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ECHOES

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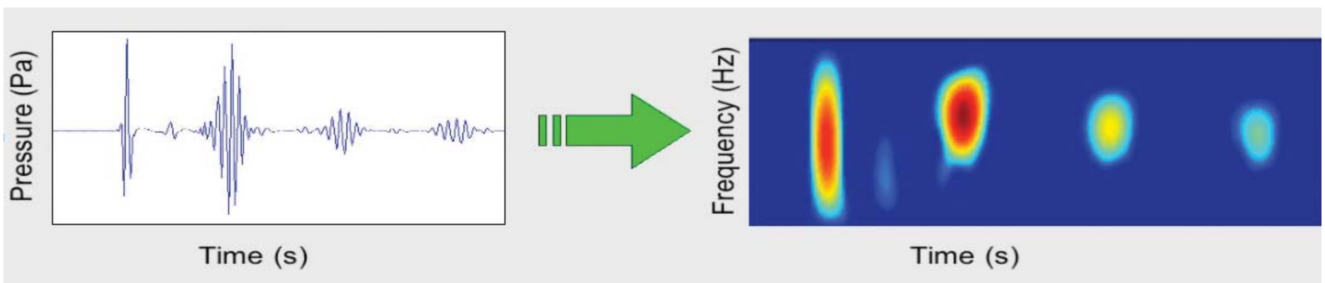
Bio-inspired method to distinguish man-made objects in the ocean

Shaun D. Anderson, Karim G. Sabra, Manell E. Zakharia, Mario Zampolli, Henrik Schmidt, and William A. Kuperman



Example of converting a time-pressure signal into time-frequency-strength plot by time-frequency analysis.

A familiar "ding ding ding" is heard over the conversations in a room as someone prepares to deliver a toast. This rich ring, to a trained ear, can reveal if the cup was made from expensive crystal or common glass. The particular ring created by tapping the cup is what is known as a resonance or natural frequency. Each type of cup has its own unique voice or resonance frequency that can be used to identify the material from which it is made. This process is truly an amazing and complex task that humans are easily capable of performing. The classification of a cup, while relatively simple to a person remains a challenging problem for a machine, especially when the sound is recorded in the presence of noise.

Researchers mimic the way humans are able to determine the material of a cup in order to develop new methods to classify objects in the ocean. Currently there is a desire to be able to find and classify man-made objects in the ocean without wasting time to analyze rocks, or scan every inch of the ocean floor. Scientists use sound instead of light to search for objects in the ocean, since sound travels relatively far and effectively in water whereas light is quickly absorbed. The difficulty of using sound to identify objects comes with the question of how to process and extract useful information. One method being investigated is to use time-frequency analysis to isolate the resonance of an object, and use this resonance in the same manner as identifying the cup.

Time-frequency analysis separates frequencies by the time and strength at which each frequency occurs. This process allows easy identification of distinct resonance tones and is useful for classifying an object. The distinct voice or resonance of an object is typically created by symmetry and the systematic structure found in man-made objects due to their planned and methodical designs. Such structured geometries can easily be seen in objects shaped like tubes, cylinders, and spheres. Alternatively natural objects of similar size and shape, such as rocks, tend to have more random structures which do not produce distinct tones. Additionally the time-frequency method evenly distributes the strength of background noise across frequencies which further allow resonances to be isolated even in noisy environments.

A robust method implementing the time-frequency analysis for classification is being developed. By exciting objects on the sea-floor with a sound source and recording the response, the resonance of an object can be isolated and successfully used for classification. Recorded sound data is processed with a time-frequency analysis to easily isolate the resonance information of the objects. Additional information such as material, size, and shape of an object can also be obtained from the recorded sound. A model is used to "teach" a computer different resonances "voices" to look for in order to extract this additional information for various objects. These models are being used for objects of interest such as sea mines, which to this day

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We hear that . . .

Best student paper/young presenter awards (Paris)

Acoustical Oceanography
First (poster): Paul Roberts (University of California, San Diego)
Second (poster): Aleksandra Kruss (IOPAN, Poland)
First (lecture): Meghan Ballard (Pennsylvania State University)
Second (lecture): David Barclay (University of California, San Diego)

Architectural Acoustics
First: Anne Guthrie (Rensselaer Polytechnic Institute)
Second: Yun Jing (Rensselaer Polytechnic Institute)

Engineering Acoustics
First: Thierry Le Van Suu (Université du Maine)
Second: Cyril Meynier (Vermon SA)

Musical Acoustics
First: Chen Jier-Ming (University of New South Wales)
Second: Ed Berdahl (Stanford University)

Psychological and Physiological Acoustics
First: Marion Cousineau (Université Paris Descartes)
Second: Jayaganesh Swaminathan (Purdue University)

Underwater Acoustics
First: Zachary J. Waters (Boston University)
Second: Jon La Follett (Washington State University)

To the editor:

Classroom acoustics

Since publication of the ANSI standard, S12.60 on Classroom Acoustics in 2002, considerable progress has been made by states or school districts adopting it as a standard or guideline for school construction. This is just a short note on this status.

This national standard has been adopted so far by at least 22 states or local districts. Other action includes: California Collaborative for High Performance Schools (CHPS) urges but does not require schools to comply with the standard. Their mandatory requirement to qualify is 45 dBA but with added points if the background level reaches 40 dBA (+1 point) or 35 dBA (3 points).

