

The newsletter of
The Acoustical Society of America

ECHOES

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Toward a safer, more efficient auditory warning signal

You are a nurse attending a patient in an intensive therapy unit. On the other side of the room, an alarm sounds. The alarm is so loud and shrill that you immediately rush to the patient attached to the piece of equipment, only to find that a food pump has become disconnected. This is a non-vital piece of equipment in terms of any threat to the immediate condition of the patient, so you relax. While fixing the food pump, you hear a much less urgent-sounding alarm, but you ignore it because you don't remember its meaning, and anyhow it is not an attention-getting sound. Later, you discover that a ventilator has become disconnected....

This scenario is wholly plausible given the way auditory warnings are typically designed and used in many work environments. Many of the traditional types of signals, such as horns, bells, buzzers, and sirens are so loud, insistent, startling, and distracting that people turn them off rather than use them. This is especially true with aviation and in hospitals. Another problem is the mismatch between the perceived acoustic urgency of an alarm and the operational urgency of the situation being signaled.

The issue is exacerbated by the fact that people often don't know the meaning of alarms. A study of hospital workers by Kathryn Momtahan and her colleagues provides a good example. Anesthetists in a large Canadian teaching hospital correctly identified an average of only 5 of the 21 alarms found in their operating theaters, and nurses correctly identified an average of only 8 of the 21 alarms recorded in their recovery room, even though both anesthetists and nurses worked in these areas on a regular basis.

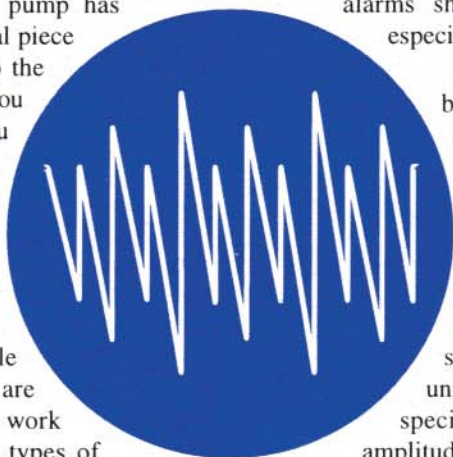
The Canadian study also showed that there was no correlation between the urgency of the medical conditions signalled by these alarms and the urgency ratings given to them by listeners. If, as this study shows, warnings are not

always readily identified, then appropriate urgency mapping should present a substantial design improvement. Urgent situations that are signaled by urgent-sounding alarms and non-urgent situations signalled by non-urgent alarms should be easier to learn and retain, especially in emergency situations.

Over the past decade or so there has been an international effort to resolve these signal design problems. In the early 1980s, Roy Patterson of the British Medical Research Council's Applied Psychology Unit proposed a design methodology that alleviates many of the problems with auditory warning signals. Basically, he recommended using a sound "pulse" as a fundamental signal unit; a sound with an onset, an offset, and a specific duration contained within one amplitude envelope. Patterson recommended that signal design be carried out in four different stages: (1) the specification of appropriate intensity levels, followed by (2) the design of a small pulse of sound, (3) the incorporation of one or more pulses into a longer burst of sound, and (4) the formation of a complete warning using one or more bursts of sound. The warnings could come on in more or less urgent versions depending upon the priority of the situation being signaled.

Patterson used this pulse-oriented methodology to develop a set of guidelines for the design of auditory warning signals for aircraft. Since then, other researchers have adopted this approach. Pulse design guidelines can be found in several international standards on warning signal design, including ISO 7731 (Auditory Danger Signals for Work Places), and ISO 8201 (Audible Emergency Evacuation Signal), which formed the basis for ANSI S3.41-1990.

One of the advantages of the signal-pulse method is that different levels of urgency can be built into the



(Continued on page 4)

We hear that...

Newly elected officers of the Society are: **Stanley L. Ehrlich**, President Elect; **Patricia K. Kuhl**, Vice-President Elect; and **David Lubman** and **Julia D. Royster**, members of the Executive Council.



