Physical Sciences

Ivars Peterson reports from Nashville, Tenn., at the meeting of the Acoustical Society of America

Sounding out cotton quality

Many cotton dealers still judge the quality of raw cotton by touch — feeling a clump of fibers to decide whether the cotton will be better used for rough fabric or fine clothing. Attempts to automate the grading process have been only partially successful. The best mechanical technique known is X-ray diffraction, but its use has been limited because the equipment is expensive and bulky. Instead, despite a relatively poor correlation between quality and spectral pattern, many companies now use optical diffraction techniques. Recent research shows that high-frequency sound waves may provide a better picture.

In a series of experiments, physicist Mack A. Breazeale of the University of Tennessee in Knoxville has shown that sound waves can be used in place of X-rays to characterize cotton fibers. In Breazeale's technique, a 1-megahertz burst of ultrasonic waves passes through a pad of cotton. Each fiber scatters the sound waves, and the resulting diffraction pattern depends on the fiber size, surface roughness and other fiber properties. "With as little as 0.36 gram of cotton, I can identify the type of cotton," says Breazeale.

Banging into a noisy background

The slams of a hammer heard against a noisy background may, over a long period of time, cause a greater hearing loss than the same steady banging heard in an otherwise quiet room, according to the results of recent experiments with animals. Donald Henderson and Roger P. Hamernik of the Callier Center at the University of Texas in Dallas show that in chinchillas, certain combinations of individually "safe" impulse noises and continuous noises produce a synergistic interaction, especially when the frequencies of the two sounds overlap.

Because chinchillas provide a good model for human hearing, these experiments indicate a potential problem, particularly for workers in places like textile mills and iron foundries, say the researchers. The worst situations involve high-level impulse noise riding on background sounds close to the 90-decibel limit set by the Occupational Health and Safety Administration (SN: 5/22/82, p. 347). "That's a deceptive situation," says Hamernik, "because the impulses are almost obscured by the background noise. They're glossed over."

In industrial and military settings, the combination of background noise and impulse noise is much more common than either by itself. However, no regulations govern this combination, partly because too little is known about its effect on human hearing. "The idea," say Hamernik, "is to generate some data so that you can identify whether there is a problem and under what conditions you have a problem."

Brushing up on computer talk

Listening to a computer speak can be a real headache. A recent study shows that synthetic speech — words made up of sound fragments generated by a computer — requires more attention and takes a greater effort to understand than natural speech. Follow-up experiments probing the reason for this effect reveal that synthetic speech lacks some of the subtle sound cues that normally help listeners to extract meaning from spoken sentences. Previously, some researchers had argued that synthetic speech was much like degraded natural speech, in which the cues are distorted rather than missing.

"We're concerned about how you can improve the intelligibility and naturalness of speech synthesized by a computer," says psychologist David B. Pisoni of Indiana University in Bloomington, who with two colleagues conducted the experiments. "There are no standards for speech synthesis," he says. "Our work is very basic research into how humans perceive natural speech versus synthetic speech, what the nature of the differences are, and how these differences may be amplified or attenuated depending on the environment in which the speech is presented to the observer."

So far, even the best commercially available speech synthesizers fail to live up to human performance, says Pisoni. Choosing the right synthesizer for a given application is very important. "If you're using one of them in the cockpit of an aircraft or a helicopter, with a lot of noise," he says, "you sure don't want speech produced by a hobbyist toy."

The quality of violin strings

Robert T. Schumacher, a physicist at Carnegie-Mellon University in Pittsburgh, has been playing the violin for 50 years. "I've always been troubled by the hit-or-miss way one goes about buying violin strings," he says. "What are the properties of a string that are essential for producing over the widest possible range of bowing parameters a useful, musical-sounding note?" Musicians rarely have access to such quantitative information.

Schumacher's studies complement recent experiments using a computer to simulate the frictional force between a violin string and a bow's hairs (SN: 3/9/85, p. 153). "What is missing is high-quality experimental data that accurately describe what a string actually does when bowed," he says.

To do this, Schumacher uses some robotics technology in the form of a "bowing machine." The violin is mounted on a moving platform. A computer-controlled motor attached to the stationary bow applies the necessary bow pressure, which varies during a stroke. The computer also logs data from various sensors that measure bow forces, string velocity and other parameters.

"Although the bowing machine does not approach the remarkable control of an expert player," says Schumacher, "within its capability, it can bow reproducibly and untiringly." The machine's long memory allows identical strokes to be applied to many types of strings to measure their different responses.

How to wreck a nice beach

The way people pronounce words while reading aloud is often quite different from the way they say them in spontaneous speech. These differences may cause problems for companies trying to develop computers that recognize normal, continuous speech.

Usually, such machines are "trained" on speech samples read by a diverse group of people. However, if the machines were expected to understand spontaneous speech, many mismatches could occur. Current machines have difficulty distinguishing between rapidly spoken phrases like "how to recognize speech" and "how to wreck a nice beach."

At SRI International in Menlo Park, Calif., Jared Bernstein and Gay Baldwin are systematically studying the differences between spontaneous and prepared speech. In casual conversations, "you get all kinds of contractions of a type that aren't normally written down," says Bernstein. Often people don't even notice the contractions — relaxed forms like "Idunno" and "gonta" — because they're listening for the content, he says.

So far, the researchers are finding that different people pronounce words differently and that the pronunciation often depends on the circumstances. They're also discovering that a person sometimes doesn't even have a consistent pronunciation for a given word. "Probably," for example, can sound like "pry," "probly," "probaly" or "prowubly."

"I was hoping that people would be consistently different," says Bernstein. Instead, people have surprisingly quirky and variable ways of pronouncing words. This means that machines that recognize and understand spontaneous speech may be even farther away than some researchers had hoped.