Let the Games Begin

Brain-training video games and stretched speech may help language-impaired kids and dyslexics

By JOHN TRAVIS

Since Nov. 14 last year, Paula Tallal has been under siege by the news media and concerned parents. On that day, the New York Times published a story about her years of research into a controversial explanation of why many children have trouble learning to understand and produce speech.

More important, the article went on to describe a month-long treatment regimen, involving specially designed video games and computer-modified speech, inspired by Tallal's theory. A small group of language-impaired children following this regimen achieved dramatic improvements in their oral skills, Tallal had found. Even more provocative, the newspaper story expressed the fervent hope of Tallal and other investigators that the novel therapy could aid the millions of children with the reading disability known as dyslexia.

After the article appeared, phone calls began to pour into Tallal's office at Rutgers University, in Newark, N.J. One day, a mother even walked in with her child to demand the treatment, recalls Tallal. And after Tallal and her colleagues published details of their experiments in the Jan. 5 SCIENCE, the deluge increased. Thousands of phone calls flooded a voice mail system established to respond to inquiries. "We've had our telecommunication system blown twice," says Steven L. Miller of Rutgers.

That overwhelming response has concerned some investigators. They worry that desperate parents are pinning their hopes on a treatment tested so far on fewer than 30 language-impaired children. They also note that Tallal and her colleagues have not yet tested their regimen directly on kids with dyslexia.

"The finding is quite remarkable. It's like a miracle cure in the field of learning disabilities, but I'm not at all convinced," warns Richard Olson, a dyslexia researcher at the University of Colorado at Boulder. "If it's true, [Tallal] deserves a Nobel prize, but I don't think that will happen. I think that when attempts to do the replication in other laboratories are done, it's not going to turn out to be anything like what is claimed now."

"The two words I would use for the research are 'preliminary' and 'intriguing,'" adds Gordon Sherman, director of the Dyslexia Research Laboratory at Beth Israel Hospital in Boston. "At this point, it's not a cure for dyslexia or for language-impaired kids. We have to sit back and wait for the long-term studies."

It was in the 1970s that Tallal first began to work with language-impaired children, a category she and other investigators estimate includes 5 to 8 percent

David Freese/ZUMA

Language-impaired kids play games that use computer-elongated sounds to retrain their brains.

of children. Though these children apparently have normal intelligence, they have great difficulty mastering oral language, often displaying an inability to understand or properly speak simple phrases.

As Tallal studied these children, she discovered that many of them had a subtle auditory defect. Their hearing seemed perfectly fine on standard tests, but the children confused words like "pack" and "packed" and were unable to distinguish speech sounds such as "ba," "pa," and "da."

Such sounds, called stop consonants, differ from other sounds in spoken language in that they possess an incredibly sharp transition from the consonant sound to the vowel. This shift takes place in less than 40 milliseconds, and Tallal speculated that the changing sounds of stop consonants and similar units of speech occur too fast for the kids to catch. "Their brains do not process at the rate necessary to pick up the subtle acoustic cues that make these differences," says Tallal.

Tallal and her colleagues found that this processing problem was not limited to phonemes, the basic sound units of a language. Some of the language-impaired children also had trouble with nonspeech sounds of rapidly shifting frequency. Tallal has shown that these children sometimes have similar difficulties in the tactile, motor, and visual systems. Other researchers also report evidence that children with dyslexia have problems processing fast-changing sensory information, especially in the visual system (see sidebar).

A few years ago, Tallal met Michael M. Merzenich, an investigator at the University of California, San Francisco. Merzenich's research focuses on brain plasticity, the ability of the brain to reshape its neural circuitry in response to experiences. In one recent series of experiments, Merzenich and his UCSF colleagues demonstrated that through intensive training, monkeys could gradually improve their identification of fast sounds. When the investigators analyzed the brains of these monkeys, they discovered that certain regions had reorganized their neural circuits.

As Merzenich and Tallal discussed their respective research efforts, the two began to wonder if Merzenich's training exercises for monkeys might be adapted to alleviate the auditory defect Tallal had observed in children.

The first part of their strategy was to find a method that would let language-impaired children hear correctly all 44 phonemes of the English language. To accomplish this, the researchers turned to "stretched" speech created by a computer program developed at UCSF. The program transforms normal speech by extending the duration of difficult phonemes by 50 percent and raising their volume slightly above normal.

Listening to this modified speech, language-impaired kids who normally confused "pack" and "packed" could distinguish between the two words. "We allow them, for the first time, to perceive those sounds as unique words," says Miller.

Miller and his coworkers used tapes of stretched speech to play games like Simon Says with the children. In addition, the researchers bought more than a dozen educational or entertainment CD-ROMs and stretched the speech in them. They recorded children's tales, such as *The Lion King* and *The Little Mermaid*, and stretched that speech as well. "We wanted to expose them to as much processed speech as possible," says William M. Jenkins of UCSF.

Since the stretching of speech enables children to recognize words they normally could not, Tallal and her colleagues call the technique "glasses for the ears." The ultimate goal of the investigators, however, is to make it possible for the children to throw away those glasses and understand normal speech.

