *cochlear echoes* were the same as those responsible for the quasi-periodic patterns (microstructure) of the hearing threshold as a function of frequency observed earlier by Elliot (1958), Van den Brink (1980), and Thomas (1975). In the last two decades, the properties of these emissions and the hearing threshold microstructure, their sensitivity to the integrity of cochlear function, and their practical utility in hearing screening have been vigorously explored. In order to provide a unified theoretical description of these emissions in terms of the basic physics of wave motion, we have recently developed a comprehensive nonlinear active (i.e. containing negative-damping elements) cochlear model, which describes most of the emission properties in detail.[1,2]

The key element in the model is the reflection of a wave that is propagating along the cochlear partition. In the classical picture of cochlear traveling waves, originally derived from observations of Georg von Bèkèsy on cadaver ears in the 1930's, only apical moving waves [propagating from the cochlear base (at the oval window) toward the cochlear apex] were considered. At a given frequency of stimulation f, the amplitude of the traveling wave peaks at a characteristic distance $x(f)$ from the cochlear base. In humans, the form of $x(f)$ is approximately given by $(1/k_\omega)\log(f_0/f)$, $k_\omega \approx 1.38\ \text{cm}^{-1}$ and $f_0 \approx 20$ kHz. In 1993, George Zweig and Christopher A. Shera[3] proposed a reflection mechanism for cochlear waves based on the effects of a low level of inhomogeneities along the cochlear partition. These inhomogeneities are most effective in producing reflections in the region of the activity maximum $x(f)$ of the apical moving classical wave. They showed, in particular, that reflections could be substantial when the peak region of the cochlear activity pattern is sufficiently tall, and broad enough to encompass at least two wavelengths of the cochlear wave. This type of cochlear activity pattern is presumably characteristic of a healthy cochlea. At the cochlear base, this mechanism gives a mixture of apical moving and the reflected basal moving (traveling toward the cochlear base) waves, with the phase of the reflectance (the ratio of the basal moving to the apical moving components) being approximately $-4\pi x(f)/\lambda_m$, where λ_m is the cochlear wave length in the region of the activity maximum. The frequency dependence of λ_m is very weak as a consequence of an approximate property of cochlear mechanics called *scale invariance*,[3] and will be neglected in the present discussion.

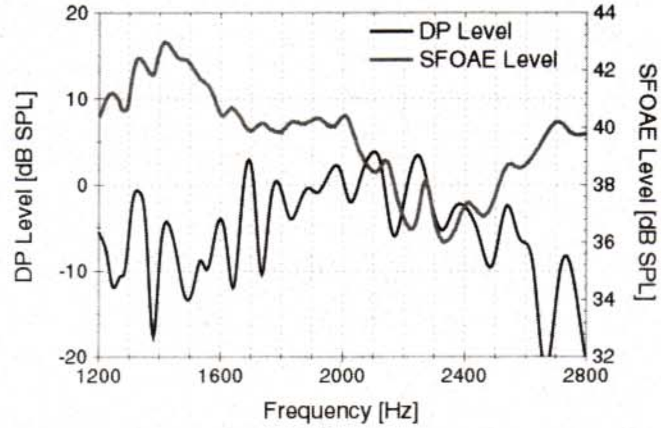


Figure 1. Stimulus frequency and distortion product $(2f_1 - f_2)$ otoacoustic emission fine structures in the same ear. The former shows up as smaller ripples because of the effects of a compressive nonlinearity in the cochlear mechanics.

