Brain Fitness for Business Success – A Controlled Study on Enhancing Entrepreneurs' Productivity and Focus through Neurotechnological Interventions

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ABSTRACT

Background: *Entrepreneurial performance critically depends on higher-order cognitive abilities and stress self-regulation in demanding professional contexts. In a competitive economic environment, advanced neurotechnological interventions can offer effective solutions for optimizing productivity, attention, and autonomic balance in entrepreneurs.*

Objective: *This study evaluated the effectiveness of a multimodal neurotechnological intervention—including personalized qEEG-based neurofeedback, gamma (40Hz) cerebral photobiomodulation, heart–brain coherence biofeedback, and non-invasive vagus nerve stimulation (Nurosym)—in enhancing cognitive performance and reducing stress in active entrepreneurs.*

Method: *This prospective, randomized, controlled clinical study included 300 entrepreneurs, equally divided into experimental and control groups. Participants were assessed using objective measurements (qEEG, cardiac coherence) and validated psychometric tools. Pearson correlations, multiple regression analyses, and effect size measurements (Cohen's d) were conducted for productivity, attention, and stress.*

Results: *Analyses revealed that although no significant correlations were found between cognitive variables, multiple regression showed a strong predictive model ($R^2 = .502$, $p < .001$), in which productivity ($\beta = .34$) and attention ($\beta = .33$) positively predicted overall performance, while stress had a significant negative effect ($\beta = –.22$). Cohen's d indicated a very large effect of the intervention on all three variables: productivity ($d = 2.68$), attention ($d = 2.78$), and stress ($d = –2.55$).*

Conclusion: *The findings support the efficacy of multimodal neurotechnological intervention in enhancing cognitive performance and regulating stress in entrepreneurs. Integrating these methods into national-level professional optimization and burnout prevention strategies is both scientifically and clinically justified.*

Keywords: *neurofeedback, photobiomodulation, biofeedback, vagus nerve stimulation, entrepreneurship, cognitive performance, stress, heart–brain coherence*

1. Introduction and Scientific Rationale

1.1 The Importance of Cognitive Performance, Productivity, and Focus for Entrepreneurial Success

Entrepreneurial success in a dynamic and competitive economic environment fundamentally depends on the entrepreneur's ability to make rapid, coherent, and effective decisions, as well as on their capacity to maintain sustained focus on long-term strategic goals. In this context, cognitive performance, productivity, and focus are not merely desirable individual traits, but key factors that define the competitiveness and sustainability of a business in an ever- changing economy.

Cognitive performance is a complex construct that encompasses information processing speed, cognitive flexibility, rapid and efficient decision-making, and the ability to correctly and coherently analyze information under conditions of risk and uncertainty. Unlike other professional categories, entrepreneurs frequently face the need to make decisions under high stress, with incomplete information and limited time. Under such circumstances, cognitive performance becomes essential for business success, directly influencing profitability, growth, and long-term viability.

Recent applied neuroscience research has demonstrated that optimal cognitive performance requires not only solid baseline intellectual capacity but also the entrepreneur's ability to maintain a clear and emotionally balanced mental state. This mental clarity enables a realistic perception of market opportunities and risks. Entrepreneurs with high cognitive performance are better able to identify business opportunities, anticipate and manage risks efficiently, and implement innovative and competitive strategies that offer them a strong market advantage.

Moreover, productivity is closely linked to personal efficiency and the entrepreneur's ability to manage both internal resources (time, energy, attention) and external ones (financial, material, human) in an optimal manner. In an entrepreneurial context, productivity is not merely about the quantity of work completed but, more importantly, about the quality and efficiency with which goals are achieved. Higher productivity implies better planning, organization, and prioritization—skills that directly impact business profitability and long-term success. For example, the ability to eliminate low-value tasks and focus energy on high-impact strategic activities is essential for sustainable economic performance.

Focus represents another crucial skill in entrepreneurship, especially as entrepreneurial environments are often characterized by informational overstimulation, multitasking, and multiple distractions. Contrary to the myth of effective multitasking, recent neuroscience studies clearly demonstrate that fragmented attention and lack of deep focus lead to decreased cognitive performance and significant decision-making errors. An entrepreneur's ability to maintain intense focus on priority tasks—while filtering out irrelevant stimuli—is directly associated with making strategic decisions that drive short-, medium-, and long-term business success.

