History of the Othmer Method
An Evolving Clinical Model and Process

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Abstract

This monograph traces the evolution of Infra-Low Frequency Neurofeedback, and the associated instrumentation development over the course of 34 years, from a clinical perspective. Early years were spent exploiting SMR-beta training. The broad clinical reach of these protocols served to delay protocol innovation for some years. The principle of individualized "optimal response frequency" then became the pilot light of further developments, leading ultimately to the deep infra-low frequency realm. The integration of ILF neurofeedback with Alpha-Theta training and EEG synchrony protocols yielded a competent neurotherapeutic approach for the challenging presentations encountered in a mental health practice. A complementary perspective is given by Siegfried Othmer in a companion piece.

Key Words: Infra-Low Frequency Neurofeedback, SMR-beta training, Alpha-Theta Neurofeedback, Optimal response frequency, EEG synchrony training

Beginnings:

Our interest in neurofeedback began in 1985, when our son Brian began sessions with Margaret Ayers for his temporal lobe epilepsy. Brian's seizures were well-controlled at the time with anticonvulsant medications, but his behavior presented many challenges – for him and for us. Brian responded quickly and dramatically to his neurofeedback sessions. He became much easier to live with, and life became much less of a burden to him, to his teachers, and to his long-suffering younger brother Kurt. Brian took to neurofeedback with great zeal. Finally there was something he could do to help his own condition. He was a serious and determined fellow.

In the course of bringing Brian to sessions for his training, I had the chance to witness the length and breadth of Ayers' practice. This focused mainly on residual symptoms of traumatic brain injury and stroke, but Margaret clearly had a comprehensive view of the potential of neurofeedback—based as it was on essentially a single protocol, the Sterman model of SMR/beta training. What we witnessed was nothing less than amazing. As scientists and concerned parents, we were convinced that the world needed neurofeedback, and we should try to make that happen. We had no idea where that would take us, or how technology and neuroscience would change in the following thirty years.

Looking back at 1985, this was a time when brain function was understood in chemical terms. Brain problems were fixed with medications. Electrical, optical, auditory, or pulsed magnetic field interventions were considered unscientific and silly. Likewise brain plasticity was considered science fiction. One neurologist stopped us in our tracks with the rejoinder: “There are ten billion neurons up there. You expect them to change?” Why yes, it’s called learning. The brain, after all, writes its own operating system software in a massive boot-strapping operation.

Computer EEG technology was just getting introduced into hospitals, even as personal computers were entering our homes and offices. The neurofeedback instrumentation in Ayers’ office had been developed in Dr. Barry Sterman’s research lab on the Sepulveda Veterans’ Administration campus. It was an analog design. The best way we could support Margaret Ayers’ impressive work was to arrange for computerization of the method. Our first move was to invite a computer engineer friend of ours, Edward Dillingham, to work with us and with Ayers to develop a modern computerized neurofeedback instrument. Merely by observing what had happened to Brian, he was gripped by the same enthusiasm as we, and he labored without pay. Three years later we had a working system on an early IBM PC. It was first exhibited at an AAPB (Association for Applied Psychophysiology and Biofeedback) meeting in 1989.

Based on EEG technology of that time, and on the existing neurofeedback experience among a small number of researchers and clinicians, there were certain limited EEG frequency bands of interest. Neurofeedback was used to reward “good” brainwaves associated with calm and alert brain states. This encompassed the sensorimotor rhythm that Sterman had first identified (SMR, 12-15 Hz) and the low beta band (15-18 Hz)). At the same time “bad” brainwaves were inhibited (theta and high beta). Electrode placements were on the central strip, targeting the sensorimotor cortex. Each of the neurofeedback researchers or practitioners favored one or another reward frequency based on their understanding of the process. There was also a separate group focused on alpha-band feedback.

