THE DEVELOPMENT OF THE OTHMER METHOD

Neurofeedback in its most advanced form

Neurofeedback has evolved significantly since its discovery in the 1960s, with the growth of entirely new forms of application, as well as an increase in opportunities for use. The so-called ILF neurofeedback, often referred to as the Othmer method, is of outstanding importance because its development has been initiated by the US Scientists Siegfried and Susan Othmer and has been in continuous development for decades. The following article describes the origin of this method from the classical beta/SMR neurofeedback, its change to an effective individual neurofeedback approach, and how this development was systematically driven by the Othmers' commitment.

Original text (german): Kirsten Segler
collaboration and technical support: PD Dr. rer. nat. Meike Wiedemann, Svenja Reiniger M.A.
English translation and proof reader: Helen McManus

Introduction

Anyone discussing neurofeedback should specify which method they are referring to. There are many different methods currently in use which have all evolved from the same root, but have developed in quite different directions.

The origin of neurofeedback

Before the potential of neurofeedback was discovered, it was a purely diagnostic tool to measure and analyse cerebral waves via the EEG. The American psychologist Barry Sterman recorded EEGs to study the activity of the brain in various sleep phases in cats. At some point he discovered a unique pattern in the EEG of these test animals. This ranged from 12 to 15 Hertz and was similar to 'sleep spindles', which typically appear while falling asleep. These spindles indicate the brain's ability to suppress alertness and sensation of external stimuli in order to stabilise and enter deeper phases of sleep. But actually, the cats in Sternman's experiment were not sleeping. They were relaxed but fully awake, conscious and attentive to external stimuli.

Sterman referred to the discovery of this pattern as 'sensorimotor rhythm' (SMR), named after the area on the cerebral cortex where he recorded it using electrodes. He then tried to see if the cats could be trained to produce more of this specific pattern intentionally, using a training that followed an operational conditioning procedure. Whenever SMR appeared in the EEG, the animals were rewarded with food. This approach was in fact successful: the frequency of the SMR increased as well as the associated state of relaxed consciousness. This was the first time that cerebral waves were used to influence the behavior of a living organism.

Initially these findings were not linked to therapeutic use, but by coincidence that soon changed. Barry Sterman experimented with the cats on behalf of NASA to investigate potentially harmful effects of a new rocket fuel on living organisms. Almost all cats suffered an epileptic seizure within a small period of time after being exposed to a certain dose of the fuel chemical — only one group of cats responded differently: epileptic seizures either did not occur at all or there was a time delay to exhibiting a seizure. Those cats were the very same ones which had previously been trained to produce more SMR rhythms. An employee in Sterman's laboratory was particularly fascinated by this result because of her own clinical history of epileptic seizures which did not respond to medication at all. So she agreed to an experiment, in which her brain was conditioned to produce more specific brain activity and to reach SMR state intentionally. In fact, this significantly reduced the number of her seizures. This self-testing was the first time that neurofeedback was clinically applied to human beings.

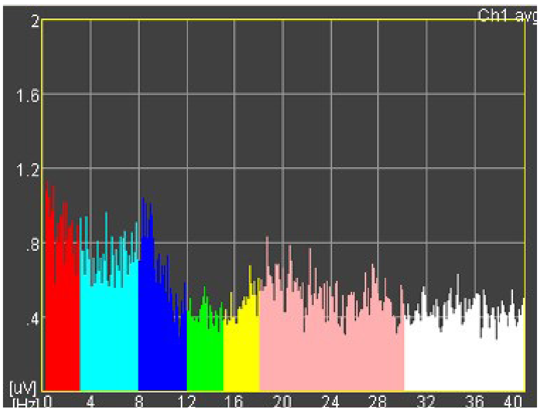
Shortly after this successful experiment with Sterman's employee, more patients with epilepsy were treated with the revolutionary procedure and even more beneficial effects were observed: improved sleep problems, reduction in hyperactive behavior and better ability to focus and concentrate were reported by the subjects. Following this, insomnia and ADHD became additional important indications for neurofeedback training. One pioneer of early research in this area was Joel Lubar, a staff member from Sterman's Laboratory, who subsequently did a lot of great research on neurofeedback in ADHD.