New chairs of ASA technical committees have also been elected: Architectural Acoustics, **Dana S. Hougland**; Acoustical Oceanography, **Darrell R. Jackson**; Speech Communication, **Terrance M. Nearey**; and **David I. Havelock** for the Interdisciplinary Technical Group on Signal Processing in Acoustics.



Steven L. Garrett, who chaired the engineering acoustics program at the Naval Postgraduate School in Monterey, has accepted the position of United Technologies Corporation Professor in Acoustics at The Pennsylvania State University College of Engineering.



Iowa State University has appointed **David K. Holger**, professor and chair of aerospace engineering and engineering mechanics, to the position of associate engineering dean for academic programs and budget.



Several ASA members have recently been elected to the National Academy of Engineering. They include **Arthur B. Baggeroer**, Ford Professor of Engineering at MIT; **Carl H. Savit**, retired senior vice president of Western Geophysical Co. in Houston; and **Charles R. Steele**, professor of applied mechanics, aeronautics and astronautics at Stanford University.



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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Nation's capital hosted large, successful ASA meeting

The meeting in Washington DC on May 30 through June 3, with 1465 registrants, was second in size only to the 1994 Cambridge meeting in ASA's history. In addition to some outstanding technical sessions, there were several activities that only could take place in the nation's capital. Examples of these were the Wednesday evening reception at the Air and Space Museum and speeches by two prominent federal government officials. Gerald Garvey of the President's Office of Science and Technology Policy spoke at the Plenary Session and Dan Hanlon from the Office of the Architect of the Capitol gave an illustrated history of the capitol building during the Fellows' Luncheon.

Fellowships and awards

At the Plenary Session, the Gold Medal was awarded to **Kenneth N. Stevens** for leadership and outstanding contributions to the acoustics of speech production and perception. The R. Bruce Lindsay Award was presented to **Beverly A. Wright** for contributions to the understanding of auditory processing of complex signals.

New Fellows of the Society, who had been elected at the Austin meeting, were also honored at the Plenary Session:

Courtney B. Burroughs
Mary Ann Cheatham
Joseph M. Cuschieri
Alexander E. Hay
Jerald R. Hyde
Darrell R. Jackson
John W. Kopec

Edwin R. Lewis
L. Gerald Marshall
Diana F. McCammon
David E. Newland
James H. Patterson
Richard J. Peppin
Christopher K.W. Tam

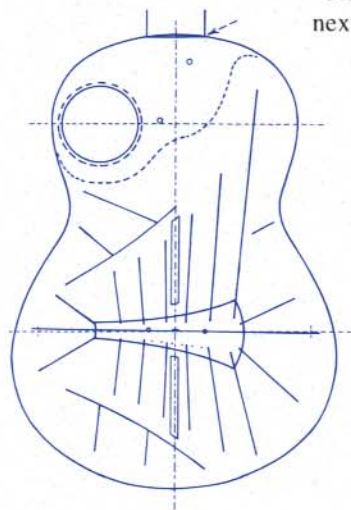
Three technical committees presented awards to students and young presenters. The Committee on Structural Acoustics and Vibration selected **Dan Russell** of Pennsylvania State University for its Best Student Paper Award, and the Committee on Engineering Acoustics gave its Student Paper Award to **D.L. Cosnowski** of Ohio State University's Department of Mechanical Engineering. The Speech Communication Committee awarded its prize to **Marilyn Y. Chen** of the Research Laboratory of Electronics and the Department of Health Science and Technology at MIT. Her paper was co-authored by Ralph Metson.