The prevailing model was that neurofeedback would be used to teach the brain how to make more good brainwaves and fewer bad brainwaves. SMR was promoted in order to calm the motor system and thus increase the threshold for the onset of seizures. Low-beta training was used to improve vigilance, attention and cognitive function. This was assumed to occur through the very same operant conditioning model that had served well in Sterman’s original animal research. We had no expectation that people would actually feel the effects during or immediately after a session.

The Arousal Model

By 1988 we were on our own as EEG Spectrum, doing clinical work and refining the software. Our partnership with Margaret Ayers had fallen apart, and by this time there was no chance of our walking away from this new frontier. Ayers’ law suit against us lingered to 1991, when matters were settled in arbitration. Our new instrument company became NeuroCybernetics. By 1990 we started teaching other professionals, starting with our first training course at our San Francisco office.

We started with the established reward frequencies of SMR and beta, and set out to determine which was more effective. We were surprised to find that they were differentially effective. SMR had a more calming effect than beta for many people – sometimes right away during the session. This was the beginning of the arousal model for understanding neurofeedback effects. We looked for clues as to who might benefit from calming with SMR feedback, versus who might function better with low beta activation.

While we were learning to sort symptoms according to high or low arousal categories, we were also thinking about left and right side electrode placements. As we targeted left or right brain functional deficits, we discovered a correlation between placement and preferred reward frequency, i.e., the frequency range in Hertz that the client preferred. (Later this came to be called the optimal response frequency, because it led to the best results in training.) The arousal model now changed to 'right brain over-arousal' or 'left-brain under-arousal'. We saw people as one or the other, calling for left side (C3) beta or right side (C4) SMR.

With more clinical experience we found that some people needed both left-brain activation and right-brain calming. This led to the concept of hemispheric balance. While we moved between right and left side placements within a session, we adjusted times to manage overall physiological arousal. We were learning that neurofeedback could lead to significant state shifts depending on frequency and placement. It was increasingly obvious that these effects were client-specific, not diagnosis-specific. The new protocol came to be called "C3-beta/C4-SMR." But, in fact, by the mid-nineties *bipolar* montage had once again become standard in our work, with C3-T3 being combined with C4-T4.

In an effort to calm the right hemisphere in clients with very high arousal, we began adjusting and extending the lowest available reward frequency in the latter half of the nineties. We now recognize these clients as having a history of developmental trauma or developmental disorders. Every step lower in available reward frequency improved the neurofeedback effectiveness with this population. This was a slow progression, as it called for new versions of the software, followed on each occasion by a period of clinical consolidation.

In the early 1990s there was renewed interest in Alpha-Theta training, with Peniston's work with PTSD and alcoholism using the protocol that had been developed at the pioneering Menninger group, led by Elmer and Alyce Green. We introduced a new A-T program for the Neurocybernetics instrument, with the addition of SMR/beta training in place of Menninger's temperature training. This added an important piece to the overall neurofeedback protocol. Awake-state bipolar training for physiological self-regulation, plus A-T for processing of unresolved trauma. There was clear distinction between bipolar difference training and referential or sum-of-channels training. The bipolar training presented the brain with the subtle differences between two sites at the selected frequency. This promoted differentiation and control of function. When the signals from two sites were added together for training purposes, the large common-mode signal dominates, and the brain responds to that more prominent signal.

Efficacy of the new Alpha-Theta protocol was proved out in the largest controlled study done on neurofeedback to this day-- the CRI-Help study on addictions. With three-year follow-up, the study took four years, and then it took another six years to get published. Both the SMR-beta and Alpha-Theta components contributed to the favorable outcomes, which held up over the three-year follow-up.

As we continued along these two paths of difference versus sum training, we found that difference training called for fine-tuning of the training frequency for each individual based on the response to training. In contrast, sum training (A-T or synchrony) leads us to certain preferred frequencies related to normal rhythmic activity of different brain areas, frequencies at which a high degree of EEG synchrony is well tolerated. Those frequencies are mostly the same from person to person.