The Frequency Band Training

The process discovered by Barry Sterman is one of what is called today 'Classical Frequency Band Training'. The electrical waves of cerebral activity seen in the EEG can be divided into six groups, the so-called frequency bands. One of these is Sterman's SMR, while there are five further frequency bands (see box). Dominant frequency patterns seen in the EEG can be used to estimate the brain's level of vigilance, as specific arousal levels are associated with frequency bands.

Frequency bands

Frequency-band	Range	Vigilance state
Delta	1 to 3 Hertz	Deep sleep phase
Theta	4 to 7 Hertz	drowsy, somnolent
Alpha	8 to 12 Hertz	awake, moony, unable to concentrate
SMR	12 to 15 Hertz	relaxed, conscious and attentive
(Low) Beta	15 to 18 Hertz	very concentrated, intensive thinking
High Beta	18 to 30 Hertz	tensed, high stress level
Gamma	> 30 Hertz	meditative state, clear minded, flow-like



Graph showing range of frequencies. Electrical filters enable separation of the EEG into its single frequencies. The SMR frequency, discovered by Barry Sterman, is displayed in green here, the Beta frequency in yellow.

Figure 1: Frequency bands

The first neurofeedback applications were primarily just SMR training, but soon developed into beta/SMR training. Clients train to produce fewer frequencies associated with inattentiveness (Theta) and tension (High-Beta) in the EEG. Simultaneously they train to produce more SMR and (Low) Beta Frequencies.

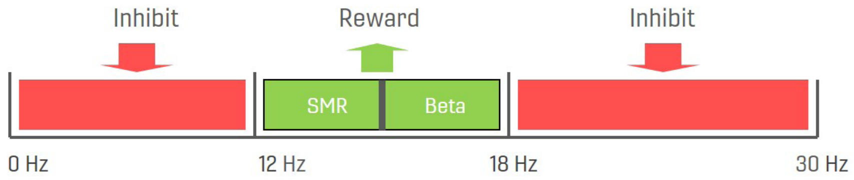


Figure 2: Beta-SMR Frequency band

The goal is to enter a relaxed but attentive, focused and aware state and to intensify this state. The feedback reward to clients for showing specific frequencies, is usually a pleasant sound or the appearance of a positive reward symbol. If amplitudes of unwanted frequencies increase, this reward is withdrawn or even replaced by an unpleasant warning sound as an inhibit marker.

Inhibit/ Reward Specific terms in neurofeedback used to describe rewarding or inhibiting stimuli or signals

Classical Frequency Band Training is based on prescribed rules. For example which frequencies are inhibited or rewarded is determined prior to the training, on the basis of theoretical considerations. This could be compared to not being able to set equipment in the gym to one's individual physical conditions but to operate all the machines with the same predetermined weights and adjustments for everyone. This also applies to SCP training (see box), another form of neurofeedback developed alongside German universities and being used with good success in the treatment of epilepsy and AD(H)D. *SCP training is therefore another prescriptive procedure.

SCP training

This type of neurofeedback is based on the so-called Slow Cortical Potentials (SCP). Starting at 0,1 Hertz and lower, those are 10 to 300 times slower than the frequency bands. Apart from addressing much slower frequencies, the SCP method is similar to Classical Frequency Band Training in that certain thresholds in cortical activity are determined. A moving symbol on a screen is presented to the client. The movements of this symbol are determined by the client's cortical activity, recorded by EEG. He or she is asked to move the symbol on the screen over or under a visual line, the direction of the symbol is indicated by an arrow pointing up or down. This can only be done by increasing or decreasing specific activity. If the client manages to move the symbol correctly corresponding to the instruction, visual and auditory reward is presented.

At first glance SCP training therefore seems to be a prescriptive procedure. However, because SCP are much slower than usual frequencies, they do not reflect the current level of the brain's arousal, but rather it's general excitability – meaning the willingness to respond appropriately to a stimulus. The SCP seem to reflect the interaction of three important neuronal networks which control attention. This indicates that there are deeper? reasons for the success of the method than the superficial explanatory model (see section "Effects of ILF training").

The evolution of the Othmer method

Frequency Band Training as a prescriptive method, is grounded on the assumption that there are specific desirable as well as undesirable frequencies in the brain's activity during cognitive skills training. The definition of those inhibit and reward frequencies are based on theoretical or statistical considerations on what should be the "norm" in the brain's activity. At first there was little reason to question those theoretical considerations, especially as impressive results could be achieved with the beta/SMR training. Nowadays, such general definitions on one individual's brain activity can be doubted - because we are familiar with the concept of neuroplasticity which was not well-known back then.