Science writing awards

The judging panel of the Public Relations Committee selected the winners of ASA's 1994 science writing competition. The winner of the award for journalists is **Sandra Blakeslee** of *The New York Times* for the article appearing August 15 entitled "New Clue to Cause of Dyslexia Seen in Mishearing of Fast Sounds." The science writing award for professionals in acoustics was split between two acousticians. They are: **Christopher E. Ruckman** of the Naval Surface Warfare Center in Washington, DC for his article entitled "Active noise control," which was published electronically during 1994 in the Internet's Frequently Asked Questions' (FAQ) newsgroup; and **Lawrence A. Crum** of the Applied Research Laboratory, University of Washington, for the article "Sonoluminescence," which appeared in the September 1994 issue of *Physics Today*.

Celebrating the guitar

One of the meeting's highlights was the Thursday evening guitar concert at Lisner Auditorium, starring American Kurt Rodarmer, Colombian Ricardo Cobo, and Brazilian Carlos Barbosa-Lima, playing guitar masterpieces from the purely baroque Bach to the sensuous South American composers like Piazzolla and Jobim. A short lecture and slide show about the construction and acoustics of guitars through the ages served as an academic interlude between musical performances. It was given by Professor Michael Kasha, who was also the designer of the instrument played by Mr. Rodarmer, the Schneider-Kasha guitar. Using rigorous acoustical analysis techniques, the designers of this instrument sought to increase low-frequency response by an unusual asymmetrical placement of the sound hole and interior bracing design, in addition to other beneficial changes. Much credit for the success of the concert is due to the efforts of the organizer, Francis Kirschner.



The concert was followed the next day by a special technical session on guitar acoustics and performance, and the next evening by a performance at the Embassy of Colombia by Mr. Cobo.

*Design of the
Schneider-Kasha
model guitar,
1990-1995*

ASA co-sponsors "Save Your Hearing Day"

In an effort to inform the public about the importance of conserving hearing, ASA joined forces with four other professional organizations: the American Speech-Language-Hearing Association (ASHA), the American Industrial Hygiene Association, (AIHA), The Institute of Noise Control Engineering (INCE), and the Military Audiology Association (MAA). The five organizations have declared May 31, "National Save Your Hearing Day." With pooled resources, they contracted with a mobile audiometric service and provided free hearing tests to about 230 interested people on the Mall outside the Smithsonian Institution. Volunteers from ASHA and MAA counselled individuals about their hearing test results and queried them about their noise exposures and their attitudes toward their hearing.



Preliminary results from the questionnaires showed that approximately 58 percent of the respondents indicated that they had learned something new from the hearing test, and about half of these were aware that excessive noise could cause hearing loss. Of those who reported that they didn't learn anything new about their hearing, some 37 percent were aware that noise could cause hearing loss.



This was the third hearing testing activity carried out by the ASA since the idea was first proposed in the workshop arranged by ASA's Noise Task Group at the Ottawa meeting in 1993. The inter-society Coalition for Hearing and Noise, chaired by Robert Bruce, hopes to repeat and expand on "Save Your Hearing Day" in future years.

Auditory Warning Signals

(...signals continued from page 1)

warnings themselves. Auditory alarm parameters may be designed to be appropriately urgent in the same way that we intuitively understand that a speaker is angry or distressed by the general level, pitch, or speed of the voice. In a similar manner we are sensitive to the moods produced by the style and elements of music in a film soundtrack. Exploring the relationship between sound parameters and perceived urgency has thus been a topic of research concern for several years.

Judy Edworthy of the University of Plymouth in the United Kingdom adopted Patterson's methodology as the basis of a series of studies in which she examined the effects of combinations of sound parameters on the perceived urgency of auditory warnings. She found that a wide variety of acoustic pulse and burst parameters had clear and consistent effects on the perceived urgency of auditory warnings and that subjects showed a high level of agreement about the urgency of such warnings. Pulse parameters, such as fundamental frequency, the degree of inharmonicity of the pulse, and its amplitude envelope affected perceived urgency. So did burst rhythm, speed, melodic pattern, pitch contour, and length.

