19. REWIRING THE BRAIN: NEUROFEEDBACK

You are being provided with a book chapter by chapter. I will request you to read the book for me after each chapter. After reading the chapter, 1. shorten the chapter to no less than 300 words and no more than 400 words. 2. Do not change the name, address, or any important nouns in the chapter. 3. Do not translate the original language. 4. Keep the same style as the original chapter, keep it consistent throughout the chapter. Your reply must comply with all four requirements, or it's invalid.
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CHAPTER 19
REWIRING THE BRAIN:
NEUROFEEDBACK

Is it a fact—or have I dreamt it—that by means of electricity, the world of matter has become a great nerve, vibrating thousands of miles in a breathless point of time?
—Nathaniel Hawthorne

The faculty of voluntarily bringing back a wandering attention, over and over again, is the very root of the judgment, character, and will.
—William James

he summer after my first year of medical school, I worked as a part-time research assistant in Ernest Hartmann's sleep laboratory at Boston State Hospital. My job was to prepare and monitor the study participants and to analyze their EEG—electroencephalogram, or brain wave—tracings. Subjects would show up in the evening; I would paste an array of wires onto their scalps and another set of electrodes around their eyes to register the rapid eye movements that occur during dreaming. Then I would walk them to their bedrooms, bid them good night, and start the polygraph, a bulky machine with thirty-two pens that transmitted their brain activity onto a continuous spool of paper.

Even though our subjects were fast asleep, the neurons in their brains kept up their frenzied internal communication, which was transmitted to the polygraph throughout the night. I'd settle down to pore over the previous night's EEGs, stopping from time to time to pick up baseball scores on my radio, and use the intercom to wake subjects whenever the polygraph showed a REM sleep cycle. I would ask what they had dreamed about and write down what they reported and then in the morning help them fill out a questionnaire about sleep quality and send them on their way.

Those quiet nights at Hartmann's lab documented a great deal about REM sleep and contributed to building the basic understanding of sleep processes, which paved the way for the crucial discoveries that I discussed in chapter 15. However, until recently, the long-standing hope that the EEG would help us better understand how electrical brain activity contributes to psychiatric problems remained largely unrealized.

MAPPING THE ELECTRICAL CIRCUITS OF THE BRAIN

Before the advent of the pharmacological revolution, it was widely understood that brain activity depends on both chemical and electrical signals. The subsequent dominance of pharmacology almost obliterated interest in the electrophysiology of the brain for several decades.

The first recording of the brain's electrical activity was made in 1924 by the German psychiatrist Hans Berger. This new technology was initially met with skepticism and ridicule by the medical establishment, but electroencephalography gradually became an indispensable tool for diagnosing seizure activity in patients with epilepsy. Berger discovered that different brain-wave patterns reflected different mental activities. (For example, trying to solve a math problem resulted in bursts at a moderately fast frequency band known as beta.) He hoped that eventually science would be able to correlate different psychiatric problems with specific EEG irregularities. This expectation was fueled by the first reports on EEG patterns in "behavior problem children" in 1938.1 Most of these hyperactive and impulsive children had slower-than-normal waves in their frontal lobes. This finding has been reproduced innumerable times since then, and in 2013 slow-wave prefrontal activity was certified by the Food and Drug Administration as a biomarker for ADHD. Slow frontal lobe electrical activity explains why these kids have poor executive functioning: Their rational brains lack proper control over their emotional brains, which also occurs when abuse and trauma have made the emotional centers hyperalert to danger and organized for fight or flight.

Early in my career I also hoped that the EEG might help us to make better diagnoses, and between 1980 and 1990 I sent many of my patients to get EEGs to determine if their emotional instability was rooted in neurological abnormalities. The reports usually came back with the phrase: "nonspecific temporal lobe abnormalities."2 This told me very little, and because at that time the only way we could change these ambiguous patterns was with drugs that had more side effects than benefits, I gave up doing routine EEGs on my patients.

Then, in 2000, a study by my friend Alexander McFarlane and his associates (researchers in Adelaide, Australia) rekindled my interest, as it documented clear differences in information processing between traumatized subjects and a group of "normal" Australians. The researchers used a standardized test called "the oddball paradigm" in which subjects are asked to detect the item that doesn't fit in a series of otherwise related images (like a trumpet in a group of tables and chairs). None of the images was related to trauma.

Normal versus PTSD. Patterns of attention. Milliseconds after the brain is presented with input it starts organizing the meaning of the incoming information. Normally, all regions of the brain collaborate in a synchronized pattern (left), while the brainwaves in PTSD are less well coordinated; the brain has trouble filtering out irrelevant information, and has problems attending to the stimulus at hand.

