

How **NeurOptimal®** Dynamical Neurofeedback® Operates



Executive Summary

NeurOptimal® Dynamical Neurofeedback® is a 100% non-invasive, safe method for increasing focus, better managing stress and anxiety, while building greater confidence and wellness in your life; along with training your brain to be more flexible and resilient. Without pushing your brain in any direction, the **NeurOptimal®** system interacts with your central nervous system (CNS) in a way that improves the learning process of your brain. Since each person's brain is different, everyone responds differently according to their subconscious choices. No electricity, magnetic fields, or altered brainwaves are imposed into your brain. A more flexible brain that responds quicker is more adaptive to changes in your environment. The more easily your brain adjusts to encounter changes in a normal, busy day, the better you feel. The **NeurOptimal®** "whole brain training system" may also help build brain resilience or increase the CNS's ability to "bounce back" from a negative event. Negative feelings associated with a personal conflict or bad day at work can "loop" for hours or days, long after the event has passed. The destructive effect of nervous, repetitive or self-critical thinking is magnified in more severe events such as physical and emotional trauma, or current and past grief. Instead of staying stuck in the negativity of these events, the resilient brain will snap-back and return to its normal baseline more quickly. Individuals with a more resilient brain report enjoying a more profound sense of peace, happiness, and success.

NeurOptimal® Dynamical Neurofeedback® monitors all the major brainwave frequencies (0.001 to 64 Hz) by detecting abrupt changes in brain electrical patterns, providing real-time audio feedback (256 times per second) via brief pauses in the music. **NeurOptimal®** is not protocol-driven and does not induce, force, entrain, augment, or inhibit a specific state, frequency, or outcome. **No electricity, magnetic fields, or altered brainwaves are introduced into your brain.** Brain training only provides an accurate mirror to inform the brain about what it just did in order for your brain to make different choices and create fresh neural pathways. This signals the subconscious brain of its own activity, which promotes self-regulation, flexibility, and resilience, leading to a grounded, relaxed and peaceful state.

Brain Functionality

To understand how neurofeedback works, it's important to begin with a basic understanding of how the brain functions. The brain, as a highly complex organ, is always attempting to function efficiently, conserve energy, and move away from a state of discomfort to comfort as information is processed from external and internal sources. The brain operates at conscious and subconscious levels. The conscious brain takes in information for immediate processing and reactions, whereas the subconscious brain processes long-term memory and directs organ functions. Brain cells communicate via electrical impulses between the brain's neurotransmitters. Please see **Attachment A** on page 15 for further details. There are several factors that influence how our brain operates. By altering the number and/or strength of connections between brain cells, information is written into the brain's memory in the space between neurons, called the Synapse, where they communicate with each other. This is how conscious and unconscious memories are produced in our brain. The brain cells' communication creates electrical impulses which may be scanned by an electroencephalogram (EEG) process, for example, a procedure at the hospital. EEG measures brain activity but does not directly capture memory encoding. Neurofeedback utilizes this type of technology in the signal filtering process. Several other brain function processes are discussed below. Brain processing pathways are the neural routes information travels through the brain to be interpreted and acted upon.

Negativity Bias: *Negativity bias* is the psychological tendency for humans to be more affected by negative experiences than positive ones. It is a cognitive bias that influences how we perceive, remember, and process the world around us, leading negative events to hold more weight in our minds. Experts believe that the negativity bias developed as a survival mechanism in early human history. The amygdala, often called the brain's "alarm bell," uses more neurons to look for potential threats. Research on human learning shows that negative reinforcement leads to faster learning than rewards for a correct response. The National Science Foundation suggests that upwards to 80% of our daily thoughts are negative. Most of our responses become patterns which are encoded in our brain to protect us. However, those patterns may produce additional negative thoughts and behaviors, which lead to stuck emotional or physical behavior patterns.

Brain Process Variability: There are several brain processes which allow neurofeedback to work on the dynamical human brain. One such process is called *Brain Process Variability*, which includes *Neural*, *Cognitive*, and *Behavior Variability*. *Neural Variability* refers to the natural brainwave fluctuations in how the brain processes information over time, across different tasks, or between individuals; where differences in brain activity patterns, even when performing the same task repeatedly. *Neural variability* may affect attention, perception, decision-making, motor responses, memory, and emotional regulation. The significance is that some variability reflects flexibility and adaptability, while excessively too much may cause dysfunction. *Cognitive Variability*, which includes day-to-day changes, factors like sleep, stress, mood, and nutrition may affect cognitive influence. Individual differences of genetics, life experiences, and personality may contribute to how each brain processes information differently. Momentary lapses in attention may result in different task performances. Finally, *Behavioral Variability* is the brain and body's way of staying flexible, adaptive, and open to change. These variabilities impact the day-to-day brain's activity in coping with our cognitive and emotional modalities in learning and being stable.

Neuroplasticity: *Neuroplasticity* is another process where the brain can reorganize itself by learning to ensure survival. There are two types of Neuroplasticity, the first being *Functional Plasticity*, which is the brain's ability to move functions from one area of the brain to another area. The second type is *Structural Plasticity*, which is the brain's ability to change its physical structure (neurons, synapses, vascular cells, and glial cells) due to learning. Learning and memory are neuroplastic processes that involve chemical and structural changes in the brain. Overall, the brain can form new neural pathways and strengthen or prune existing ones in response to experience or injury. This ability, called neuroplasticity, allows for learning and adaptation throughout life.

Limbic Crossover: Limbic crossover primarily describes a neurological state where the brain's emotional control center—the limbic system—becomes hypersensitized and begins to trigger intense physiological

responses to non-threatening stimuli, which manages the “fight/flight/freeze/fawn response and develops a “cross-wired” association between harmless triggers (like a specific scent, food, or sound) and a high-alert survival response. Based on the principle that “neurons that fire together, wire together,” the brain incorrectly links a traumatic or stressful event with whatever was in the environment at that time. Consequently, encountering that environment later can trigger a full-scale immune or stress response even if no actual danger exists. When limbic crossover occurs, it often results in “downstream” symptoms because the body remains in a state of chronic sympathetic arousal. Over time this process increases emotional and behavioral consequences that must be unpacked to relieve the brain’s tension and anxiety.

Emergent Variability: Refers to unpredictable, unprogrammed fluctuations or behavioral differences that arise spontaneously within a complex system. Rather than being planned, it is a byproduct of interactions between the system's underlying parts. Instead of just tracking and responding to the brain’s activity, the system encourages the emergence of variability within the brain’s natural rhythms. This variability, driven by dynamical feedback, helps the brain reorganize itself in response to internal and external changes, supporting overall brain health and function.

Neurofeedback Defined

Neurofeedback is a type of brain training that allows neuroscientists to teach self-control of brain functions by measuring the electrical activity on the surface of the scalp and providing feedback signals to the brain; having existed for 50 years with a wide range of applications. These include the management of epilepsy, migraines, focus issues, traumatic brain injuries (including concussions), chronic pain, cognitive brain fog, addiction recovery, enhanced sports performance and stress reduction for personal and work environments. The processes discussed above are only several of the brain’s mechanisms that allow for neurofeedback to accommodate change within the brain. Entire books are written on neurofeedback, and this paper will only lightly reference the subject and focus on the two general types of neurofeedback: linear (Traditional) and non-linear (Dynamical).

Linear (traditional neurofeedback)

Linear or traditional neurofeedback systems require a diagnosis, along with ongoing medical live-brain scans, called a Brain Map (QEEG), to determine which brainwaves (e.g., alpha, beta, delta, gamma, or theta) are inhibited or augmented into the brain over time to improve symptoms. These images are compared with a normal brain activity picture, not individually monitored during each session. Additionally, the current sessions are only responding to where the brain was 1-2 weeks ago. As we all can agree, every person is different at every moment while constantly moving and adapting to their current environment in addition to their own personal variables of sleep, diet, family dynamics, etc. Given this dynamic, the concept of structuring a neurofeedback protocol based upon a specific historical moment in time is far less than optimal. In other words, the brain is dynamical and changes hourly, daily and/or weekly. The major limitation that lies with traditional neurofeedback is with the push/pull of only doing a limited brain frequency group at a time, even though they may be monitoring 19 channels. This is called protocol-based training, the predominant model for linear neurofeedback in use today. Many traditional neurofeedback systems typically cap their upper frequency limits often around 42 Hz.

While the linear neurofeedback systems may be effective, the medical or professionally licensed operator must be well experienced to make “educated guesses” about the brainwave type and dosage for the brain to be flooded. Which, to say the least, is complicated, especially when the presenting picture was not especially clear, or as often happens, the client has symptoms of several disorders, all of which required different and sometimes opposing protocols. Protocol implementation is highly complex and consequently dependent upon the skills of the clinician. Therefore, one symptom fades by allowing another symptom to become worse. And the only way you know when to change the procedure is by monitoring the client’s side effects. Unfortunately, whenever several problems are active within the brain, one inhibited or augmented type of brainwave may cause problems for the other conditions, resulting in side-effects that create additional challenges for the client. Please see **ATTACHMENT B** for further details.

Non-Linear (Dynamical) Neurofeedback

NeuroOptimal® Dynamical Neurofeedback® is a system that views the brain as a nonlinear, self-organizing entity that optimizes through real-time feedback on momentary instabilities—originally termed turbulence (now referenced as “flutter”) in its electrical activity. This flutter reflects brief deviations or “wobbles” signaling that the brain is energetically approaching a shift in phase or electrical activity, represented by a corresponding shift in measured electrical activity. Note that **NeuroOptimal®** does not detect, target, or train specific brain states; rather, it provides subtle auditory interruptions (e.g., feedback, specifically provided as micro-pauses or interruptions in the audio stream that is played during a Session) as an informational mirror, allowing the brain's innate intelligence to self-regulate and enhance resilience, flexibility, and brain present-moment awareness without any directive intervention. The brain's activity behaves in a nonlinear fashion, meaning that small changes can lead to large, unpredictable effects. **NeuroOptimal®** uses dynamical thresholding, a technique that adapts to fluctuations in EEG patterns, continuously adjusting in real-time. This allows the system to better guide the brain toward optimal function without pushing it into any fixed state.