Edworthy used these results to design a set of warnings for which the urgency order was predicted prior to testing, and then confirmed the predictions experimentally. More quantitative studies were carried out by Elizabeth Hellier from City University in London, who showed that the relationship between single acoustic parameters and perceived urgency can be quantified to a high degree using an application of Stevens' Power Law. A joint study by Ellen Haas of the U.S. Army Research Laboratory and John Casali of Virginia Tech explored the perceived urgency and detection time of multitone and frequency-modulated signals in broadband noise. The results showed, not unexpectedly, that the greater the perceived urgency of a signal, the shorter the response time to that signal.

Recently, Edworthy and Haas have undertaken a joint research program to explore the effects of a wide range of acoustic signal parameters on the perceived urgency and response time to a variety of auditory warnings. The objective of their first experiment was to examine the effect on perceived urgency of pulse fundamental frequency, sound pressure level above ambient, and time between signal pulses. Perceived urgency was measured by listener magnitude estimation ratings. Their research goal was to develop a mathematical model showing the relationship between perceived urgency and these temporal, level, and spectral parameters.

So far, the results of their research indicate that fundamental frequency, sound pressure level, and time between pulses all influence perceived urgency. They found, not unexpectedly, that the louder the signal, the more urgent it was judged to be. Time between signal

pulses also displayed a consistent effect on urgency: the shorter the inter-pulse interval, the greater the perceived urgency, and signals with zero ms between the end of one pulse's offset and the onset of the next were rated as the most urgent of all. In addition, perceived urgency increased with rising fundamental frequency. In general, perceived urgency is greatest when fundamental frequency and signal level are highest, and when time between pulses is smallest.

The authors were able to develop a mathematical model of the relationship between auditory warning parameters and perceived urgency. All three experimental variables, their interactions, and some second-order effects were good predictors of perceived urgency, and could be expressed as an algorithm that defined approximately 70 percent of the variance. The model, which was obtained by a stepwise multiple regression, indicated that pulse level predicted a large proportion of perceived urgency, while fundamental frequency by itself played a relatively small role. Data on listener reaction time are currently being added.

In addition to the design of new warning signals, the model may be used to predict listener perceived urgency and user response time to existing signals, not only in hospital environments, but in industrial and military settings, such as utility and chemical plant control rooms, in aircraft cockpits, or any place where auditory signals are needed to warn operators of impending conditions. In any of these kinds of applications, proper design guidance can result in signals that are safe, efficient, effective, and appropriate for the environments in which they are used.

Editor's note: In addition to the above information, interested readers may want to see: "Why are people turning off our alarms?" by Robert Sorkin, J. Acoust. Soc. Am., 84., 1988, pp. 1106-1107.

Judy Edworthy, Ph.D. is Professor of Psychology at the University of Plymouth in the U.K., where she performs research on auditory warnings for the Ministry of Defence and for the BSI hospital warning committee. She has published several papers on music cognition, as well as auditory warning design and ergonomics, and is an editor of the journal Ergonomics. She will publish a book on research in warning signal design in the near future.

Ellen Haas, Ph.D. is a Research Engineer at the U.S. Army Research Laboratory, Aberdeen Proving Ground in Maryland. She conducts basic and applied research in the design of auditory displays and warnings, and has published several papers in this area. Her specific interest is the development of standards, guidelines and design methodologies for speech and non-speech signals.

Meet Us in St. Louis

Features of the upcoming St. Louis meeting

ASA's 130th meeting will take place in St. Louis at the Adam's Mark Hotel, Nov. 27 through Dec. 1, 1995. Vital information on such matters as submitting abstracts (electronically as well as by mail), room sharing, transportation, tours, etc. is available in the Call for Papers. Readers should note that assistive devices for the hearing impaired will again be available but should be requested in advance by writing to ASA headquarters (500 Sunnyside Blvd., Woodbury, NY 11797).

There will be a "Town Meeting" for all ASA members on Wednesday, Nov. 29, immediately following the Plenary Session on the topic "Societal Growth—How Big is Big Enough?" The first Town Meeting was held at the Austin meeting in the fall of 1994; this will be the second. All meeting attendees are invited and encouraged to participate.