The Green Building Council also recommends application of the ANSI Standard with 45 dBA as mandatory to qualify with added points of +1 for 40 dBA or 2 points for 35 dBA.

A National Academy of Sciences Interim Study recommends that all green schools comply with the ANSI standard.

It has taken over 58 years for the school construction/education infrastructure to begin to come to grips with the no-brainer statement made in 1950 by the late Vern Knudsen (ex-chancellor of UCLA) and Prof. Cyril Harris, in their classic book *Acoustical Designing in Architecture* (1950): "The school was established to promote learning, which is acquired largely by word of mouth and listening. Therefore, acoustics is one of the most important physical properties that determine how well the school building can serve its primary function. Thus the exclusion of noise and the reduction of reverberation are indispensable in adapting classrooms to the function of oral instruction"

Hopefully, other school districts and states will begin to see the light (or hear the noise) in their classrooms. If anyone has recent data on background levels in unoccupied classrooms or other pertinent information on classroom acoustics, the undersigned would be pleased to receive it.

Tennessee Congressman Chandler has proposed a House bill (HR 3021) to provide funding for school construction. It would be a major step forward if this bill included a requirement for good classroom acoustics so the funding support could help new school buildings "serve their primary function".

If you want a copy of the ANSI standard or other ASA booklets on classroom acoustics, they can be obtained at no cost from the ASA web site, http://asa.aip.org

Louis Sutherland
David Lubman
Ex-cochairs, ANSI Working Group that prepared ANSI S12.60

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.

Echoes Editor . . . . Thomas Rossing
ASA Editor-in-Chief . . . . Allan Pierce
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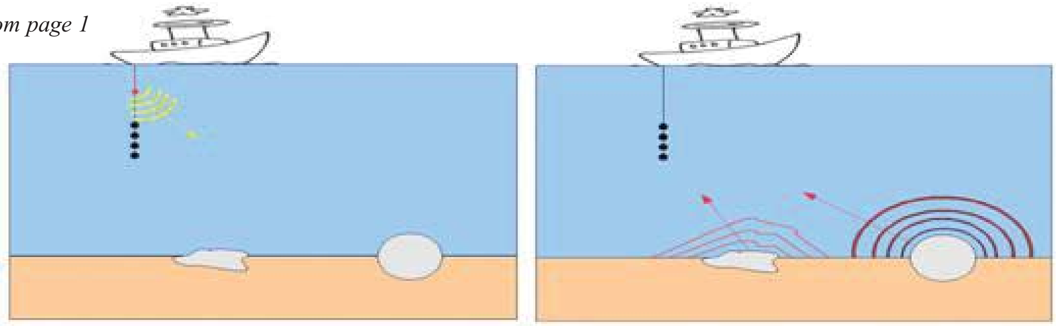
Phone inquiries: 516-576-2360. Contributions, including Letters to the Editor, should be sent to Thomas Rossing, Stanford University, CCRMA Department of Music, Stanford, CA 94305 <rossing@ccrma.stanford.edu>

Echoes from Paris

Continued from page 1



Cartoon of targets being excited and their response.

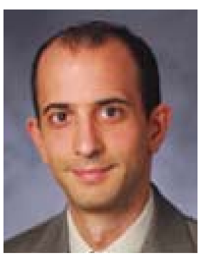
pose a continuous threat to sea lanes throughout the world.

In order to extract this additional information for a large variety of objects of interest in the ocean, a model was created to "teach" the computer different resonance signatures for objects of interest such as sea mines. Additionally the environment in which the object is located becomes important to the response of the object, and it, too, must be added to the model.

Thus the method mimics the complexity of the human processing of sound to identify resonance, as the ring of a crystal glass or a musician tuning an instrument by ear. The benefits of the time-frequency processing technique lends itself perfectly to object classification in the ocean due to resonance isolation and noise reduction. By identifying an object's resonance, information about the object's size, material, and structure can be determined.

This article is based on the lay-language version of paper 5pUWb8 at Acoustics'08 in Paris.

Shaun Anderson



Karim Sabra

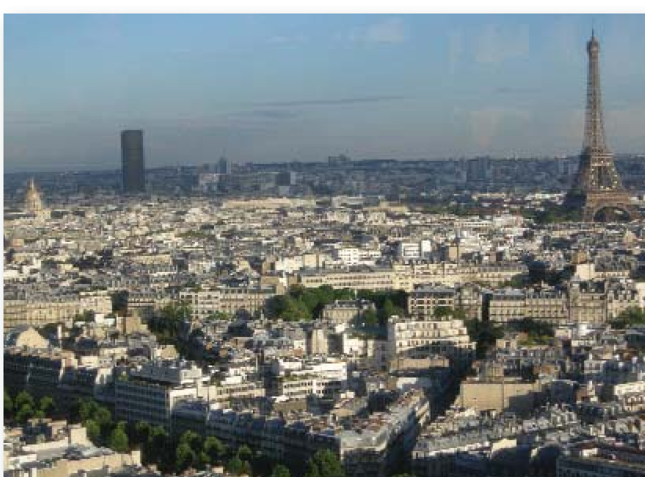
Manell Zakharia

Mario Zampolli

Henrik Schmidt

William Kuperman

Shaun Anderson is currently pursuing his masters and PhD in the Mechanical Engineering program at the Georgia Institute of Technology. **Karim Sabra**, an Assistant Professor at Georgia Tech, was previously at Scripps Institution of Oceanography. **Manell Zakharia** is a professor at the French Naval Academy, where he specializes in underwater acoustics and signal processing. **Mario Zampolli** is at the NATO Undersea Research Centre, where his work is focused mostly on the low to mid-frequency scattering of sound from elastic objects located near the sea floor. **Henrik Schmidt** is Associate Head of Ocean Engineering and Associate Director for Research for the MIT Sea Grant College Program. **William Kuperman** is a professor of oceanography and director of the marine physical laboratory at Scripps Institution of Oceanography.