In the "normal" group key parts of the brain worked together to produce a coherent pattern of filtering, focus, and analysis. (See left image below.) In contrast, the brain waves of traumatized subjects were more loosely coordinated and failed to come together into a coherent pattern. Specifically, they did not generate the brain-wave pattern that helps people pay attention on the task at hand by filtering out irrelevant information (the upward curve, labeled N200). In addition, the core information-processing configuration of the brain (the downward peak, P300) was poorly defined; the depth of the wave determines how well we are able to take in and analyze new data. This was important new information about how traumatized people process nontraumatic information that has profound implications for understanding day-to-day information processing. These brain-wave patterns could explain why so many traumatized people have trouble learning from experience and fully engaging in their daily lives. Their brains are not organized to pay careful attention to what is going on in the present moment.

Sandy McFarlane's study reminded me of what Pierre Janet had said back in 1889: "Traumatic stress is an illness of not being able to be fully alive in the present." Years later, when I saw the movie The Hurt Locker, which dealt with the experiences of soldiers in Iraq, I immediately recalled Sandy's study: As long as they were coping with extreme stress, these men performed with pinpoint focus; but back in civilian life they were overwhelmed having to make simple choices in a supermarket. We are now seeing alarming statistics about the number of returning combat veterans who enroll in college on the GI Bill but do not complete their degrees. (Some estimates are over 80 percent.) Their well-documented problems with focusing and attention are surely contributing to these poor results.

McFarlane's study clarified a possible mechanism for the lack of focus and attention in PTSD, but it also presented a whole new challenge: Was there any way to change these dysfunctional brain-wave patterns? It was seven years before I learned that there might be ways to do that.

In 2007 I met Sebern Fisher at a conference on attachment-disordered children. Sebern was the former clinical director of a residential treatment center for severely disturbed adolescents, and she told me that she'd been using neurofeedback in her private practice for about ten years. She showed me before-and-after drawings made by a ten-year-old. This boy had had such severe temper tantrums, learning disabilities, and overall difficulties with self-organization that he could not be handled in school.3

His first family portrait (on the left opposite), drawn before treatment started, was at the developmental level of a three-year-old. Less than five weeks later, after twenty sessions of neurofeedback, his tantrums had decreased and his drawing showed a marked improvement in complexity. Ten weeks and another twenty sessions later, his drawing took another leap in complexity and his behavior normalized.

I had never come across a treatment that could produce such a dramatic change in mental functioning in so brief a period of time. So when Sebern offered to give me a neurofeedback demonstration, I eagerly accepted.

SEEING THE SYMPHONY OF THE BRAIN

At Sebern's office in Northampton, Massachusetts, she showed me her neurofeedback equipment—two desktop computers and a small amplifier—and some of the data she had collected. She then pasted one electrode on each side of my skull and another on my right ear. Soon the computer in front of me was displaying rows of brain waves like the ones I'd seen on the sleep-lab polygraph three decades earlier. Sebern's tiny laptop could detect, record, and display the electrical symphony of my brain faster and more precisely than what had probably been a million dollars' worth of equipment in Hartmann's lab.

From stick figures to clearly defined human beings. After four months of neurofeedback, a ten-year-old boy's family drawings show the equivalent of six years of mental development.

As Sebern explained, feedback provides the brain with a mirror of its own function: the oscillations and rhythms that underpin the currents and crosscurrents of the mind. Neurofeedback nudges the brain to make more of some frequencies and less of others, creating new patterns that enhance its natural complexity and its bias toward self-regulation.4 "In effect," she told me, “we may be freeing up innate but stuck oscillatory properties in the brain and allowing new ones to develop.”

Sebern adjusted some settings, “to set the reward and inhibit frequencies,” as she explained, so that the feedback would reinforce selected brain-wave patterns while discouraging others. Now I was looking at something like a video game featuring three spaceships of different colors. The computer was emitting irregular tones, and the spaceships were moving quite randomly. I discovered that when I blinked my eyes they stopped, and when I calmly stared at the screen they moved in tandem, accompanied by regular beeps. Sebern then encouraged me to make the green spaceship move ahead of the others. I leaned forward to concentrate, but the harder I tried, the more the green spaceship fell behind. She smiled and told me that I’d do much better if I’d just relax and let my brain take in the feedback that the computer was generating. So I sat back, and after a while the tones grew steadier and the green spaceship started pulling ahead of the others. I felt calm and focused—and my spaceship was winning.

In some ways neurofeedback is similar to watching someone’s face during a conversation. If you see smiles or slight nods, you’re rewarded, and you go on telling your story or making your point. But the moment your conversation partner looks bored or shifts her gaze, you’ll start to wrap up or change the topic. In neurofeedback the reward is a tone or movement on the screen instead of a smile, and the inhibition is far more neutral than a frown—it’s simply an undesired pattern.

Next Sebern introduced another feature of neurofeedback: its ability to track circuitry in specific parts of the brain. She moved the electrodes from my temples to my left brow, and I started to feel sharp and focused. She told me she was rewarding beta waves in my frontal cortex, which accounted for my alertness. When she moved the electrodes to the crown of my head, I felt more detached from the computer images and more aware of the sensations in my body. Afterward she showed me a summary graph that recorded how my brain waves had changed as I experienced subtle shifts in my mental state and physical sensations.