Dr Siegfried Othmer and his wife Susan Othmer came into contact with neurofeedback as a powerful therapy option for their son – who was autistic - and became enthusiastic about the method. As a neuroscientist, Susan Othmer had an immediate professional interest in neurofeedback — and her husband Siegfried Othmer, a physicist – was the perfect complement for developing solutions for technical requirements. Together they started their own neurofeedback development institution (EEG Spectrum Inc.) in the mid-80s in Los Angeles, which later expanded to include a clinic and the name was changed to EEG Institute.

The Othmers worked with the beta/SMR training first, but they soon developed the first improvement in the procedure. They decided to no longer simply reward exceeding a single threshold level, but to work with the dynamic of the reward frequency band. The clients were now given feedback of their brain activity from an animation in which a bar moved up or down. The bar represents the proportion of Beta/SMR frequencies in the Frequency Bands recorded from the EEG.

"Neurocybernetic" was the first system that provided feedback in the form of animation.

Working with dynamic feedback has been made possible by advances in computer technology, which, moreover, could increasingly reflect the EEG signals in 'real time', with almost no delay. Using the dynamic of reward frequency bands as a feedback signal marked the first of many subsequent shifts away from the initial explanatory model because this neurofeedback was no longer based on operant conditioning.

The importance of electrode positions

In Sterman's beta/SMR training, electrodes were placed on the sensorimotor cortex, which was logical in epilepsy research involving psycho-motor seizures. Susan Othmer developed an individualised refinement of this treatment protocol; she enhanced the reward of SMR frequencies in the right hemisphere when working with tense and highly aroused clients, which produced calming effects for those clients.

Protocol means a detailed explanation of framework conditions in therapy (details provided in the box on page 4).

In contrast when working with inert and low aroused clients, she enhanced the reward of beta frequencies of the left hemisphere which was more beneficial for them. This so-called C3Beta/C4SMR protocol produced good treatment outcomes.

Different parameters of the training protocol

Training protocols – including the framework conditions – contain information on rewarded and inhibited frequencies and potentials. Also, electrode positions and the type of recording are elaborated in the protocol. These details may appear very technical, but are essential in classifying study results.

The international standard system of electrode positions

C = Central (front parts of the crown)
T = Temporal (in the area of temporal lobe, around the ear)
P = Parietal (rear parts area of the crown)
F = Frontal (brow, forehead towards hairline)
PF = Präfrontal (brow, slightly above nasal root)

The additional figures indicate the hemisphere, odd numbers indicate the left hemisphere, even numbers the right hemisphere.

Type of recordings

Unipolar: Each channel delivers only the signals from one electrode (referential recording). The second electrode is placed at an electrical neutral point, most often the earlobe. It is possible to get in feedback from several channels.
Bipolar: The signals of both electrodes from one channel are analyzed and their ratio (i.e. difference) goes into the feedback. Multiple channels can be used here too.

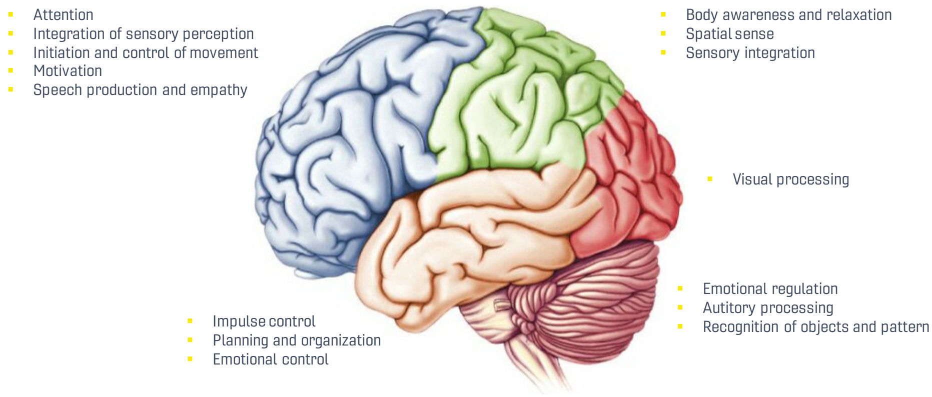
Intrahemispheric: Signals are recorded from the same hemisphere.
Interhemispheric: BipolarBiploar recording with electrodes on the left and right side of head
Homotop: Interhemispheric, with corresponding electrical exposures, such as T3 and T4.

