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What New Brain Wave Research Tells Us About Language-Based Learning Disabilities

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Introduction

For decades, most child language scientists have believed that human beings possess an innate capacity to learn the language spoken to them during the first few years of life. Indeed, the vast majority of children worldwide are never "taught" their mother tongue; rather, they acquire it naturally, just by living in a world where people are speaking the language.

Parsing Speech Sounds

Child language specialists have a word for the ability to tease out the sounds within words—they call it "parsing". When children are first learning their native language they must also "parse" words into sounds so that they can figure out all the sounds in a word as well as the sequence of those sounds. All children have to learn to do this.

Children's speech errors, like saying "top" for stop or "aminal" for animal, often reflect trouble children have with parsing. Language learning also requires parsing to learn grammatical forms like plural or verb tenses. The difference between the words rock,
rocked and rocks necessitates the ability to distinguish all the sounds in each word. But for children with language-learning disabilities, it turns out that this problem parsing words into sounds is particularly difficult, and it affects not only language learning, but also reading and other school achievement.

Audiologists (hearing specialists) and brain researchers have long been interested in how the brain is able to parse words into relevant speech sounds and why some children struggle so much with that task. New research centering on the electrical brain signals picked up by electroencephalogram (EEG) is clarifying the relationship between auditory processing—specifically the ability to parse sounds in words—and language learning.

Brain wave oscillation bands—sometimes thought of as differing brain wave patterns—appear to be a major mechanism coordinating billions of nerves across different brain regions to perform even basic cognitive tasks such as paying attention to someone who is talking and understanding what they are saying. These bands are grouped by their frequency; so-called alpha bands, beta bands, gamma bands and theta bands all refer to brain oscillations of different frequencies.

Brain scientists have discovered ways to use features of these oscillations bands to "see" how different parts of the brain work together. Katia Lehongre and colleagues have found that in humans, gamma bands are especially important for parsing words into sounds. Significantly, in children with language-based learning disabilities (including dyslexia) and children with aspects of language learning disabilities—poor auditory working memory and rapid naming—language and reading problems appear to be related to specific differences in brain oscillation patterns in the areas of the brain important for learning language.

New Research Questions

Scientists postulate that some children's brains may be inefficient for learning language, but very efficient for certain other aspects of learning—perhaps visual processing or even aspects of sound processing important for musical learning. What might cause differences in brain oscillation patterns is largely unknown and open to speculation, but for parents and teachers who work with struggling learners, the question to ask is:

Does remediation of the brain wave patterns improve language skills in children with language problems?

A study published in January 2013, addressed that question and found that the answer is "yes".

Sabime Heim and colleagues at the Center for Molecular and Behavioral Neuroscience, Rutgers University, examined whether oscillations in the gamma band range of the auditory cortex of children with specific language impairments (SLI) change after a specific kind of audio-visual training (Fast ForWord Language), and if that change resulted in improved gamma band efficiency as well as language skills among those children. Study details:

- Twenty-one elementary school students diagnosed with language learning impairment (LLI) underwent the intervention for an average of 32 days.
- Pre- and post-training assessments included standardized language/literacy tests and EEG recordings.
- A control group of twelve children with no language difficulties received the same testing, but no intervention was given.

Questions

The ability to efficiently perceive and sequence two non-speech sounds presented as quickly as speech sounds are in words is often referred to as Rapid Auditory Processing (RAP).

Heim et al wanted to know:

1. In children with language learning problems who have problems parsing words into sounds, could their difficulty with RAP be seen in the efficiency measure of the gamma band oscillations?
2. Does intervention with the Fast ForWord Language program, designed in part to improve RAP, improve gamma band efficiency measures and if so…
3. Does an improvement in gamma band efficiency correlate with improvements in language?

Answers

EEG measures made by the authors before Fast ForWord Language showed what they expected— reduced efficiency components of the oscillations in the gamma-band range (29–52 Hz) among the children with LLI. The reductions occurred where the scientists expected, on the second of two rapidly presented tones. Some answers to the questions above:

1. In short, the answer is yes. The children with language-based learning disabilities did in fact have a reduction in brain activity associated with sounds that occur as rapidly as speech sounds do during normal talking.
2. In answer to the second question—*do the brain efficiency measures and language skills improve after training?*—the authors found that yes, there was an improvement in gamma band efficiency. Amplitude, one of the two efficiency measures, was no longer reduced on the second tone after Fast ForWord training.
3. Finally, and perhaps most importantly, improvements in gamma band efficiency did – in the majority of cases- correlate with language improvements on standardized tests. The children with language-based learning disabilities who had used Fast ForWord Language showed improvements in core language skills, expressive language skills, and receptive language skills (as measured by the CELF-4).

The authors concluded that measures of brain wave efficiency are not only correlated with auditory processing problems in children with language-based learning disabilities, but that the Fast ForWord Language program improves at least one measure of the brain wave efficiency and that is in turn correlated with improvements both in RAP accuracy and also language skills.

References

Heim, S., Keil, A., Choudhury, N., Thomas Friedman, J. & Benasich, A. (2013). Early gamma oscillations during rapid auditory processing in children with a language-learning impairment: Changes in neural mass activity after training. Neuropsychologia, 51, 990-1001.

Lehongre, K., Ramus, F., Villiermet, N., Schwartz, D., & Giraud, A. (2011)Altered Low-Gamma Sampling in Auditory Cortex Accounts for the Three Main Facets of Dyslexia. Neuron, 72, 1080–1090.

Siegel, M., Donner, T., & Engel, A. (2012) Spectral fingerprints of large-scale neuronal interactions. Nature Reviews Neuroscience, 13, 121-131.