

Acoustical Society To Address Hundreds Of Questions

Is it possible to stop internal bleeding at the scene of an accident by broadcasting sound into the body? Can environmentally unfriendly "red tides" in coastal waters damage the hearing of critical fish species? How have the acoustics of churches and synagogues shaped the evolution of Western architecture and religious liturgy?

These and other questions will be addressed at the 142nd Meeting of the Acoustical Society of America (ASA), to be held December 3-7 at the Greater Fort Lauderdale Broward County Convention Center in Fort Lauderdale, Florida.

Over 680 papers will be presented. The ASA is the largest scientific organization in the United States devoted to acoustics, with over 7,000 members worldwide.

Here are some highlights from among the many papers being given at the meeting. Full abstracts of the papers mentioned below can be viewed by typing in the last name of the author or the appropriate paper code at the [ASA Meeting Abstracts Database](#).

Stopping Internal Bleeding Without Surgery

It may sound like a device out of Star Trek, but researchers at the University of Washington's Applied Physics Laboratory are showing that stopping internal bleeding is possible without cutting open a patient. [Dr. Shahram Vaezy](#) and his colleagues will present the latest developments (Paper 2aBB4, Tuesday, December 4, 9:05 a.m.) on the use of high-intensity focused ultrasound (HIFU) as an effective method of hemostasis (stopping bleeding).

In recent experimental studies, Vaezy and his colleagues employed a combination of conventional imaging and Doppler ultrasound to locate internal bleeding, and then used HIFU to stop the bleeding. HIFU generates a lot of heat very quickly (70 degrees Celsius in less than a second), which causes biological tissues to shrink and fuse together, and small blood vessels to collapse -- stopping the bleeding.

Unlike current techniques that work only on visible bleeding, such as electrically produced heat or manual suturing, Vaezy says HIFU can be delivered to bleeding

sites deep in the tissue and does not require an incision. The researchers believe HIFU could be used in surgery and pre-hospital settings for treating bleeding in both trauma and elective surgery patients. Vaezy and his colleagues are also working on acoustic hemostasis devices that can stop bleeding in solid organs like the spleen, where current hemostasis techniques are not effective.

The Maestro's New Clothes

When conductor Gil Rose walked on stage for a performance at Boston's Symphony Hall last May, one thing was obviously missing -- the orchestra. But that didn't stop Rose. With his first flourish, music filled the hall as recorded passages were triggered by sensors built into his conductor's jacket. Live musicians soon joined the wired maestro in the premier of "Concerto for Conductor."

Teresa Marrin Nakra of Immersion Music, Inc. in Boston, MA will recount the performance and discuss the inner workings of the high tech conductor's jacket, which provides conductors with new avenues for musical expression while recording conductors' motion for later analysis. (3aAA2, Wednesday, Dec. 5, 9:25 a.m.)

Silicon Fly on the Wall

A new microphone currently in development at Binghamton University in New York could end up being as cute as a bug's ear, and will likely be just as tiny. That's because the microphone was inspired in part by the ears of *Ormia ochracea*, a small fly that uses sound to track down its cricket prey, sometimes in complete darkness.

Most directional sound systems are based on our understanding of human hearing; and because the spacing between our ears determines how well we can identify the direction to a sound source, directional microphones tend to be large. The design of *Ormia's* ears is fundamentally different from mammal ears, primarily because its head is only about a millimeter across.

The directional sensitivity of insect ears in such a minuscule package led Ronald Miles and colleagues to design a differential microphone sculpted in silicon that may ultimately lead to novel hearing aids, security devices, or "smart dust" sensors that could be scattered across battlefields to monitor enemy activities. The researchers will present data collected in tests of their prototype microphone in paper 2aEA1 (Tuesday, Dec. 4, 8:20 a.m.).

Red Tides Damage Goldfish Hearing

A new study provides the first evidence that red tides can cause damage to the sensory systems of living organisms. Red tides are patches of colored seawater formed by blooms of phytoplankton, which are tiny or microscopic plants.