Eiffel Tower

Hotel de Ville

Brassiness and the characterization of brass musical instrument designs

Arnold Myers and D. Murray Campbell

To a first approximation, woodwind instruments are grouped into families by obvious criteria – flute or reed, conical or cylindrical, etc. We don't agonize over deciding if an instrument is a clarinet or a saxophone. With brass instruments things are not so simple. Radically different instruments such as a trombone and a euphonium are readily distinguished, but how about all the hundreds of "different" kinds of brass instruments that have been invented at various times? To the extent that different instruments produce differing timbres, the problem of brasswind taxonomy is clearly an acoustical question.

Music textbooks often classify brasses as "cylindrical," "conical" and (sometimes) "intermediate," but these terms are clearly imprecise. One or more parameters would clearly be preferable.

To construct a useful taxonomy, firstly we need to determine what are the most significant design features, and secondly to identify parameters which can be used to measure them. Our aim has been not only to classify instruments but also to be equipped to say something useful about their development and evolution.

Wrap
Mouthpiece design
Hand in bell, muting
Dynamic level
Pitch bending by the player (centerdness of pitch)
Bore profile
Oral and vocal tract

Factors influencing timbre

The factors influencing timbre which are under the control of the instrument maker rather than the player are the bore profile, the wrap (the way the instrument is folded to make it manageable) and the materials. The wrap and the materials have in previous work been identified as second order factors, with significant effects noticeable only if the bends in the tubing are very tight or the tube walls very flimsy. And (except in some signaling instruments), the mouthpiece selection of the player over-rides what may have been provided by the maker. So if we seek to identify characteristics of the instruments as designed and made, rather than the combined properties of instruments plus their players, the distinguishing feature is the bore profile.

The bore profile affects the timbre in different ways, mechanisms which can be looked at individually. Researchers often study the acoustic impedance, but despite its importance, the properties of the series of input impedance peaks plotted against frequency so far have not led to any simple way of characterizing brass instruments. The profile of the bell flare clearly influences the way the energy in standing and traveling waves inside the instrument is radiated from the instrument, but parameters such as the cut-off frequency of the bell flare have proved to be of limited value in classifying instruments.

Some 12 years ago the phenomenon of shock waves in brass instruments was identified.[1] At high dynamic levels some instruments are readily sounded in a cuivré (brassy) manner: it was recognized that this phenomenon is due to shock wave generation as wave fronts travel over the length of the instrument. This non-linear propagation is also evident to some extent in playing at lower dynamic levels and contributes to the overall tonal character of the various kinds of brass instrument. In 2006 Robert Pyle[2] suggested that the properties of the bore profile determining the relative susceptibility of the instrument to non-linear wave propagation could be used as a means of classifying the various families of brass instrument.

Fig. 1. Five brass instruments of 8-ft or 9-ft pitch: Kaiserbaryton (euphonium), ophicleide, bass saxhorn, modern bass trombone, baroque tenor trombone.

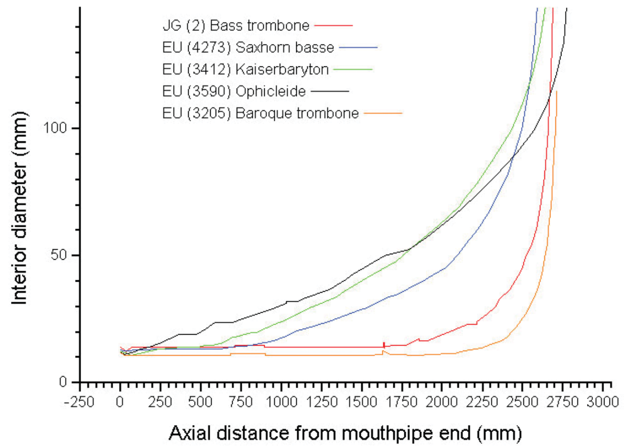


Fig. 2. Graph of bore profiles of the five 8-ft / 9-ft instruments

Echoes from Paris

Standard acoustical theory defines a “coordinate stretching function” as a measure of the degree to which sound in a tube will be propagated non-linearly and give rise to shock waves:

$$z(x) = \int_0^x \left({D_o}/{D(y)} \right).dy$$

This is the coordinate stretching function at a distance x along the tube, where at each point y, D is the duct diameter and D_0 is the diameter at its initial point of wave propagation, in our case the mouthpiece end of a brass instrument, and y is the distance along the duct from this initial point. To calculate the total effect in an instrument we set x to the sounding length of the instrument. We notice here that a wide section of tubing (high value of *D*) makes little contribution to non-linear propagation. Shock waves are mainly generated in the narrower sections of an instrument. Another way of looking at this formula is that z is the length of a cylinder which has the same brassiness as the tube at point x.