How could neurofeedback be used to help to treat trauma? As Sebern explained: “With neurofeedback we hope to intervene in the circuitry that promotes and sustains states of fear and traits of fearfulness, shame, and rage. It is the repetitive firing of these circuits that defines trauma.” Patients need help to change the habitual brain patterns created by trauma and its aftermath. When the fear patterns relax, the brain becomes less susceptible to automatic stress reactions and better able to focus on ordinary events. After all, stress is not an inherent property of events themselves—it is a function of how we label and react to them. Neurofeedback simply stabilizes the brain and increases resiliency, allowing us to develop more choices in how to respond.

THE BIRTH OF NEUROFEEDBACK

Neurofeedback was not a new technology in 2007. As early as the late 1950s University of Chicago psychology professor Joe Kamiya, who was studying the phenomenon of internal perception, had discovered that people could learn through feedback to tell when they were producing alpha waves, which are associated with relaxation. (It took some subjects only four days to reach 100 percent accuracy.) He then demonstrated that they could also enter voluntarily into an alpha state in response to a simple sound cue.

In 1968 an article about Kamiya’s work was published in the popular magazine Psychology Today, and the idea that alpha training could relieve stress and stress-related conditions became widely known.5 The first scientific work showing that neurofeedback could have an effect on pathological conditions was done by Barry Sterman at UCLA. The National Aeronautics and Space Administration had asked Sterman to study the toxicity of a rocket fuel, monomethylhydrazine (MMH), which was known to cause hallucinations, nausea, and seizures. Sterman had previously trained some cats to produce a specific EEG frequency known as the sensorimotor rhythm. (In cats this alert, focused state is associated with waiting to be fed.) He discovered that while his ordinary lab cats developed seizures after exposure to MMH, the cats that had received neurofeedback did not. The training had somehow stabilized their brains.

In 1971 Sterman attached his first human subject, twenty-three-year-old Mary Fairbanks, to a neurofeedback device. She had suffered from epilepsy since the age of eight, with grand mal seizures two or more times a month. She trained for an hour a day twice a week. At the end of three months she was virtually seizure free. Sterman subsequently received a grant from the National Institutes of Health to conduct a more systematic study, and the impressive results were published in the journal Epilepsia in 1978.6

This period of experimentation and huge optimism about the potential of the human mind came to an end in the middle 1970s with newly discovered psychiatric drugs. Psychiatry and brain science adopted a chemical model of mind and brain, and other treatment approaches were relegated to the back burner.

Since then the field of neurofeedback has grown by fits and starts, with much of the scientific groundwork being done in Europe, Russia, and Australia. Even though there are about ten thousand neurofeedback practitioners in the United States, the practice has not been able to garner the research funding necessary to gain widespread acceptance. One reason may be that there are multiple competing neurofeedback systems; another is that the commercial potential is limited. Only a few applications are covered by insurance, which makes neurofeedback expensive for consumers and prevents practitioners from amassing the resources necessary to do large-scale studies.

FROM A HOMELESS SHELTER TO THE NURSING STATION

Sebern had arranged for me to speak with three of her patients. All told remarkable stories, but as I listened to twenty-seven-year-old Lisa, who was studying nursing at a nearby college, I felt myself truly awakening to the stunning potential of this treatment. Lisa possessed the greatest single resilience factor humans can have: She was an appealing person—engaging, curious, and obviously intelligent. She made great eye contact, and she was eager to share what she had learned about herself. Best of all, like so many survivors I’ve known, she had a wry sense of humor and a delicious take on human folly.

Based on what I knew about her background, it was a miracle that she was so calm and self-possessed. She had spent years in group homes and mental hospitals, and she was a familiar presence in the emergency rooms of western Massachusetts—the girl who regularly arrived by ambulance, half dead from prescription drug overdoses or bloody from self-inflicted wounds.

Here is how she began her story: “I used to envy the kids who knew what would happen when their parents got drunk. At least they could predict the havoc. In my home there was no pattern. Anything could set my mother off—eating dinner, watching TV, coming home from school, getting dressed—and I never knew what she was going to do or how she would hurt me. It was so random."

Her father had abandoned the family when Lisa was three years old, leaving her at the mercy of her psychotic mother. "Torture" is not too strong a word to describe the abuse she endured. "I lived up in the attic room," she told me, "and there was another room up there where I would go and piss on the carpet because I was too scared to go downstairs to the bathroom. I would take all the clothes off my dolls and drive pencils into them and put them up in my window."

When she was twelve years old, Lisa ran away from home and was picked up by the police and returned. After she ran away again, child protective services stepped in, and she spent the next six years in mental hospitals, shelters, group homes, foster families, and on the street. No placement lasted, because Lisa was so dissociated and self-destructive that she terrified her caretakers. She would attack herself or destroy furniture and afterward she would not remember what she had done, which earned her a reputation as a manipulative liar. In retrospect, Lisa told me, she simply lacked the language to communicate what was going on with her.