In the coastline of West Florida, a phytoplankton known as *P. brevis* produces many neurotoxins which result in massive kills of fishes, birds, and marine mammals, including endangered species. Zhongmin Lu and Zemin Xu of the University of Miami have now found that a purified version of a *P. brevis* neurotoxin causes significant hearing loss in goldfish, which, like humans, are also vertebrates.

In addition to understanding risks to marine life, the work enhances awareness of neurotoxin effects on the sensory systems of other vertebrates including humans (2aAB3, Tuesday, Dec. 4, 8:55 a.m.).

Richard Fay of Loyola University of Chicago has done extensive experiments on the hearing of goldfish. He has found that goldfish hear sound in ways that are remarkably similar to humans and other vertebrates. For example, experiments suggest that they can perceive different notes in a musical chord. The research suggests that vertebrates, whether they live on land or water, have a number of deep similarities in their hearing systems. (2aAB2, Tuesday, Dec. 4, 8:30 a.m.)

The Science of Steel Drums

Steelpans built of hammered portions of forty-gallon oil drums are important instruments in contemporary Caribbean music. Session 2pMU (Tuesday, Dec. 4, 1:00 PM) is dedicated to Caribbean musical instruments and traditions generally, with particular emphasis on the steelpan, or steel drum. In back-to-back talks (2pMU3 and 2pMU4), Thomas D. Rossing (Northern Illinois University) and Uwe J. Hansen (Indiana State University) will discuss the body of existing steelpan science and new analyses of steelpan vibrating modes.

Brian Copeland and Clement Imbert of the University of the West Indies will delve into the intricacies of steelpan manufacturing (2pMU5, 2pMU6, and 2pMU7), while Martha Ellen Davis (University of Florida) and Nina Wood will focus on broader overviews of Caribbean musical traditions (2pMU1 and 2pMU2).

Treating Cancer with Sound

Traditional methods for eliminating tumors either require invasive surgery, chemotherapy drugs which can have potential side effects, or ionizing radiation

such as x-rays which can damage the genetic material in healthy cells. At session 2aBB (Tuesday, Dec. 4, 8:05 a.m.), scientists will discuss the latest progress towards developing a potentially safer tumor-destroying alternative: high-intensity focused ultrasound (HIFU).

In HIFU techniques, researchers use an array of speakers outside the body to broadcast ultrasound waves that converge at a spot inside the body. The heat from the ultrasound kills or burns away tumor cells. Although ultrasound has been available for a long time, recent technological advances, such as faster computer processing and more sophisticated speaker arrays, now enable researchers to aim ultrasound waves with sufficient precision at tumors inside the body.

Narendra T. Sanghvi of Focus Surgery in Indianapolis (2aBB9) and colleagues will discuss experimental tests for treating human prostate diseases, including cancer, using Sonoblate, a device that combines ultrasound imaging and treatment of cancer tissue to burn away tumors while keeping surrounding tissue safe. The device is currently in Phase III human clinical trials in the US and has received approval for various medical uses from Japan and British health agencies (2aBB9).

Using ultrasound to treat prostatic adenocarcinoma, the most common kind of prostate tumor, will be discussed by Jean-Yves Chapelon of INSERM in France (2aBB7). Gail ter Haar of the Royal Marsden Hospital in England will discuss a Phase II clinical trial for using ultrasound to treat liver tumors 4-12 cm under the skin in fully conscious patients (2aBB6). Feng Wu of the Institute of Ultrasound Engineering in Medicine at Chongqing Medical University in China will discuss their experiences, since 1997, in using HIFU to treat patients with malignant tumors. They report satisfactory results in 400 cases, including some patients with a rare but often aggressive form of bone cancer known as a sarcoma (2aBB10, Tues., Dec. 4, 11:15 a.m.).

How Church Acoustics Influenced Western Architecture and Liturgy

Acoustical communication has been a vital element in the simultaneous evolution of worship-space architecture and religious liturgy. Acoustical consultant David Lubman will explore this topic in paper 1pAA5 (Monday, Dec. 3, 2:35 p.m.). The acoustics of worship spaces is bound by fundamental scientific principles, yet speech and music are two different types of acoustical information.