To achieve that, Merzenich and his colleagues at UCSF created a number of computer games designed to retrain the brains of language-impaired kids.

One of the games used in the training regimen is called Circus Sequence. A child must distinguish between nonspeech sounds like "whoop," which quickly goes down in frequency, and "wheep," which goes up. After pressing a start button, the child hears two sounds in quick succession and must press buttons signifying whether the sounds were a wheep-wheep, a whoop-whoop, a wheep-whoop, or a whoop-wheep.

For correct answers, the child gains points and sees an animated figure climb up a notch on a rope. Once the climber reaches the top, the child is rewarded with bonus points and an animated cartoon.

As long as the child continues to do well, the interval between the two sounds gradually shortens, as does the duration of the sounds themselves. "We start with stimuli that will be easy for the child to detect and then make it harder when the child is successful," says Jenkins. This training strategy can be compared to that of body builders, who build up enormous muscles by gradually increasing the weights used in their workouts.

A second game, Phoneme Identification, follows a similar approach but with phonemes such as the stop consonants "ba" and "da." The child hears an animated clown say a target phoneme and then hears two phonemes in a row. The child's task is to discern whether the target phoneme came first or second. In this game, a bear crossing a tightrope marks a child's success.

Initially, phonemes are considerably stretched and separated by a significant time interval. But by the end of a month, says Jenkins, many of the language-impaired youngsters can distinguish normal-length phonemes with only small intervals between the two sounds. "The more you played the game, the better you got," says Jenkins.

Tallal and her colleagues first tried their training regimen two summers ago. Seven language-impaired kids trained in the laboratory for 3 hours a day, 5 days a week, and did additional work at home. After about a month, the investigators were stunned by the progress the children had made in their language skills. "The results we saw were so scary we felt we needed a comparison group," says Miller.

Last summer, the Rutgers team began working with 22 language-impaired children whom they divided into two groups. One group got the full treatment: the brain-training video games and intense exposure to stretched speech. The other listened to unmodified versions of the same tapes and CD-ROMs. This control group also played video games that challenged skills other than their ability to hear sounds.

Before these exercises, notes Miller, the children, who had an average age of around 7 years, had, on average, the language skills that of a child 4.5 years old. At the end of the month-long training, the control group had progressed about 6 months in their development of language skills. The other group, however, had gained 2 years of language skills. Equally important, says Miller, the children retained those new skills more than a month after the therapy ended.

One unresolved issue for the researchers is that they cannot determine whether the observed gains in language skills result from the intense exposure to modified speech, the computer games, or the combination of both efforts.

Visualizing vision in dyslexic brains

While Paula Tallal and her colleagues test the idea that individuals with dyslexia may have difficulty processing certain sounds, other researchers pursue the somewhat similar notion that dyslexic brains have trouble processing fast-moving visual stimuli. This controversial hypothesis may have gained a measure of support recently from the first functional magnetic resonance imaging (fMRI) study of people with dyslexia.

In the study, six adults with dyslexia and eight adults without a reading disorder watched dots moving on a screen while investigators used fMRI to visualize the brain regions active during the task.

In the control group, a grape-sized brain region called V5, thought to be specialized for the processing of visual motion, flared into action, Guinevere F. Eden of the National Institute of Mental Health in Bethesda, Md., and her colleagues reported in November at the Society for Neuroscience meeting in San Diego. In the dyslexic group, however, V5 was barely active.

That finding is provocative because V5 belongs to a part of the visual system known as the magnocellular system. This system shares the duties of processing visual information with the parvocellular system. From the retina back into the brain, each system functions predominantly through an independent chain of cells. The parvocellular system appears to be specialized for the perception of patterns and colors, while the magnocellular system responds particularly well to moving stimuli. Researchers also believe that the magnocellular system is active during the eye movements required for reading words quickly.

Over the last decade, a growing body of evidence has suggested that many people with dyslexia have defects in their magnocellular system, abnormalities that may make it difficult to process the visual information that streams in during reading.

Though Eden and her colleagues have shown that V5 behaves abnormally in adults with dyslexia, they have not established any direct link between that abnormality and the adults' poor reading skills. Instead of hindering reading, the V5 abnormality may simply co-exist with or result from other deficits that are the true cause of the reading disorder in dyslexia.

Tallal, for example, has suggested that the difficulties her kids have in perceiving rapid changes in sound may reflect a more general problem in processing quickly changing sensory information, whether it is auditory, visual, or tactile. "What's wrong with vision seems awfully similar to what's wrong with audition. It's a timing problem," says Tallal.

Generalizing from studies is tricky, notes Eden, because Tallal's group studied language-impaired children whereas her team examined adult dyslexics. "Maybe there is this overall temporal processing deficit, but no one really knows," says Eden.

A research group led by Deborah Waber of Children's Hospital in Boston may soon resolve the issue. Waber and her colleagues have received funding to collect a group of 200 children with learning disabilities and give them a comprehensive battery of tests designed to uncover time-dependent processing problems in the auditory, visual, and motor systems. — *J. Travis*

Olson also suggests that some of the improvement may simply be attributed to the focused attention given to the children. "It's very tricky doing this kind of research, because kids respond to so many different things in terms of how well they do at tasks," says Olson.

