Re-training the Brain: Using Neurofeedback to Help Individuals with Autism Spectrum Disorders

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Evan's mom was desperate; her son tantrummed ten to twenty times most days. She could not leave him alone with his younger brother Daniel, even for a few minutes, without Evan becoming aggressive and attacking his little brother. He was intensely bothered by any change in routine. Evan's "play" consisted entirely of obsessively lining up or arranging toys or other objects and he would immediately become furious if his arrangement were in any way altered. He used only two to three word phrases. He avoided all interactions with peers at school and showed only brief and inconsistent bouts of engagement with his parents. An experienced autism therapist was unable to work with him using a social developmental approach due to his severe levels of anxiety and over-arousal. Here is Evan's mother's description of the situation:

"My son was a normal baby who, around 15 months old, stopped talking, more or less stopped smiling, started screaming a lot, and became very obsessive….By the time he was 3.5 years old, he was very non-compliant, and aggressive toward his younger brother. He spent much of the day screaming or smashing his head into the wall or floor. His obsessions were so strong they ran our lives. I had difficulty bathing him, getting him dressed, and especially, keeping him from hurting his brother. Everything was a struggle. He was diagnosed with autism (PDD-NOS) around this time. A few months later my son started EEG biofeedback."

At each EEG biofeedback session, (also called neurofeedback or neurotherapy) Evan would sit on his mother's lap (as if she were a booster seat) while silver electrodes (we called them magic rings) were attached with a conductive paste to his scalp and to each of his earlobes. Then he would watch the computer monitor while Pacman gobbled up dots.

Pacman gobbled quickly and glowed brightly at those times when the brain area being monitored by the electrodes showed a more organized, controlled, or modulated brainwave response – when it showed a level of physiological activation that was consistent with a calm and alert state of mind and with increased resilience and flexibility. Pacman stopped gobbling and turned black whenever this brain area became over- or under-activated, when it showed the electrophysiological signature of disorganization, breakdown, or diminished function.

Initially, we had to reward Evan with his favorite treat every 60 seconds to help him sit still and watch the screen. Gradually the length of the time he could focus increased.

After about two months of twice weekly training sessions, Evan's mood, behavior, and social relatedness had shifted significantly. He became calmer, showed much less repetitive behavior, and much more social engagement. After three months, his overall profile was dramatically different. Far from being a booster seat, his mom became his favorite play partner. Instead of looking at the feedback screen, he was constantly turning around to look at his mom and play silly face games with her, with both erupting with laughter. What a great problem - that he was more interested in her face than the feedback screens!

After six moths of neurofeedback, Evan played with Daniel frequently and cooperatively, including pretend play. Once, while getting a toy for himself with his mother, he asked her to get a toy for Daniel that he thought Daniel would like. On another occasion, when Daniel felt afraid at night, Evan invited him into his bed to comfort him. Evan's mom summarized these changes:

"He is now a nice little boy. He gives me kisses when I am sad. He is no more aggressive with his brother than any normal kid. In fact, he is very tolerant. His obsessions have decreased markedly. I am extremely grateful to have my child back. I am convinced that it is this treatment (EEG biofeedback) that has changed him."

Especially in the context of these very positive results, it is important to emphasize that those were not magic rings. They were common, everyday disk electrodes that simply transmitted the tiny electrical signal gathered at the scalp (measured in millionths of a volt) through a wire to an amplifier and from there to computer. The treatment or training was not magic either. It simply

involved employing the computational power of the computer to analyze the brain's electrical activity, decompose it into its component parts or bands, and then present this activity to Evan in a simplified visual and auditory form together with a series of hints about a desired direction of change. We know now from numerous scientific studies that the human brain is able to use this type of information to reorganize or shift its function in the direction of improved function.

THE EEG

We are accustomed, due at least in part to the dominance of the pharmaceutical industry and the medical model, to think of brain activity in chemical terms, as occurring through the work of neurotransmitters. But neurotransmitters serve the purpose of enabling the transmission of a nerve impulse – an electrical event – between nerves. The brain is a bioelectric organ in which literally billions of nerves work in incredibly complex networks.
One window into this domain of brain functioning is the electroencephalogram, commonly called EEG. The EEG has been used since it was discovered in 1929 to record and study the electrical activity of the outermost layer of the brain – the cerebral cortex. It is usually thought of exclusively as a way to diagnose epilepsy (seizure disorders). In a routine EEG, a neurologist or electroencephalographer (EEG specialist) visually examines the traces of the oscilloscope which show the brain's electrical activity in the form of a line with repetitive wave-like activity. Hence the name "brainwaves"

It has long been known that the speed of this EEG waveform, measured as the number of times per second that the wave goes from one peak to the next (cycles per second or cps), reflects the degree of activation of the area of the brain beneath the electrode. Slower waveform activity (fewer cycles per second) indicate lowered blood flow and fuel (glucose) use in that part of the brain. Faster EEG activity indicates increased brain activity. These types of brain electrical activity also reflect the level of arousal of the person: delta activity (2-4 cps) accompanies deep sleep, theta (4-7cps) states of drowsiness, alpha (8-11 cps) relaxed states. Beta range activity reflects an engaged or active brain, and, with very fast beta activity, an excited or urgent/emergency state of mind.