QEEG („Quantitative EEG“): The client wears a cap with 32 or more, electrodes. All the electrodes' signals are analysed. The aim is to display the interaction of brainwaves in different brain areas.

Figure 3: Different parameters of the training protocol

However, in many cases other electrode positions have proved to be more helpful. When searching for those other positions, the Othmers were guided by the knowledge that cortical areas are associated with specific functions (see figure). The most effective electrode positions were previously empirically chosen, nowadays thanks to advancements in knowledge, we know that they are located at major main hubs of cerebral networks (more on this in the section "ILF Training's Mode of Action").

Physical location of various functions on the cerebral cortex



Mapping of the cerebral areas: frontal lobe (blue), parietal lobe (green), temporal lobe (beige), occipital lobe (red). The cerebellum and brainstem with medulla oblongata and passage into the spinal cord are displayed caudally in the cerebral cortex.

Figure 4: Training on specific areas

Individualization of reward frequencies

Besides the impressive effects of the beta/SMR training, some clients did not achieve the expected effects. Therefore, Susan Othmer started to modify the filters so that other frequencies were rewarded – based on the client's feedback. Like adjustments to lenses, she gradually offered a new setting to the client's brain and identified the reactions to this adjustment. Identifying symptoms of under- or overexcitation was particularly helpful. She modified the training to the point where the best individual frequencies for this client were found for their current situation.

Symptoms of various conditions of excitability

Various symptoms of under- or overexcitation enable the best individual frequencies to targetand train on an optimal level.

Restrained, slower	**agitation, overwhelmed**
Dizziness, nausea	muscle tension, convulsions
Lethargy, somnolence	hyperactivity; impulsivity
Slowness	Tics, compulsive acts
Emotional vulnerability	palpitations, tachycardia
Sorrowfulness, crying	emotional reactivity
Lack on deep sleep	anxiety, fear, anger, despair
Problems waking up	aggressive behavior
Symptoms of low glucose level	problems falling asleep, nightmares

Figure 5: Symptoms of various conditions of excitability

Discovering the need to individualise the reward frequencies for each client was revolutionary. It implied that the brain is able to perceive and differentiate between feedback signals in a very sensitive way - despite the short time delays arising from the necessary signal filtrations and processing. However, the successes confirmed to the practitioners that this approach, of achieving the optimal response frequency, was correct.

Nowadays the impact of the feedback signals is better understood, thanks to further research by the Othmers and fundamental changes in neuroscience's understanding of the brain. This is further described in the section "Effects of ILF training". It is important to note that with the individualisation of response frequencies, the Othmer method was no longer a prescriptive method. The frequencies were no longer assessed in accordance to a standardised schedule, but purely in terms of clients' responses.

This became more significant when Susan Othmer continued to change the reward signals to even lower frequencies. Clients began to react faster to very low frequencies than to the traditional frequency ranges, which was completely unexpected from what was then known. Some researchers were fascinated by this contraindication and put great effort into understanding the phenomenon of why lower frequencies seem to have greater impact on neurofeedback. This curiosity finally brought about ILF Neurofeedback, which was influenced by the combined knowledge of clinicians, scientists, engineers and software developers. Today research indicates that neurofeedback training with ultra-low frequencies stimulates the brain's connectivity. In 2020 a team of researchers under the direction of Olga Dobrushina published the randomized controlled study "Modulation of Intrinsic Brain Connectivity by Implicit Electroencephalographic Neurofeedback", where 52 healthy subjects underwent brain fMRI pre and post a neurofeedback session. They found that one single session of ILF Neurofeedback led to significant changes in the brain's connectivity and activity.

Infra Low Frequency: Training with extremely slow potentials

Understanding the effectiveness of neurofeedback training with very low frequencies is the major innovation of the Othmer method and has led research and therapy since 2006. From a technical point of view, today's infra-low-brain signals, ranging between 10 and 0.0001 millihertz are no longer 'frequencies' in the usual sense, because one single oscillation would last for hours. Whilst frequencies can be described as waves, ILF could correspond to the ebb and flow of tides. Therapists choose only a small sample of the electrical activity and examine this 'under a magnifying glass'. They monitor how the electrical potential increases — or to maintain the image — how high and fast the flow is coming. By selecting a frequency as well as the electrode's position, different regions can be trained according to the client's individual needs.

