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Better reading through brain research

Almost a quarter of a million children are participating in a training program derived from systems neuroscience research to ameliorate reading problems. Their schools, including public schools in big districts such as Philadelphia, have hired Scientific Learning Corporation to help make their students into better readers. The publicly traded company was founded in 1996 by neuroscientists Paula Tallal (Rutgers) and Michael Merzenich (UCSF). It sells software based on research showing that intensive training can improve auditory processing deficits that may underlie reading difficulties such as dyslexia. The company reports that children with reading problems can make language gains of 1 to 2 years after regularly training with the software for a month or two.

In principle, this represents a major achievement in translating basic research into practical benefits. By some estimates, more than 10% of children have language or reading trouble—and problems of poor readers often snowball into even bigger problems later in life. But as the product in this case is software, it does not require the level of scrutiny—such as FDA approval—that is demanded of new pharmaceuticals. It is therefore essential that the long-term outcomes of this large effort be reported in peer-reviewed publications and made available for discussion by scientists. The results will certainly be of theoretical interest for those interested in reading problems. In addition, parents and educators need this information to make informed educational decisions.

Early work from the laboratories of Tallal and others showed that many poor readers have general deficits in discriminating auditory stimuli, such as determining the order of brief, rapidly presented sounds. Because basic speech sounds, or phonemes, are often distinguished from each other by brief acoustic cues (on the order of tens of milliseconds), it is proposed that these low-level auditory deficits may be the root cause of reading problems. More specifically, they may initiate a cascade of subsequent problems, which make it difficult to learn to map phonemes to letters, a skill essential for proficient reading. This mapping is also important for rhyming and sounding out pseudowords, and dyslexics are often impaired on these tasks as well.

In parallel with this work, Merzenich's laboratory demonstrated that auditory training could cause changes in the representation of sounds in the brain. This led to the hypothesis that training might reverse the processing deficits thought to underlie language problems. Scientific Learning Corporation now develops and markets patented interactive computer software based on this idea. The software—the most popular program is called Fast ForWord—takes the form of games that sharpen children's auditory skills while rewarding them in various fun ways for improved performance. In one exercise, children practice skills that are needed to discriminate phonemes. For example, the task might be to determine the order of rapidly presented sounds. As performance improves, the computer delivers subsequent trials at faster speeds, approaching speeds necessary for natural speech distinctions. In another listening exercise, the computer presents speech sounds that are modified to exaggerate the differences between them, so that children can learn important distinctions between the component sounds.

After using these programs, children with language impairments show improvements on various psychophysical tests of auditory processing, and, importantly, their speech discrimination and overall language skills improve as well. A recent fMRI study[1] published by Tallal, Merzenich and others concludes that after Fast ForWord training, brain activation in 20 dyslexic children during a rhyming exercise more closely resembles activation patterns in normal readers, suggesting that the auditory training may set in motion a series of events that previously were unable to develop normally.

Although these are promising results, which have been replicated using related methods in other laboratories, studies in peer-reviewed publications have had a relatively small number of subjects compared with those that would be required for a new drug. In addition, practical experience suggests that there are many different reading strategies, and thus there may be various reasons why children have trouble reading. For these reasons, it is important to track the long-term efficacy of the training on large and diverse populations. This is especially relevant because several schools are now administering the program to all children, not just those at risk for language or reading trouble. This is a questionable move, as for many grade school students, a standard training protocol—100 minutes a day, 5 days a week—represents more than one-third of their school instruction time. And of course the program costs money: although the company does not release cost-per-child figures, its revenue in the 3rd quarter of 2003 was 8 million dollars.

Scientific Learning Corporation has had outside advisors conduct larger field tests of the program, and the results are available on the company's web site. But an independent review is critical to ensure that even unfavorable data would still get published. Many of the schools participating in Fast ForWord upload students' results to the company's computers, so data for a large number of children should be available.

Of course parents and educators should be involved in a critical evaluation of the program. However, scientific studies are important as well, because many schools are under intense pressure to raise test scores to get funding. Thus there is a reasonable concern that schools may be biased toward short-term measurable gains as opposed to long-term practical benefits. Additionally, despite a lack of evidence of their efficacy, parents are often tempted to purchase products that claim to give any kind of edge to their children—such as Mozart tapes to play to their unborn children in the hope of improving their future math skills.

Practical applications of systems neuroscience research have been slow to develop, so we applaud the efforts to distribute the public benefits of this work. As pioneers, however, the new company's owners have no clear path to follow in ensuring that their products are fully tested. Thus it will be critical for the research community to learn to regulate itself to maintain public trust.

1. Temple, E. *et al. Proc. Natl. Acad. Sci. USA* **100**, 2860–2865 (2003).