Additionally, sustained attention impacts how entrepreneurs communicate, negotiate, and interact with business partners, clients, and employees. Those who exhibit clear and focused attention during discussions and negotiations are better equipped to identify and understand the needs and intentions of others, gaining a notable competitive advantage over those who cannot manage their attention effectively.

In conclusion, cognitive performance, productivity, and focus are foundational pillars for entrepreneurial success in today's economic climate. Entrepreneurs who succeed in optimizing these capacities become more resilient, efficient, and better equipped to face market challenges, significantly increasing their chances of achieving exceptional business outcomes. Therefore, the implementation of a multimodal neurotechnological intervention targeting these cognitive dimensions is not only justified but scientifically grounded—a strategic initiative for supporting and advancing successful entrepreneurship in Romania.

1.2 The Need for Validated Neurotechnological Interventions for Optimizing Cognitive and Autonomic Abilities Specific to Entrepreneurial Performance

In the current context, defined by rapid change, intense competition, and complex decision-making environments, neurotechnological interventions represent cutting-edge, scientifically grounded, and clinically validated solutions for optimizing the cognitive and autonomic abilities essential to entrepreneurial performance (Gruzelier, 2014; Arns et al., 2017). Entrepreneurs are constantly exposed to high-pressure situations that require quick decision- making, strong mental clarity, and optimal autonomic regulation of both physiological and emotional stress. As such, neurotechnological methods such as quantitative EEG neurofeedback (qEEG), cerebral photobiomodulation, and heart–brain biofeedback are powerful tools for directly and measurably enhancing these critical parameters (Thatcher & Lubar, 2014; Hamblin, 2016; McCraty & Shaffer, 2015).

qEEG neurofeedback is based on the principles of neuroplasticity and conscious neural self-regulation, with the capacity to train and optimize brainwave activity related to executive functions such as sustained attention, focused concentration, decision-making speed, and the ability to efficiently process complex information (Enriquez-Geppert et al., 2017; Vernon, 2005). Extensive research has shown that neurofeedback induces stable and lasting improvements in neural connectivity by increasing EEG coherence in frontal and parietal regions—areas directly involved in decision-making and problem-solving (Thatcher, 2010; Gruzelier, 2014). In entrepreneurial contexts, these neural shifts have been associated with measurable improvements in decision efficiency, productivity, and performance in cognitively demanding tasks (Gruzelier, 2014; Sherlin et al., 2011).

Cerebral photobiomodulation, which uses pulsed light in the near-infrared spectrum at specific alpha and gamma frequencies, is an emerging technique scientifically validated for stimulating neuronal metabolism and enhancing neuroplasticity (Hamblin, 2016; Salehpour & Hamblin, 2019). Recent studies have demonstrated that photobiomodulation directly affects neuronal mitochondria through cytochrome c oxidase, significantly improving neuronal energy

and ATP synthesis, with remarkable results in optimizing cognitive clarity and decision-making speed (Cassano et al., 2016; Naeser & Hamblin, 2015). In particular, the work of Barrett and Gonzalez-Lima (2013) has shown that gamma light stimulation leads to improved cognitive performance and concentration—core aspects of entrepreneurial success.

The ability to effectively regulate physiological and emotional stress is another critical factor in entrepreneurial success, which is why heart–brain biofeedback (cardiac coherence) is essential. This clinically validated method enables voluntary and effective control of autonomic nervous system activity via real-time monitored breathing techniques (Lehrer & Gevirtz, 2014; McCraty & Shaffer, 2015). Scientific studies support that heart–brain biofeedback fosters a state of cardiac coherence, objectively reflected in optimized heart rate variability (HRV), with measurable effects on reducing stress, anxiety, and cortisol levels (McCraty & Zayas, 2014; Goessl et al., 2017). In entrepreneurial contexts, these autonomic improvements directly translate into better cognitive performance under stress and during complex decision-making processes (Lehrer et al., 2020).

The combination of these three neurotechnological interventions—personalized qEEG neurofeedback, alpha–gamma cerebral photobiomodulation, and heart–brain coherence biofeedback—has demonstrated significant therapeutic synergy, producing objective and quantifiable improvements in productivity, decision efficiency, and cognitive clarity, all essential for high-level entrepreneurial performance (Gruzelier, 2014; Hamblin, 2016; McCraty & Shaffer, 2015). A particularly valuable feature of this multimodal approach is the ability to deeply personalize therapeutic interventions by using quantitative EEG assessments (brain mapping) and cardiac coherence measurements as the basis for tailoring protocols to each entrepreneur's individual needs (Thatcher, 2010; Collura, 2014).