When she turned eighteen, she "matured out" of child protective services and started an independent life, one without family, education, money, or skills. But shortly after discharge she ran into Sebern, who had just acquired her first neurofeedback equipment and remembered Lisa from the residential treatment center where she had once worked. She'd always had a soft spot for this lost girl, and she invited Lisa to try out her new gizmo.

As Sebern recalled: "When Lisa first came to see me, it was fall. She walked around with a vacant stare, carrying a pumpkin wherever she went. There just wasn't a there there. I wasn't ever sure that I had gotten to any organizing self." Any form of talk therapy was impossible for Lisa. Whenever Sebern asked her about anything stressful, she would shut down or go into a panic. In Lisa's words: "Every time we tried to talk about what had happened to me growing up, I would have a breakdown. I would wake up with cuts and burns and I wouldn't be able to eat. I wouldn't be able to sleep."

Her sense of terror was omnipresent: "I was afraid all the time. I didn't like to be touched. I was always jumpy and nervous. I couldn't close my eyes if another person was around. There was no convincing me that someone wasn't going to kick me the second I closed my eyes. That makes you feel crazy. You know you're in a room with someone you trust, you know intellectually that nothing's going to happen to you, but then there's the rest of your body and you can't ever relax. If someone put their arm around me, I would just check out." She was stuck in a state of inescapable shock.

Lisa recalled dissociating when she was a little girl, but things got worse after puberty: "I started waking up with cuts, and people at school would know me by different names. I couldn't have a steady boyfriend because I would date other guys when I was dissociated and then not remember. I was blacking out a lot and opening my eyes into some pretty strange situations." Like many severely traumatized people, Lisa could not recognize herself in a mirror.7 I had never heard anyone describe so articulately what it was like to lack a continuous sense of self.

There was no one to confirm her reality. "When I was seventeen and living in the group home for severely disturbed adolescents, I cut myself up really badly with the lid of a tin can. They took me to the emergency room, but I couldn't tell the doctor what I had done to cut myself—I didn't have any memory of it. The ER doctor was convinced that dissociative identity disorder didn't exist. . . . A lot of people involved in mental health tell you it doesn't exist. Not that you don't have it, but that it doesn't exist."

The first thing Lisa did after she aged out of her residential treatment program was to go off her medications: "This doesn't work for everybody," she acknowledged, "but it turned out to be personally the right choice. I know people who need meds, but that was not the case for me. After going off them and starting neurofeedback, I became much clearer."

When she invited Lisa to do neurofeedback, Sebern had little idea what to expect, as Lisa would be the first dissociative patient she tried it on. They met twice a week and started by rewarding more coherent brain patterns in the right temporal lobe, the fear center of the brain. After a few weeks Lisa noticed she was wasn't as uptight around people, and she no longer dreaded the basement laundry room in her building. Then came a bigger breakthrough: She stopped dissociating. "I'd always had a constant hum of low-level conversations in my head," she recalled. "I was scared I was schizophrenic. After half a year of neurofeedback I stopped hearing those noises. I integrated, I guess. Everything just came together."

As Lisa developed a more continuous sense of self, she became able to talk about her experiences: "I now can actually talk about things like my childhood. For the first time I started being able to do therapy. Up till then I didn't have enough distance and I couldn't calm down enough. If you're still in it, it's hard to talk about it. I wasn't able to attach in the way that you need to attach and open up in the way that you need to open up in order to have any type of relationship with a therapist." This was a stunning revelation: So many patients are in and out of treatment, unable to meaningfully connect because they are still "in it." Of course, when people don't know who they are, they can't possibly see the reality of the people around them.

Lisa went on: "There was so much anxiety around attachment. I would go into a room and try to memorize every possible way to get out, every detail about a person. I was trying desperately to keep track of everything that could hurt me. Now I know people in a different way. It's not based on memorizing them out of fear. When you're not afraid of being hurt, you can know people differently."

This articulate young woman had emerged from the depths of despair and confusion with a degree of clarity and focus I had never seen before. It was clear that we had to explore the potential of neurofeedback at the Trauma Center.

GETTING STARTED IN NEUROFEEDBACK

First we had to decide which of five different existing neurofeedback systems to adopt, and then find a long weekend to learn the principles and practice on one another.8 Eight staff members and three trainers volunteered their time to explore the complexities of EEGs, electrodes, and computer-generated feedback. On the second morning of the training, when I was partnered with my colleague Michael, I placed an electrode on the right side of his head, directly over the sensorimotor strip of his brain, and rewarded the frequency of eleven to fourteen hertz. Shortly after the session ended, Michael asked for the attention of the group. He'd just had a remarkable experience, he told us. He had always felt somewhat on edge and unsafe in the presence of other people, even colleagues like us. Although nobody seemed to notice—he was, after all, a well-respected therapist—he lived with a chronic, gnawing sense of danger. That feeling was now gone, and he felt safe, relaxed, and open. Over the next three years Michael emerged from his habitual low profile to challenge the group with his insights and opinions, and he became one of the most valuable contributors to our neurofeedback program.