NeuroOptimal® is built on a different way of thinking about the brain than the “train a specific site/frequency for a specific problem” model. Dr. Val Brown (cocreator of **NeuroOptimal®**) explains that the CNS shows graded equipotentiality—meaning there’s a graded ability for virtually any part of the system to support or take over functions as needed, because the brain is always operating as an integrated whole rather than isolated modules. That’s why **NeuroOptimal®** doesn’t try to “push” the brain toward targets with rewards; instead, it provides precise, moment-to-moment negative feedback that the brain can use to self-organize back toward stability and resilience. In other words: we’re not telling the brain what to do—we’re giving it high-resolution information about what it’s doing, so it can make its own adjustments in the way it already does naturally.

A trained person places sensors on the client’s head with conductive paste and then the client rests in a comfortable chair and listens to relaxing music from the software, usually through ear buds or by speakers. The music has intentional pauses and static-like sounds that provide feedback or messaging to the brain. The software reads the electrical signal through the sensors and then responds. **NeuroOptimal®** software was created to match the brain’s own internal communication process, mirroring back the client’s activity through an audio/visual feedback system. The feedback allows the brain to become aware of its own imbalances and to recognize itself spontaneously, at its own pace, according to its internal priorities. Since the brain is always seeking balance, the feedback causes the brain to self-regulate on a subconscious level, while reducing unwanted variability to optimize performance. The client is not required to interact with the screen.

What is the difference between DYNAMIC and DYNAMICAL?

In the context of **NeuroOptimal® Dynamical Neurofeedback®**, this distinction is key to understanding how the system works with the brain’s electrical activity (EEG) and the mathematical principles behind it.

DYNAMIC = Change: This refers to change in general, implying that the system detects and responds to the ongoing fluctuations in the brain’s electrical activity. The brain is constantly in motion, shifting between various states of activity, but **NeuroOptimal®** does not specifically train or target these states. Instead, it recognizes the brain’s natural variability and uses real-time feedback to encourage self-regulation and adaptation.

DYNAMICAL = Changes in Response to Noted Change: Going deeper, dynamical refers to a more sophisticated level of change, particularly in systems that are governed by feedback loops and nonlinear behavior. The brain, when viewed as a dynamical system, is not just reacting to external stimuli or arbitrary changes—it actively adapts based on the feedback it receives. In **Dynamical Neurofeedback®**, the brain’s EEG activity is guided by this self-organizing process, responding to real-time feedback in a way that supports its inherent self-regulation.

The brain's activity behaves in a nonlinear fashion, meaning that small changes can lead to large, unpredictable effects. **NeurOptimal®** uses dynamical thresholding, a technique that adapts to fluctuations in EEG patterns, continuously adjusting in real-time. This allows the system to better guide the brain toward optimal function without pushing it into any fixed state. Thus, dynamic refers to the constant change in the brain's activity, while dynamical emphasizes the adaptive, feedback-driven process that fine-tunes these changes in real time. **Dynamical Neurofeedback®** works by allowing the brain to naturally adjust and optimize itself, creating lasting improvements in brain function without imposing rigid control over any particular state.

Origins and development

In 1946 **Dennis Gabor** invented the hologram mathematically, describing a system where an image can be reconstructed through information that is stored throughout the hologram. He demonstrated that the information pattern of a three-dimensional object can be encoded in a beam of light, which is more-or-less two-dimensional. Gabor also developed a mathematical model for demonstrating a holographic associative memory. One of Gabor's colleagues, **Pieter Jacobus Van Heerden**, also developed a related holographic mathematical memory model in 1963. This model contained the key aspect of non-locality, which became important years later when, in 1967, experiments by both **Braitenberg** and **Kirschfield** showed that exact localization of memory in the brain was false.

Karl Pribram had worked with psychologist **Karl Lashley** on Lashley's engram experiments, which used lesions to determine the exact location of specific memories in primate brains. Lashley made small lesions in the brains and found that these had little effect on memory. On the other hand, Pribram removed large areas of cortex, leading to multiple serious deficits in memory and cognitive function. Memories were not stored in a single neuron or exact location but were spread over the entirety of a neural network. Lashley suggested that brain interference patterns could play a role in perception but was unsure how such patterns might be generated in the brain or how they would lead to brain function.

Several years later an article by neurophysiologist **John Eccles** described how a wave could be generated at the branching ends of pre-synaptic axons. Multiple of these waves could create interference patterns. Soon after, **Emmett Leith** was successful in storing visual images through the interference patterns of laser beams, inspired by Gabor's previous use of Fourier transformations to store information within a hologram. After studying the work of **Eccles** and that of **Leith**, **Pribram** put forward the hypothesis that memory might take the form of interference patterns that resemble laser-produced holograms. In 1980, physicist **David Bohm** presented his ideas of holomovement and Implicate and explicate order. **Pribram** became aware of Bohm's work in 1975 and realized that, since a hologram could store information within patterns of interference and then recreate that information when activated, it could serve as a strong metaphor for brain function. **Pribram** was further encouraged in this line of speculation by the fact that neurophysiologists **Russell and Karen DeValois** together established "the spatial frequency encoding displayed by cells of the visual cortex was best described as a **Fourier transform** of the input pattern."

Early Scientist's Research on Neurofeedback related to **NeurOptimal®**

Alexander Romanovich Luria was a Soviet neuropsychologist, often credited as a father of modern neuropsychology. He developed an extensive and original battery of neuropsychological tests during his clinical work with brain-injured victims of World War II, which are still used in various forms. He made an in-depth analysis of the functioning of various brain regions and integrative processes of the brain in general. Luria's portrayal of the brain as plastic, interdependent systems reorganizing through contextual activity aligns with flutter as cues for intrinsic correction. Like compensatory shifts in Luria's clinical cases, **NeurOptimal®** reflects these "wobbles" to facilitate emergent flexibility, emphasizing the anticipatory flutter in measured electrical activity before natural realignment.

Maurice Merleau-Ponty's "Phenomenology of Perception" is a 1945 book about perception by the French philosopher in which the author expounds his thesis of "the primacy of perception". The work established Merleau-Ponty as the pre-eminent philosopher of the body and is considered a major statement of French

existentialism, where he attempts to define **phenomenology**, which according to him has not yet received a proper definition. He asserts that phenomenology contains a series of apparent contradictions, which include the fact that it attempts to create a philosophy that would be a rigorous science while also offering an account of **space**, **time** and the world as people experience them. Merleau-Ponty denies that such contradictions can be resolved by distinguishing between the views of the philosopher **Edmund Husserl** and those of the philosopher **Martin Heidegger**, commenting that **Heidegger's *Being and Time* (1927)** "springs from an indication given by Husserl and amounts to no more than an explicit account of the 'natürlicher Weltbegriff' or the 'Lebenswelt' which Husserl, toward the end of his life, identified as the central theme of phenomenology, with the result that the contradiction appears in Husserl's own philosophy".

Following Husserl, Merleau-Ponty attempts to reveal the phenomenological structure of **perception**. He writes that while the "notion of sensation ... seems immediate and obvious", it is in fact confusing. Merleau-Ponty asserts that because "traditional analyses" have accepted it, they have "missed the phenomenon of perception." Merleau-Ponty argues that while sensation could be understood to mean "the way in which I am affected and the experiencing of a state of myself", there is nothing in experience corresponding to "pure sensation" or "an atom of feeling". He writes that, "The alleged self-evidence of sensation is not based on any testimony of consciousness, but on widely held prejudice." Merleau-Ponty's central thesis is that of the "primacy of perception." He critiques the **Cartesian** stance of "*cogito ergo sum*" and expounds a different conception of consciousness. Cartesian dualism of mind and body is called into question as the primary way of existing in the world, and is ultimately rejected in favor of an intersubjective conception or dialectical and intentional concept of consciousness. The body is central to Merleau-Ponty's account of perception. In his view, the ability to reflect comes from a pre-reflective ground that serves as the foundation for reflecting on actions.

Merleau-Ponty's account of the body helps him undermine what had been a long-standing conception of consciousness, which hinges on the distinction between the for-itself (subject) and in-itself (object), which plays a central role in the philosophy of Jean-Paul Sartre, whose *Being and Nothingness* was released in 1943. The body stands between this fundamental distinction between subject and object, ambiguously existing as both. In Merleau-Ponty's discussion of human sexuality, he discusses psychoanalysis. Merleau-Ponty suggests that the body "can symbolize existence because it brings it into being and actualizes it (the body)."

Sigmund Freud's "Project for a Scientific Psychology"

Freud's energetic model of psychic equilibrium (excitation flow and discharge) resonates with these "wobbles" as momentary imbalance, while flutter captures the precise, anticipatory adjustment preceding redistribution. **NeurOptimal®**'s mirror-like feedback supports this dynamical homeostasis intrinsically, without training or pushing toward any state.

Karl Pribram's Holonomic Brain Theory from The Form Within:

Pribram's distributed, holographic processing—where patterns reconstruct flexibly via interference patterns—complements flutter as global signals of impending reconfiguration. The delicate flutter metaphor underscores holonomic adaptability, as feedback on detected, flutter in the measured electrical activity enables the brain to emergently reassemble optimal functioning across its networked whole. Memory recall is not entirely precise. **Karl Pribram's** holonomic brain theory implies that memories are not perfectly accurate reproductions of events because they are stored and retrieved as distributed interference patterns, similar to holograms. The sensory interference patterns involved in the process of memory recall offer merely a representation of what happened. Ongoing sensory inputs constantly interfere with these stored patterns, causing present perceptions and recalled memories to be dynamically reconstructed—integrating past encodings with current waves—rather than exact, verbatim retrievals.