Note that the non-linear propagation depends entirely on the tube diameters, and thus in a very direct way on the bore profile. Moreover, the conditions which favor shock wave generation (a bore closer to cylindrical) are the often same conditions that favor an extensive series of impedance peaks, so the ability of a tube to support high-frequency standing waves goes hand in hand with a mechanism for converting acoustical energy to higher frequencies.

We have gone on to define a dimensionless Brassiness Parameter *B*

$$B = {z(L)}/{L(ecl)}$$

Here *L* is the whole length of the tube, in our case an instrument, and *Lecl* is the length of a pure cone which would sound notes at the same pitch. The length of real instruments is always shorter than this equivalent cone length, usually around nine tenths. The mouthpiece and end correction make up the other tenth.

Fortunately, *B* can be calculated quite simply from the geometry of the instrument; this is something any instrument maker, musician or museum curator can do with simple measuring tools. The data needed to calculate B are the diameters of the bore at the beginning of the instrument and at sufficient points along the length of the bore to give useful accuracy. If the bore of an instrument is divided into n elements, brassiness B is approximated by the sum:

$$B \approx \sum_1^n \frac{\ln}{L(ecl)} \left({2D_0}/{(Dn + D(n-1)} \right)$$

Dividing the length of the instrument into n manageable sections, *Dn-1* and *Dn* are the bore diameters at the beginning and end of each section, and ln is the length of the section.

How useful is Brassiness in defining different kinds of brass instrument? We look at five very different instruments at 8-ft or 9-ft pitch, the Kaiserbaryton, ophicleide, saxhorn basse, modern bass trombone and the baroque trombone. We can compare our results in a table:

Instrument, Nominal Pitch		Maker, Place, Date	B
EU3590	Ophicleide, keyed for A	Gautrot, Paris, c 1860	0.31
EU3412	Kaiserbaryton, 9-ft Bb	Cerveny, Königgraetz, c 1900	0.37
EU4273	Saxhorn basse, 9-ft Bb	Ad. Sax, Paris, 1867	0.51
JG2	Bass trombone, 9-ft Bb	Courtois, Paris, 2000	0.67
EU3747	Tenor trombone, 9-ft Bb	Courtois, Paris, 1865	0.77

Looking at a larger sample of 8-ft and 9-ft instruments:

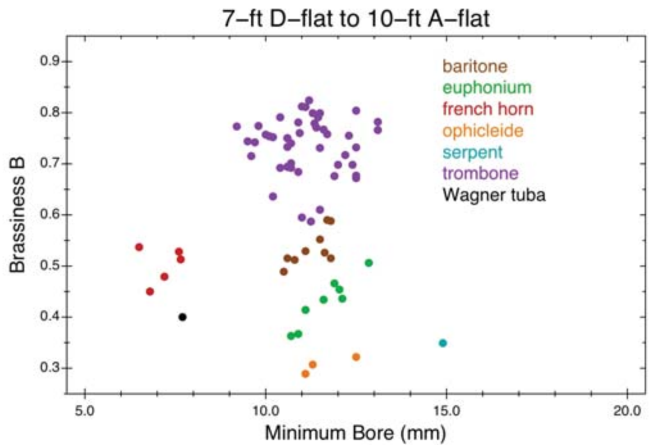


Fig. 3. B *for instruments with equivalent cone lengths in the range 2500 mm - 3500 mm (8-ft and 9-ft nominal pitches)*

Here we find it is useful to plot parameter *B* against the minimum bore diameter. Instruments recognized as euphoniums (or similar) have values of *B* in the range 0.37 to 0.47. Instruments recognized as baritones (or instruments similar to narrower bore saxhorns) have values of *B* in the range 0.44 to 0.60. The Wagner tuba and french horn have comparable values of *B* to the euphoniums and baritones, so consideration of factors other than brassiness (such as the distinct difference in minimum bore) is required to differentiate the shorter french horns from baritones. Trombones cover quite a wide area of the graph, but have values *B* over 0.67.

The same kind of picture can be seen with larger and smaller instruments, though the number of distinguishable classes is much reduced for brasses of extreme sizes such as piccolo trumpets and contrabasses. We defined parameter *B* to be dimensionless, and it can be observed that where instrument models are designed in families (for example, alto, tenor, bass and contrabass trombones; the saxhorns) the parameter *B* is rather similar for all sizes: brassiness is kept constant as designs are scaled.

It should be pointed out that that the brassiness parameter does not completely determine how brassy an instrument sounds. This depends on the absolute bore diameter, the mouthpiece, the player and the dynamic level. What it does

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describe is the relative rate at which the timbre brightens as the dynamic level is increased.

Brassiness is proving a useful tool in taxonomy. It does not provide a complete definition of an instrument: to arrive at a complete taxonomy of brass instruments, other factors need to be considered. However, it is a parameter which satisfactorily distinguishes generally recognized instrument families, and can be used to compare the more obscure models which inventors have dreamed up: clavicors, neocors, cornophones, koenighorns, saxtubas, etc.