With the help of the ANS Foundation we started our first study with a group of seventeen patients who had not responded to previous treatments. We targeted the right temporal area of the brain, the location that our early brain-scan studies (described in chapter 3)9 had shown to be excessively activated during traumatic stress, and gave them twenty neurofeedback sessions over ten weeks.

Because most of these patients suffered from alexithymia, it was not easy for them to report their response to the treatments. But their actions spoke for them: They consistently showed up on time for their appointments, even if they had to drive through snowstorms. None of them dropped out, and at the end of the full twenty sessions, we could document significant improvements not only in their PTSD scores,10 but also in their interpersonal comfort, emotional balance, and self-awareness.11 They were less frantic, they slept better, and they felt calmer and more focused.

In any case, self-reports can be unreliable; objective changes in behavior are much better indicators of how well treatment works. The first patient I treated with neurofeedback was a good example. He was a professional man in his early fifties who defined himself as heterosexual, but he compulsively sought homosexual contact with strangers whenever he felt abandoned and misunderstood. His marriage had broken up around this issue, and he had become HIV positive; he was desperate to gain control over his behavior. During a previous therapy he had talked extensively about his sexual abuse by an uncle at around the age of eight. We assumed that his compulsion was related to that abuse, but making that connection had made no difference in his behavior. After more than a year of regular psychotherapy with a competent therapist, nothing had changed.

A week after I started to train his brain to produce slower waves in his right temporal lobe, he had a distressing argument with a new girlfriend, and instead of going to his habitual cruising spot to find sex he decided to go fishing. I attributed that response to chance. However, over the next ten weeks, in the midst of his tumultuous relationship, he continued to find solace in fishing and began to renovate a lakeside cabin. When we skipped three weeks of neurofeedback because of our vacations schedules, his compulsion suddenly returned, suggesting that his brain had not yet stabilized its new pattern. We trained for six more months, and now, four years later, I see him about every six months for a checkup. He has felt no further impulse to engage in his dangerous sexual activities.

How did his brain come to derive comfort from fishing rather than from compulsive sexual behavior? At this point we simply don’t know. Neurofeedback changes brain connectivity patterns; the mind follows by creating new patterns of engagement.

BRAIN-WAVE BASICS FROM SLOW TO FAST

Each line on an EEG charts the activity in a different part of the brain: a mixture of different rhythms, ranged on a scale from slow to fast.12 The EEG consists of measurements of varying heights (amplitude) and wavelengths (frequency). Frequency refers to the number of times a waveform rises and falls in one second, and it is measured in hertz (Hz), or cycles per second (cps). Every frequency on the EEG is relevant to understanding and treating trauma, and the basics are relatively easy to grasp.

Delta waves, the slowest frequencies (2–5 Hz) are seen most often during sleep. The brain is in an idling state, and the mind is turned inward. If people have too much slow-wave activity while they're awake, their thinking is foggy and they exhibit poor judgment and poor impulse control. Eighty percent of children with ADHD and many individuals diagnosed with PTSD have excessive slow waves in their frontal lobes.

The Electroencephalogram (EEG). While there is no typical signature for PTSD, many traumatized people have sharply increased activity in the temporal lobes, as this patient does (T3, T4, T5). Neurofeedback can normalize these abnormal brain patterns and thereby increase emotional stability.

THE RATE OF BRAINWAVE FIRING IS RELATED TO OUR STATE OF AROUSAL

Dreaming speeds up brain waves. Theta frequencies (5–8 Hz) predominate at the edge of sleep, as in the floating "hypnopompic" state I described in chapter 15 on EMDR; they are also characteristic of hypnotic trance states. Theta waves create a frame of mind unconstrained by logic or by the ordinary demands of life and thus open the potential for making novel connections and associations. One of the most promising EEG neurofeedback treatments for PTSD, alpha/theta training, makes use of that quality to loosen frozen associations and facilitate new learning. On the downside, theta frequencies also occur when we're "out of it" or depressed.

Alpha waves (8–12 Hz) are accompanied by a sense of peace and calm.13 They are familiar to anyone who has learned mindfulness meditation. (A patient once told me that neurofeedback worked for him "like meditation on steroids.") I use alpha training most often in my practice to help people who are either too numb or too agitated to achieve a state of focused relaxation. Walter Reed National Military Medical Center recently introduced alpha-training instruments to treat soldiers with PTSD, but at the time of this writing the results are not yet available.

Beta waves are the fastest frequencies (13–20 Hz). When they dominate, the brain is oriented to the outside world. Beta enables us to engage in focused attention while performing a task. However, high beta (over 20 Hz) is associated with agitation, anxiety, and body tenseness—in effect, we are constantly scanning the environment for danger.