The Brain Instability Model

As work progressed on the path of combining left and right brain training within the frame of the arousal model, we found it necessary to include a new category of symptoms – instabilities. This issue arose with the highly sensitive nervous systems vulnerable to explosive symptoms – migraines, seizures, panic, asthma, mood swings, etc. It was difficult to balance left-brain activation and right-brain calming during a session. And, training the left or right side separately could destabilize these individuals—even within minutes. Inter-hemispheric T3-T4 training was found to be more effective in stabilizing hyper-excitable nervous systems, but it required very careful optimizing of the training frequency for each individual.

Discovery of the Frequency Rules

In the beginning we had worked with beta reward frequencies almost exclusively on the left hemisphere. SMR training was initially done on the midline, following Michael Tansey and Joel Lubar. That evolved into the “left-side beta plus right-side SMR” protocol that we taught to thousands of professionals over a number of years. As we moved down to lower frequencies, we maintained the 3-Hz difference between left and right side training frequencies. With inter-hemispheric placements we were able to target parietal and pre-frontal sites, but we struggled to find optimal training frequencies at those new sites. Eventually we did find our way: pre-frontal training optimized at frequencies 2 Hz lower than at T3-T4, and parietal training optimized at frequencies 4 Hz lower. The results were strong and specific. These findings were not ambiguous.

After a year or two in which the various inter-hemispheric placements dominated our protocol decision-making (2002-2004), we moved to re-integrate lateralized training into the inter-hemispheric training regime. T3-T4 placement then became the default protocol for brain stabilization. Lateralized placements gave us stronger and more specific effects, and also gave us the opportunity to reconsider left and right side training frequencies. We quickly found our way from the earlier 3 Hz difference to a more effective left/right difference of 2 Hz.

Emerging Primary Categories of Dysregulation

Our model of brain dysregulation and neurofeedback as self-regulation training was continually being extended and refined. Arousal was still the core variable, dependent on the selected reward frequency. Instabilities were understood as a consequence of hyper-excitability, and as distinct from the arousal issue. (Of course, it goes without saying that the triggering of instabilities in the moment can be coupled to arousal state.) Instabilities responded best to T3-T4. Lack of prefrontal control resulted in disinhibition, and responded best to prefrontal training. These three categories have remained primary in our organization of the clinical agenda.

Over time two core placements presented themselves as reliable starting sites – T4-P4 for right side calming and T3-T4 for inter-hemispheric stabilization. One or both of these sites together were a good choice for the task of optimizing the training frequency. Other placements, including prefrontal, might then be added as needed over time. A hierarchy was emerging in the training agenda.

Entering the Infra-Low Frequency Range: 2006

By the end of 2002 we had left EEG Spectrum International, but continued to use NeuroCybernetics instrumentation for years. We had reached the lowest frequency limit of 1.5 Hz target frequency by 2003. This limit was imposed by the 3-Hz bandwidth of the filters. By 2004, a pile-up of clients preferring the lowest training frequency had become apparent. It was clear that a way needed to be found to get lower than 1.5 Hz, and we put the word out to our clinician network, looking for opportunities to test the hypothesis on other systems.

We were teaching our professional training course with Brainmaster instrumentation at the time, even while we retained our fondness for the NeuroCybernetics in our own clinical work. As it happens, Carl Shames used his Brainmaster to step down below 1.5 Hz, and observed that the frequency specificity of the training was if anything even greater as he went lower. Every 0.1 Hz downward step made an observable difference. The training became even stronger and more frequency-specific. Carl kept me apprised of his observations.

With that compelling confirmation, we then adopted the popular BioExplorer program to explore this new terrain further, down to the lowest target frequency of 0.1 Hz allowed in that program. Literally from one day to the next, the NeuroCybernetics fell from grace. It was removed overnight from all of our clinic rooms, never to be touched again. Siegfried was in shock. The infra-low frequency region had become the enticing new frontier, the all-consuming new focus.