Thus, neurotechnological interventions offer entrepreneurs a scientifically validated alternative to traditional methods (e.g., standard cognitive training, stress management courses, or generic coaching), which cannot provide objective feedback on individual progress (Gruzelier, 2014; Sherlin et al., 2011). In contrast, neurotechnology leads to durable neuroplastic and autonomic changes that far exceed the transient effects of conventional methods.

In this light, the implementation of scientifically validated neurotechnological interventions is not merely a complementary option but a **strategic necessity** in today's entrepreneurial landscape—strongly supported by rigorous evidence. By applying these methods, entrepreneurs can gain a clear and sustainable competitive advantage by objectively and measurably enhancing the cognitive and autonomic skills fundamental to long-term entrepreneurial success.

1.3 Scientific Basis for qEEG Neurofeedback, Gamma (40Hz) Cerebral Photobiomodulation, Heart–Brain Biofeedback, and Vagal Nerve Stimulation in the Context of High-Level Professional Performance

High-level professional performance—particularly relevant to entrepreneurs and corporate leaders—directly depends on the brain's ability to sustain attention, maintain cognitive clarity, make rapid and accurate decisions, and the body's capacity to efficiently regulate physiological and emotional stress. In this context, neurotechnological interventions such as personalized qEEG neurofeedback, 40Hz gamma cerebral photobiomodulation, heart–brain coherence biofeedback, and vagus nerve stimulation (VNS) represent innovative, scientifically and clinically validated strategies with a major impact on optimizing brain and autonomic functions essential to professional success (Thatcher, 2010; Hamblin, 2016; Lehrer & Gevirtz, 2014; Breit et al., 2018).

Personalized Quantitative EEG Neurofeedback (qEEG)

Quantitative EEG neurofeedback is a non-invasive technique that enables direct, voluntary self- regulation of brain activity through real-time monitoring of brainwaves and precise visual and auditory feedback (Sherlin et al., 2011; Gruzelier, 2014). Its scientific foundation lies in the principle of neuroplasticity, which posits that the brain can reorganize its structure and function in response to specific, repeated stimuli (Enriquez-Geppert et al., 2017).

Multiple clinical studies and meta-analyses have demonstrated that neurofeedback significantly improves neural regulation in frontal and parietal regions—areas involved in executive and cognitive functions such as concentration, selective attention, processing speed, and decision- making capacity (Thatcher, 2010; Arns et al., 2014). Specifically, qEEG neurofeedback helps optimize the ratio between slow-wave activity (Delta/Theta), often associated with cognitive fatigue and attention deficits, and fast-wave activity (Beta/Gamma), which supports alertness, concentration, and peak performance (Gruzelier, 2014; Vernon, 2005). In professional contexts, this neural optimization has been directly linked to increased productivity and cognitive efficiency in high-performance tasks requiring sustained mental clarity and resilience to stress (Sherlin et al., 2011; Vernon, 2005).

Gamma (40Hz) Cerebral Photobiomodulation

Gamma-frequency cerebral photobiomodulation is a clinically validated neurotechnology that uses near-infrared (NIR, 810 nm) pulsed light at 40Hz to non-invasively stimulate targeted brain regions (Hamblin, 2016; Cassano et al., 2016). Its effectiveness stems from the photobiological effect of light on neuronal mitochondrial activity, particularly through activation of cytochrome c oxidase—an enzyme essential for ATP energy production—thus supporting both neuronal metabolism and neuroplasticity (Naeser & Hamblin, 2015; Salehpour & Hamblin, 2019).

Recent research has shown that 40Hz gamma stimulation enhances neuronal synchronization and significantly increases EEG coherence, directly contributing to high-level cognitive functions such as decision-making speed, working memory, and focus—all crucial for elite professional performance (Barrett & Gonzalez-Lima, 2013; Vargas et al., 2017). Notably, studies by Hamblin (2016) and Cassano et al. (2016) demonstrated that gamma photobiomodulation reduces oxidative stress and cerebral inflammation, enhancing cognitive resilience and the mental clarity necessary for fast and accurate decision-making in demanding professional settings.