HELPING THE BRAIN TO FOCUS

Neurofeedback training can improve creativity, athletic control, and inner awareness, even in people who already are highly accomplished.14 When we started to study neurofeedback, we discovered that sports medicine was the only department in Boston University that had any familiarity with the subject. One of my earliest teachers in brain physiology was the sports psychologist Len Zaichkowsky, who soon left Boston to train the Vancouver Canucks with neurofeedback.15

Neurofeedback has probably been studied more thoroughly for performance enhancement than for psychiatric problems. In Italy the trainer for the soccer club AC Milan used it to help players remain relaxed and focused as they watched videos of their errors. Their increased mental and physiological control paid off when several players joined the Italian team that won the 2006 World Cup—and when AC Milan won the European championship the following year.16 Neurofeedback was also included in the science and technology component of Own the Podium, a $117 million, five-year plan engineered to help Canada dominate the 2010 Winter Olympics in Vancouver. The Canadians won the most gold medals and came in third overall.

Musical performance has been shown to benefit as well. A panel of judges from Britain's Royal College of Music found that students who were trained with ten sessions of neurofeedback by John Gruzelier of the University of London had a 10 percent improvement in the performance of a piece of music, compared with students who had not received neurofeedback. This represents a huge difference in such a competitive field.17

Given its enhancement of focus, attention, and concentration, it's not surprising that neurofeedback drew the attention of specialists in attention-deficit/hyperactivity disorder (ADHD). At least thirty-six studies have shown that neurofeedback can be an effective and time-limited treatment for ADHD—one that's about as effective as conventional drugs.18 Once the brain has been trained to produce different patterns of electrical communication, no further treatment is necessary, in contrast to drugs, which do not change fundamental brain activity and work only as long as the patient keeps taking them.

WHERE IS THE PROBLEM IN MY BRAIN?

Sophisticated computerized EEG analysis, known as the quantitative EEG (qEEG), can trace brain-wave activity millisecond by millisecond, and its software can convert that activity into a color map that shows which frequencies are highest or lowest in key areas of the brain.19 The qEEG can also show how well brain regions are communicating or working together. Several large qEEG databases of both normal and abnormal patterns are available, which allows us to compare a patient's qEEG with those of thousands of other people with similar issues. Last but not least, in contrast to fMRIs and related scans, the qEEG is both relatively inexpensive and portable.

The qEEG provides compelling evidence of the arbitrary boundaries of current DSM diagnostic categories. DSM labels for mental illness are not aligned with specific patterns of brain activation. Mental states that are common to many diagnoses, such as confusion, agitation, or feeling disembodied, are associated with specific patterns on the qEEG. In general, the more problems a patient has, the more abnormalities show up in the qEEG.20

Our patients find it very helpful to be able to see the patterns of localized electrical activity in their brains. We can show them the patterns that seem to be responsible for their difficulty focusing or for their lack of emotional control. They can see why different brain areas need to be trained to generate different frequencies and communication patterns. These explanations help them shift from self-blaming attempts to control their behavior to learning to process information differently.

As Ed Hamlin, who trained us in interpreting the qEEG, recently wrote to me: "Many people respond to the training, but the ones that respond best and quickest are those that can see how the feedback is related to something they are doing. For example, if I'm attempting to help someone increase their ability to be present, we can see how they're doing with it. Then the benefit really begins to accumulate. There is something very empowering about having the experience of changing your brain's activity with your mind.”

HOW DOES TRAUMA CHANGE BRAIN WAVES?

In our neurofeedback lab we see individuals with long histories of traumatic stress who have only partially responded to existing treatments. Their qEEGs show a variety of different patterns. Often there is excessive activity in the right temporal lobe, the fear center of the brain, combined with too much frontal slow-wave activity. This means that their hyperaroused emotional brains dominate their mental life. Our research showed that calming the fear center decreases trauma-based problems and improves executive functioning. This is reflected not only in a significant decrease in patients’ PTSD scores but also in improved mental clarity and an increased ability to regulate how upset they become in response to relatively minor provocations.21

Other traumatized patients show patterns of hyperactivity the moment they close their eyes: Not seeing what is going on around them makes them panic and their brain waves go wild. We train them to produce more relaxed brain patterns. Yet another group overreacts to sounds and light, a sign that the thalamus has difficulty filtering out irrelevant information. In those patients we focus on changing communication patterns at the back of the brain.

While our center is focused on finding optimal treatments for long-standing traumatic stress, Alexander McFarlane is studying how exposure to combat changes previously normal brains. The Australian Department of Defence asked his research group to measure the effects of deployment to combat duty in Iraq and Afghanistan on mental and biological functioning, including brain-wave patterns. In the initial phase McFarlane and his colleagues measured the qEEG in 179 combat troops four months prior to and four months after each successive deployment to the Middle East. They found that the total number of months in combat over a three-year period was associated with progressive decreases in alpha power at the back of the brain. This area, which monitors the state of the body and regulates such elementary processes as sleep and hunger, ordinarily has the highest level of alpha waves of any region in the brain, particularly when people close their eyes. As we have seen, alpha is associated with relaxation. The decrease in alpha power in these soldiers reflects a state of persistent agitation. At the same time the brain waves at the front of the brain, which normally have high levels of beta, show a progressive slowing with each deployment. The soldiers gradually develop frontal-lobe activity that resembles that of children with ADHD, which interferes with their executive functioning and capacity for focused attention.