Pribram suggests that there are two layers of cortical processing: a surface structure of separated and localized neural circuits and a deep structure of the dendritic arborization that binds the surface structure together. The deep structure contains distributed memory, while the surface structure acts as the retrieval mechanism. Binding occurs through the temporal synchronization of the oscillating polarizations in the

synaptodendritic web. It had been thought that binding only occurred when there was no phase lead or lag present, but a study by **Saul** and **Humphrey** found that cells in the lateral geniculate nucleus do in fact produce these. Here phase lead and lag act to enhance sensory discrimination, acting as a frame to capture important features. These filters are also similar to the lenses necessary for holographic functioning.

Pribram notes that holographic memories show large capacities, parallel processing and content addressability for rapid recognition, associative storage for perceptual completion and for associative recall. In systems endowed with memory storage, these interactions therefore lead to progressively more self-determination.

This specific theory of quantum consciousness was developed by neuroscientist **Karl Pribram** initially in collaboration with physicist **David Bohm** building on the initial theories of **holograms** originally formulated by **Dennis Gabor**. This describes human cognition by modeling the brain as a holographic storage network. Pribram suggests these processes involve electric oscillations in the brain's fine-fibered dendritic webs, which are different from the more commonly known action potentials involving axons and synapses. These oscillations are waves and create **wave interference** patterns in which memory is encoded naturally, and the wave function may be analyzed by a Fourier transform.

Gabor, Pribram and others noted the similarities between these brain processes and the storage of information in a hologram, which can also be analyzed with a Fourier transform. In a hologram, any part of the hologram with sufficient size contains the whole of the stored information. In this theory, a piece of a long-term memory is similarly distributed over a dendritic arbor so that each part of the dendritic network contains all the information stored over the entire network. This model allows for important aspects of human consciousness, including the fast associative memory that allows for connections between different pieces of stored information and the non-locality of memory storage (a specific memory is not stored in a specific location, i.e. a certain cluster of neurons).

Merleau-Ponty, Luria, Freud, and Pribram together conceptualize the mind-brain as an embodied, “plastic,” energetic, and distributed system primed for self-optimization—echoing how **NeurOptimal®** leverages flutter (its graceful, hummingbird-inspired precursor) to inform the brain of its own flux. This refinement avoids any implication of state detection or training, reinforcing the system's ethos of effortless empowerment. It bridges philosophical and neuropsychological insights with modern dynamical practice, fostering resilience and well-being through the brain's natural response to subtle awareness of its flutter dynamics.

"Turbulence" is complemented or softened by the term “flutter” — likening it to the rapid, subtle wing vibrations of a hummingbird hovering near a flower just before it gracefully darts away. This flutter metaphor emphasizes the delicate, anticipatory nature of the detected flutter in the measured electrical activity of the brain, which precedes a natural adjustment or shift during a Session. This turbulence/flutter distinction highlights **NeurOptimal®**'s gentle, non-invasive approach: feedback empowers intrinsic “dynamicalism” (i.e., change that may occur in response to noted change in the electrical activity of the brain) rather than imposing change. **Karl Pribram's** work on the **Holographic Theory of the brain/CNS, interference patterns**, “In every part of the brain, lies the whole of our experience in terms of perception and memory.” Flutter is natural and occurs preceding every time our brains shift from one phase to another – i.e., from wakefulness to beginning to nod off into rest or sleep or as we become excited about something or bored, etc. **NeurOptimal®** makes no judgment about flutter but only signals the brain as it occurs during a session and offers it the orienting response to the event and allows it to decide whether to respond to the flutter or not and in the context of what the brain does all the time – detect difference in information that is relevant to it and adjust as needed (or not) in order to minimize discomfort to the brain.

Dr. Val Brown's Philosophy Behind NeurOptimal® (Drs. Val & Sue Brown are the co-creators)
Karma or Dharma: Three Acronyms That Can Clarify The Core of Neurofeedback Training

"In this field we have a lot of theories – and we seem to continue to reinvent a number of wheels. Coming from a largely Western basis, and with a belief in a particular application of the scientific method, it seems that many can easily forget the depths of prior, well-established approaches to understanding and promoting the process of personal transformation. However, this is changing and increasingly modern science has come face to face with its own reflection in several ancient mirrors – most notably Buddhist practice.

Karma and Dharma are two fundamental concepts in Buddhist practice. The first refers to the repetitive patterns of cause and effect that re-create habitual cycles of suffering, while the second refers to the precise view and practice that leads to the realization of releasing such suffering. In the Buddhist view we remain in the choice point of Karma (i.e. repeating our past suffering) or Dharma (i.e. stepping off of the wheel that recreates our suffering). It is that “OR” that remains critical for we always have a choice: Karma or Dharma. But we can make these ideas a little more approachable by seeing them as acronyms. Karma: Continued Affective Re-triggering Maintains Attachment. Dharma: Disrupting Habitual Affective Re-triggering Maintains Aliveness. And the “OR”? It refers to the two fundamental operations of the CNS that are most critical to successful neurofeedback training: viz, the Orienting Response and the Relaxation Response.

We can choose to either repeat our past – and recreate the attachments we have to our own history and experience of suffering – OR we can choose to release that process of attaching by disrupting it, as it begins to reappear, and thereby return to the aliveness of the present. We do this in neurofeedback by providing audiovisual events that disrupt that process of Affective Re-triggering, invoking the Orienting Response (to directly perceive the relative safety of the present) and thereby invoking the Relaxation Response – when the CSN recognizes and experiences the safety of the training environment.”

NeuroOptimal® Music

The optimal music for NeuroOptimal® was created by Jeff Bova, utilizing 440 Hz frequency, which is also known as **A440 or the Stuttgart pitch**: a subjective psychoacoustical attribute of sound, where the tonal center is the tone of complete relaxation and stability according to Western cultural standards. This process retrains the brain for flexibility and resilience by bringing the CNS back to the present moment so that it can acquire and adapt from the information that is being provided. Other music or non-streamed movies may be played with the system that allows children to stay focused and relaxed while undergoing their brain training session.

NeuroOptimal® neurofeedback session length

While the standard NeuroOptimal® neurofeedback session length is normally 33 minutes, sessions may be shortened to 15 minutes or extended up to 45 minutes to accommodate client’s desires. The main reason for a 33-minute session is that it fits neatly into the classic therapeutic hour and then there is time for a short talk prior to the session, adhere the sensors, initiate the software, clean up afterwards, and for a short talk after the session. Since NeuroOptimal® operates subconsciously, the client has the options to talk during their session, read, relax, close their eyes, or watch the visual feedback graphics. However, most clients report falling asleep, which satisfies their brain’s need in the moment.

NeuroOptimal® Mathematical Processes

To explain the inner workings of NeuroOptimal® the software utilizes mathematical processes of Nonlinear Dynamical Systems Control Process Mathematics and Fourier Transform Series of Joint-Time-Frequency-Analysis (JTFA) in four-dimensional terms of *Duration* (e.g., a mismatch like playing a musical note too long), *Intensity* (like playing a musical note too loud or soft), *Frequency* (a mismatch like playing a musical note too sharp or flat), and *Shift* (a mismatch like changing a melody or just off-beat) progression. While incredibly complex, this allows the brainwave patterns observed to be internally mapped from a one-dimensional time domain signal into a two-dimensional representation of energy contrasted with frequency and time. In JTFA, the Fourier Transform series is not a single, fixed formula but rather a foundation for various time-frequency representations, where a signal is broken down into smaller time segments and then Fourier transformed on each segment, effectively showing how the frequency content of a signal changes over time. Essentially, it’s a two-dimensional representation of a signal’s energy distribution across both time and frequency domains,

typically visualized as a spectrogram. Processing further, the Gabor Transform variation is utilized, which is a variation of the Short-Time Fourier Transform (the most basic method, using a fixed window size to analyze the signal) with a Gaussian window function, offering better time frequency localization. Additional processes include Chaos Theory, where algorithms allow for real-time operation of the software.

NeurOptimal® monitors 20 EEG targets across the full range of brainwave activity, including high frequencies from 0.001 to 64 Hz — with no limits on processing capacity. The **NeurOptimal**® software continuously monitors *specific frequency ranges* in real time. The feedback mechanisms monitor brainwave activity across multiple frequency bands. Rather than targeting fixed frequencies, it operates with 20 “floating target bins”, which are mathematically constructs formulated target bins that float with the fluctuating amplitude of the individual brain’s electrical output. There are sixteen (16) floating target bins, eight (8) on each side of the brain. The software trains synchrony and coherence across the two sides of the brain. As the brain shows emerging turbulence or instability, the software provides feedback to let the brain see these instabilities in real time and adjust itself. This adaptive, real-time monitoring allows the brain to reorganize using its own intrinsic dynamics, rather than being pushed toward a predetermined target. This software enables the person’s brain and CNS to train toward its own self-determined optimal functioning, comprehensively. Each target bin corresponds to a segment of the brain’s electrical activity (EEG) from very slow delta waves up through high gamma waves. Instead of forcing the brain toward a “pre-set” ideal, **NeurOptimal**® simply alerts the brain when it detects sudden shifts or instability with any of these ranges, allowing the brain to self-correct and optimize.

The frequency coverage targets span the full EEG spectrum:

Band	≈ Range (Hz)	Typical Associations
Delta	0.001–4 Hz	Deep sleep, restoration
Theta	4–8 Hz	Creativity, daydreaming, memory encoding
Alpha	8–12 Hz	Relaxation, calm alertness
Beta (low–mid)	12–30 Hz	Focus, problem-solving, active thinking
High Beta	30–40 Hz	Intense concentration, stress responses
Gamma	40–64 Hz	Integration, peak performance, insight

As a reminder, many traditional neurofeedback systems *cap their upper frequency limits often around 42 Hz and only read 4% of the electrical activity*. **NeurOptimal**® does **not** impose a ceiling, this allows the brain to address patterns in high gamma ranges, which are linked to cognitive processing speed, learning, and complex information integration. The high frequencies matter because *High Gamma* can become dysregulated during trauma, brain injury, or neurodegenerative conditions. Accessing these frequencies may support more complete self-optimization, especially for Peak performers (athletes, musicians, executives), individuals recovering from brain injury, and/or people seeking sharper focus or creativity.