Of course all of the neurofeedback instruments in the U.S. had been designed for the EEG band, for which 0.5 Hz was the typical lower cutoff frequency. A new design was called for, and by the end of 2007 we were working with the new Cygnet software that had been developed for us by Bernhard Wandernoth, a Swiss space engineer. He had pursued an interest in neurofeedback for the sake of his son. After hearing Siegfried lecture in Winterthur, Switzerland in 2004, he immediately signed up for our training course, conveniently scheduled for Starnberg, Germany. His fascination mounted, and he asked to participate in our development. "Even if only ten percent of what you are telling me turns out to be valid, I want to be involved."

We were interested in the development of instruments that everyone in the field could use, and with that cue, Bernhard designed and built the QIKtest for Continuous Performance Testing entirely on spec. He then also designed an impedance meter that anyone could use. At the time, Brainmaster badly needed an upgrade for its amplifier, and that represented but a small step up from the impedance meter. Bernhard eagerly took on that task. In January 2006, we surprised Tom Collura with Bernhard's new amplifier, and much to our surprise, he was not delighted. He then pulled out of his pocket the mockup of his Atlantis amplifier that he had in development. He chose that moment to disclose it to us. Our efforts had been in vain.

We were now stuck with an amplifier without software. Just a few months later, however, we needed the new amp to match up to the BioExplorer software. Then came the Cygnet opportunity, and the rest is history. We were now fully back in the instrumentation development business. Cygnet gave us more refined control over the infra-low frequency training bands along with extending our range to lower frequencies. Each move to a lower reward frequency allowed not only more calming, but also a more impactful training effect for many clients.

The infra-low frequency range called for another look at the reward frequency rules. It didn't make sense to add 2 Hz to a right side frequency of, say, 0.01 Hz when moving to the left. We spent some time focused on optimizing left and right side frequencies with a number of clients. When we looked at the overall results, a new rule emerged. Moving from right to left side placements in the infra-low frequency range required a doubling of the reward frequency. That rule has been tested and validated over many years for thousands of clinicians. It is surprisingly specific.

If it was not already obvious before, then it was certainly so now that our kind of training could not be explained in terms of the operant conditioning model. With these low frequencies, there was no threshold and no reward, no good or bad criterion of any kind. The infra-low frequency signal moves very slowly, without any indication of success or failure. The brain witnesses its own low frequency activity, which facilitates its improved self-regulation. There is no value judgment or correction implied. We do not need the conscious mind to figure out what to do, or to try hard to succeed.

We now understand neurofeedback as a process that allows the brain to see its own reflection in the feedback display. One could think of this process as a kind of 'augmented reality' for the brain. This is qualitatively similar to mindfulness, where we are encouraged to focus on the breath – not to change it or control it, but rather to attend to it. That focus on our internal state promotes self-regulation. Likewise neurofeedback allows the brain to witness its own internal activity, and on that basis migrate toward calmer and better-regulated states. Eventually the brain learns to live there. This understanding fits our earlier work with higher frequencies as well. Even though the EEG-band training involves the elements of an operant conditioning design, that cannot be the whole story. More on that topic is to be found in Siegfried's companion monograph.

Key Modes of Dysregulation

As alluded to earlier, two principal modes of dysregulation shape our understanding of presenting symptoms and of how to best help our neurofeedback clients. Arousal was our first and most universal category, and it continues to guide our search for the optimal training frequency in each client. We now understand that developmental trauma is the most common causal factor underlying chronic high arousal, with hypervigilance, emotional reactivity, and lack of resilience. We most effectively calm high arousal symptoms with right-hemisphere training. That means typically T4-P4, with the subsequent addition of T4-Fp2.

The second core mode of dysregulation is excitability. Excitability is most often a genetic trait. Migraines, seizures, panic, asthma, mood swings, and other instabilities are generally seen in the family tree, and unrelated to developmental trauma. Excitability can also be acquired with physical brain injury, including TBI, stroke, infection, etc. Instability symptoms respond best to T3-T4. In fact training right side without including T3-T4 can trigger instabilities among those who have a latent vulnerability.