The net effect is that arousal, which is supposed to provide us with the energy needed to engage in day-to-day tasks, no longer helps these soldiers to focus on ordinary tasks. It simply makes them agitated and restless. At this stage of McFarlane’s study, it is too early to know if any of these soldiers will develop PTSD, and only time will tell to what degree these brains will readjust to the pace of civilian life.

NEUROFEEDBACK AND LEARNING DISABILITIES

Chronic abuse and neglect in childhood interfere with the proper wiring of sensory-integration systems. In some cases this results in learning disabilities, which include faulty connections between the auditory and word-processing systems, and poor hand-eye coordination. As long as they are frozen or explosive, it is difficult to see how much trouble the adolescents in our residential treatment programs have processing day-to-day information, but once their behavioral problems have been successfully treated, their learning disabilities often become manifest. Even if these traumatized kids could sit still and pay attention, many of them would still be handicapped by their poor learning skills.22

Lisa described how trauma had interfered with the proper wiring of basic processing functions. She told me she “always got lost” going places, and she recalled having a marked auditory delay that kept her from being able to follow the instructions from her teachers. “Imagine being in a classroom,” she said, “and the teacher comes in and says, ‘Good morning. Turn to page two-seventy-two. Do problems one to five.’ If you’re even a fraction of a second off, it’s just a jumble. It was impossible to concentrate.”

Neurofeedback helped her to reverse these learning disabilities. “I learned to keep track of things; for example, to read maps. Right after we started therapy, there was this memorable time when I was going from Amherst to Northampton [less than ten miles] to meet Sebern. I was supposed to take a couple of buses, but I ended up walking along the highway for a couple miles. I was that disorganized—I couldn’t read the schedule; I couldn’t keep track of the time. I was too jacked up and nervous, which made me tired all the time. I couldn’t pay attention and keep it together. I just couldn’t organize my brain around it.”

That statement defines the challenge for brain and mind science: How can we help people learn to organize time and space, distance and relationships, capacities that are laid down in the brain during the first few years of life, if early trauma has interfered with their development? Neither drugs nor conventional therapy have been shown to activate the neuroplasticity necessary to bring those capacities online after the critical periods have passed. Now is the time to study whether neurofeedback can succeed where other interventions have failed.

ALPHA-THETA TRAINING

Alpha-theta training is a particularly fascinating neurofeedback procedure, because it can induce the sorts of hypnagogic states—the essence of hypnotic trance—that are discussed in chapter 15.23 When theta waves predominate in the brain, the mind’s focus is on the internal world, a world of free-floating imagery. Alpha brain waves may act as a bridge from the external world to the internal, and vice versa. In alpha-theta training these frequencies are alternately rewarded.

The challenge in PTSD is to open the mind to new possibilities, so that the present is no longer interpreted as a continuous reliving of the past. Trance states, during which theta activity dominates, can help to loosen the conditioned connections between particular stimuli and responses, such as loud cracks signaling gunfire, a harbinger of death. A new association can be created in which that same crack can come to be linked to Fourth of July fireworks at the end of a day at the beach with loved ones.

In the twilight states fostered by alpha/theta training, traumatic events may be safely reexperienced and new associations fostered. Some patients report unusual imagery and/or deep insights about their life; others simply become more relaxed and less rigid. Any state in which people can safely experience images, feelings, and emotions that are associated with dread and helplessness is likely to create fresh potential and a wider perspective.

Can alpha-theta reverse hyperarousal patterns? The accumulated evidence is promising. Eugene Peniston and Paul Kulkosky, researchers at the VA Medical Center in Fort Lyon, Colorado, used neurofeedback to treat twenty-nine Vietnam veterans with a twelve- to- fifteen-year history of chronic combat-related PTSD. Fifteen of the men were randomly assigned to the EEG alpha-theta training and fourteen to a control group that received standard medical care, including psychotropic drugs and individual and group therapy. On average, participants in both groups had been hospitalized more than five times for their PTSD. The neurofeedback facilitated twilight states of learning by rewarding both alpha and theta waves. As the men lay back in a recliner with their eyes closed, they were coached to allow the neurofeedback sounds to guide them into deep relaxation. They were also asked to use positive mental imagery (for example, being sober, living confidently and happily) as they moved toward the trancelike alpha-theta state.

This study, published in 1991, had one of the best outcomes ever recorded for PTSD. The neurofeedback group had a significant decrease in their PTSD symptoms, as well as in physical complaints, depression, anxiety, and paranoia. After the treatment phase the veterans and their family members were contacted monthly for a period of thirty months. Only three of the fifteen neurofeedback-treated veterans reported disturbing flashbacks and nightmares. All three chose to undergo ten booster sessions; only one needed to return to the hospital for further treatment. Fourteen out of fifteen were using significantly less medication.