NeurOptimal® is a next-generation brain training that works with your brain’s natural ability to self-correct. Using these levels across the full range of brainwave activity, from the slowest, restorative delta waves to high gamma, **NeurOptimal**® monitors your brain in real time, alerting it to shifts or instabilities as they happen, giving the brain an opportunity to self-correct.

With no artificial limits on the frequencies it can track, **NeurOptimal**® gives your brain the information it needs to function at its best. There’s no pushing, forcing, or guessing. Your brain decides what to adjust, moment by moment, creating lasting improvements in focus, mood, sleep, resilience, and overall well-being. Whether you’re looking to boost performance, recover from life’s challenges, or simply feel more like yourself, **NeurOptimal**® is designed to help you get there — naturally. Listed below are two general areas where the brain delivers brain optimization.

Performance-Oriented

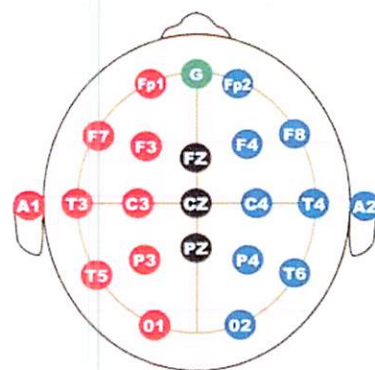
NeurOptimal® trains your brain to perform at its best — naturally. **NeurOptimal®** empowers your brain to perform at its best, without limitations. Elite athletes, top executives, artists, and high achievers know that success comes down to focus, adaptability, and resilience under pressure. **NeurOptimal®** gives your brain the information it needs to fine-tune itself, no guesswork, no forcing. With the system monitoring the full brainwave spectrum, including high gamma, **NeurOptimal®** captures nearly every detail of your brain's performance in real time. The system alerts your brain to tiny shifts that can interfere with mental clarity, reaction speed, and creativity — allowing you to adjust instantly. This results in more flow, faster recovery, sharper thinking, and the mental edge to stay ahead in sport, business, and life.

Wellness-Focused (from feeling overwhelmed to being inner calm, naturally)

NeurOptimal® gives your brain real-time feedback, helping you think clearer, feel calmer, and live more fully. **NeurOptimal®** targets spanning the full brainwave spectrum, helping you find focus, balance, and resilience by gently training your brain, from the slowest restorative waves to the fastest high gamma, supporting balance, clarity, and resilience. Stress, burnout, and life's challenges can leave the brain stuck in patterns that make rest, focus, and emotional balance feel out of reach. **NeurOptimal®** tracks your brain's activity moment by moment, alerting it to patterns of instability. With no pushing or forcing, your brain learns to find its own balance again. Over time, many people report better sleep, more stable moods, greater resilience, and a renewed sense of clarity.

NeurOptimal® Sensor Placement

"Read-only" EEG (electroencephalogram) gel sensors are designed exclusively to detect and record the brain's natural electrical activity (the EEG signal) without sending any energy or stimulation back into the brain. The EEG readings from the client, measured 256 times per second, are derived from the voltage drop measured between the Active (**yellow**) Sensors placed on the scalp and the Reference (**blue**) Sensors placed on top of each ear. The placement of the sensors (**C₃/C₄** on the scalp and **A₁/A₂** on the ears) is based upon science accepted standards created in 1958 in accordance with the 10 - 20 International System of Electrode Placement for EEG readings. The term "10 - 20" refers to the placement of electrodes (sensors) over 10% or 20% of the total distance between specified skull locations. The letters correspond with the brain regions; the numbers pertain to the locations of each hemisphere. Typically, there are two types of sensor placement for neurofeedback: unipolar and bipolar. The **NeurOptimal®** system foundation utilizes bipolar with two active sensors placed on opposite sides of the skull. The major advantage of bipolar recording is the "**Common Mode Rejection Ratio**" that occurs during the recording process, which allows for any external artifact occurring at both channels. At the same time, its amplitude and phase are subtracted, and the spatial selectivity is improved. The **C₃** sensor monitors the cognitive tasks and the **C₄** sensor monitors the emotional/calm brain status. The **C₃** and **C₄** points are at the Limbic Crossover, where 96% of the electrical fluctuations through the entire CNS are addressed versus only 4% are utilized with the Shannon math-based systems throughout the traditional neurofeedback field.



The Ground (**black**) Sensor, placed on the bottom right ear, allows for the **Common Mode Rejection Ratio** mode to be performed and functions as part of process where the **zAmp** converter "denoises" the EEG renditions by minimizing electrical line noise, which is critical in obtaining clear readings. The **zAmp** converter also amplifies and converts the micro-voltage electrical readings from analog to digital mode for processing by the software. The conductive non-toxic water salt-based paste, used to adhere the sensors to the client, bolsters the overall quality of the measured micro-voltage. Without this paste, the signal is weak, unreliable, and significantly less accurate.

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NeurOptimal® Triggers the Feedback

The key part of explaining how **NeurOptimal®** works is describing what specifically triggers the feedback, as the timing of the music's interruptions are key to the flutter that immediately precedes a shift in brainwave

patterns. Normally, the electrical signal remains in a fixed pattern. **NeurOptimal®** creates an interruption anytime there is a difference in the electrical signal read from the sensors. The software simply monitors the electrical output of the brain and senses this low voltage present on the scalp. **NeurOptimal® is not protocol-driven and does not induce, force, entrain, augment, or inhibit a specific state, frequency, or outcome. There are no electricity, magnetic fields, or altered EEG readings introduced back into the brain.** This means the sensors used are “read only” for the system to redirect or mirror your readings back to you. By interrupting that pattern with a milli-seconds of silence or static input, the brain will adjust and realize a new place of internal comfort. When a neuronal circuit is interrupted and not allowed to fire (as happens during a feedback event), there's an opportunity for neurons to begin subconsciously disengaging from that circuit and are then freed up to connect in more efficient patterns. Your brain chooses how to respond. The feedback is triggered by a specific brainwave event. That is the information that lets the brain know what it just did. This is the mirror aspect. For example, when looking in a mirror and combing your hair, the mirror provides visual feedback information about what you just did. You may or may not like what you just did and may choose to comb your hair in a different way. But the mirror doesn't have an opinion about it and it's not trying to influence how you style your hair. It simply provides information that allows you to make different choices.

In the same way the feedback during a **NeurOptimal®** session is basically saying, “Hey you're about to do something else, “Is that what you really want to be doing right now?” The flutter in the brainwave pattern that triggers feedback (and indicates a shift in electrical activity is imminent) is not an indication that something is wrong or should be changed. It's just information. The answer may very well be, “Yes, that's exactly what I want to be doing right now.” Again, it's just giving the brain information about what it just did and now giving the brain a choice to either continue doing what it is doing, or it can choose to shift to something else. While the software is complex, the basic process is sophisticatedly simple. In daily life, the brain does not have a direct channel of information about itself when normal feedback loops that operate are delayed in time, and that time-delay can make feedback not useful for the brain.

It is important to understand that the brain wave flutter activity that triggers feedback within **NeurOptimal®** is indifferent, only indicating that the brain is about to shift gears, but the software doesn't know whether the brain is trying to shift into a more efficient brain state or an old stuck pattern. Therefore, **NeurOptimal®** allows the brain to identify every time the software detects a change when the brain is about to react and interrupts the brainwave that allows the brain to process accordingly. We know that when the brain is given information about what it just did and given a choice on where to go, the brain always chooses the most efficient and optimal option.

Fundamentally, **NeurOptimal®** is a dynamical neurofeedback system that reads your “*brainwaves*” and mirrors them back to your brain, so that the brain can self-regulate in the moment, thereby training your brain to enhance efficient patterns. With **NeurOptimal®**, the brain is in a feedback loop with itself and removes the time-delay from the equation, which allows all feedback to have instant value to the brain. That's the concept of the mirror. Since the brain is constantly attempting to optimize its functioning, there is no need for the software to direct or influence, only present an accurate mirror. **NeurOptimal®** simply supports the brain's natural drive towards optimization. Essentially, the brain training program is infinitely cycling thereby mirroring through an auditory and visual feedback system, a process for the brain to subconsciously self-regulate. This retrains the brain for flexibility and resilience, supporting the CNS's innate ability of infinitely cycling through a “rebalancing” or a “reorganizing” so the brain can more efficiently use neural pathways. This process results in the brain choosing to accept new thoughts and/or different behavior patterns. Some mistakenly envision **NeurOptimal®** as correcting or imposing something on the brain. The process only embraces the intrinsic self-organizing wisdom of the CNS and all that is required is to give the brain information about what it just did and nothing more.

Another process included in the **NeurOptimal®** system is *alternating bilateral stimulation* which affects the electrical activity in key brain areas associated with stress and anxiety. This process involves rhythmically

alternating left-right auditory input to help enhance grounding, assists in the processing of emotions, supports focus, emotional regulation, and relaxation practices.

Despite outward appearances, many people walk with mental/emotional pebbles in their shoes, making for an uncomfortable and sometimes desperate life journey. Unprocessed trauma of all kinds may cause the CNS to become “stuck” in the conditioned response of a fight/fight/freeze/fawn state, which may cause dysregulation of many body processes. **NeurOptimal®** is often the missing piece for those who have worked extremely hard to overcome their different issues yet still have lingering negative effects and defensive coping behaviors developed while surviving from trauma. **NeurOptimal®** trains the brain to “release” the fight/flight conditioned response, thereby interrupting and breaking down old inefficient or stuck patterns and setting into motion the establishment of new and more optimal patterns. This process enhances the brain in choosing to accept new thoughts and different behavior patterns.