Clinical work making use of a more advanced form of electroencephalogram called the quantitative EEG (see article in previous issue of the Digest) has shown that individuals with autism show abnormalities in the brain's electrical

activity or function in a variety of areas of the cerebral cortex - the outermost layer of the brain and the part of the brain responsible for higher forms of thinking or processing. These clinic-based qEEG findings are also largely consistent with results from other forms of functional neuro-imaging research, including fMRI, SPECT, and PET, which, like qEEG allow us to see the brain at work.

Based on these findings, it is clear that the EEG reveals aspects of brain function that are significantly related to the pattern or profile of neurological strengths and weaknesses involved in autistic spectrum disorders, even if they are not the cause (or one of the causes) of the dysfunction. In short, the EEG is showing us (at least some aspects of) the neurological dysfunction in autism. And it is providing us with a means to alter that dysfunction, because when we are given real time information about our brain's electrical activity (through EEG biofeedback), we are capable of altering it in the direction of improved function.

BIOFEEDBACK

In virtually every area of our lives, we are able to improve our performance when we get clear and immediate feedback about how we are doing. That is one of the key reasons why athletic performance has shown such dramatic improvements recently—sophisticated physiological monitoring technology has enabled the athlete to gain a much greater degree of information about all aspects of physical performance, and this allows for sharpening of skills. The same sort of technological sophistication now enables us to directly alter the functioning of our brains to improve performance. Neuroscience has shown repeatedly that the brain is capable of enormous change or plasticity; the brain is amazingly adaptable. Advanced EEG biofeedback technology provides instantaneous (real time) information to the brain about how it is functioning along with continuous hints or cues about how to make adjustments toward improved functioning. And repeated studies have shown that our brains are able to use this information to re-regulate its function.

Though the technology is quite complex, the training activity is simple, painless, and non-invasive. Electrodes are placed on the scalp and EEG activity is transmitted to a computer. Auditory and visual feedback is provided instantly, so that you see and hear representations of your brain in action. The goal is to reduce or limit certain types of brainwaves and increase others. As your brain reorganizes itself based on this instantaneous information, it develops increased resilience and flexibility.

Ordinarily, we cannot influence our brain's activity because we lack awareness of it. However, when you can see the changes in this activity on a computer screen a few thousandths of a second after they occur, you gain the ability to influence and change this activity. The mechanism of action is similar to every other form of learning or training. Neurofeedback is a form of training or exercise for the brain, assisted with a very sophisticated technology, and guided or directed by knowledge gained through the advances of neuroscience.

At the most basic level, the process of neurofeedback is like a game of hide and seek. If the seeker is having a hard time, he will often get a series of hints about where to look: “You’re getting colder. Now warmer, warmer, hot….” In neurofeedback, the trainee is seeking improved brain function, and the feedback is exactly like the “hotter” and “colder” hints: as the brain moves momentarily in the direction of improved function, the feedback shows and tells the trainee, essentially, “You’re getting warmer”. Conversely, as the brain moves momentarily in the direction of diminished function, the feedback tells and shows the trainee, “You’re getting colder”.

The format for the feedback may take many forms. It is sometimes provided in the form of videogame-like displays, or a simpler display of bars or squares of color. Auditory feedback may take the form of beeps or tones when all goals are met or continuous auditory feedback, like rising and falling pitch or volume. A promising new modality employs NASA developed technology to use off the shelf (PlayStation, X-Box, Nintendo) videogames to provide feedback; the EEG continuously alters the play of a specially modified game controller so that when the trainee’s brain is responding positively, the trainee has full speed and directional control. When the EEG shows signs of dysfunction, the trainee loses speed and control. This technology promises to solve the sometimes difficult problem of motivation. Most trainees find the initial training sessions interesting, exciting, and fun. But after multiple sessions, the novelty wears off and the task can become boring and repetitious, leading to resistance and opposition. Few trainees will resist the opportunity to play their favorite videogame

Most adults ask how the trainee alters the EEG, what does he actually do to control those brainwaves? The answer is nothing - nothing intentional, conscious, or willful. The trainee just watches and listens – takes in the information and the hints and allows the brain to continuously and

progressively adjust or re-organize its function so that the goal is attained over time.

In this respect, the activity of neurofeedback is no different from most human actions. We learn to do everything we do through a feedback informed learning process: we take an action, receive feedback regarding that action, adjust the response based on this feedback toward a closer approximation of the desired action, and so on. EEG biofeedback simply makes it possible to follow this process for learning brain function.

THE EVIDENCE ON EFFECTIVENESS

Multiple studies in numerous research centers around the world have demonstrated the effectiveness of neurofeedback for several types of neurologically based difficulties. The research is strongest and the results most conclusively show the efficacy of neurofeedback for ADHD and for seizure disorders. Even here however, as is invariably the case in science, individual scientists draw quite different conclusions from the same body of evidence. For example, Russell Barkeley, a well known ADHD expert views neurofeedback "as an unproven and highly experimental treatment for ADHD at best…" By contrast, several other internationally recognized ADHD experts (Sears, Thompson, Hartmann to name a few) strongly recommend neurofeedback for ADHD.