The effect of a basal moving cochlear wave component is to give an interference pattern of maxima and minima for the magnitude of the ear canal pressure as a function of frequency. The spacing Δf between successive amplitude maxima or minima is described by $\Delta f/f \approx k_\omega \lambda_m/2$, with Δf corresponding to a change of 2π in the phase of the apical reflectance function. The interference pattern is further complicated by the effects of multiple internal reflections of cochlear waves at the cochlear base and in the apical reflectance region around $x = x(f)$.[1] The quasi-periodic variation of the pressure in the ear canal as the frequency of a pure tone is swept (see Figure 1) constitutes the phenomenon of stimulus frequency otoacoustic emissions (SFOAEs). The same cochlear wave reflection mechanism can be shown to account for a similar variation in the frequency dependence of the hearing threshold.[1]

Spontaneous otoacoustic emissions (SOAEs) are quasi-sinusoidal narrow-band (0.5 Hz or less) ear canal signals that can be detected in the absence of external stimulation (Figure 2). They correspond to discrete instability modes (with temporal behaviors $\exp(i\omega t)$, $\omega = \omega_R + i\omega_I$, $\omega_I < 0$) of the linear active portion of the cochlear model. When a compressive

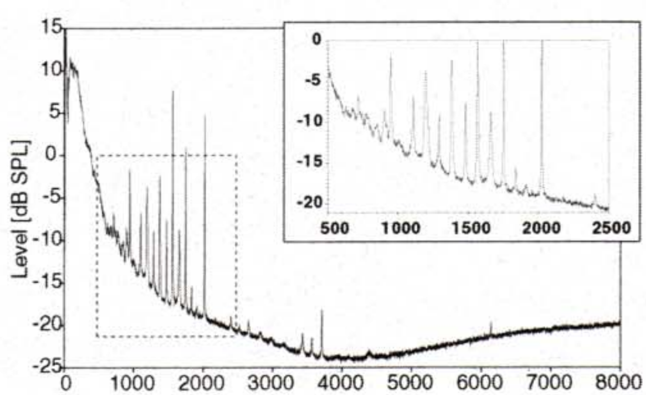


Figure 2. Spectrum of spontaneous otoacoustic emissions in a single ear.

nonlinearity is included in the model, these instability modes become transformed into stable limit-cycle oscillations. The existence of these *instability modes* is related to the fact that in an active cochlea, the apical reflectance $R_a(\omega)$ may actually exceed unity in magnitude for certain ranges of ω. Edward Burns and Douglas Keefe have given experimental evidence for this in 1998.[4] We have also shown that the approximate frequency spacing between SOAEs is predicted to be the same as that for SFOAEs and the hearing threshold microstructure described above.[1]

Distortion product otoacoustic emissions (DPOAEs) are produced when the ear is stimulated by two sinusoidal tones of frequencies f_1 and f_2 ($> f_1$). The most common DPOAE is associated with $f_{dp} = 2f_1 - f_2$. DP cochlear waves are initially generated around the f_2 tonotopic place and propagate both basally and apically. If the apical moving component is reflected around the f_{dp} tonotopic place via cochlear inhomogeneities as described above for SFOAEs, the two DP basal moving components that pass through the middle ear and into the ear canal will interfere and again produce an ear canal signal with amplitude maxima and minima (see Figure 2) and