U.S. Food & Drug Administration (FDA) General Wellness Designation for NeurOptimal®

NeurOptimal® is about optimal functioning and is not considered a medical treatment. In fact, **Zengar® Institute** sought a Food & Drug Administration designation as a *General Wellness Device* as opposed to a medical device designation. At the very core and foundation of how it works, it is goalless practice. The software is agnostic, where clients may have specific goals to achieve, but the software focus has no goals. The Brain Training only provides an accurate mirror to inform the brain what it just did. **NeurOptimal®** meets every client where they are, as each client’s brain is different. It also does not matter what pharmaceutical medications the client may be prescribed. However, clients should be informed that they should continue following their physician’s guidance regarding any prescribed medications as **NeurOptimal®** is not a medical treatment and should not be used to guide medication changes. However, dosages may need adjustment by their medical doctor as brain training sessions proceed. According to FDA regulations, due to this designation, no medical or professional license is required to provide brain training services to clients. **Zengar®** does provide Basic, Advanced, and Master neurofeedback certifications.

The **U.S. F.D.A.** has determined that **NeurOptimal®** is a General Wellness product..., which presents a low risk to the safety of users, along with maintaining or encouraging a general state of health, while helping to reduce the risk or impact of certain chronic diseases or conditions... and where it is accepted that healthy lifestyles choices may play an important role in health outcomes for the disease or condition.

Here is the official statement from the FDA:

*“Pursuant to Section 513(g) of the Federal Food, Drug, and Cosmetic Act (Act), you requested information regarding the regulatory requirements applicable to **NeurOptimal®** under the Act. Based on the information provided in your submission, we have determined that the **NeurOptimal®** is a general wellness product. In accordance with our guidance¹, CDRH defines general wellness products as products that meet the following two factors: (1) are intended for only general wellness use as defined in the guidance, and (2) present a low risk to the safety of users and other persons. A general wellness product has (1) an intended use that relates to maintaining or encouraging a general state of health or a healthy activity, or (2) an intended use that relates the role of a healthy lifestyle with helping to reduce the risk or impact of certain chronic diseases or conditions and where it is well understood and accepted that healthy lifestyle choices may play an important role in health outcomes for the disease or condition.*

*Our determination that **NeurOptimal®** is a general wellness product is based on the following information provided in your submission: (i) the intended use of the product is for passive brain training for personal enrichment; (ii) noninvasively records brain activity to provide a brief interruption in the sound of media playing through earbuds. Therefore, we do not intend to enforce any applicable regulatory requirements under the Act, including premarket notification, and its implementing regulations for the **NeurOptimal®**.”*

Observing results from NeurOptimal® Neurofeedback

While **NeurOptimal®** has positive outcomes, there are no graphs or images to indicate progress. Since there is no treatment or therapy, the client’s life shifts are the outcome. Sometimes a client doesn’t recognize the changes in their life until a friend or family member points out those changes to their attention. Sometimes

the changes the clients seek are not changed until other shifts take place. To avoid any confusion, clients must be open to changes that are only unique to them and not about fixing or changing anything. Many clients reported positive effects relating to a decrease in anxiety, improvement in mood, an increasing sense of well-being, improved sleep habits, increased self-awareness, improved overall functionality and improved coping life skills.

There are no direct negative side effects of the system. A client may experience forgotten memories or increased dream activity which yields suppressed traumas covered up by coping mechanisms. The mirror's job is to be an accurate reflection of reality. In the **NeurOptimal**® process, we know the brain will use feedback information to optimize itself in a unique way for that individual and there is no prediction in advance or control of the optimization process.

When clients focus on the journey rather than a specific destination, they will see the “now while seeing progress” in an overly broad spectrum. Clients need to realize that every single session is a good session. Their brain self-observes in the mirror for 33 minutes and the brain can't help but change when that information is mirrored back. Whether change is showing up immediately or takes time, it doesn't really matter. The understanding is to direct clients away from a direct outcome. The only data that matters is “how you are right now.” The protocol is to fill out the informed consent and to score each of the symptoms on the Tracker Sheet. This is critical because most people forget how they acted and thought in the past. In other words, how one acts or thinks becomes the new norm and clients may need to be reminded of previous thoughts to see the new self. Changes can be subtle and seamless over time and perhaps not exactly the way someone is seeking. Returning to resilience and flexibility does not occur in a straight line as our brains and our lives are nonlinear and dynamical.

Interestingly, some clients do not observe changes in their thoughts, behaviors, or self-esteem. Only after family members and/or close friends observe and make comments to the client about positive changes do those clients acknowledge positive outcomes. Another example, a client may have felt that nothing was changing and yet, after a discussion, they noticed that a life-long nail-biting habit went completely away and there were a lot more promising changes that occurred as the training continued. While 15-20 sessions are the typical starting point for most clients, many clients continue with additional sessions. **Clients are allowed to start and/or stop whenever they want.** Change is the nature of our lives, and it takes enormous amounts of energy to keep things the same. Many people only proceed with change when the pain of life's consequences becomes overwhelming. The **NeurOptimal**® process of change seems to occur from **with-in**, emergent rather than from learning, conscious effort, or other techniques of change that are incorporated from the **with-out**. Each client responds in their own way in their own time; their own brain and CNS using the information to increase self-regulatory capacities and increase resilience and flexibility, reflected by the positive effects.

The number of sessions is strictly up to the client. Having sessions daily is acceptable, having sessions 2 or 3 times per week is also acceptable, provided the client agrees. A client may want two sessions per day, for example one in the morning and the other in the late afternoon (4-hour minimum due to the brain needing time to rest and gain new stability). Some rare clients may see some positive results after their first session, while most others may have upward of ten sessions before reporting changes. Every brain is unique and different, so the results are different for each. **NeurOptimal**® meets people where they are. Most brain shifts are permanent over time, while some may return for deeper re-enforcement or continued brain training.

Sensitive Clients and “Side Effects”

A useful starting point is clarifying the language. True “**side effects**” usually come from something that physiologically induces change, such as medication, entrainment, vibration, or electrical stimulation. **NeurOptimal**® is not protocol-driven and does not induce, force, entrain, augment, or inhibit a specific state, frequency, or outcome. It provides information to the central nervous system about its own electrical activity, allowing the CNS to notice and respond in its own way. So, when a sensitive client has a powerful

experience or noticeable shift, it may be more accurate to describe it as what Dr. Valdeane Brown has called a “**side journey**” rather than a side effect.

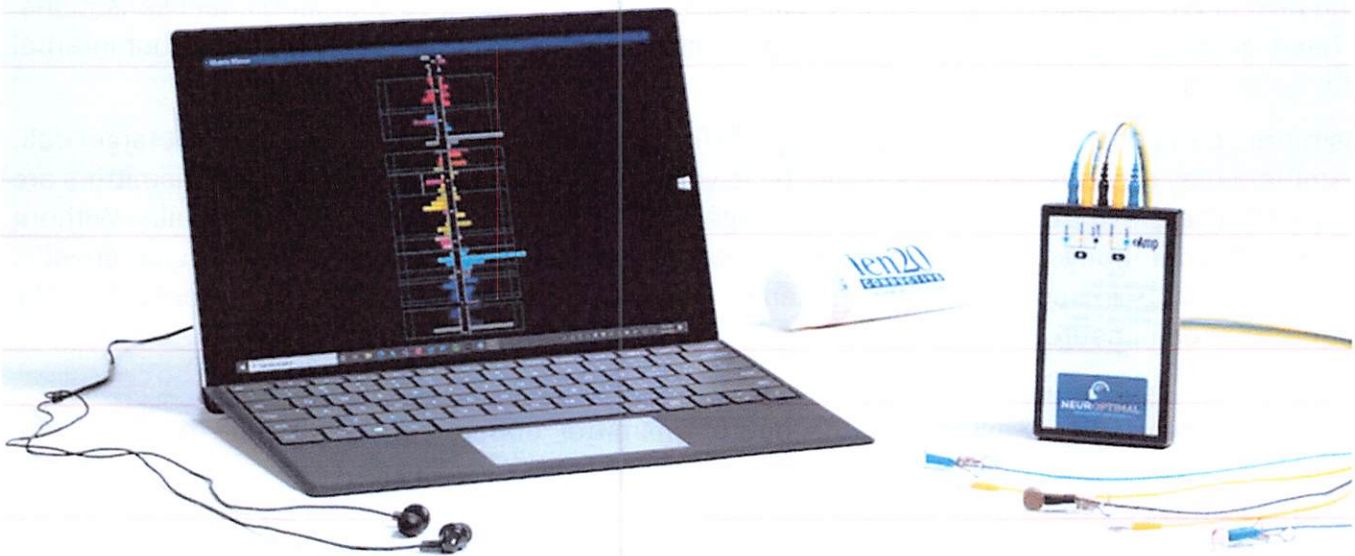
Sensitive clients may sometimes notice more because their systems may already be highly responsive, vigilant, patterned around safety, or sensitive to change. They may temporarily report fatigue, emotional release, irritability, increased sensitivity, unsettled sleep, or simply feeling “different.” These experiences should not be framed as treatment effects or as **NeurOptimal**® forcing change. They are better understood as the person’s system noticing information and responding through its own existing patterns.

This distinction matters. In the early development of **NeurOptimal**®, the movement away from linear, protocol-driven approaches was intentional. Rather than pushing someone toward a clinician-selected norm or “best” frequency state, **NeurOptimal**® was designed as a comprehensive, adaptive, client-directed training process. The practical guidance is simple: do not over-interpret, do not chase symptoms, and do not make medical claims. When medical or mental health concerns are present, clients are encouraged to consult an appropriate licensed healthcare professional.

The best part is without any technical protocols, without using any normative databases, without trying to direct the client's brain in any particular direction at all, **NeurOptimal**® puts absolutely all the power in the hands of the client. Any benefits that the client notices are solely because their Central Nervous System chooses to use feedback information about itself in this powerful and positive way. This process is quite empowering and renders a deeper trust in themselves. Not only in their self-esteem, but in the deepest part of their Central Nervous System. That the process can be trusted that it’s powerful, and that their brain knows exactly what to do. Dr. Sue Brown’s “keep on keeping on” belongs in that same client-directed context. It is not a directive to continue regardless of experience. The client decides whether to continue, at what pace, and in what way.