Those interested in musical acoustics and speech communication should note that the session planned for St. Louis, "Exchange of research ideas and findings between music and speech perception," has been postponed until the Indianapolis meeting in May 1996.

There is an exciting activity that has only recently been confirmed and, therefore, is not mentioned in the Call for Papers. The Social on Tuesday Nov. 28 will be held in the museum at the base of the Jefferson National Expansion Memorial (a.k.a. The Arch), located only one-half block from the Adam's Mark Hotel. Included will be a tram-ride up the arch and movies in the museum about the construction of the arch.

The Adams Mark Hotel is well situated for recreation. It is close to Laclede's Landing, location of several restaurants, nightclubs, and jazz clubs. St. Louis also has a light

rail system, "MetroLink," which provides easy connections to its well-known zoo, art museums, and Forest Park, the home of the 1904 World's Fair.

Visual appeal of acoustics

Another feature not mentioned in the Call for Papers is the "Gallery of Acoustics" being organized by the Interdisciplinary Technical Group for Signal Processing in Acoustics. The gallery will consist of posters and video displays of images generated by acoustic processes or resulting from signal processing of acoustic data. The posters and videos can portray actual visualizations of acoustic processes or aesthetically and technically interesting images resulting from various signal processing techniques. There is still time to submit entries. Notification of intent to contribute must be received by Oct. 1, video submissions by Oct. 15, and poster contributions may be submitted during the first day of the meeting. Contact David Havelock: voice (613)993-7661, fax (613)952-3670, e-mail david.havelock@nrc.ca; or Randall Smith voice (512)835-3768, fax (512)835-3259, e-mail smithr@arlut.utexas.edu.

Future ASA Meetings

Get out your long-range calendars to plan for these ASA meetings:

Honolulu-December 1996

Seattle-June 1998

(joint with the International Congress on Acoustics)

Berlin-March 1999

(joint with the European Acoustics Association)

Soundings

Attention women members of ASA!

Many organizations that wish to encourage participation of younger members, women, or minorities, have realized some success through mentoring programs. ASA's Ad Hoc Committee on the Status of Women is seeking individuals to serve as mentors and people who wish to be mentored.

ASA's mentoring program will consist of established members who will mentor younger, newer members by meeting with or calling them periodically, being good listeners, and supporting them in their endeavors to function more successfully in their work environments, whether they are in government, academia, industry, or consulting. Mentors also encourage their proteges to participate in ASA activities and help them network within the Society.

Those interested should contact Alex Tolstoy in Honolulu at (808)735-8070 (voice); (808)735-8086 (fax); e-mail, atolstoy@atinc.com.

New hearing research center opens

On July 7 and 8, 1995, the University of Washington officially opened the new Virginia Merrill Bloedel Hearing Research Center with a ribbon-cutting ceremony and the symposium, "Frontiers in Hearing Research." The Center is dedicated to interdisciplinary research on hearing, hearing loss, and related communication disorders. Endowed in 1988, the Center has been operating with offices and laboratories scattered across the UW campus and the city of Seattle. The new center contains five core laboratories that will be used to study hair cell regeneration, molecular genetics of hearing, auditory neurophysiology, and clinical outcomes. It also contains six multi-user laboratories, to be used for tissue culture, histology, cellular neurophysiology, and human auditory performance testing.

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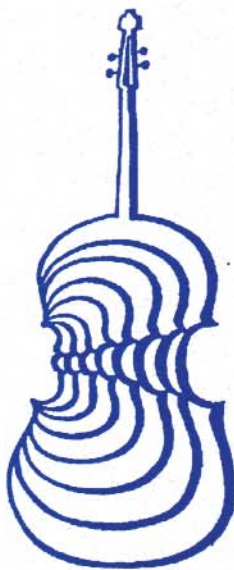
The Acoustical Society will soon have its own "home page" on the WWW, thanks to ASA members Paul Baxley and Carr Everbach. The home page will reside on a computer at the American Institute of Physics (address to be published in the next issue of *Echoes*). The home page is one of several electronic services to ASA members, including the submission and receipt of abstracts and access to publications and standards.