References

1 A. Hirschberg, J. Gilbert, R. Msallam, A.P.J. Wijnands: Shock waves in trombones. Journal of the Acoustical Society of America, 1996, 99 (3), pp.1754-1758

2 R.W. Pyle and A. Myers: Scaling of brasswind instruments. ASA Meeting, Providence, 2006. Journal of the Acoustical Society of America (May 2006) 119 No. 5 Pt. 2, Musical Acoustics: Scaling on Musical Instrument Families session, p. 3259.

Further reading

J. Gilbert: Differences between cylindrical and conical brass instruments, the nonlinear propagation point of view from experiments and simulations. Joint Meeting of ASA and ASJ, Hawaii, (December 2006).

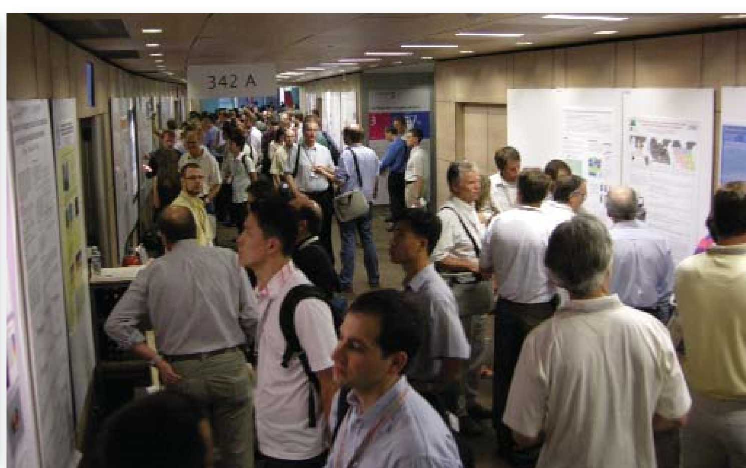
A. Myers, J. Gilbert, R.W. Pyle, and D.M. Campbell: Nonlinear propagation characteristics in the evolution of brass musical instrument design. Proceedings, 19th International Congress on Acoustics, Madrid (September 2007).

J. Gilbert, D.M. Campbell, A. Myers, and R.W. Pyle: Differences between brass instruments arising from variations in brassiness due to non linear propagation. Proceedings of International Symposium on Musical Acoustics, Barcelona (September 2007).

Arnold Myers read physics at St Andrews University and completed his doctorate at the University of Edinburgh with research into the application of acoustical techniques for the study of brass instrument history. He is the Director of the Edinburgh University Collection of Historic Musical Instruments, and was appointed, in 2006, to a Personal Chair in Organology in the University of Edinburgh.

Murray Campbell is Professor of Musical Acoustics in the School of Physics at the University of Edinburgh. He is an enthusiastic musical performer and conductor, with a special interest in the music and instruments of the Renaissance and Baroque periods.

Ji Ho Chang, Kang Hyun Chu and Jin-Young Park at opening session



Poster sessions were well attended

Echoes from Paris

Palais des Congrès

Acoustics'08 Paris

Speakers at special session honoring Johan Sundberg

Speakers at special session honoring Henning von Gierke

Speakers at special session honoring Jens Blauert

Manfred Schroeder and Uwe Hansen

Thanks to Charles Schmid for several photos

Echoes from Paris

Charles Schmid, Pat Kuhl, Larry Crum, Tyrone Porter

Gunnar Rasmussen received the Award for Lifetime Achievement in Acoustics from the European Acoustics Association

ASA vice-presidents Vic Sparrow (2009) and George Frisk (2008)

Executive Council meets in Paris, above

Red and Jinny Wetherill and Bill Cavanaugh

Jean Kergomard, president of SFA, left

Gold medalist Pat Kuhl with Fredericka Bell-Berti and Gilles Daigle

Stan Ehrlich, Avon and George Wilson

Scanning the Journals

Thomas D. Rossing

• Being able to measure long-period waves of up to one hour has made it possible for seismologists to establish the overall size of **great earthquakes** accurately, according to a paper in the January issue of *Nature*. With older instruments, wave amplitudes were measured over only a short period range, leading to underestimates of the magnitude of great earthquakes. Force-balanced seismographs, not widely used, can record ground motion over periods of 0.02 s to hours and have large dynamic range in amplitude. According to new estimates 40% of the total seismic energy released during the 20th century occurred during a burst of activity between 1952 and 1965. Another important finding is that most earthquakes involve a relatively low stress change, 1-10 MPa. A better understanding of great earthquakes has also contributed to an improved understanding of the relationship between earthquakes and global plate motion.

• "Music is partly a trick of the brain. Don't believe everything you hear," warns an article on **musical illusions** in the 23 February issue of *New Scientist*. The brain extracts basic, low-level features from music using specialized neural networks that decompose the signal into information about pitch, timbre, loudness, spatial location, reverberant environment, tone durations, and the onset times for different notes. This bottom-up processing occurs in the peripheral and phylogenetically older parts of our brains. Parts of the higher brain—mostly in the frontal cortex—receive the basic features from lower brain regions and work top-down to integrate them into a perceptual whole. The brain constructs a representation of reality, based on both the component features of what we actually hear and our expectations of what we think we should be hearing. The article cites the "top five musical illusions" in music ranging from Chopin to the Beatles. Recorded music, the article points out, allows us to experience sensory impressions that we never actually have in the real world.