Finally, many **NeurOptimal**® users have reported that they find out who they really are. This process resembles the story about the statue of David by Michelangelo, when he was asked “how he saw “David” in the uncut low-quality block of marble?” Michelangelo responded by saying, “that he only cut off the pieces of marble that weren’t David.” Here, the overall process is basically similar.

NeurOptimal® **Dynamical Neurofeedback**® meets your brain where you are, you are in control of changing the parts of you that may need changing, and the process occurs naturally at your own pace.



NeurOptimal® Dynamical Neurofeedback® monitors all the major brainwave frequencies (0.001 to 64 Hz) by detecting abrupt changes in brain electrical patterns, providing real-time audio feedback (256 times per second) via brief pauses in the music. **NeurOptimal®** is not protocol-driven and does not induce, force, entrain, augment, or inhibit a specific state, frequency, or outcome. **No electricity, magnetic fields, or altered brainwaves are introduced into your brain.** Brain training only provides an accurate mirror to inform the brain about what it just did in order for your brain to make different choices and create fresh neural pathways. This signals the subconscious brain of its own activity, which promotes self-regulation, flexibility, and resilience, leading to a grounded, relaxed and peaceful state.

This work is not endorsed by **Zengar®** and has not been reviewed by the company. The content and opinions expressed in this publication are solely those of the author(s) and do not represent the official stance of **Zengar®** or its affiliated entities. **Zengar®** is not responsible for the accuracy, completeness, or reliability of any information presented herein. Any reference to **NeurOptimal®** or **Zengar®** products, services, or technologies in this publication is for informational purposes only and does not imply endorsement or approval by **Zengar®**.

ATTACHMENT A

Neurotransmitters

Neurotransmitters are your body's chemical messengers. They carry messages from one nerve cell across a space to the next nerve, muscle or gland cell. These messages help you move your limbs, feel sensations, keep your heart beating, and take in and respond to all information your body receives from other internal parts of your body and your environment.

Neurotransmitters carry chemical signals ("messages") from one neuron (nerve cell) to the next target cell. Neurotransmitters play a role in nearly every function in your body. More specifically, neurotransmitters are chemical communicators that carry a nerve message from one nerve cell to the next cell. Without neurotransmitters, your body can't function. Too high of a level or too low of a level of specific neurotransmitters results in specific health problems. Medications work by increasing or decreasing the amount of or the action of neurotransmitters.

Here are the major types of brain processing pathways:

Dopaminergic Pathways: Pathways utilize the neurotransmitter dopamine to influence behavior and cognition.

- **Mesolimbic Pathway:** Involved in reward and motivation.
- **Mesocortical Pathway:** Plays a role in higher cognitive functions like attention and planning.
- **Nigrostriatal Pathway:** Essential for motor control.
- **Tuberoinfundibular Pathway:** Involved in regulating hormone release.

Here are the visual Pathways that are divided into two main streams in the cortex:

- **Ventral pathway ("What pathway"):** Processes information about an object's identity, such as its shape and color.
- **Dorsal pathway ("Where" or "How pathway"):** Processes information about an object's location, motion, and how to interact with it.

Here are examples of how pathways function:

- **Transduction:** Senses convert external stimuli into neural signals.
- **Transmission:** The signals travel along neural pathways, which are bundles of axons known as tracts.
- **Interpretation:** The signals reach the cerebral cortex or other brain regions for interpretation.

Response: The brain processes this information to generate a behavioral or emotional response.

What are neurotransmitters?

Neurotransmitters are chemical messengers that your body can't function without. Their job is to carry chemical signals ("messages") from one neuron (nerve cell) to the next target cell. The next target cell can be another nerve cell, a muscle cell or a gland. Your body has a vast network of nerves that send and receive electrical signals from nerve cells and their target cells all over your body. Your nervous system controls everything from your mind to your muscles, as well as organ functions. In other words, nerves are involved in everything you do, think and feel. Your nerve cells send and receive information from all body sources. This constant feedback is essential to your body's optimal function.

What body functions do nerves and neurotransmitters help control?

Your nervous system controls such functions as your:

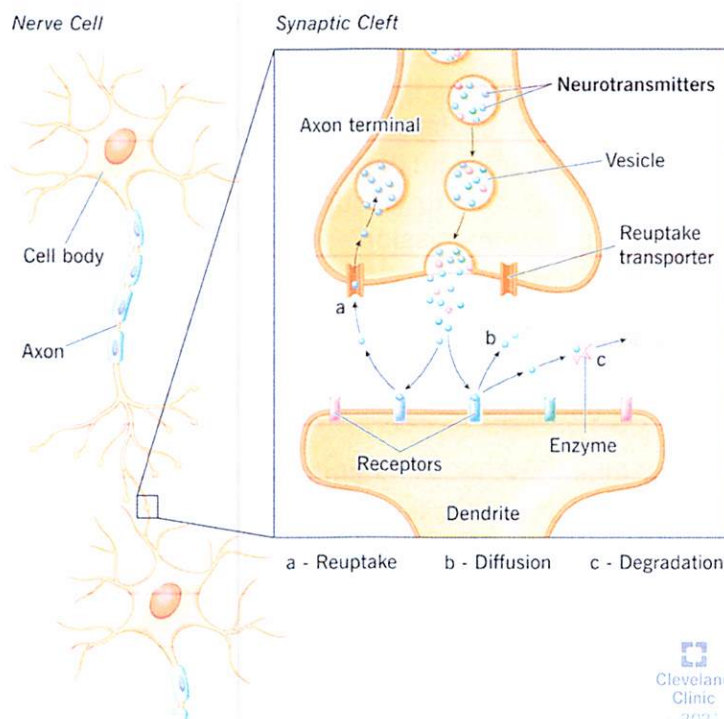
- Heartbeat and blood pressure.
- Breathing.
- Muscle movements.
- Thoughts, memory, learning and feelings.
- Sleep, healing and aging.
- Stress response.
- Hormone regulation.
- Digestion, sense of hunger and thirst.
- Senses (response to what you see, hear, feel, touch and taste).

How do neurotransmitters work?

You have billions of nerve cells in your body. Nerve cells are generally made up of three parts:

- **A cell body.** The cell body is vital to producing neurotransmitters and maintaining the function of the nerve cell.
- **An axon.** The axon carries the electrical signals along the nerve cell to the axon terminal.
- **An axon terminal.** This is where the electrical message is changed to a chemical signal using neurotransmitters to communicate with the next group of nerve cells, muscle cells or organs.

Neurotransmitters are located in a part of the neuron called the axon terminal. They're stored within thin-walled sacs called synaptic vesicles. Each vesicle can contain thousands of neurotransmitter molecules. As a message or signal travels along a nerve cell, the electrical charge of the signal causes the vesicles of neurotransmitters to fuse with the nerve cell membrane at the very edge of the cell. The neurotransmitters, which now carry the message, are then released from the axon terminal into a fluid-filled space that's between one nerve cell and the next target cell (another nerve cell, muscle cell or gland). In this space, called the synaptic junction, the neurotransmitters carry the message across less than 40 nanometers (nm) wide (by comparison, the width of a human hair is about 75,000 nm). Each type of neurotransmitter lands on and binds to a specific receptor on the target cell (like a key that can only fit and work in its partner lock). After binding, the neurotransmitter then triggers a change or action in the target cell, like an electrical signal in another nerve cell, a muscle contraction or the release of hormones from a cell in a gland.



What action or change do neurotransmitters transmit to the target cell?

Neurotransmitters transmit one of three possible actions in their messages, depending on the specific neurotransmitter.

- **Excitatory.** Excitatory neurotransmitters “excite” the neuron and cause it to “fire off the message,” meaning, the message continues to be passed along to the next cell. Examples of excitatory neurotransmitters include glutamate, epinephrine and norepinephrine.
- **Inhibitory.** Inhibitory neurotransmitters block or prevent the chemical message from being passed along any farther. Gamma-aminobutyric acid (GABA), glycine and serotonin are examples of inhibitory neurotransmitters.
- **Modulatory.** Modulatory neurotransmitters influence the effects of other chemical messengers. They “tweak” or adjust how cells communicate at the synapse. They also affect a larger number of neurons at the same time.

What happens to neurotransmitters after they deliver their message?

After neurotransmitters deliver their message, the molecules must be cleared from the synaptic cleft (the space between the nerve cell and the next target cell). They do this in one of three ways.

Neurotransmitters:

- Fade away (a process called diffusion).
- Are reabsorbed and reused by the nerve cell that released it (a process called reuptake).
- Are broken down by enzymes within the synapse so it can't be recognized or bind to the receptor cell (a process called degradation).

How many different types of neurotransmitters are there?

Scientists know of at least 100 neurotransmitters and suspect there are many others that have yet to be discovered. They can be grouped into types based on their chemical nature. Some of the better-known categories and neurotransmitter examples and their functions include the following:

Amino acids neurotransmitters

These neurotransmitters are involved in most functions of your nervous system.

- **Glutamate.** This is the most common excitatory neurotransmitter of your nervous system. It's the most abundant neurotransmitter in your brain. It plays a key role in cognitive functions like thinking, learning and memory. Imbalances in glutamate levels are associated with Alzheimer's disease, dementia, Parkinson's disease and seizures.
- **Gamma-aminobutyric acid (GABA).** GABA is the most common inhibitory neurotransmitter of your nervous system, particularly in your brain. It regulates brain activity to prevent problems in the areas of [anxiety](#), irritability, concentration, sleep, seizures and depression.
- **Glycine.** Glycine is the most common inhibitory neurotransmitter in your spinal cord. Glycine is involved in controlling hearing processing, pain transmission and metabolism.

Monoamines neurotransmitters

These neurotransmitters play a lot of different roles in your nervous system and especially in your brain. Monoamines neurotransmitters regulate consciousness, cognition, attention and emotion. Many disorders of your nervous system involve abnormalities of monoamine neurotransmitters, and many drugs that people commonly take affect these neurotransmitters.

