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Glasses for the Ears' Easing Children's Language Woes

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SCIENTISTS have developed a radically different treatment for children with severe language and reading difficulties, one that may have applications for millions of children with dyslexia. They call it "glasses for the ears."

The treatment uses a special form of computer-generated speech to train the children to hear differences in sounds that they could not hear before. The researchers believe their program actually results in changes in the parts of the brain that process simple sounds. Unlike eyeglasses the treatment is designed to produce permanent changes in the ability to understand spoken and written language.

Recent experiments show that after just four weeks of treatment, language-disabled children advanced two full years in their verbal comprehension skills, researchers say. They said the improvements endured after training had stopped. In effect, the children could throw their "glasses" away.

The two scientists spearheading the research, Dr. Paula Tallal of Rutgers University in Newark and Dr. Michael Merzenich of the University of California School of Medicine in San Francisco, said in interviews that they believed that the treatment would help many children and adults with milder forms of language and reading disability -- the condition widely known as dyslexia. But Dr. Tallal, who is director of the Center for Molecular and Behavioral Neuroscience at the Newark campus, and Dr. Merzenich, who is a professor of otolaryngology and physiology, cautioned that dyslexia had numerous causes and that not everyone with reading problems would respond to the treatment.

Their new findings, along with the first detailed description of the treatment, have just been submitted for publication in a leading scientific journal. The researchers declined to disclose the precise contents of the journal article. But they have talked about their work at several scientific meetings this year, and presented results on Sunday in San Diego at the annual meeting of the Society for Neuroscience.

Dr. Sally Shaywitz, a leading expert on dyslexia at Yale University, heard an oral presentation of the research two weeks ago and said the findings were "tremendously exciting." But, she added, "I am not convinced" that the majority of dyslexic children will be helped by these methods. "I've seen many things with promise over the years fail to deliver," Dr. Shaywitz said, adding that "while this work sounds credible, we need more experiments" before parents and teachers get their hopes aroused.

But other experts are more optimistic. "I think Paula Tallal and Mike Merzenich's work is just superb," said Dr. Ursula Bellugi, director of the Laboratory for Cognitive Neuroscience at the Salk Institute in San Diego. She said it was possibly the first therapy for dyslexia based on a deeper understanding of the way the brain is organized.

Ten million American children suffer from dyslexia, defined as having great difficulty in reading single words despite normal intelligence and motivation. The social costs are tremendous. A high percentage of dyslexic children drop out of school and have substance abuse problems. They also tend to have trouble finding jobs.

Dr. Tallal is an expert on language impairments in children. Dr. Merzenich is an authority on brain plasticity -- how brain cells and cortical maps change in response to experience. The two began collaborating a couple of years ago under a grant from the Charles A. Dana Foundation in New York.

Dr. Tallal's research focuses on children with a condition called specific language impairment. These children do not talk normally by the age of 3 or 4, Dr. Tallal said. They have trouble hearing and generating speech -- they might say titty tat for kitty cat -- and often cannot follow directions from parents and teachers.

Four in five of these children go on to become severely dyslexic in grade school, Dr. Tallal said. But they are a small subset of the larger population of children with reading problems.

Nevertheless, Dr. Tallal said she believed that these children provided insights into the wider problem. And she thinks she knows what it is.

Research shows that tiny infants can discriminate the sounds in all spoken languages, Dr. Tallal said. But by 6 months of age, if their hearing is normal, they begin to extract sounds that are salient in their native tongue. Specifically, they focus on phonemes -- the basic sound units of a language -- and begin to practice them by babbling. English has 44 phonemes -- sounds like bah, dee and moo -- that can be combined to make up the hundreds of thousands of words in the English language.

Given this normal process, Dr. Tallal decided to take a closer look at phonemes and the way children learn language. Some sounds, such as pure vowels like aaaahhh, occur in a steady flow that continues for more than 100 milliseconds (a tenth of a second), she said. But other sounds, such as ba, da, ga, pa, ta and ka, have a different spectral shape. For example, in the phoneme "ba" the initial "b" is formed by pressing the lips together silently. But then there is a rapid transition, lasting 40 milliseconds, to the "aaah" sound, she said.

The brain has to distinguish these fast transitions to discriminate "ba" from "da" or "ta" from "ka," Dr. Tallal said. It must be able to detect frequency changes in four-tenths of a second.

Other phonemes do not require a fast transition, she said. The intial "m" in the phoneme "ma" is formed by pressing the lips together and voicing the sound. There is a slow transition lasting perhaps 300 milliseconds before the "aaah" is voiced.

These slow and rapid sound transitions carry meaning, Dr. Tallal said. It is the glue that holds speech together.

Dr. Tallal suspects that this is where the problem lies in language-impaired children. For reasons that are not yet well understood, cells in their primary auditory cortex cannot detect rapid transition phonemes, she said. In some cases, the problem could be genetic. In others, chronic ear infections in infancy might cause the auditory cortex to miss important cues during a critical period of development; cells could become tuned to slower but not faster frequencies.

A child with this problem cannot hear the difference between "ba" and "da," Dr. Tallal said. Certain phonemes are eternally garbled, while others make sense.