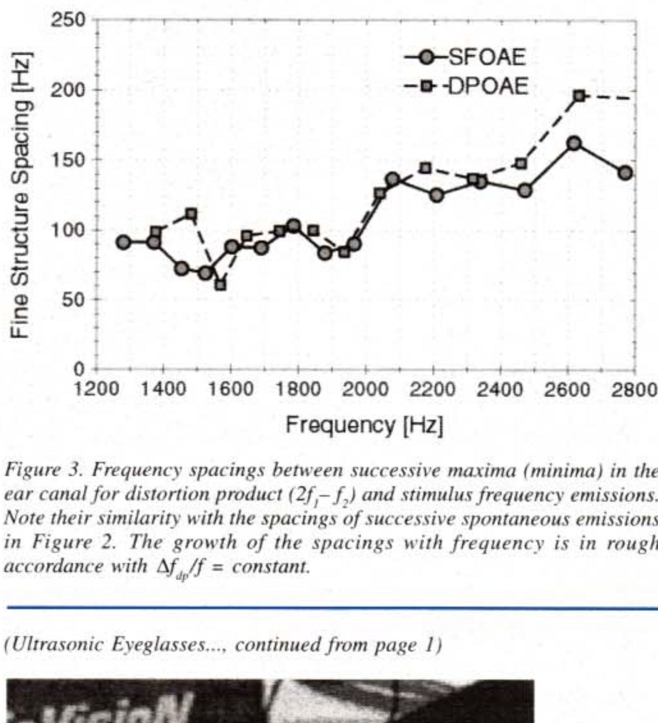


Figure 3. Frequency spacings between successive maxima (minima) in the ear canal for distortion product ($2f_1 - f_2$) and stimulus frequency emissions. Note their similarity with the spacings of successive spontaneous emissions in Figure 2. The growth of the spacings with frequency is in rough accordance with $\Delta f_{dp}/f$ = constant.

frequency spacing given by $\Delta f_{dp}/f_{dp} \approx k_\omega \lambda_m/2$.[1,2] Multiple internal reflections of DP cochlear waves will give additional modifications of the interference pattern just as in the case of SFOAEs.[1]

In summary, the cochlear reflectance concept of Zweig and Shera provides a theoretical basis for approximately the same characteristic frequency spacings observed in SFOAEs, SOAEs, DPOAEs (see Figures 1, 2, and 3) and the microstructure of the hearing threshold. There is at present a great deal of interest in the possible use of OAEs as objective probes of the integrity of the ear in hearing screening programs. Whether or not OAEs ultimately turn out to be valuable clinically, these emissions nevertheless illustrate a most interesting class of wave motions that take place in 35 mm long chambers inside of our heads.

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Arnold Tubis is a professor emeritus at Purdue University and a Visiting Fellow at the Institute for Nonlinear Science, University of California, San Diego, in La Jolla, California. His current research interests include otoacoustic emissions, cochlear modeling, and musical acoustics.

Glenis Long is a professor of audiology and speech sciences at Purdue University in West Lafayette, Indiana. Her research interests include otoacoustic emissions in humans and animals, and psychoacoustics.

Carrick Talmadge is a research scientist at the National Center for Physical Acoustics at the University of Mississippi in Oxford, Mississippi. His research interests are otoacoustic emissions, cochlear modeling, infra-sound, and gravitational physics.

(Ultrasonic Eyeglasses..., continued from page 1)

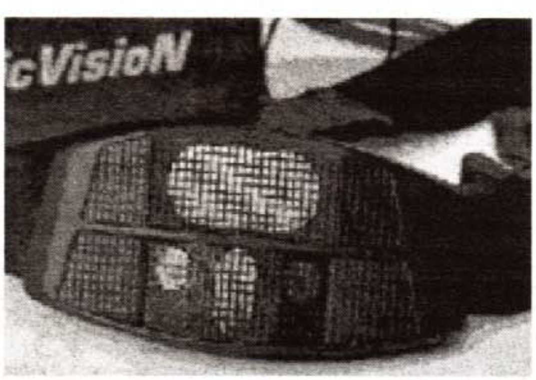

Figure 1. Sensor fitted in a head band.

the case of hitting a ball because the bio-acoustic vision substitution eyeglasses must provide information of the trajectory of the ball and the brain must interpret this in real-time if contact is to be made at the appropriate moment. The bio-acoustic mechanism is not yet fully understood. We do know however, that the acoustic flow that is generated by the echo from the ball is rich in spatial information.

Leslie Kay is a researcher at Spatial Sensing Laboratory, Bay Advanced Technologies Ltd., P.O. Box 124, Russell, New Zealand. This is a lay-language version of a Distinguished Lecture presented December 5 at the 140th ASA meeting at Newport Beach, reprinted with the author's permission.

Center for Mind, Brain, and Learning

edited from University of Washington News & Information Service

A center to conduct innovative research on early brain and behavioral development has been established at the University of Washington with a $35.5 million pledge from the Seattle-based Talaris Research Institute. Patricia Kuhl, speech and hearing sciences professor, and Andrew Meltzoff, psychology professor, have been named co-directors of the interdisciplinary center. Kuhl and Meltzoff are internationally known for their research on child development and the brain mechanisms underlying learning, and they are also husband and wife.