• An imprint from the **relativistic sound waves** that raced through the hot plasma of the universe for its first 380,000 years is still discernible in the cosmic microwave background (CMB), according to a feature article in the April issue of *Physics Today*. Measurements of the sound waves manifested in the CMB provides the foundation of our standard model of cosmology (see, for example, the Winter 2004 and the Fall 2004 issues of *ECHOES*). The primordial cosmos was hot enough that the baryonic matter was ionized. As the cosmos expanded, the baryonic material grew cooler and less dense, but more lumpy. After 380,000 years, its temperature fell below 3000 K, allowing the nuclei and electrons to bind into atoms, decoupling the cosmic radiation field from matter. The photons liberated at decoupling are what we now see as the CMB.

For density perturbations larger than a mean free path, the photons and plasma were coupled together to produce a baryon-photon fluid. The compressing plasma, opposed by increased radiation pressure, led to sound waves similar to sound waves in an ordinary fluid. Temperature fluctuations in the CMB, recorded by the Wilkinson Microwave Anisotropy Probe (WMAP) are essentially a freeze-frame image of the sound-wave pattern at decoupling (see Fall 2004 issue of *ECHOES*). The acoustic peaks of the CMB temperature fluctuation provide some of our strongest cosmological information (see the November 1997 issue of *Physics Today*). By measuring the Hubble parameter of the red shift and the angular diameter distance at different red shifts, the baryon acoustic peak probes the history of dark energy.

• "**Electronic publication** and the narrowing of science and scholarship" is the title of a timely article in the 18 July issue of *Science*. Using a database of 34 million articles, their citations (1945 to 2005), and online availability (1998 to 2005), the author shows that as more journals come online, the articles referenced tend to be more recent, fewer journals and articles are cited, and more of these citations were to fewer journals and articles.

• Feature article of the June issue of *American Scientist* on "The **Psychoacoustics of Harmony Perception**" attempts to explain why different chords sound tense or resolved, cheerful or melancholy. More than a century ago, Helmholtz explained the acoustical basis of musical dissonance. However, the authors argue for an acoustical model of harmony perception that goes beyond consonance and dissonance to explain harmony in chords in terms of the relative positions of three pitches. Two qualities which they call *tension and valence* explain the perception of "stability" and explain how major chords differ acoustically from minor chords. Tension in certain triads arises from the equivalence of the two intervals within them. If the intervals are the same size, the music takes on an unsettled character. If the triad has two unequal intervals and no dissonance, the listener hears stability. Finally the authors speculate as to why acoustical valence carries an emotional valence (which may have a biological basis) as well.

• **Female frogs have selective hearing**, according to a paper in the 9 July issue of *Science*. Although the simple auditory regions of the lower brainstem look the same in males and females, deeper in the brain, in an area called the laminar nucleus, there is a marked difference. The female's brain tissue shows activity only after listening to the calls of a male from her species; males' neurons are activated regardless of the species that made the calls. These findings give researchers a new area of the brain to target when investigating questions about the development and evolution of sex differences in social behavior.

• The brains of **tune-deaf** people know when a sour note has been played, but the people themselves are unaware of it, according to a story in the 11 June issue of *Science*. The problem lies somewhere within the conscious mind. About two to four percent of the U. S. population is tune deaf. People with the disorder, which is highly heritable, have trouble telling the difference between a good melody and a bad one.

• "**Listening to Black Holes**" is the title of an article in the June 16 issue of *Photonics*. That question was among those explored at the Royal Society Summer Science Exhibition at the Royal Society facilities in London. Colliding black holes were demonstrated by means of supercomputer simulation, and the chal-

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lenging task of digging weak gravitation-wave signals out of noisy detector data was presented in a game in which visitors could listen to actual black-hole signals. Gravitation waves convey less of a picture than sound. Just as sound waves contain information about the musical instrument that created them, the gravitation waves carry an imprint of the event in which they were generated. The strongest gravitation-wave signals come from the most violent events in the universe, involving the acceleration of large masses in small regions of space. Sophisticated tools are needed to dig the very weak signals out of detector noise.

• Vocal communication involves both speaking and hearing, often taking place concurrently. It is important for the auditory system to monitor external sounds from the acoustic environment continuously during speaking despite the potential for **sensory masking by self-generated sound**. Although the mechanism for vocalization-induced suppression in the human brain is largely unknown, it has been observed that the neurons in the auditory cortex of marmoset monkeys are sensitive to auditory feedback during vocal production according to a letter in the 19 June issue of *Nature*. Cortical suppression during vocalization actually increased the sensitivity of these neurons to vocal feedback which suggests that they may have an important role in auditory self-monitoring.

• With over 3500 hours of recorded material from all over the world, Wild Sanctuary is the largest archive of **natural soundscapes** in private hands, according to an interview with former composer and performer Bernie Krause in the 12 July issue of *New Scientist*. He describes the soundscape as consisting of *biophony* (sounds produced by living organisms), *geophony* (non-biological sound), and *anthrophony* (human noise). He is hoping that Google will incorporate his soundscapes into Google Earth and Google Maps in the future.