The ILF also reflects the excitability of the brain and, just as in SCP training, clients are expected to learn and practice to better regulate themselves. However, clients are no longer given an active task to intentionally self-regulate. Instead, they watch TV programmes and films — their content can be very different — or play computer games. It is now even possible to train using virtual realities. The computer program assimilates? information from the EEG, onto the screen by way of tones and images?. Additionally, tactile feedback can also be provided using vibrating units. The changes are very subtle, and examples of affect are brightness, color intensity, volume, speed or frequency of events on the screen. It is neither possible nor necessary to consciously understand how the feedback is generated.

Cygnet / Neuroamp: the development of software and corresponding amplifier were required for ILF training's demanding signal processing.

There is a major difference between the frequency-based neurofeedback training and the SCP training, which is also based on very slow potentials: the signals are no longer a reward but give non-value feedback on the brain's activity. Only the inhibits classify certain frequencies as 'desirable/undesirable' if certain amplitudes of the usual frequency bands are exceeded.

Effects of ILF training

Now, with the progression into extremely low potentials for which there is no more reward signal, the effect of neurofeedback can no longer be explained by operant conditioning (alone). But how does it work?

The feedback signals are like a mirror for the brain

The feedback signals reflect the brain's activity like a mirror. Electrode positions and feedback parameters can adjust the range of neuronal activity that is presented to the brain through visual, auditory and tactile modalities. The brain is constantly working to match the observed signals to its own activity and to identify its own influence on those. Automatically it moves from 'What has this stimulus to do with me?' to 'Did I do that?'. Subconsciously the brain tries to find patterns in the observed stimuli and internalises them?. That means that details of what happens on the screen is less important than the link between those stimuli and the brain's subconscious awareness of 'I affect these changes'. This self-detection is the reason why an additional observer would not be affected by the feedback presented by another person's EEG activity because there would be no link between the feedback and the brain's sensory integration process.

Neurofeedback training therefore increases the self-perception that the brain, along with all other available information, uses quite automatically for self-regulation and self-optimization. Standing and walking are typical examples of such brain activity, where a wealth of internal and external information is constantly integrated and adapted, without involving consciousness. However, a person who wishes to learn a new pattern of movement often needs additional support in the beginning. Infants will have to pull themselves up using table legs to support learning to stand alone. Also dancers use mirrored walls to check their body posture and compare their internal view of a new pose with the outer representation. The rule is: the more something new is practiced, the more specific the inner signals develop, so they can increasingly rely on their internal image only, without extrinsic tools and even without conscious control.

These examples illustrate the brain's neuroplasticity: For a long time, the presence of neuroplasticity in the adult brain was neglected. Neuroplasticity doesn't just refer to those who have danced since childhood and continously add and learn more skills for example, but refers to every adult. New neuronal compounds are also emerging in the brains of over 50 year olds, who for example practice Tango for the first time, try to learn a new language or begin taking long-desired piano lessons. Totally new neuronal connections are created in their brains. It is true that learning something new as an adult feels more difficult than when younger, but it is not established that this is because the brain is less flexible. Its possible the brain maintains its willingness to learn when we practice as motivated and persistently as children do, and stay enthusiastic about every progress, instead of becoming dissatisfied by our own limitations. ILF neurofeedback, which does not judge ability, supports the hypothesis that aging does not remove the brain's ability to learn as it can be observed that adults react to ILF neurofeedback quite similarly as children do.

The specificity of slow potentials

But why do clients show such powerful effects to the slow-changing signals used in SCP and even more in ILF training? Research findings suggest that those low potentials influence the brain at the level of neural networks— that is, the interaction of different areas of the brain. Of particular importance are those networks dedicated to self-regulation of internal arousal and excitability (see box).

Essential self-regulation networks

The Default Mode Network (DMN) becomes active in the state of inner attention, especially when external stimuli are nonexistent. This provides the brain with small breaks where it can schedule and organize - a mini version of what it does during sleep. A healthy brain reduces its excitability naturally every 90 to 120 minutes during the day.

In contrast, the Central Executive Network (CEN) needs to be active in order to be alert and focused on the outside world.

The ability to change between those networks according to given situations, is in the Salience Network (SN). It filters incoming stimuli and determines which may be consciously perceived and which are not.