Talaris has already provided one million dollars to launch the center, and the balance will be contributed over the next five years. Bruce and Jolene McCaw are the primary benefactors of Talaris, which is headed by Sam Smith, former president of Washington State University, and John Medina, former molecular biologist at the University of Washington.

The new center will assemble an interdisciplinary team of faculty members in developmental psychology, brain plasticity, education, computer science and molecular biology. These researchers will explore five major themes: basic principles of human development; neuroscience and mechanisms of developmental change; brain-behavior links; nature-nurture; and computer vs biological learning.

"Research on the developing mind is one of the next great scientific frontiers," according to Kuhl. "Like genetics, biotechnology and informatics, great strides are expected in the next decade, and we are poised to contribute substantially to this effort." Meltzoff added: "This center is unique in focusing on the important brain and behavioral changes in the first five years of life. That's where the mother lode is. It is the foundation for later development."

Talaris is located on the former site of Battelle Pacific Northwest Laboratories, near the University of Washington campus in Seattle. A new research facility to support the institute's activities is planned. Experimental programs, including a child-care nursery and a preschool, will examine and apply scientific discoveries to early learning. An investment of more than $150 million for learning and brain research is planned over the next five years.

Heartiest congratulations on the new center, Pat and Andy, and we look forward to many more interesting ASA and *JASA* papers from you and your staff!

Pat Kuhl is well-known to members of the Acoustical Society, as well as to speech scientists all over the world. She served ASA in many roles, including that of president in 1999–2000. Her role in the White House Conference on Early Childhood Development and Learning in 1997 was featured in the Summer 1997 issue of ECHOES, which included photos of her with former President Clinton and with Hillary Clinton. Her husband, Andy Meltzoff, has joined her as co-author of papers at ASA meetings and in JASA.

Scanning the Journals

by Thomas D. Rossing

- The February issue of *Applied Acoustics* is a special issue on **Spatial Impression in Concert Halls**, guest edited by John Bradley. It includes eight papers by well-known acousticians in New Zealand, Japan, UK, Canada, and Germany.
- The August issue of *Acoustics Australia* is a special **international issue** featuring papers on "Atmospheric Infrasound," "The Physiological Demands of Wind Instrument Performance," and "Science and the Stradivarius."
- The July/August issue of *Acustica* is a special issue on **musical wind instrument acoustics** with papers on physical modeling, organ pipes, recorders, reed instruments, brass instruments, and musical performance.
- "The **Music of Nature and the Nature of Music**" is the catchy title of a paper by Patricia M. Gray, et al. in the 5 January issue of *Science.* "People who live close to nature perceive a wider range of sounds than those of us living in industrialized societies, who rely heavily on advances in sound technology," the authors argue. The sounds of whales have been heard for many years by seafaring tribes and the low-frequency sounds of elephants have been incorporated into the songs of the Hutu and Tutsi tribes of East Africa, they point out, although these sounds have rather recently become known to the rest of us.

The authors go on to discuss the sounds of whales and birds and to analyze their songs for musical content. Although humpback whales are capable of singing over a range of at least seven octaves, they use musical intervals between their notes that are similar to or the same as the intervals in our scales. They mix percussive and noisy elements in their songs with relatively pure tones in a ratio similar to that used by humans in symphonic music. Examination of bird songs reveals every elementary rhythmic effect found in human music, including interval inversions, simple harmonic relations, and retention of key changes. Some birds pitch their songs to the same scales as Western music, one possible reason for human attraction to these sounds. The canyon wren, for example, sings to a chromatic scale which divides the octave into 12 semitones.