• **Nonlinear amplification of sound** in the inner ear generates distortion that leaks out through the eardrum, according to an article in the April issue of *Physics Today*. How these waves travel backward along the cochlear spiral remains unsettled. Using laser interferometry to measure the dynamics of the basilar membrane in live animals, scientists in the US, China and Sweden attempted to determine whether the backward waves were slow transverse waves on the basilar membrane or faster compressional waves in the cochlear fluid. They never saw evidence of backward propagating transverse waves which suggests that compressional waves are responsible for otoacoustic emission in a healthy cochlea. However these waves have yet to be observed experimentally.

• A reinforced carbon composite material that can **vary its Young's modulus** and therefore its resonant frequency can make airframes less noisy, according to a paper in the April issue of *Smart Materials and Structures*. The material is a composite incorporating two layers of shape memory alloy (SMA) which can switch between two shapes at a specific temperature. Passing a current through the SMA wires heats them to their switching temperature. Only 7% of the composite is SMA, yet the stiffness can be changed by a factor of three.

• **European noise regulations** are raising controversy among symphony orchestras according to a story in the 20 April issue of *The New York Times*. One piece about to premiered by the Bavarian Radio Symphony Orchestra had to be cancelled. Across Europe, musicians are being asked to wear sound-measuring devices and to sit behind transparent noise screens. Conductors are reconsidering the definition of "fortissimo." Rock musicians have talked openly about loud music and ear protection for years, but the issue is more delicate for classical musicians, who have been reluctant to accept that their profession can lead to hearing loss, even though studies have shown that to be the case.

• Music can cause epileptic seizures in a few individuals who suffer from **musicogenic epilepsy**, according to a story in the June issue of *Scientific American*. Although musicogenic epilepsy was first described in 1937, scientists do not know what causes it or, for that matter, what causes epilepsy, which plagues roughly 2.5 million Americans. Although seizures would seem to be a loss of control, they're actually the result of much of this activity falling into step like soldiers in a marching army. It has been suggested that responding to a song emotionally could cause groups of cells to become extremely excited and cause a seizure. Music—perhaps its rhythms—generates a pattern of rhythmic activity in the brain. When medications prove ineffective, the only option for relief is surgery, which leaves surgeons with a difficult choice.

• **Vertebrates make sounds** with an astounding variety of mechanisms, but use only some of these to produce most communication sounds, according to a paper in the 18 July issue of *Science*. Fish do not have the vibration-producing structures of terrestrial vertebrates (larynx in mammals and reptiles or syrinxes in birds) nor do they have an air-filled tube leading to the mouth. Instead, some fishes vocalize with the swim bladder, an air sac used mainly for buoyancy control. To determine the relationships among vertebrate vocal systems the authors examined the spatial organization of neurons in the neural network of three species of batracoid fish, the Gulf toadfish, the oyster toadfish, and the midshipman fish, and compared them to other vertebrates. Single origin for aspects of the neural control of vocalizations leads to other questions about the system, including how much deeper into the history of vertebrates this circuit goes.

• "**Nature's surround sound**" is the title of an interview with pop musician Bernie Krause in the 12 July issue of *New Scientist*. He has abandoned his successful career as performer and composer to become a "bioacoustician," creating an archive of natural soundscapes called Wild Sanctuary. His archive contains over 3500 hours of material collected from all over the world. Forty percent of this archive comes from habitats now seriously altered, compromised or even extinct sound-wise, which is what makes the archive so valuable, according to Krause. He describes the soundscape as consisting of biophony (sound produced by living organisms), geophony (non-biological sound), and anthrophony (human noise).

Acoustics in the News

• *Acoustics'08* received nice coverage in a two-page summary by John Bohannon in the 18 July issue of *Science*. A story entitled "Sound Science Maps Venetian Canals and Peruvian Ruins" reported on the special sessions on archaeological acoustics. "The newest generation of (archaeological) researchers may be as likely to wield sensitive microphones and recorders." One group uses a newly developed shallow-water sonar system to trace the contours of canals and structures buried for millennia beneath the shifting water. As a result, a previously undiscovered Roman brick embankment is now being unearthed. Another group is mapping the acoustic environment within the 3000-year old labyrinthine galleries of Chavin de Huántar in the Peruvian highlands. Their work shows that the layout of galleries creates reverberations that make it impossible to pinpoint sound sources.

Other researchers reported using ultrasound to see interior structure of bones and thus determine quality, while others used high-intensity focused ultrasound (HIFU) to heat a spot inside a brain tumor. In another session, acousticians reported using hydrophone arrays to analyze the sound of cracking ice in Antarctica. Still another session reported the results of the first hearing tests of polar bears and tigers.

• The previous issue of *Science* (11 July) also included an *Acoustics'08* report by John Bohannon entitled "Major European Cities Are Quietly Missing Antinoise Deadline." European acoustical scientists admitted that they are not close to meeting an 18 July deadline to develop action plans to shush the European Union's (E.U.'s) largest cities. The action plan deadline stems from a 2002 E.U. antinoise directive. The first stage of the E.U. directive required mapping noise levels in all cities with at least 250,000 people. One problem is that an urban noise map is a moving target, with infrastructure and traffic patterns constantly changing. Urban noise reduction is a daunting and expensive task, and most scientists are still struggling to locate noise hot spots.

• For about a decade we've known about the Earth's quiet vertical hum, probably caused by the steady thumping of deep waves on the ocean floor. Now, by examining 11 years of data from seismometers in Germany, Japan, and China, scientists in Germany have identified a second hum, characterized by minute horizontal motion parallel to the Earth's surface. The source of this signal is still unknown, according to a story in the 23 February issue of *New Scientist*, but it seems to be amplified by earthquakes, volcanoes, and large storms. The frequency of this hum suggests that something is twisting the surface of the Earth's crust.