Most children learn to compensate, Dr. Tallal said. There is a lot of redundancy in spoken language, so they can listen for words they do understand. They pay attention to body language and facial expressions. And they pull meaning from context. For example, "the man chased the dog" and "the man chased the bog" would sound similar but the child knows, from common sense, that the first sentence carries the intended meaning, Dr. Tallal said.

Some language-impaired children appear to speak normally by the age of 5 or 6 but they are faking it, Dr. Tallal said. They get the gist of many sentences but not all the meaning.

Others live in a language fog, she said. "It's like you having a minimal ability in a foreign language and visiting that country," she said. "All day long you struggle." Boys tend to act out and become aggressive or hyperactive. "If someone spoke mumbo jumbo to you all day long, would you be able to sit still?" she asked.

Then the children hit first grade, Dr. Tallal said. Teachers are under the impression that speech has been learned automatically, before children come to school. And so they teach reading by phonics, featuring the very phonemes that language-impaired children cannot fathom.

When Dr. Merzenich, an expert on the plasticity of brain organization, met Dr. Tallal, she told him about the problem some children had in hearing fast transition sounds. The two thought that perhaps they could force changes in the human auditory cortex. Perhaps they could "wake up" sluggish cells to help children hear fast transition phonemes.

"We decided to give kids information in a way their brains can process it," Dr. Merzenich said. The key ingredient is "processed speech" generated by a computer. Fast transition phonemes are stretched out artificially. Instead of the natural 40 milliseconds between "b" and "ah," the computer generates "ba" with 300, 400 or even 500 milliseconds between "b" and "ah." The computer also emphasizes difficult to hear phonemes, making them louder, longer and more salient to the child's brain.

To a normal adult, the processed speech sounds like someone shouting underwater. To language-impaired children, it is miraculous, the researchers said. The children can hear many words clearly for the first time in their lives.

The new treatment exploits what most parents already know -- namely, that children will sit for hours in front of a video game. Dr. William Jenkins at the San Francisco campus developed four colorful computer games with processed speech. The games drill children in hearing pairs of tones and phonemes at faster and faster rates of speed.

The training is done with flair and fanfare. Cows on rocket ships float across the screen. Clowns appear and make wild noises. Bells, flashing lights and other surprises appear when children make high scores.

An important feature is that the games are driven by the child's own performance, Dr. Merzenich said. For example, when children show they can reliably hear the difference between "ba" and "pa" -- processed with say 300 milliseconds of transition time -- the transition is shortened, to say 280 milliseconds. If the child makes errors, the time is lengthened back to 300 milliseconds and drilling continues. Whenever a level is mastered, the time is shortened, thus driving the child's auditory cortex to handle faster and faster sounds.

Children practice thousands of sounds each session, always returning to the level they achieved on the previous day, Dr. Merzenich said. Processed speech is the grammar they can use to win points in the computer games, he said, and they play to win.

Processed speech, played on a tape recorder, is also used in a variety of one-on-one exercises with the children. They learn to listen to speech, attend to grammar and follow directions.

Finally, the children take home books on tape, like "Cat in the Hat," recorded in processed speech.

Two summers ago, Dr. Tallal and Dr. Merzenich gave their experimental treatment to seven language-impaired children ranging in age from 5 to 9. The children were at least two years behind in language skills, Dr. Tallal said. Their speech was often garbled.

Children visited a laboratory at Rutgers for three and a half hours a day, five days a week, for six weeks. Their language and reading comprehension were tested the first week. The therapy was given for four weeks. Then the children were re-tested on the sixth week.

These children made two years of progress in just one month, Dr. Tallal said. After the therapy, they were performing at or a little above their age level in receptive grammar -- the ability to comprehend spoken words.

Three months later the children were tested again. They had not slid backward. Evidently, natural speech served to reinforce the gains they had made in the laboratory, Dr. Merzenich said.

Amazed by these results, Dr. Tallal and Dr. Merzenich held off from submitting a scientific article. Valid questions came up, Dr. Tallal said. "Maybe just the intense intervention, that warm and cuddling feeling, made the difference," she said. "When someone is constantly telling you you're good, doing a good job, you may do better. Maybe we just improved their memories."

To control those variables, the researchers repeated their experiment this summer with 22 similar children. Half got all the computer games and one-on-one exercises with processed speech. The other half got the same treatment, including computer games, but without processed speech.

Results were again striking. While all the children improved, those exposed to the processed speech outperformed the others -- achieving two years' improvement after one month of therapy.

These gains should help the children with their reading, Dr. Tallal said. But long-term follow-up studies have yet to be done.

"We really don't know how far we can drive these kids to improve," Dr. Merzenich said. One month's therapy is probably not enough, he said. "They've had a lifetime of practicing the wrong speech sounds, but there's nothing to indicate that we can't change that."

A major question remains. Do these findings on severely language-impaired children apply to the hundreds of thousands of people diagnosed with dyslexia?

Dr. Shaywitz, who is carrying out an epidemiological study on dyslexia, said that the condition was like hypertension or obesity. It seems to fall on a continuum from mild to severe. While some children cope, the deficit does not go away. It is not something they simply outgrow, she said.

But it is not yet known if language-impaired children are on a continuum with dyslexia, Dr. Shaywitz said.

Dr. Tallal agreed and said that more studies were needed. There are certainly children who have speech problems that are not related to temporal coding, she said. "But my hunch is that the vast majority of kids with reading problems have phonological access problems," she said.