The traveling violin octet

The renowned set of instruments known as the violin octet continues to star in performances around the world. Last fall a set of the octet was played by eight professors from the St. Petersburg State Conservatory before an overflow audience in St. Petersburg. Several ASA members attended the concert and Carleen Hutchins, Joan Miller, and Anders Askenfelt presented symposia. The Russian group has produced a 15-minute videotape and a cassette of some of the music played at the concert. Both are available at the office of the Catgut Acoustical Society, 112 Essex Ave., Montclair, NY 07042.

The violin octet consists of eight new instruments of the violin family, designed to carry the violin's power, clarity, and tone, but extended to cover a four-octave range. Each violin is one-half octave above or below the next. (See *Echoes*, vol.4, no.1.)

In other performances, the octet was played to a full house in the Reid Concert Hall at the University of Edinburgh on Feb. 21 and is being displayed in the Museum of Art at Brigham Young University in Provo Utah, in an exhibition entitled "Our Tuneful Heritage." Students of the Princeton University Music Department performed on another set, and five of the eight instruments are scheduled to be played at Harvard in October. A recording of Yo Yo Ma, playing Bartok's Viola Concerto on one of the Alto Viols (the Vertical Viola), is now available on a Sony CD.



СКРИПИЧНЫЙ
ОКТЕТ

Acoustical qualifications for meeting rooms proposed

ASA's technical committees on Architectural Acoustics and Noise have drafted a preliminary set of qualifications for meeting rooms to be considered acoustically suitable for effective speech communication. These qualifications are intended for small and medium-sized meeting rooms, with or without audio systems.

Rooms must be tested by a qualified consultant in acoustics. The measurements must be performed in at least 10 percent of the seating locations for typical sources or talkers, and performance requirements must be met in all tested configurations.

Among the proposed requirements for room acoustics are: C50 values from 125 Hz to 4000 Hz of 2 dB or greater, or Speech Transmission Index Values of 0.75 or greater, or AICon score of 5% or less, as well as demonstrated absence of echoes and other anomalies.

Also proposed are criteria for background and intruding noise. For example, background noise levels due to the operation of audio, visual, and other presentation equipment, as well as mechanical systems, must not exceed RC-30. Requirements for the Noise Isolation Class between adjacent rooms are being developed. Audio systems must be free of feedback, equalized to achieve a certain frequency response (to be defined), and their components must be synchronized to achieve the impression that sound is traveling from the talker.

In addition to comments on and additions to the above requirements, the committees pose these questions for discussion:

- Should separate performance criteria be established for small (50 seats or less), medium (50 to 300 seats), and large (greater than 300 seats) meeting rooms?
- How is a "qualified consultant in acoustics" to be defined?
- Who will publish these qualifications?

The next steps are to bring together additional representatives from the Architectural Acoustics and Noise committees, as well as other professional groups to continue the development of these performance requirements and prepare them for circulation, and to obtain the support of other professional societies. The intention is to release the resulting document to the travel industry and other groups who can urge the owners and managers of meeting facilities to meet the acoustical requirements.

Contact: Rick Talaske, (708)524-2800 voice; (708)524-2818 fax; talaske@mcs.com.

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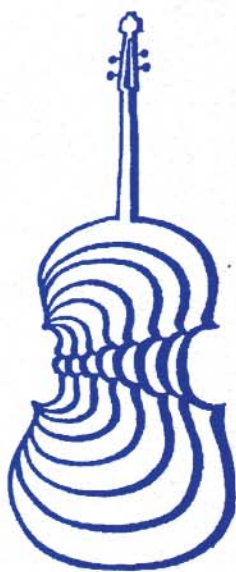
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Acoustics in the News