Figure 6: Essential networks for self-regulation

The interaction of the three networks, however, not only affects the ability to concentrate, but it goes much further than that. This can best be explained by considering the balance between performance and internal arousal as a simple bell-shaped curve.

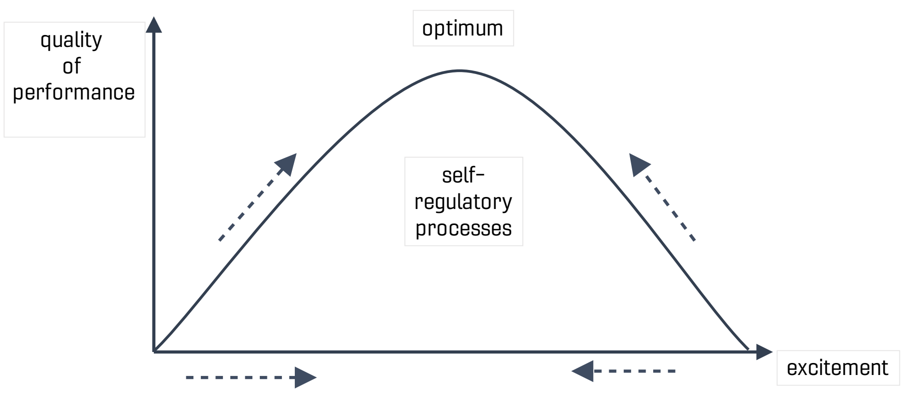


Figure 7: Self-regulation processes

A level of low arousal manifests in sleepiness and lethargy. The higher the arousal level, the better the performance: one is able to concentrate and focus. But a further increase in arousal, beyond an optimum level, leads to a decline in performance: in an excessively stressful situation, each task consumes more attention than is actually necessary. Moreover, a positive manifestation of 'concentration' becomes increasingly obscure when focused on difficulties and hazards. As arousal rises further, such as in a life-threatening situation, one goes into fight or flight mode. This overstimulation can also cause constriction and paralysis. In traumatized people this can sometimes even be caused by very mild and harmless external triggers.

The level of arousal essentially determines the way that an individual perceives oneself in the world: lethargic and paralysed, active and self-efficient or threatened and overwhelmed. Mild forms of these conditions can fluctuate on a daily basis, but they can also fundamentally influence mental health.

In a well-regulated human the arousal of the brain rises and falls naturally over short and long periods of time. But ideally it fluctuates within a 'normal' range and never reaches the extreme states on the curve. Meaning whenever mild symptoms of over-arousal occur one takes a break and recovers – by taking days off, relaxing or sleeping - to bring the arousal back to a level where optimal performance is possible.

But these days many people run on very high levels of arousal, non-stop every day. Sometimes this results in a collapse into the opposite state of extreme and ongoing exhaustion. This is also referred to as 'burnout' or a depressive episode. In other people over-arousal can result in anxiety disorders or compulsive syndromes; even migraine seizures, epilepsy or panic attacks can be understood as expressions of very high arousal levels. In addition, the curve can look different in some people, often the ones with the above-mentioned conditions: their field of optimal performance is smaller, they are less resistant to stress and are more likely to collapse.

Evidence from neurofeedback also gives us a better understanding of AD(H)D when explaining the phenomena regularly occurring with this indication, in terms of arousal and optimum performance. It is known that AD(H)D symptoms result from an under-arousal in the brain. Referring to the arousal performance curve, this means that the course of the curve is displaced to the right side and starts flat. People with AD(H)D need a lot of stimulation to get active. This also applies to hyperactive patients. Agitation and wriggling can be unconscious strategies to stay focused and enable action rather than letting the attention drift. This is also why methylphenidate – a stimulant – may be effective for affected clients.

These explanations help to understand why ILF neurofeedback in particular leads to clear and sustainable positive changes in many disorders. This therapeutic approach trains and improves a basic skill on which a lot of human behavior depends - self-regulation of arousal level. In neurofeedback, clients - unconsciously and without feeling a pressure to 'perform'- develop a skill that they can apply universally. Thus, clients don't need to focus on their shortcomings nor come up with a well-defined diagnosis; it is sufficient that clients - and/or their relatives - describe their conditions to the therapist. This description should be as accurate as possible which is why it is recommended that a comprehensive catalogue of neurological and physical symptoms is used.

Since the early 1990s, therapists and researchers have also relied on objective tests to support clinical observation of symptoms. The CPT (Continuous Performance Test, see box) is such a tool, used to assess various aspects of attention.