- **Serotonin.** Serotonin is an inhibitory neurotransmitter. Serotonin helps regulate mood, sleep patterns, sexuality, anxiety, appetite and pain. Diseases associated with serotonin imbalance include seasonal affective disorder, anxiety, depression, fibromyalgia and chronic pain. Medications that regulate serotonin and treat these disorders include selective serotonin reuptake inhibitors (SSRIs) and serotonin-norepinephrine reuptake inhibitors (SNRIs).
- **Histamine.** Histamine regulates body functions including wakefulness, feeding behavior and motivation. Histamine plays a role in asthma, bronchospasm, mucosal edema and multiple sclerosis.
- **Dopamine.** Dopamine plays a role in your body's reward system, which includes feeling pleasure, achieving heightened arousal and learning. Dopamine also helps with focus, concentration, memory, sleep, mood and motivation. Diseases associated with dysfunctions of the dopamine system include Parkinson's disease, schizophrenia, bipolar disease, restless legs syndrome and attention deficit hyperactivity disorder (ADHD). Many highly addictive drugs (cocaine, methamphetamines, amphetamines) act directly on the dopamine system.
- **Epinephrine.** Epinephrine (also called adrenaline) and norepinephrine (see below) are responsible for your body's so-called "fight-or-flight response" to fear and stress. These neurotransmitters stimulate your body's response by increasing your heart rate, breathing, blood pressure, blood sugar and blood flow to your muscles, as well as heighten attention and focus to allow you to act or react to different stressors. Too much epinephrine can lead to high blood pressure, diabetes, heart disease and other health problems. As a drug, epinephrine is used to treat anaphylaxis, asthma attacks, cardiac arrest and severe infections.
- **Norepinephrine.** Norepinephrine (also called noradrenaline) increases blood pressure and heart rate. It's most widely known for its effects on alertness, arousal, decision-making, attention and focus. Many medications (stimulants and depression medications) aim to increase norepinephrine levels to improve focus or concentration to treat ADHD or to modulate norepinephrine to improve depression symptoms.

Peptide neurotransmitters

Peptides are polymers or chains of amino acids.

- **Endorphins.** Endorphins are your body's natural pain reliever. They play a role in our perception of pain. Release of endorphins reduces pain, as well as causes "feel good" feelings. Low levels of endorphins may play a role in fibromyalgia and some types of headaches.

Acetylcholine

This excitatory neurotransmitter does several functions in your central nervous system (CNS [brain and spinal cord]) and in your peripheral nervous system (nerves that branch from the CNS). Acetylcholine is released by most neurons in your autonomic nervous system regulating heart rate, blood pressure and gut motility. Acetylcholine plays a role in muscle contractions, memory, motivation, sexual desire, sleep and learning. Imbalances in acetylcholine levels are linked with health issues, including Alzheimer's disease, seizures and muscle spasms.

Why would a neurotransmitter not work as it should?

Several things can go haywire and lead to neurotransmitters not working as they should. In general, some of these problems include:

- Too much or not enough of one or more neurotransmitters are produced or released.
- The receptor on the receiver cell (the nerve, muscle or gland) isn't working properly. The otherwise normal functioning neurotransmitter can't effectively signal the next cell.
- The cell receptors aren't taking up enough neurotransmitter due to inflammation and damage of the synaptic cleft (see myasthenia gravis).
- Neurotransmitters are reabsorbed too quickly.
- Enzymes limit the number of neurotransmitters from reaching their target cell.

Problems with other parts of nerves, existing diseases or medications you may be taking can affect neurotransmitters. Also, when neurotransmitters don't function as they should, disease can happen. For example:

- Not enough acetylcholine can lead to the loss of memory that's seen in Alzheimer's disease.
- Too much serotonin is possibly associated with autism spectrum disorders.
- An increase in activity of glutamate or reduced activity of GABA can result in sudden, high-frequency firing of local neurons in your brain, which can cause seizures.
- Too much norepinephrine & dopamine activity and abnormal glutamate transmission contribute to mania.

How do medications affect the action of neurotransmitters?

Scientists recognized the value and the role of neurotransmitters in your nervous system and the importance of developing medications that could influence these chemical messengers to treat many health conditions. Many medications, especially those that treat diseases of your brain, work in many ways to affect neurotransmitters. Medications can block the enzyme that breaks down a neurotransmitter so that more of it reaches nerve receptors.

- For example: Donepezil, galantamine and rivastigmine block the enzyme acetylcholinesterase, which breaks down the neurotransmitter acetylcholine. These medications are used to stabilize and improve memory and cognitive function in people with Alzheimer's disease, as well as other neurodegenerative disorders.

Medications can block the neurotransmitter from being received at its receptor site.

- For example: Selective serotonin reuptake inhibitors are a type of drug class that blocks serotonin from being received and absorbed by a nerve cell. These drugs may be helpful in treating depression, anxiety and other mental health conditions.

Medications can block the release of a neurotransmitter from a nerve cell.

- For example: Lithium works as a treatment for mania partially by blocking norepinephrine release and is used in the treatment of bipolar disorder.

ATTACHMENT B

Traditional (Linear) Neurofeedback

Linear or traditional neurofeedback systems require a diagnosis, along with ongoing medical live-brain scans, called a Brain Map (QEEG), to determine which brainwaves (e.g., alpha, beta, delta, gamma, or theta) are inhibited or augmented into the brain over time to improve symptoms. These images are compared with a normal brain activity picture, not individually monitored during each session. Additionally, the current sessions are only responding to where the brain was 1-2 weeks ago. As we all can agree, every person is different at every moment while constantly moving and adapting to their current environment in addition to their own personal variables of sleep, diet, family dynamics, etc. Given this dynamic, the concept of structuring a neurofeedback protocol based upon a specific historical moment in time is far less than optimal. In other words, the brain is dynamical and changes hourly, daily and/or weekly. The major limitation that lies with traditional neurofeedback is with the push/pull of only doing a limited brain frequency group at a time, even though they may be monitoring 19 channels. This is called *protocol-based training*, the predominant model for linear neurofeedback in use today. As a reminder, many traditional neurofeedback systems *cap their upper frequency limits often around 42 Hz and only read 4% of the electrical activity*.

While the linear neurofeedback systems may be effective, the medical or licensed operator must be well experienced to make “educated guesses” about the brainwave type and dosage for the brain to be flooded. Which, to say the least, is complicated, especially when the presenting picture was not especially clear, or as often happens, the client has symptoms of several disorders, all of which required different and sometimes opposing protocols! Protocol implementation is highly complex and consequently dependent upon the skills of the clinician. Therefore, one symptom fades by allowing another symptom to become worse. And the only way you know when to change the procedure is by monitoring the client’s side effects. Unfortunately, whenever several problems are active within the brain, one inhibited or augmented type of frequency may cause problems for the other conditions, resulting in side-effects that create additional challenges for the client.

An example of this process may be metaphorically explained by the concept of the arcade game of “**Whac-a-Mole™**”, where players use a mallet to hit the moles as they randomly pop up. The term whack-a-mole is also used metaphorically to describe situations where dealing with one issue leads to the emergence of another, often in a repetitive or frustrating manner. According to Wiktionary*, the term “whack-a-mole is often used colloquially to refer to a situation characterized by a series of futile, unending tasks, where the successful completion of one just yields another popping up elsewhere.” In other words, “*whac-a-mole*” may be compared to traditional neurofeedback, where dealing with one issue, matters in a piecemeal manner leads to not achieving a desired complete solution. The outcome for the patient may be that when different symptoms pop up, the protocol is moved to treat the new symptom, while still not addressing the original desired outcome.

Summary of Traditional Neurofeedback

1. Protocol Dependence

- Traditional neurofeedback requires several ongoing **QEEG (brain maps)** to decide which frequencies to train.
- Protocols may be based on general patterns rather than the unique, moment-to-moment needs of the individual brain. Most traditional neurofeedback systems *cap their upper frequency limit* around 42 Hz.
- If the wrong protocol is chosen, results can be limited or even negative (e.g., worsening anxiety, sleep disruption, or mood swings).

2. Overtraining and Side Effects

- Because training is usually directed at specific brainwave ranges, there’s a risk of overtraining (too much suppression or enhancement).
- Side effects may include fatigue, headaches, irritability, difficulty concentrating, or sleep changes.
- Adjustments are often trial-and-error and can take multiple sessions to correct.

3. Time and Cost

- A full QEEG assessment can be expensive, upward to \$600 **each**. Traditional neurofeedback usually requires 30–60 sessions or more, often multiple times per week.
- This can make treatment long and costly, as well as time away from school and/or work.

4. Clinician Dependency

- Outcomes depend heavily on the clinician's skill in reading the QEEG, interpreting patterns, and designing the right training protocol. Practitioner error equals poor results and wasted money.
- Different practitioners may recommend different protocols for the same client, leading to inconsistency.

5. Limited Adaptability

- Traditional neurofeedback systems train according to set parameters.
- The brain is dynamic, but the protocol may not adapt instantly to changing neural activity mid-session.
- This can reduce effectiveness compared to more adaptive systems.

6. Client Variability

- Not everyone responds the same way, some people improve quickly, while others show minimal changes.
- Factors like age, medication, neurological conditions, and lifestyle all influence results, not including day-to-day life crisis influencing the state of mind.

7. Expectations and Communication

- Some clients expect a "cure" for conditions like ADHD, PTSD, or depression.
- Traditional neurofeedback is better understood by directing the brain towards a fix, not a guarantee.
- Poor expectation management may lead to disappointment.

Typical Linear System Timeline

Why Neurofeedback Requires a 4–6 Month Commitment

Understanding How the Brain Changes Over Time

Neurofeedback creates long-term change by training the brain in stages. Each phase builds on the previous one, which is why completing the full process is essential.