Speech is most effectively transmitted in small, reverberation-free indoor spaces and well suited to the spoken liturgies of synagogues, early Christian house churches, and other small churches prior to the time of Constantine, the Roman emperor who converted to Christianity.

Lubman argues that the historic and fateful change from a spoken to a musical liturgy around 313 AD, shortly after Constantine's conversion, was likely driven by the highly reverberant acoustics of large basilicas that rendered speech unintelligible. Such highly reverberant spaces are well suited for specific types of musical communication. For example, the Gregorian chant is shown to be an ingenious use of reverberant spaces.

The historic return to spoken liturgies beginning with the Protestant reformation and counter-reformation of the 15th century was accompanied by reductions in church reverberation. Acoustics in Protestant spaces also engendered a need for music suited to less reverberant spaces, for example, simple melodies with rapidly changing chordal harmonies. In modern times, electronics is a new element driving the evolution of worship space architecture and liturgical form.

Opening the Blood Brain Barrier

The brain protects itself from possible toxins in our blood with tightly constructed blood vessels that don't let much beyond oxygen and small nutritional molecules pass through. This structure is known as the blood brain barrier (BBB). While the BBB protects brain cells from damage that can occur in other parts of our bodies, it also prevents the use of therapeutic agents such as chemotherapy to treat disease when something does go wrong.

Previous research was able to demonstrate that ultrasound could temporarily open the BBB, and now researchers at Brigham and Women's Hospital and Harvard Medical School have gone one step further -- controlling the opening of the BBB at a desired location without any damage to the brain (2aBB1, Tuesday, Dec. 4, 8:05 a.m.).

Localizing the opening of the BBB is important to making targeted drug therapy in the brain a reality. For example, localized opening of the BBB would allow chemotherapy agents to be targeted only to the cancerous tumor and not to surrounding healthy tissue. Medical physicist Kullervo Hynynen and his colleagues used MRI to monitor the targeted opening of the BBB and uptake of a MRI contrast agent using focused ultrasound. The success of this procedure creates the possibility of using focused ultrasound for the localized delivery of everything from chemotherapy to gene therapy treatments to the brain, and could revolutionize fields like neuropharmacology and neuroimmunology.

Marine Mammal Acoustics

Navy sonar systems, ocean cruises, underwater experiments -- human activities

such as these make the ocean a noisier place. What impact does this noise have on marine mammals such as dolphins, whales, and seals? To help decision makers balance human interests with marine mammal safety and well-being, researchers are performing a wide range of scientific studies on this issue.

Many new scientific findings in marine mammal acoustics will be presented in sessions 3aUW, 3pAB, 4aAB, 4pABa, and 4pABb. In addition, Charles Schmid of the Acoustical Society of America will chair a panel discussion on these topics at session 4aABc (Thursday, Dec. 6, 4:10 p.m.). In long-term efforts to establish noise exposure limits for marine mammals similar to those set for humans, James J. Finneran of Science Applications International Corporation will review studies on marine mammals' "temporary threshold shifts" (TTS), the short-lived upward shift in the minimum sound level that the mammal is able to hear after short exposure to noise. Such shifts are intended to protect a mammal from loud noise, but could also progress into permanent hearing loss (4aAB1, Thursday, Dec. 6, 8:05 a.m.).

Paul Nachtigall of the Hawaii Institute of Marine Biology will describe experimental measurements of the time it takes bottlenose dolphins to recover from temporary threshold shifts. (4aAB3, Thursday, Dec. 6, 8:45 a.m.)

Observing the coast of Australia, which has relatively low levels of anthropogenic (human-made) noise, Doug Cato of the Defence Science and Technology Organization in Australia, Doug Cato and colleagues have found that noise levels from natural processes are often comparable to noise from distant shipping operations and at times reach the high anthropogenic noise levels that exist in the northern hemisphere (4pABb5, Thu., Dec. 6, 3:10 p.m.).