• "Does the Queen **speak the Queen's English**?" A paper in the 21/28 December issue of *Nature* reports on analyses of vowel sounds from the annual Christmas message broadcast by Queen Elizabeth II during the period between the 1950s and 1980s. These analyses reveal that the Queen's pronunciation of some vowels has been influenced by the standard southern-British accent of the 1980s which is typically associated with speakers who are younger and lower in the social hierarchy. First and second formant frequencies for 11 vowel sounds in the 1950s and the 1980s are compared with those found in the standard southern-British (SSB) accent. In most cases, the average position of the 1980 vowels in the formant space is between those of the 1950s and the SSB positions. Conclusion: the Queen no longer speaks the Queen's English of the 1950s, although the vowels of the 1980s are still clearly set apart from those of an SSB accent.

• Friends of Per Brüel (and people who have used B&K equipment over the years) will enjoy his autobiographical essay "A Lucky Man" in the December issue of *Sound and Vibration*. While serving in the Danish army's radio laboratory, he was inspired by a paper in *JASA* to build a tuned amplifier using the double-T network. His instrument had a selectivity of about 35 dB over a frequency range of 45-5600 Hz, but it launched his career. After the Danish army was demobilized, he started working on his doctor's thesis research on room acoustics. The rest is history, as they say. One of the first successful Brüel & Kjaer products was a level recorder to replace the German "Pegel-Schreiber" which became unavailable after World War II.

• Real-time direct interfaces between the brain and electronic and mechanical devices could one day be used to restore sensory and motor functions lost through injury or disease, according to an article in the 18 January issue of *Nature*. **Hybrid brain-machine interfaces** (HBMIs) have the potential to enhance our perceptual, motor, and cognitive capabilities. Cochlear implants are one of the first, if not the first, HBMIs to be realized. These auditory prostheses work by converting features of acoustic signals, such as speech, into patterns of electrical stimuli that are delivered through an array of implants to auditory nerve fibers lying on the basilar membrane of the cochlea. More than 30,000 deaf patients, ranging in age from 12 months to 80 years, have had such devices successfully implanted. Although results vary from case to case, even slight improvements in auditory performance have helped people to communicate better and to become more aware of their surroundings. This article on HBMIs is one of a set of "insight foreward" articles on ten topics selected by editors of *Nature* and other science review journals to help readers peer into the future.

• Using an array of **micro-barometers** that detects low-frequency (0.002 to 40 Hz) sound waves, scientists at the Royal Netherlands Meterorological Institute report detecting a 0.15 Hz signal on November 8, 1999, according to a report in *Geophysics Research Letters* **28**, 41 (2001). The signal came from the northeast, and the source was identified as a meteor explosion in the atmosphere over northern Germany, as confirmed by eyewitness accounts and photographs. This signal was accompanied by a continuous 0.19 Hz signal from the northwest, which was associated with standing ocean waves coupled to the atmosphere. The authors estimated that the meteor explosion occurred at about 15 km in altitude and released energy equivalent to about 1.5 kilotons of TNT, within the range of nuclear explosion.

• **"Sound Velocities in Iron to 110 Gigapascals"** is the title of a paper in the 19 January issue of *Science*. The dispersion of longitudinal acoustic phonons was measured by inelastic x-ray scattering in the hexagonal close-packed (hcp) structure of iron from 19 to 110 gigapascals. The longitudinal wave velocity was found to increase from 7000 to 8800 m/s. Knowledge of the elastic constants of the phases of iron, which makes up 70 to 90% of planetary cores, is essential for comparison with global velocity models of Earth. The hcp high-pressure phase of iron is stable to at least 300 GPa.

• Not only do **humpback whales** change their tune according to the season (see "Scanning the Journals" in the Fall issue of *ECHOES*), their song depends upon where they live, according to a note in the 30 November issue of *Nature*. Populations inhabiting different ocean basins sing quite distinct songs, researchers at the University of Sydney have found. A unique and radical song change by whales in the Pacific Ocean off the Australian east coast was recorded when they encountered a small number of "foreign" singers from the Indian Ocean.

Male humpback whales sing while migrating to and from their breeding grounds, and when they are at the grounds themselves. Song is thought to be a form of sexual display, but it is not known whether its main purpose is to repel other males or to attract females. All males in a given population sing the same song.