Continuous Performance Test (CPT)

Different parameters of attention can be measured by the CPT. It can give information about how well the client can focus attention and respond correctly over time. The CPT is performed on a small electronic device with a screen in the middle and two buttons, one on the left and one on the right side. On the screen, a large square formed of smaller squares appears. Either all the small squares or all except the middle square light up. The client is asked to press a button when all squares except the middle light up and not to press a button when all squares light up (Go/No go task). The client's average response time is measured as well as whether the response was correct or incorrect. Excessive impulsivity can be seen when the client reacts before the stimuli has been properly presented or not presented at all. Not pressing on a go-condition indicates a lack of attention.

The test takes 20 minutes. Stimuli are presented with increased speed in the middle of the test and the speed is reduced towards the end of the test – which is extremely challenging because clients tend to get bored towards the end. Some clients with major attention problems initially struggle to complete the test at all.

Figure 8: Continuous Performance Test (CPT)

Typical therapeutic process

The discovery of ILF training's effectiveness has not brought Susan and Siegfried Othmers research projects to an end. They continue to gather experience and adapt their method to new knowledge.

It is useful to consider a certain order in neurofeedback training. This is based on the chronology of the brain's natural development process in childhood. It starts with regulatory functions, which are mainly connected with the brain's right hemisphere. For this reason, treatment typically starts on the right hemisphere (at least with one electrode). This can have a positive impact on functions of other important networks in the brain. It seems that superior brain functions need a specific foundation to become developed – not only in natural development but also in neurofeedback. Following this chronology may also increase the effectiveness of the ILF neurofeedback training.

This client-centered procedure also shows that experience of the neurofeedback providers (e.g. therapists) is a highly relevant factor for clinical effectiveness. Certain technical equipment is a prerequisite to be able to use neurofeedback, but neurofeedback training goes far beyond simply using technical devices. The ILF procedure in particular therefore, is neither suitable for patient's home use, nor should it be provided by untrained practitioners.

Neurofeedback research

While interest in neurofeedback research has remained low for decades, it has grown sharply since 2009, as shown in the number of published papers available in PubMed's database.

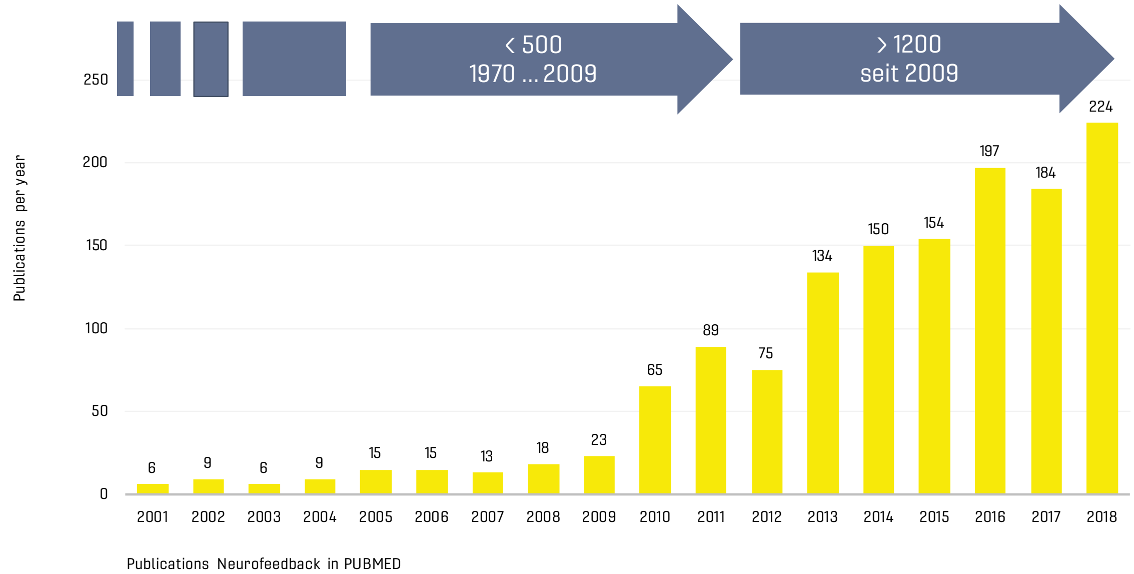


Figure 9: PubMed listed publications per year

AD(H)D and learning difficulties so far are the most common indications in neurofeedback research (PubMed Search until 2018).

