Giving Language Skills a Boost

A new training program that uses computer games to help language-impaired children hear the fast elements of speech improves their ability to understand and respond to language

Some parents worry that too much time spent at computer games will stunt their children's intellectual development. But on pages 77 and 81, a research team led by experimental psychologist Paula Tallal of Rutgers University in Newark, New Jersey, and neuroscientist Michael Merzenich of the University of California, San Francisco, reports new results suggesting that for some language-impaired children, computer games may instead be part of the ticket to a brighter educational future.

The researchers have shown that a training program made up of specialized computer games and other language exercises can dramatically improve the oral language ability of children who lag several years behind their peers in their ability to understand and respond to spoken language. The exercises are aimed at remedying a basic auditory problem that Tallal's research suggests is at the root of the language impairment: an inability to recognize the very short-duration sounds of spoken speech. "The results are quite provocative and intriguing ... and certainly suggest that this [therapy] is very potent," says University of Iowa speech-language pathologist Bruce Tomblin.

What's more, Merzenich and Tallal think their results could have implications for more than the roughly 5% to 8% of children who have the kind of oral language impairment they studied. Up to 85% of those children go on to develop reading problems symptomatic of dyslexia. And Tallal and Merzenich believe that a general difficulty in distinguishing the fast elements of speech may be the underlying problem in nearly all dyslexic children, even those who don't have obvious oral-language problems. If that is true, their training scheme might help the majority of dyslexic children, a group that by some estimates includes 15% to 20% of all children.

Many speech researchers have doubts about those broader claims, however. The present study is "a stunning piece of work," says Purdue University speech pathologist Rachel Stark. But she adds that "it is not clear yet how it will apply to the broad spectrum of all language-impaired children, because there is so much variability among them."

The present experiment grew naturally out of studies Tallal began more than 20 years ago on children who have normal IQs but who score below the 16th percentile on oral language tests. Using exercises that required children to discriminate between different sounds, Tallal found that these children have trouble distinguishing syllables such as "ba" and "da" that begin with consonant sounds that last only tens of milliseconds. The problem was not limited to speech sounds; the children also had trouble discriminating nonspeech sounds that arrived in rapid succession and had similar "fast-element" recognition problems in other sensory modalities, including vision and touch. For example, if they were touched in rapid succession on two different fingers, they could not identify the fingers, something a normal child can do easily.

MERZENICH ET AL.

Attentive listener. A subject in Merzenich and Tallal's study plays a specially designed audio-based computer game.

These findings led Tallal to hypothesize that the children's brains are unable to process information that flashes by on time scales of tens of milliseconds, a deficit that she says would have its most disruptive impact on speech. "In the real world we don't have to process that much information in the tens of milliseconds range," Tallal explains. But speech is an exception, she adds, "because many of the critical changes that differentiate one speech sound from another ... occur within this time window."

Originally, Tallal says, she feared that "these kids were 'broken' and there was nothing you could do" to fix their primary defect. But her early results had provided a possible avenue for improving their speech comprehension: She had shown that they could distinguish "ba" and "da" when the consonant sounds were stretched from 40 to 80 milliseconds. That suggested that they might better understand altered speech in which the fast consonant sounds were slowed.

Merzenich, meanwhile, had been gathering evidence that training could improve the brain's response to fast-paced stimuli. While training monkeys to discriminate among subtle differences in rapid sequences of sounds or touches, his team had found that, as the animals' skills improved, the timing of the responses of neurons in their brains changed, becoming more synchronous. Merzenich reasoned that if training could improve the monkeys' discrimination skills by actually reshaping their brains' responses, similar exercises might reshape the brains and improve the discrimination skills of the children Tallal was studying. Three years ago, he and Tallal teamed up to test that idea.

To do this, they used two complementary sets of exercises. For one set, Gail Bedi and Steve Miller in Tallal's group designed a series of games such as "Simon Says," in which the children were required to follow spoken commands. A group of scientists and engineers in Merzenich's lab modified the commands using a computer algorithm that stretched the speech by 50% and emphasized rapidly changing speech components, such as short consonant sounds, by making them louder—a formula that, according to Tallal's and Merzenich's research, should make the speech easier for language-impaired children to understand. The subjects—22 language-impaired children with normal IQs—were divided into two matched groups. One group heard the commands in modified speech, while the other children, who served as controls, played the same games, but received their commands in normal speech.

During the same 4-week period, the children in the experimental group also played computer games designed by William Jenkins in Merzenich's lab, in which they won points by being able to distinguish various sound cues. The games began at a very easy level, with long-duration and well-spaced sounds—either nonspeech sounds or speech components that had been modified so even the language-impaired children could easily distinguish them. The children improved at the games, and as they did, the games got harder, the sounds becoming shorter in duration and spaced more closely in time. The control group played computer games that exercised the children's memory and eye-hand coordination, but did not specifically hone their listening skills.

At the end of 4 weeks of training, a battery of language tests showed improvement in both groups. But the experimental group did significantly better, gaining 1 to 2 years' worth of language ability during the 4-week training period. Much of the improvement was maintained when the children were tested again 6 weeks after the end of the training.