• Auto-tune programs are widely used by musicians to correct pitch in vocal and instrumental performance, according to an article in *ANSI News* dated June 10. Notes are altered to match the nearest exact pitch. Generally auto-tune programs are used in a way that is imperceptible to the listener, but some singers have been known to alter pitches dramatically to produce a new, nearly robotic sound, which has come to be known as the "Cher effect," named after pop star Cher's 1998 song "Believe." ANSI S1.1-1994 from ASA provides definitions to make sure that the programmers who develop auto-tune software and the producers who use it in the studio are speaking the same language, according to the article.

• Mysterious bands of shadow which sometimes pass across the ground during an eclipse might be produced by infrasound, according to a story on *BBC News* May 22. Prior to the eclipse totality, the bands are usually seen to pass over the ground in the direction in which the eclipse is traveling. As the eclipse shadow moves through the atmosphere, the sudden disappearance of the Sun changes the Earth's temperature, according to one theory. The sound pulses are not generated as single events, but instead they are created continuously along a shock front which moves ahead of the eclipse itself. The bands are created by refraction by "peaks" and "troughs" in the atmosphere. These infrasonic waves might also explain why animals have been seen to exhibit unusual behavior before an eclipse.

• Some of the nation's leading scientists, including Nina Fedoroff, science advisor to Secretary of State Condoleezza Rice, have sharply criticized the diminished role of science in the United States and the shortage of federal funding for research, according to a story in the May 28 *Washinton Post*. The United States is losing stature because of a perceived high-level disdain for science. A panel of experts at the World Science Festival noted the loss of American power and prestige that came about as a result of our anti-science policies. Although the United has long been the recognized global leader in science, that position is now being challenged by others, specifically China, which is educating 10 times as many students as is the U.S.

• A 60-year old man learned to sing so he could learn to talk again, according to a story in the April 22 issue of *The New York Times*. An ischemic stroke, caused by a blockage in blood flow to part of the left half of his brain, had paralyzed the right side of his body and brought on a condition known as aphasia. After three weeks in the hospital and two years of therapy, his paralysis had mostly disappeared and his smile was back to normal, but he could communicate only through small words and the help of a chalkboard. Complex verbal communication remained elusive. One day the therapist asked him to sing. "How can I ever sing? I can't talk," the patient recalled thinking. But as soon as the therapist began to sing "Happy Birthday," he chimed in. The technique, called melodic intonation therapy, aims to help patients with damage to Broca's areal—the speaking center of the brain located in the left hemisphere. While the left hemisphere is largely responsible for speaking, the right hemisphere is used in understanding language, as well as processing melodies and rhythms. Melodic intonation therapy seems to engage the right hemisphere by asking patients to tap out rhythms and repeat simple melodies. Therapists first work with patients to create sing-song sentences that can be set to familiar tunes, then work on removing the melody to leave behind a more normal speaking pattern.

• A questions column in the 14 June issue of *The New York Times* was entitled "Nasty Noises" and devoted to the noise made by nails on a chalkboard. A reader wrote "Is there a

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name and an explanation for the 'nails on a chalkboard reaction'?" One term used in describing the phenomenon is "saccular acoustical sensitivity" (the saccule is a bed of sensory cells in the inner ear), but the goose bumps and extreme aversion are unexplained. One explanation is that the response may come from "a vestigal reflex related to the warning cries of monkeys."

• A Rotterdam soccer stadium briefly was to become a giant physics laboratory July 19 when Dutch researchers carried out experiments to study the "wave," the ripple that races through a crowd as fans briefly stand up and raise their arms according to a story in the 18 July issue of *Science.* Scientists from the University of Technology in Eindhoven want to test the idea that the wave is a soliton, a singular wave that keeps its shape and travels at constant speed. Results of the experiment were not available at press time.

• A federal appeals court ruled in favor of environmentalists seeking protection for the endangered North Atlantic right whale, according to a story in July 19 issue of the *Washington Post*. This decision gave activists a victory in a long-running fight to prevent whale-ship collisions. The decision, from the U.S. Court of Appeals for the District of Columbia Circuit, overturns a lower-court ruling that the Coast Guard should not have to perform a review of the ways that cargo-ship traffic might endanger the whales. Activists want ships to slow down in areas where whales congregate or go around them. But a proposed rule aimed at setting speed limits in whale areas has been held up by Bush administration officials for more than a year.

• Scientists generally agree that sonar can trigger strandings of certain whales, but no one really knows what leads these deep divers to the beach, according to a story in the July 19 issue of *Science News*. This summer scientists will head to the Great Bahama Canyon off Andros Island to study the relationship between military sonar and stranded, dying whales. Beaked whales, some of the deepest diving and least known animals on Earth, have washed up on the beach, sometimes with blood in their ears and eyes but often with no obvious cause of death. The mystery is compounded by several factors. No one knows where the whales are before strand, so assigning safe distances from sonar is problematic. The strandings have been associated with specific geologic features, such as deep oceanic trenches near land, but since the stranded whales end up on or near land distinguishing between cause and effect is difficult.

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