In addition to questioning whether the training regimen was responsible for the gains, researchers aren't convinced the gains are permanent. "The jury is still out," says G. Reid Lyon, who directs the research programs in learning disabilities, language disorders, and disorders of attention at the National Institute of Child Health and Human Development in Bethesda, Md.

Nevertheless, Tallal and her colleagues plan to set up pilot programs using the treatment regimen at selected schools around the country. They also plan to study whether they can identify infants with the auditory defect, which would allow them to start treatment even earlier.

Furthermore, Tallal is convinced that the modified speech and brain-training games can benefit children with dyslexia as well as those with language impairments. The cause of dyslexia is a hotly debated issue, but most researchers agree that the primary difficulty for those with the condition is a lack of phonological awareness—an inability to break words into individual phonemes.

In order to read new words, explains Lyon, a child must understand how to decode them. "If you come across a word you've never seen before, you can crack it into pieces and blend it back together," says Lyon.

What causes problems with phonological awareness? That's the issue on which investigators are bitterly divided. One camp, says Lyon, maintains that humans have specialized regions of the brain that handle language, including areas devoted to phonological awareness. According to that camp, when those brain regions develop improperly, dyslexia results.

In contrast, Tallal and her colleagues contend that dyslexia may not be a language-specific problem but a reading disorder resulting from difficulties in processing rapid auditory information, whether in speech or other sounds. For the same reason that deaf children face profound challenges in learning to read, she says, children with an inability to distinguish between certain phonemes may never develop the proper phonological awareness needed for reading.

"It's as much of a roadblock to accessing and setting up those individual phonemes in the brain as being deaf is," says Tallal, who estimates that more than 80 percent of language-impaired children have reading problems once they enter school.

Noting that teachers often concentrate more on developing reading skills than proper speech, Tallal suggests that many children with dyslexia have subtle language impairments that have gone undiagnosed. And in an admittedly unknown number of those children, Tallal asserts, the causative agent of the reading and language difficulties may be the auditory defect she and her colleagues have identified. If so, early diagnosis and treatment like that practiced with the language-impaired children could prevent young children from becoming dyslexic.

Researchers are understandably cautious about proclaiming a cure for dyslexia, however. "People in this field have become quite conservative because there have been a number of quick cures proclaimed for dyslexia," comments Sherman. "In life, however, there are usually no quick fixes."

The current furor over how far Tallal's work can be extended will ultimately be settled when her technique is tried on children with dyslexia, says Raymond M. Klein of Dalhousie University in Halifax, Nova Scotia. In the December 1995 PSYCHONOMIC BULLETIN AND REVIEW, he and his colleague Mary E. Farmer reviewed Tallal's past research and the evidence of other investigators tying a time-dependent processing problem to dyslexia.

"If researchers play the slowed up speech to people with dyslexia and their reading improves, that would be powerful evidence," says Klein. □

Letters continued from p. 99

viduals nor groups replicate. Genes are the replicators in DNA-based life, so there is no individual selection and no group selection. There is only gene selection. Gene selection explains both selfishness and altruism, as well as combinations of the two that cannot be explained by either individual selection or group selection.

I think evolution is the most important and most misunderstood idea of our time, and I'm afraid this article both reflects and perpetuates the misunderstanding. In contrast, *The Selfish Gene* and *The Extended Phenotype*, by Richard Dawkins, provide entertaining and definitive explanations of gene selection and the ideas that compete with it.

Roy Sprowl
Seattle, Wash.

Neither Dawkins nor anyone else has set all questions about the nature of evolution to rest. One area of debate now revolves around whether natural selection preserves inherited traits that mainly benefit individuals or, in important ways, groups as well. This debate will not vanish simply because genes are replicators, which both sides agree on.

See the December 1994 BEHAVIORAL AND BRAIN SCIENCES *for D.S. Wilson and E. Sober's critique of Dawkins' views and replies by Dawkins and many others.* — B. Bower

"Return of the Group" seems to refute an old saw. I refer to the statement that groups "... usually do about as well as the sharpest solo decision maker." To me this says that two heads aren't better than one if that one head is sharp!

If businesses could select the sharp individuals, they could really do some downsizing at the upper levels. And think how much money the government could save! Of course the whole process would require intelligent leadership: There's the rub.

Roy E. Landstrom
Cumberland, Ohio

You refer to a set of laboratory experiments often best designed for evoking individual judgments that nonetheless found a surprising amount of power in group decisions. Real-world group studies, such as those mentioned in the article, can begin to address the strengths and weaknesses of group decisions.

Successful businesses usually emphasize coordinated group efforts, not decisions handed down by isolated head honchos. The ways in which businesses select and attempt to control upper-level individuals would make for an interesting study. — B. Bower

CORRECTION

The photograph on p. 13 of "Just Looking' for a Home" (SN: 1/6/96, p. 12) shows the ruffling of a host cell surface that occurs just before a bacterium enters the cell.