Studies have also documented effectiveness of neurofeedback for the neurological sequelae of closed head injury or traumatic brain injury, for anxiety, depression, learning disabilities, and migraines. More research needs to be completed before the effectiveness of neurofeedback in these areas can be considered proven. However, I believe that a fair and balanced reading of all of the research indicates that there is substantial scientific evidence demonstrating the efficacy of neurofeedback for neurodevelopmental difficulties in general. (A comprehensive bibliography on the research on neurofeedback can be obtained at www.isnr.org/nfbarch/nbiblio.htm.) This view is shared by many other empirically minded experts. For example, Frank Duffy, MD, Neurologist, Head of the Neuroimaging Department and of Neuroimaging Research at Boston Children's Hospital, conducted an independent review of the research on neurofeedback for the peer edited neurology journal Clinical Electroencephalography (2000). He summarized his findings as follows:

"The literature, which lacks any negative study of substance, suggests that EEG

biofeedback therapy should play a major therapeutic role in many difficult areas. In my opinion, if any medication had demonstrated such a wide spectrum of efficacy, it would be universally accepted and widely used. “
One preliminary study has been completed investigating the use of neurofeedback specifically with children with autism. Twenty-four autistic children were divided into two groups, which were similar in sex, age, and severity. One group received neurofeedback training and the other acted as a control. The Autism Treatment Evaluation Checklist (ATEC) was used to measure outcome. Neurofeedback training resulted in a 26% average reduction in total autistic symptoms compared to a 3% reduction in the control group. Improvements were seen in all areas rated: socialization, vocalization, anxiety, schoolwork, tantrums, and sleep. This study represents a promising beginning, but much more research needs to be done.

The rationale for using neurofeedback for ASD is in many respects similar to that for use of psychiatric medications. No psychiatric medication has been conclusively shown to specifically benefit individuals with ASD. However, since most individuals with ASD have problems with attention, anxiety, and mood, and since psychiatric medications have been shown effective for these specific areas of difficulty, it makes sense to try them with individuals with ASD. Precisely the same is true for neurofeedback: research has demonstrated effectiveness of NFB with attention, anxiety, and mood, indicating that it may help in these areas with ASD.

Another type of evidence for the effectiveness of an intervention comes from individual case examples and the accumulated experiences of practitioners and their clients around the world - anecdotal evidence. Although there are many weaknesses in this type of evidence, when the formal research science is uncertain, and there are reasons to believe the intervention may have significant benefit, this level of evidence remains important to evaluate. Neurofeedback is now being provided to individuals with autistic spectrum disorder in clinics, offices, and treatment centers all over the world. This includes individuals with more severe forms of ASD and individuals with high functioning autism, Asperger’s disorder, and non-verbal learning disorder. The internet and practitioner and client list servers allow for the rapid dissemination of the findings from this very widespread body of evidence. Overall, results are quite promising, and seem quite consistent across centers doing this work.

In our experience at The NeuroDevelopment Center, approximately 90% of individuals with ASD benefit. Most benefit substantially. We reliably see

improved attention, organizational skills, and other aspects of what is called executive function. We almost invariably see a greater degree of awareness of or attention to the environment. For example, one special educator described the changes she had observed after 8 sessions of neurofeedback with a boy with Asperger's: "Since Sean began his appointments with you we have noticed the following changes in him:

• A new interest in conversing with his peers; he has been joining in conversations during snack
• He now listens to whole group instructions and asks appropriate questions if he does not understand something, instead of needing the directions repeated one on one after the lessons
• He works more independently in all curriculum areas and is very proud of his independence
• He is able to generate ideas for writing and organizes his thoughts independently
• He remembers to do his classroom job without prompting
• When he is out of the classroom for services, he asks a classmate without prompting for the assignment he missed and writes it down
• In general, he seems more "aware" of everything than he used to be"

Neurofeedback also reliably helps the ASD trainees to feel calmer, happier, and less prone to anxiety and anger. Linked to this are improvements in flexibility, with greater capacity to tolerate and successfully cope with change or unexpected events. Behavioral and emotional self- control is frequently improved. Another frequent result is improved motor function – motor planning, improved tone, better handwriting. All of these together seem to lead to improved social functioning.

It is important to recognize though that there are difference among trainees in the degree of change. With a few clients, we have seen no discernible change. This is rare, representing only 6% of the individuals we have worked with, and in all of those cases, the individuals completed no more than 15 sessions. Sometimes the results are subtle. Our most frequent outcome is a substantial improvement in most of the areas listed above, so substantial that family members, educators, and other professionals involved agree that there has been benefit. We have seen a few individuals where neurofeedback has made a huge, probably life-course altering impact.

Neurofeedback is not a cure for autistic spectrum disorders. It is not

miraculous. It doesn’t help every child. It can be complicated and trying. Sometimes it helps a lot, sometimes a little. But it does often help in ways that no other method I know of can match.