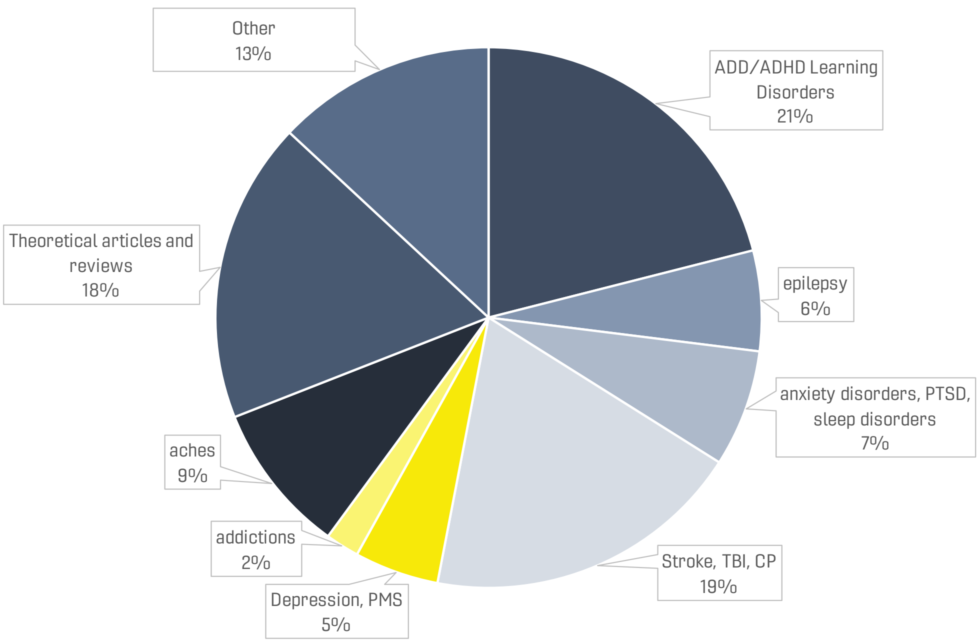


Figure 10: Study situation

The basic research by Barry Sterman and Joel Lubar has shown that neurofeedback is an effective therapeutic tool. Also the effectiveness of subsequent neurofeedback methods, especially the widely-used Beta/SMR training, and the Othmer's developments of it, are well documented today and are embedded in treatment guidelines as an evidence-based procedure.

Reminder: In beta/SMR training, a client trains to reduce the proportion of frequencies associated with inattention (theta) and restlessness (high beta) in the EEC by creating more SMR and (Low) beta-frequencies with higher amplitudes.

Finally, as previously stated, the procedures lead to the ILF neurofeedback, which is empirically documented with comprehensive clinical data. An extensive archive containing systematic analysis of treatment processes and therapy outcomes has been generated within the EEG Institute in Los Angeles. However, scientific research of various treatment protocols for all ILF neurofeedback indications for different client populations, require extremely complex study designs. As this is an individualised, client-centered, non-prescriptive symptom-based procedure, randomized, controlled study designs are more demanding and challenging than for standardised procedures. In addition, treatment protocol is continually optimised with regard to the progression of treatment.

Despite these challenges, there are already some good studies and ongoing promising clinical investigations. In particular, it should be mentioned that the study already cited by Dobrushina et al., demonstrates a significant change in the brain's connectivity during a 30-minute session of ILF neurofeedback. The study shows that the implicit processing of the feedback signal modulates neuronal networks and increases the connectivity of those networks. This work is a milestone to better understanding neurofeedback's mode of effect. It also gives insights on how powerful ILF neurofeedback can be as a therapeutic tool and emphasises the clinical potential of this particular therapeutic method.

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On request, we can of course also provide you with English-language sources and references.

BEE Medic GmbH Germany
Zeppelinstr. 7 · 78224 Singen
Phone +49 7731 96969-0
Mail office@beemedic.de
www.beemedic.de

BEE Medic GmbH Switzerland
Husenstrasse 57 · 9533 Kirchberg
Phone +41 71 9314020
Mail office@beemedic.ch
www.beemedic.ch

Neurofeedback Scotland
enquiries@neurofeedback.scot
Phone 07714322427 / 07484130933
www.neurofeedback.scot