• **Auditory models for gifted listeners** are discussed in a paper in the November issue of the *Journal of the Audio Engineering Society*. Various psychoacoustic tests were performed in order to measure the characteristics of these listeners. Some had unusual abilities to detect weak signals buried in noise, for example. Other listeners can detect unusually small pitch differences, whereas still others are extremely sensitive to brief temporal events such as pre-echo. The subjects for the experiment were selected and ranked according to the threshold at which real codec noise (quantization noise at low bit rate) became perceptible.

Acoustics in the News

Quite a few news articles based on papers at the ASA meeting in Newport Beach have appeared. *Business Week* (December 18), for example, featured acoustic sensors based on carbon nanotubes (paper 2aEA2 by Flavio Noca, et al.) and how they might lead to hearing aids complete with stereocilia. *Science Now* (on-line AAAS science magazine) picked up on paper 4aMUb1 by Diana Deutsch et al. for an article about how interpretation of the tritone paradox is shaped by a listener's first language.

Science (22 December) reported on Jerry Goodman's paper (1pNSc8) on noise in the International Space Station. Readings taken aboard the Russian space station Mir shortly after the service module was attached in July show that noise levels average more than 70 dB, making it as noisy as a machine room. Installing sound absorbent padding in the first Russian module reduced the noise to "acceptable" levels, but the solution is far from optimal, Goodman said.

Papers in *JASA* also form the basis for news stories in the media. An example is "Close Encounters" which appeared as a news brief in the *Nature Science Update* website. This is based on the paper "Analysis of acoustic communications by ants" by Robert Hickling and Richard Brown in the October issue of *JASA*. The paper was similarly featured as a Research Brief in the *American Entomologist* under the title "Ants have an acoustical world of their own."

- Snowflake sounds (see Acoustics in the News in *ECHOES*, Spring 2000) were the subject of a story "It's a cold world: Flakes are full of sound and flurry" in the December 20 issue of the *San Diego Union-Tribune*. The story begins with the sound of rain on water and compares the sound of snow on water.
- Granular materials inhabit a twilight zone between amorphous substances like gases and liquids, which flow freely, and solids, whose atoms are locked into fixed and often regular arrangements, a story in the January 9 *New York Times* reminds us. Physicists have found that flows, vibrations, and avalanches of granular materials hint at natural laws every bit as profound and challenging as the ones governing subatomic particles or superconductors. This story is based on a paper on granular flow published in *Physical Review Letters* by To, et al., but *ECHOES* readers will recall the cover story "Sound Propagation in Sand" in the Summer 1998 issue which dealt with sound propagation in granular materials.
- Sherwood Boehlert, new chair of the Science Committee in the US House of Representatives, is considered to be a "moderate Republican with a keen interest in environmental and energy issues," according to a news note in the 11 January issue of *Science*. Boehlert, from New York, pledged to work for additional funding for the National Science Foundation and the National Institutes of Science and Technology. He is regarded as sympathetic to science and effective at getting results in Congress, and he is also a good friend of Senator John McCain (Rep., Arizona) who chairs the Senate's Commerce, Science and Transportation Committee.
- Semiconductor devices in which single electrons are transported with the help of surface acoustic waves have been developed at the Physikalisch-Technische Bundesantalt (PTB) in Braunschweig, Germany, according to a story in *PTB News* 00.2. The novel device was used to produce a current of up to 0.75 nA determined by the charge of the electron and the applied frequency. In the GaAs devices at PTB, an applied high frequency produces a surface acoustic wave by means of the piezoelectric effect. The associated propagating modulation of the electrostatic near the surface can act as a microscopic "scoop" which transports single electrons with the speed of sound through a narrow constriction. The device has possible applications as a quantum current standard, the story explains.
- Ultrasound can help to reduce chemical pollution in India's leather processing plants, according to a note in the 2 December issue of *New Scientist*. A powerful ultrasound device developed by researchers in Madras generates microbubbles in the chemicals bathing the leather hide. These bubbles vibrate and collapse near the surface of the leather hide, forcing the chemicals through the pores faster and reducing the amount of chemicals needed.

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