Phase 1: Stabilization (Sessions 1–10)

- The brain is getting familiar with the training
- Initial improvements may appear
- Helps the nervous system settle and regulate

Phase 2: Training & Change (Sessions 10–25)

This is where the real shifts begin as the brain starts reorganizing and responding to training.

Temporary Symptoms Around Sessions 12–16

Some clients may notice:

- A return of old symptoms
- A brief increase in symptoms
- Mild new symptoms that feel unfamiliar

Why this happens: The brain is actively rewiring—similar to muscle soreness after starting a new workout. These effects are temporary, normal, and safe. They usually pass within a few sessions.

Phase 3: Reinforcement (Sessions 25–40+)

- Locks in new brain patterns
- Reinforces long-term stability
- Prevents improvements from fading

Why 4–6 Months?

Neurofeedback is a retraining process. Completing all three phases ensures changes are strong, stable, and long-term. Consistency is what allows the brain to integrate and maintain improvements.

Comparison of **NeurOptimal® (NO)** versus **Traditional Neurofeedback (TN)**

1. PROTOCOL DEPENDENCE

- **TN:** Requires **QEEG brain maps** and fixed protocols. Wrong protocol = poor or negative outcomes.
- **NO:** No protocol, no diagnosis-based targeting. Simply giving the brain info about own activity in real time.

2. OVERTRAINING & SIDE EFFECTS

- **TN:** Possible side effects if training is too intense or misapplied (sleep problems, irritability, headaches)
- **NO:** Designed to avoid overtraining, the system only mirrors what the brain is doing, then stops the feedback instantly when instability is detected.

3. TIME & COST

- **TN:** Expensive QEEG brain scan setup, ongoing clinician adjustments, **39 to 60+ sessions** are common.
- **NO:** No QEEG brain scans required, less practitioner time, can be learned for home use, fewer office costs.

4. CLINICIAN DEPENDENCY

- **TN:** Strongly depends on clinician expertise to select and adjust protocols, practitioner error = poor results.
- **NO:** Automated, the system doesn't rely on practitioner interpretation, reducing human error.

5. ADAPTABILITY

- **TN:** Trains set frequency bands, doesn't adapt instantly if the brain's needs shift mid-session.
- **NO:** Dynamical provides continuous feedback 256x/s, always matching what the brain is doing now.

6. CLIENT VARIABILITY

- **TN:** Some clients improve; others don't. Results depend on accurate brain mapping + training match.
- **NO:** Presented as brain-training for resilience & flexibility, supports well-being, not as a cure for a disorder.

7. EXPECTATIONS

- **TN:** Marketed as a Tx for specific Dx's.(ADHD, PTSD, etc.), which may lead to frustration if results vary,
- **NO:** Presented as a training tool for resilience & flexibility, supports well-being broadly, not as a cure.

BOTTOM LINE

- **Traditional Neurofeedback = directive, clinician-driven, side-effects, protocol-dependent**
- **NeurOptimal® Dynamical Neurofeedback® = non-directive, brain-driven, self-adjusting.**

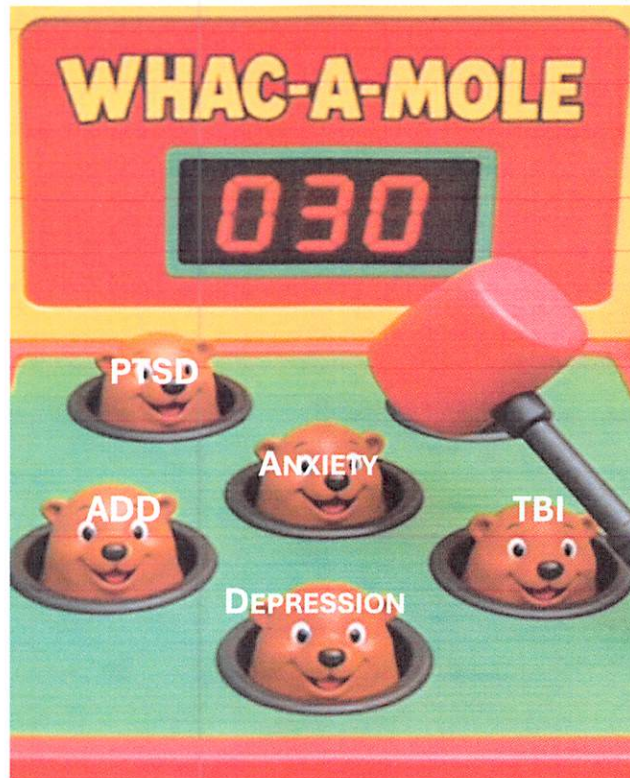
Ask a linear system practitioner, "do they use their own system on themselves?"

Probably NOT!

SUMMARY

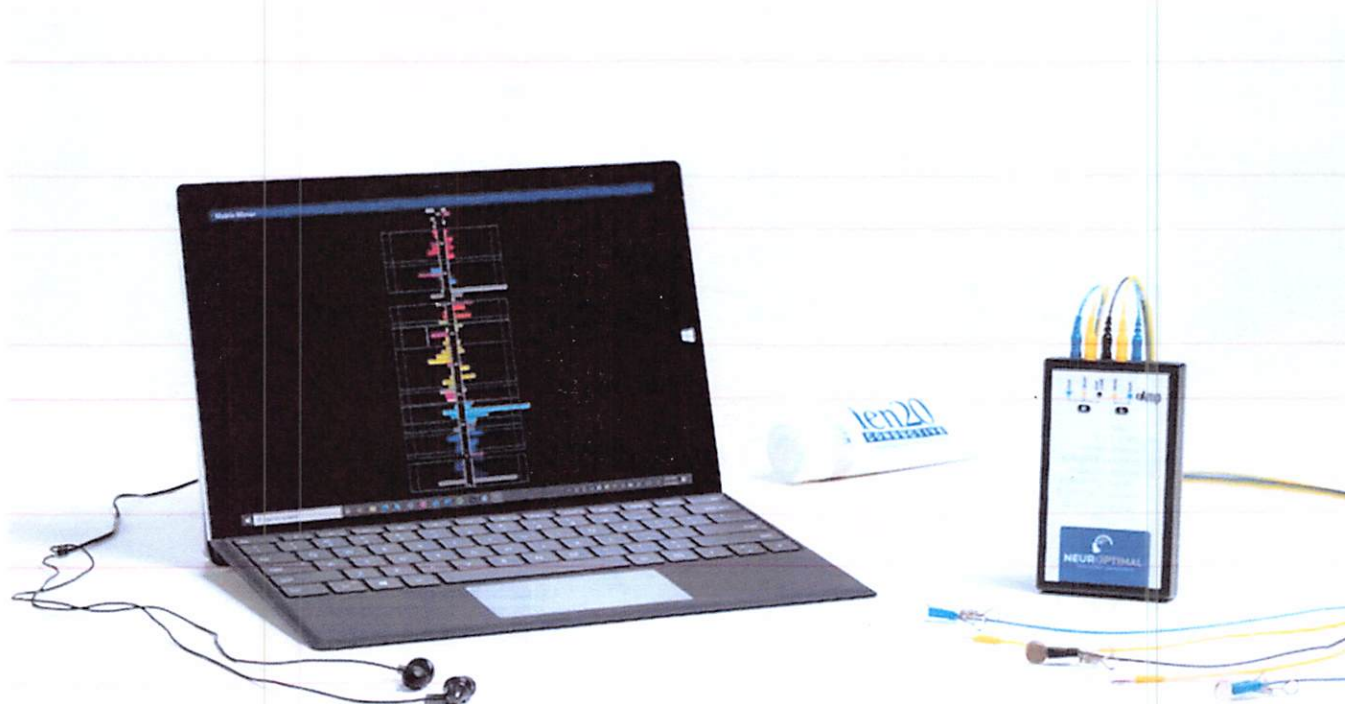
WHY PLAY “WHAC-A-MOLE” ON YOUR BRAIN USING LIMITED FREQUENCIES WITH
TRADITIONAL LINEAR NEUROFEEDBACK?

USE **NEUROPTIMAL® DYNAMICAL NEUROFEEDBACK®**
NON-LINEAR WHOLE-BRAIN TRAINING.



NeurOptimal® Dynamical Neurofeedback® monitors all the major brainwave frequencies (0.001 to 64 Hz) by detecting abrupt changes in brain electrical patterns, providing real-time audio feedback (256 times per second) via brief pauses in the music. **NeurOptimal®** is *not protocol-driven and does not induce, force, entrain, augment, or inhibit a specific state, frequency, or outcome.* **No electricity, magnetic fields, or altered elements are introduced into your brain.** Brain training only provides an accurate mirror to inform the brain about what it just did in order for your brain to make different choices, creating fresh neural pathways. This signals the subconscious brain of its own activity, which promotes self-regulation, flexibility, and resilience, leading to a grounded, relaxed and peaceful state.

NeurOptimal® Dynamical Neurofeedback® is a 100% non-invasive, safe method for increasing focus, better managing stress and anxiety, while building greater confidence and wellness in your life; along with training your brain to be more flexible and resilient. Without pushing your brain in any direction, the **NeurOptimal®** system interacts with your central nervous system (CNS) in a way that improves the learning process of your brain. Since each person's brain is different, everyone responds differently according to their subconscious choices. No electrical/magnetic fields or brainwaves are imposed into your brain. A more flexible brain that responds quicker is more adaptive to changes in your environment. The more easily your brain adjusts to encounter changes in a normal, busy day, the better you feel. The **NeurOptimal®** "whole brain training system" can also help build brain resilience or increase the CNS's ability to "bounce back" from a negative event. Negative feelings associated with a personal conflict or bad day at work can "loop" for hours or days, long after the event has passed. The destructive effect of nervous, repetitive or self-critical thinking is magnified in more severe events such as physical and emotional trauma, or current and past grief. Instead of staying stuck in the negativity of these events, the resilient brain will snap-back and return to its normal baseline more quickly. Individuals with a more resilient brain report enjoying a more profound sense of peace, happiness, and success.



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