Musical acoustics was the topic of several recent articles in the media, with ASA's guitar performance, lecture, and technical sessions leading the way. *The Washington Post's* music critic, Joseph McLellan reviewed the concert and lecture at Lisner Auditorium in the 6-3-95 "Music" section. He commented that the Kasha-Schneider model played by Kurt Rodarmer "has taken a substantial step closer to human vocal qualities." A few days later (6-12-95), another article about the guitar appeared in *The Washington Post* which also mentions the ASA concert and meeting: "Quadratic Equations Tune Up Guitar's Vibrations" by Curt Suplee. The article concentrates on evolving guitar acoustics, comparing the acoustics of traditional guitars with the new ones designed according to "rigorous physical principles and quadratic equations instead of the intuition of luthiers." The same article was reprinted in *The Washington Post National Weekly Edition* as "Quadratic Equations are Helping Design the Guitar of the Future" (week of June 19-25).

In another music related article, Ivars Peterson wrote about a new bowing technique demonstrated at the ASA Washington meeting by Mari Kimura of New York University. His article, "Drawing a violin bow to new lows in music" appeared in the June 10 issue of *Science News*. The method enables a performer to play low notes below the fundamental frequency of a given string, thus expanding the violin's capabilities. In addition to Kimura, the phenomenon was discovered independently by acoustician Roger Hanson of the University of Northern Iowa.

Two articles stimulated by ASA's Washington meeting were written by David L. Wheeler for the June 23 issue of *The Chronicle of Higher Education*. In the cover story, the author presents a profile of Michael Kasha, describing his long career, including his friendship with Andres Segovia, and giving an account of the design and construction of his revolutionary new guitar with luthier Richard Schneider. The other article is devoted to the many-sided profession of acoustics, including interviews with ASA's Past-President Jiri Tichy and researcher Stephen Zahorian, who has developed an acoustical monitor for use with women whose pregnancies are considered high-risk.

The subject of noise pollution continues to attract the attention of the popular press, and the article by Janet Singleton in the April 24 issue of *The Denver Post* gives it broad coverage, quoting ASA members Chris Schweitzer, William Clark, and Margaret Mortz. Mortz, an engineering professor at the University of Denver, warns about the damaging effects of noise on hearing. With respect to her own hearing impairment, she says that "hearing loss tends to isolate you from other people" and that it can be "exhausting" to try read lips and figure out what other people are saying.

Once again, *Science* magazine has featured several articles of potential interest to acousticians over the last few months. In the "Letters" section (5-5-95) Oliver Saks comments on the earlier report by Schlaug *et al.* (*Science* 2-3-95 p.699; see also *Echoes*, Vol.5 No. 1) on the enlargement of the left planum temporale in professional musicians, especially in those possessing "perfect" pitch. Saks mentions the increased occurrence of perfect pitch in disabled but gifted populations, such as individuals with savant syndrome, and recommends high-resolution magnetic resonance morphometry to study these populations.

In another *Science* letter dated April 7, Robert Shafer comments on the article on sound localization by crickets (12-16-94, p.1809; see also *Echoes*, Vol 4 No.4) written by Sunny Bains. Shafer cites evidence suggesting that crickets' tracheas may convert amplitude disparities to temporal disparities, thus facilitating localization.

The article "High-Frequency Motility of Outer Hair Cells and the Cochlear Amplifier" by Peter Dallos and Burt Evans (*Science*, (3-31-95) proposes a model of the cochlear amplifier in which electromotility at high frequencies is driven by extracellular potential gradients across hair cells instead of the cell's own receptor potential. In a later issue of *Science* (6-9-95, p. 1420), the authors present information that corrects and adds to their earlier findings.

Long-range acoustic thermometry was the subject of another *Science* article, "Listen Up! The World's Oceans May Be Starting to Warm" by Antonio Regalado (6-9-95). Although the ATOC experiment is temporarily on hold, smaller scale projects in the Arctic and Pacific are being conducted and suggest that the ocean's temperature may indeed be rising.



ACOUSTICAL SOCIETY OF AMERICA

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