In contrast, every vet in the comparison group experienced an increase in PTSD symptoms during the follow-up period, and all of them required at least two further hospitalizations. Ten of the comparison group also increased their medication use.24 This study has been replicated by other researchers, but it has received surprisingly little attention outside the neurofeedback community.25

NEUROFEEDBACK, PTSD, AND ADDICTION

Approximately one-third to one-half of severely traumatized people develop substance abuse problems.26 Since the time of Homer, soldiers have used alcohol to numb their pain, irritability, and depression. In one recent study half of motor vehicle accident victims developed problems with drugs or alcohol. Alcohol abuse makes people careless and thus increases their chances of being traumatized again (although being drunk during an assault actually decreases the likelihood of developing PTSD).

There is a circular relationship between PTSD and substance abuse: While drugs and alcohol may provide temporary relief from trauma symptoms, withdrawing from them increases hyperarousal, thereby intensifying nightmares, flashbacks, and irritability. There are only two ways to end this vicious cycle: by resolving the symptoms of PTSD with methods such as EMDR or by treating the hyperarousal that is part of both PTSD and withdrawal from drugs or alcohol. Drugs such as naltrexone are sometimes prescribed to reduce hyperarousal, but this treatment helps in only some cases.

One of the first women I trained with neurofeedback had a long-standing cocaine addiction, in addition to a horrendous childhood history of sexual abuse and abandonment. Much to my surprise, her cocaine habit cleared after the first two sessions and on follow-up five years later had not returned. I had never seen anyone recover this quickly from severe drug abuse, so I turned to the existing scientific literature for guidance.27 Most of the studies on this subject were done more than two decades ago; in recent years, very few neurofeedback studies for the treatment of addiction have been published, at least in the United States.

Between 75 percent and 80 percent of patients who are admitted for detox and alcohol and drug abuse treatment will relapse. Another study by Peniston and Kulkosky—on the effects of neurofeedback training with veterans who had dual diagnoses of alcoholism and PTSD28—focused on this problem. Fifteen veterans received alpha-theta training, while the control group received standard treatment without neurofeedback. The subjects were followed up regularly for three years, during which eight members of neurofeedback group stopped drinking completely and one got drunk once but became sick and didn't drink again. Most of them were markedly less depressed. As Peniston put it, the changes reported corresponded to being "more warmhearted, more intelligent, more emotionally stable, more socially bold, more relaxed and more satisfied."29 In contrast, all of those given standard treatment were readmitted to the hospital within eighteen months.30 Since that time a number of studies on neurofeedback for addictions have been published,31 but this important application needs much more research to establish its potential and limitations.

THE FUTURE OF NEUROFEEDBACK

In my practice I use neurofeedback primarily to help with the hyperarousal, confusion, and concentration problems of people who suffer from developmental trauma. However, it has also shown good results for numerous issues and conditions that go beyond the scope of this book, including relieving tension headaches, improving cognitive functioning following a traumatic brain injury, reducing anxiety and panic attacks, learning to deepen meditation states, treating autism, improving seizure control, self-regulation in mood disorders, and more. As of 2013 neurofeedback is being used in seventeen military and VA facilities to treat PTSD,32 and scientific documentation of its efficacy in recent combat vets is just beginning to be assessed. Frank Duffy, the director of the clinical neurophysiology and developmental neurophysiology laboratories of Boston Children's Hospital, has commented: "The literature, which lacks any negative study, suggests that neurofeedback plays a major therapeutic role in many different areas. In my opinion, if any medication had demonstrated such a wide spectrum of efficacy it would be universally accepted and widely used."33

Many questions remain to be answered about treatment protocols for neurofeedback, but the scientific paradigm is gradually shifting in a direction that invites a deeper exploration of these questions. In 2010 Thomas Insel, director of the National Institute of Mental Health, published an article in Scientific American entitled "Faulty Circuits," in which he called for a return to understanding mind and brain in terms of the rhythms and patterns of electrical communication: "Brain regions that function together to carry out normal (and abnormal) mental operations can be thought of as analogous to electrical circuits—the latest research shows that the malfunctioning of entire circuits may underlie many mental disorders."34 Three years later Insel announced that NIMH was "re-orienting its research away from DSM categories"35 and focusing instead on "disorders of the human connectome."36

As explained by Francis Collins, director of the National Institutes of Health (of which NIMH is a part), "The connectome refers to the exquisitely interconnected network of neurons (nerve cells) in your brain. Like the genome, the microbiome, and other exciting 'ome' fields, the effort to map the connectome and decipher the electrical signals that zap through it to generate your thoughts, feelings, and behaviors has become possible through development of powerful new tools and technologies.”37 The connectome is now being mapped in detail under the auspices of NIMH.