Arthur Popper of the University of Maryland will discuss what little is known about the physiological and behavioral impact of sound on fish, which are not marine mammals (4pABb2). Robert Gisiner of the Office of Naval Research (ONR) will discuss ONR's research program on the environmental and biological impacts of underwater sound (4pABb1, Thu, Dec. 6, 1:35 p.m.).

Protecting Florida Manatees

Appearing on Earth approximately 50 million years ago, manatees are aquatic mammals with two front flippers and an oval tail. They are found in warm coastal waters, such as Florida. They are also an endangered species.

Ann Bowles of Hubbs-Sea World Research Institute in San Diego and her colleagues have found that often-used high-frequency "pingers" may not effectively turn away manatees from fishing gear in which they can become entangled

(2pAB4, Tuesday, Dec 2, 2:15 p.m.). Manatees are also susceptible to collisions with boats.

Studying the underwater hearing abilities and acoustical environment of Florida manatees, Edmund R. Gerstein of Leviathan Legacy, a Florida-based consulting firm, and his colleagues have concluded that the sounds of slower-moving boats are particularly difficult for Florida manatees to detect. These sounds are often obscured by the noises of snapping shrimp and more distant fast-moving boats. The information from this study may help researchers to design effective low-intensity alarms to alert manatees to oncoming boats (4aAB5, Thursday, Dec. 6, 9:25 a.m.).

Joseph Blue of Leviathan Legacy proposes that acoustical effects known as acoustical shadowing and the Lloyd mirror effect, may make it more difficult for whales to detect approaching ships. He will discuss proposed acoustical signals which could defeat these effects and enable whales to hear the ships (4aAB9, Thursday, Dec. 6, 11 a.m.).

Fuzzy Logic in Hearing Aids

Over 5 million people in the United States use hearing aids, and this number is only expected to increase with the coming boom in the elderly population. A hearing aid doesn't automatically improve hearing off the shelf; one has to adjust it or "fit" it so it can work as best as it can. In a typical fitting process, an audiologist adjusts settings in the hearing aid after determining how the patient responds to a series of artificial tones. However, there are disadvantages to this procedure. For example, the traditional fitting process does not take into account how a person hears speech in a noisy background, the kind of real-world situation needed to adjust the hearing aid for optimal performance.

Bozena Kostek of the Institute of Physiology and Pathology of Hearing in Poland and Sound & Vision Engineering Department, Technical University of Gdansk, Poland, and her colleagues have developed an alternative to the traditional fitting process. The researchers use modern computer technology with a more versatile sound system to deliver what they believe to be more reliable fitting tests. To make adjustments to the hearing aids, these computer tests use "fuzzy logic." In this process, the computer makes choices by analyzing the patient's responses and then answers questions with replies that can lie somewhere between a simple "yes" or "no." Some results of the experiments will be presented in the paper. (2pPP10, Tues., Dec. 4, 4:45 p.m.)

Mysteries and Paradoxes in Marine Ears

Different fish species exhibit remarkable variations in the anatomy of their inner ears, including the size and shape of their sensory cells. Arthur Popper of the University of Maryland and his colleagues will report on these differences, which are not well understood. These differences are surprising given that many different fish species have had to adapt their hearing systems in highly similar ocean environments. The researchers speculate that the fish hearing systems evolved in divergent ways perhaps because they process signals differently (2aAB1, Tues., Dec. 4, 8:05 a.m.).

Darlene Ketten of the Woods Hole Oceanographic Institution points out that marine mammals present an interesting hearing paradox. Their ears are fundamentally the same as human ears, but they evolved in the ocean, which has higher amounts of naturally present noise. Such an environment may have caused marine mammals to develop "tougher ears." Studying hearing loss in captive and wild marine mammals, Ketten and her colleagues will describe how their data have offered important insights into marine mammal ears. (4aAB2, Thu., Dec. 6, 8:25 a.m.)

Latest Developments in Time Reversal Mirrors

Many scientific inventions seem brilliant when they first emerge, but only a few turn out to be highly useful. The meeting will feature many talks on a brilliant idea, known as a time reversal mirror (TRM), which has turned out to be very useful. The TRM takes an incoming sound wave and sends a reversed version of the wave right back to the source.