Our process is more efficient and effective if we address these core issues of arousal and excitability jointly in the beginning sessions as we attempt to optimize the training frequency for the best clinical outcome. If excitability is an issue, it cannot be ignored even at the outset. Establishing this foundation of optimal placement and frequency then allows the addition of other placements for more specific effects. Both of these starting sites will train with the same optimal frequency.

As needed, and as tolerated, most people benefit from the addition of some prefrontal training. For our arousal dysregulation group, that typically means the addition of right prefrontal (T4-Fp2) placement for emotional self-regulation. For the excitability group, that might mean the addition of left prefrontal (T3-Fp1) for executive function. This includes ADHD—provided that they are not in the developmental trauma category. Moving both active electrodes to the left side of the head requires that we double the training frequency.

Basic sites

Over the years we have found certain electrode sites to be more impactful for most people, so we include them more often in our usual protocols. These sites in fact correspond to cortical areas of highest level integrative processing – multimodal association areas. Our basic sites are T4-P4 for physical calming, T4-Fp2 for emotional self-regulation, T3-P3 for detail and symbolic processing, T3-Fp1 for attention and impulse control, and T3-T4 for stabilization. Beyond basic sites, we sometimes add other sites targeting specific symptoms.

Current applications

We now have three strong neurofeedback applications – Infra-Low Frequency, Alpha-Theta and EEG Synchrony. ILF bipolar training promotes physiological self-regulation of the central nervous system and the autonomic nervous system. This should improve regulation of sleep, emotions, attention, coordination, etc. This is our starting point to calm and stabilize the nervous system and also prepare it for successful A-T and Synchrony sessions.

Alpha-Theta follows ILF sessions when there are unprocessed experiences that continue to trigger symptoms. This has been one part of our approach to PTSD. This is best done with two-channel A-T, following the long tradition in the field of doing multi-channel Alpha band training.

Two-channel synchrony training can best be thought of in the frame of optimal performance. It is a finishing tool that often follows Alpha-Theta or ILF. Typically this is done in the alpha and gamma bands, and utilizes either front-back placement on the midline or lateralized placements pre-frontally or parietally. These protocols likewise have a long history within the field. A recent innovation is synchrony training extending down into the ILF regime.

Summary and Conclusion

Seen collectively, these protocols have a very broad clinical footprint, and they extend our reach into the domain of optimal performance. A key virtue is that they can be understood by the client entirely in an optimal functioning framework. There is no inherent deficit-focus. One does not have to qualify by virtue of dysfunction, and therefore this technology can be readily introduced into the fields of early childhood development, education, and professional peak performance, along with applications to mental illness, criminal justice and geriatrics.

It has been a simply amazing journey, and we have been privileged to play a role in bringing the self-regulation technologies to greater technical competence as well as to greater recognition. Already between one and two million people have benefited from our protocols, and the method has spread around the planet. There is no implication here that these protocols constitute any kind of complete set of such protocols to cover the clinical terrain. Other systems have specific strengths that may also be called for, and the Cygnet suite is also subject to ongoing further development. This chapter is just to be seen as a snapshot in time, and as a reflection.

Guide to the literature

The broad applicability of SMR-beta protocols and their low-frequency derivatives is well illustrated by the application to pain syndromes, as covered in Weiner's Pain Management, Chapter 50 (Othmer S., and Othmer S.F., 2005). The centrality of inter-hemispheric training to resolving cerebral instabilities led to a two-year period of almost exclusive reliance on inter-hemispheric placement (Othmer and Othmer, 2007). Early application to PTSD was presented via two case histories (Othmer and Othmer, 2009). More explicit presentation of the PTSD protocol is to be found in Othmer et al. (2011). Applications relevant to a pediatric neurology practice are presented in Legarda et al. (2011). Finally, the protocol particulars are described in detail in the 7th Edition of the Protocol Guide (Othmer S.F., 2019).

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