Ivars Peterson reports from Boston at the annual meeting of the American Association for the Advancement of Science

Using the sounds of hearing

The human ear serves as both a detector and a generator of sound. Tiny hair cells in the inner ear convert incoming acoustic vibrations into nerve signals. But as the cells move in response to sound waves, they themselves produce faint sounds, which are known as otoacoustic emissions. By listening to these feeble signals, researchers can study in remarkable detail how the inner ear works. Now, detection of these emissions shows promise as a means of evaluating a wide range of common hearing problems involving damage to hair cells.

"It gives scientists a chance to listen to what's going on inside the ear," says Brenda Lonsbury-Martin of the University of Miami (Fla.) Ear Institute. The technique also makes it easy for hearing specialists and physicians to begin assessing hearing difficulties without having to ask anything of their patients. Such a test would be especially useful for screening infants and young children.

To detect otoacoustic emissions, researchers insert a miniature probe — which looks somewhat like a hearing aid and contains a sound source and a sensitive microphone — into the outer ear canal. The sound source generates either a click or a tone, and the microphone picks up the resulting ear-generated sound. In an ear with normal hearing, the faint output sound is nearly identical to the input sound.

"In damaged ears or in ears with hearing difficulties, we see a systematic degradation of this response," Lonsbury-Martin says. From such data, "the hope is that we'll be able to predict what the hearing level is and what the hearing problems are without having to ask the patient to try to describe the problem."

This type of test may prove particularly valuable because many hearing difficulties involve damage to hair cells. Such damage can be caused by exposure to prolonged or excessively loud noise, various drugs, and bacterial and viral infections. "These cells are very fragile, and they're very susceptible to all of the agents that damage hearing," Lonsbury-Martin says. "It just happens that what we listen to are these cells."

Neural networks for learning verbs

Children show a remarkable ability to learn language, whatever its idiosyncrasies. In English, one well-studied example of this process involves the effort required to learn the past tense of verbs. Although expressing the past tense usually involves simply adding the ending "-ed" to the verb's present tense, English has a number of important exceptions, especially among frequently used verbs.

Psychologists have theorized that children learn such forms by going through a set of stages. At first, they merely memorize a few important, common verbs, remembering that "go" and "went" go together, "make" and "made," "play" and "played," and so on. As their vocabulary expands, they presumably learn a rule: Given an unfamiliar verb, add the ending "-ed." However, in this second stage, children often apply the rule indiscriminately — even to such verbs as "go," saying "goed" or "wented." In the third stage, they realize they shouldn't use the rule in every case, and they proceed to learn the correct form of each of the exceptions.

Psychologist David Rumelhart and his co-workers at Stanford University have now developed a neural-network computer model that challenges the view that such learning occurs in stages by the adoption of new rules. Their simple model stumbles into the same kinds of mistakes that children make as they learn their verbs, yet it doesn't rely on the addition of new rules to achieve the desired results.

A neural network consists of a number of "elements" — roughly corresponding to neurons in the human brain — connected together in various ways. Learning involves changes in the strengths of these connections as the network responds to various types of inputs. Rumelhart and his colleagues used a simple type of neural network. They offered it examples of verbs in both their present and past forms, which strengthened connections activated by frequently occurring verbs. The network then attempted to predict the past tense of new verbs.

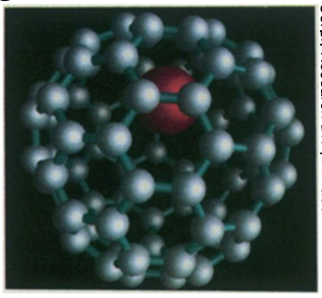
Following the same pattern as young children, the network initially tended to add "-ed" to new verbs. As it learned additional examples, it began to organize its knowledge of exceptions into clusters — for example, "ring" and "rang," "sing" and "sang" would belong to the same cluster. Eventually, the network learned how to handle a wide range of exceptions.

"To a first approximation, a very simple learning system recapitulated data collected from children," Rumelhart concludes.

The findings suggest that children may learn verb forms not by remembering and invoking rules they have been taught, but simply by listening and generalizing from one example to another. The learning process itself yields the observed behavior, Rumelhart notes. "That's all you need to explain this kind of result."

"We don't expect our model to be perfect," he adds. "It provides a hypothesis rather than an answer and suggests what else might be tried or tested."

Atoms in buckyball cages


IBM Corp., Research Div., Almaden Res. Ctr.

It doesn't take much to trap a lanthanum atom inside a buckyball. Robert D. Johnson and his colleagues at the IBM Almaden Research Center in San Jose, Calif., create such metallofullerenes by drilling a hole in a graphite rod, stuffing the hole with a mixture of graphite and metal powders, then vaporizing the rod with an electric arc. Of the fullerenes found in the resulting soot, about 1 percent contain metal atoms.

Johnson and his colleagues are particularly interested in determining the electronic properties of these encapsulated atoms. In the case of a lanthanum atom inside a C_{82} cage (see illustration), spectroscopic studies suggest that the trapped atom loses three electrons, which migrate to the carbon cage. Thus, the cage ends up with a negative charge, and the atom becomes an ion with a positive charge.

Cutting water droplets down to size

Chemist George Whitesides and his collaborators at Harvard University have developed a system for making uniform water droplets so small that each one has a volume — 10^{-11} liter — approximately equal to the fluid content of a typical biological cell. "No one has ever seen such drops before," Whitesides says. "When you work on this scale, fundamentally new phenomena show up."

Whitesides anticipates that these tiny water droplets may serve as a starting point for studying the kinds of processes that go on inside cells, without having to worry about the membrane or wall that normally defines a cell's interior. "It's like a grape with the skin peeled off," Whitesides says. "You would have a naked cell." Moreover, these minuscule droplets may have unusual characteristics more typical of materials with large surface areas than bulk materials. They could also be used in microreactors to do chemical analyses of very small quantities of substances, a technique likely to prove helpful in biomedical studies, Whitesides says.