Researchers are developing TRMs to perform a variety of tasks ranging from taking pictures of objects in murky waters to pinpointing mechanical defects in airplanes to destroying kidney stones in the body. Mathias Fink, a leading pioneer in TRM, will give an overview of time-reversed acoustics (1aSPa1).

The TRM is proving to be very good at performing tasks in "random media," substances such as muddy water, whose ability to ricochet, or scatter, sound waves varies randomly from point to point. Arnaud Derode of the Ecole Supérieure de Physique et de Chimie Industrielle in France will explain experiments in which TRMs could potentially broadcast five different sequences of binary digits to five different points simultaneously in a random medium; such a task is impossible with conventional antennas in a uniform medium (1pSPb3). Many other developments in TRMs will be discussed in numerous sessions including 1aSP, 1pSPa, and 1pSPb (Monday, Dec. 3).

Implementing a Classroom Acoustics Standard

Students face many potential barriers to learning. One important -- and often overlooked -- barrier is poor classroom acoustics. Reverberation and background noise make it difficult for even the most attentive students to perceive speech. Papers in session 2aNS1 (Tues., Dec. 4, 8:35 a.m.) will report on some of the latest developments in classroom acoustics research.

Having visited numerous elementary schools over the past few years, John Erdreich of Ostergaard Acoustical Associates reports that classroom measurements "have revealed a lack of acoustical control within public schools." Noise levels are higher than expected and they can vary widely even for classrooms located on the same floor. Erdreich will present case studies that "demonstrate the need for an acoustical standard in the classroom" (2aNS1). Such formal guidelines have been drafted.

Acoustical consultant David Lubman will discuss the development of a proposed ANSI (American National Standards Institute) standard for classroom acoustics (2aNS2) Lois Thibault of the US Access Board in Washington will discuss efforts to incorporate the proposed classroom acoustics standard in the International Building Code, which is adopted by many states and local jurisdictions. The standard may also be referenced in the guidelines for the Americans with Disabilities Act (2aNS4).

Robert Wallace of the Harbor Science and Arts Charter School, a public school in East Harlem, New York, will discuss how simple modifications to the high ceilings, concrete block walls and window air conditioners of his school transformed the building acoustics, which he says "have made a significant improvement in the quality of life" at the school (2aNS3).

Conducting extensive studies of six elementary school classrooms with young students for which English is either the primary or secondary language, Sigfrid Soli of the House Ear Institute and his colleagues have estimated acceptable noise levels and reverberation times for classrooms with either type of student (4aAA2, Thursday, Dec. 6, 9 a.m.).

A Noisy Womb

One of the most common ways doctors monitor the development of a fetus is with ultrasound. Now researchers from the Mayo Foundation have found that the fetus may be hearing the process as well (1pBB6, Monday, December 3, 2:35pm). Researchers had previously noticed that when an ultrasound beam was directed toward a fetus head, the fetus began moving more vigorously. While emphasizing that the ultrasound does not negatively impact the fetus, Mostafa Fatemi and his

colleagues explain the increased movement as a response to the level of noise in the uterus created by the ultrasound pulses.

Ultrasound pulses cause the womb to vibrate, but the vibrations are too weak for the mother to feel. However, when the ultrasound is pointed at the fetal head, it directly vibrates the sensitive hearing structure of the fetus, creating high-intensity noise in the audible range.

"The fetus apparently senses these vibrations as a loud noise," says Fatemi. He adds that while the noise may be intense (between 100-120dB) where the ultrasound is focused, the sound level decreases rapidly away from this point. "This is why the sound is not audible by others, including the mother." Fatemi says this research should help physicians make better decisions when examining a fetus -- including monitoring fetal activity. Up until now, ultrasound has been perceived as a passive monitoring system. This new research shows that "such ultrasound systems can introduce unintentional stimulation to the fetus and affect the experiment or test."

(Editor's Note: These items were prepared by Ben Stein, Rory Richards and James Riordon of the American Institute of Physics in cooperation with the Acoustical Society of America.)

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