University of Washington speech researcher Patricia Kuhl calls it "remarkable" that "after training on the stretched speech, the children generalized to normal speech." That suggests that the training didn't just supply the children with specialized tricks for performing on particular exercises, but actually improved their understanding of language.

The results so far suggest that the training can help the 5% to 8% of children with deficits in general oral language skills. But they haven't addressed whether the training has an impact on the children's reading problems as well, nor whether it might help the greater number of children who are dyslexic, but may not have oral-language deficits as serious as the first set of subjects. Merzenich and Tallal are planning to try the technique on a wider range of children, including dyslexics, in a trial that will focus on reading as well as oral language skills. For that trial, the team hopes to involve speech therapists and subjects at centers around the country.

The researchers are optimistic that the training will remedy an oral language problem that speech researchers think is shared by nearly all dyslexic children: a lack of "phonological awareness," which is the ability to break words down into their sound parts, known as phonemes. It seems that because the children can't hear the distinct parts of spoken words, they have difficulty associating those spoken words with the letters that represent those sounds, and that leads to their reading problems. Tallal believes that the lack of phonological awareness may have the same roots as the more extreme oral-language impairment she has studied: a difficulty in distinguishing sounds of short duration. If that is the case, she and Merzenich expect that their training may benefit dyslexic children.

But that is still an untested hunch, and one that arouses skepticism in some speech researchers. "It is a giant leap to go from the findings of this paper to suggest that this training is of clinical importance for dyslexia," says behavioral pediatrician Sally Shaywitz, who studies dyslexic children at Yale University. Shaywitz says that the phonological awareness problem seen in dyslexics may be due not to a flaw in sound perception, but to a defect in the specialized language centers of the brain. In that case, she doubts it would be helped by Merzenich and Tallal's approach.

The simplest way to find out is to try the training on a broader sample of dyslexic children, says Reid Lyon, director of research in learning disabilities at the National Institute of Child Health and Human Development. If it works, he says, that would support Tallal and Merzenich's hypothesis about the underlying deficit. But beyond the academic interest of the result, he says, it would address the most important practical question, which is "how do you teach or treat these youngsters so they [improve]?" In other words, let the grown-ups argue theory all they want, but if the computer game works, play it.

–Marcia Barinaga

PLANETARY SCIENCE

Does Tellurium Frost Venus's Highlands?

The blistering-hot surface of Venus, where temperatures exceed the melting point of lead, might seem an unlikely place to harbor frost-capped mountains. But a leading planetary scientist is suggesting that the loftiest parts of the planet, like the highest peaks on Earth, have been nipped by a perpetual frost—a coating of the lustrous, silvery-white element tellurium.

Planetary radar specialist Gordon Pettengill of the Massachusetts Institute of Technology (MIT) didn't propose this tellurium frost to be fanciful. Instead, he hopes to explain why the highlands of Venus appear so bright in radar images of the surface. Last month, as Pettengill accepted the Whipple Prize of the American Geophysical Union (AGU) at its fall meeting in San Francisco, he seemed to be giving an ordinary historical account of radar studies of Venus. Then he jolted his colleagues by suggesting that an obscure element famous among chemists for causing intractable cases of garlic-scented bad breath has just the right electromagnetic properties to explain Venus's radar brightness, and just the right melting point to coat its highlands but not its plains.

Pettengill's proposal certainly got his colleagues' attention, if not their agreement. "If it really turns out to be tellurium," says cosmochemist Jonathan Lunine of the University of Arizona, "then I've learned something about how extremely minor constituents can dominate a radar signature, but I'm still skeptical." But he and others aren't dismissing the idea out of hand, if only because it promises a neat resolution for a long-standing mystery.

JPL/NASA

The snows of Venus? This global radar view of Venus, in simulated color, shows its bright highlands, perhaps coated with an exotic frost. Maxwell Montes is at upper left, volcanic Beta Regio at left, and western Aphrodite at center.

When the Pioneer Venus spacecraft became the first radar mapper to orbit Venus in 1979, it revealed that a few high areas—totaling 1% of the globe—were exceptionally bright in radar images. The bright regions had a sharp lower boundary that fell at a consistent altitude, about 2 kilometers above mean planetary radius, much like the snow line on terrestrial mountains.

Venus's highlands, although cooler than the lowlands, are still far too hot for ordinary ice to be responsible for their brightness. Instead, researchers suggested, the highland rocks might be flecked with bits of the mineral pyrite or pocked with decimeter-scale voids, either of which would boost their radar reflectivity. Early this year, however, planetary scientists Robert Brackett, Bruce Fegley, and Raymond Arvidson of Washington University in St. Louis pointed out weaknesses in these ideas—such as pyrite's instability under Venusian conditions—and proposed another brightening mechanism. They argued that volcanoes could be spewing metallic vapors that would freeze out onto the cooler highlands just as water ice frosts terrestrial mountains. The Washington University