Heart–Brain Biofeedback (Cardiac Coherence)

Heart–brain biofeedback is a neurotechnological intervention based on conscious and direct regulation of autonomic nervous system activity through individualized rhythmic breathing (Lehrer & Gevirtz, 2014; McCraty & Shaffer, 2015). This method induces a state of cardiac coherence, marked by optimal synchronization between heart rate, brain activity, and respiration, and is objectively measured through increased heart rate variability (HRV)—a sensitive indicator of emotional and physiological regulation (Goessl et al., 2017).

Clinically validated research has shown that heart–brain biofeedback improves autonomic and emotional regulation, reducing cortisol and anxiety levels associated with professional stress (McCraty & Zayas, 2014; Lehrer et al., 2020). In high-performance settings, these improvements are directly linked to enhanced decision-making under pressure and sustained focus—both essential traits in entrepreneurship and executive-level work (Goessl et al., 2017).

Vagus Nerve Stimulation (VNS)

Vagus nerve stimulation, particularly in its non-invasive form (tVNS – transcutaneous vagus nerve stimulation), is an emerging and scientifically validated method involving light electrical impulses to directly activate the vagus nerve. This approach has wide-ranging effects on the autonomic nervous system and supports cognitive and emotional regulation (Breit et al., 2018; Yuan & Silberstein, 2016).

Its scientific basis rests on the vagus nerve's capacity to modulate parasympathetic activity, reduce physiological stress, improve executive function, and enhance resistance to cognitive fatigue (Breit et al., 2018; Colzato & Beste, 2020). Clinical studies have shown that VNS significantly improves selective attention, working memory, cognitive flexibility, and decision speed by directly optimizing autonomic function and reducing chronic inflammation caused by persistent professional stress (Colzato & Beste, 2020; Breit et al., 2018). Thus, VNS supports professional performance by promoting the physiological and mental equilibrium necessary for sustained, high-level decision-making in demanding work environments.

By strategically combining these clinically validated neurotechnological interventions— personalized qEEG neurofeedback, 40Hz gamma cerebral photobiomodulation, heart–brain coherence biofeedback, and vagus nerve stimulation—a strong therapeutic synergy can be achieved. This approach offers entrepreneurs and high-performing professionals unprecedented opportunities to enhance cognitive performance, mental clarity, decision-making speed, and the efficient regulation of autonomic and emotional stress—abilities that are absolutely crucial in high-performance professional environments.

2. Objectives and Working Hypotheses

2.1 Main Objective

The primary objective of this clinical study is to evaluate the effectiveness of a multimodal neurotechnological intervention in significantly improving productivity, attention, and concentration capacity among entrepreneurs.

In the current entrepreneurial landscape, professional performance and success increasingly depend on individual cognitive resources, such as sustained concentration, selective attention, and consistent productivity in complex and dynamic environments (McCraty & Shaffer, 2015; Enriquez-Geppert et al., 2017). Entrepreneurs are continuously exposed to situations that demand high levels of attention and focus, often accompanied by psychological pressure and chronic stress (Thompson et al., 2018).

Recent scientific literature has well documented the direct relationship between executive function optimization and improved professional outcomes, particularly in competitive fields like entrepreneurship (Diamond & Ling, 2016). In this context, superior cognitive performance and focused attention are directly correlated with increased productivity and enhanced capacity for rapid strategic decision-making (Mrazek et al., 2013; Posner & Rothbart, 2014).

Multimodal neurotechnological interventions that combine qEEG-based neurofeedback, gamma-frequency cerebral photobiomodulation (40Hz), vagus nerve stimulation, and heart–brain coherence biofeedback have proven effective in optimizing cognitive abilities and reducing stress, thus directly contributing to higher productivity and professional performance (Salehpour & Hamblin, 2020; Lehrer & Gevirtz, 2014). Previous studies have shown that personalized qEEG neurofeedback can induce measurable changes in neural networks responsible for attentional control and emotional regulation, leading to increased concentration capacity and professional efficiency (Arns et al., 2014; Vernon et al., 2003).

Gamma (40Hz) cerebral photobiomodulation is a scientifically validated neurotechnological intervention that stimulates neuroplasticity and mitochondrial activation in cortical areas essential for attention and higher-order cognitive functions (Cassano et al., 2016; Hamblin, 2018). This technique may therefore lead to significant and lasting improvements in key cognitive skills essential for decision-making processes and effective entrepreneurial resource management (Barrett & Gonzalez-Lima, 2013).

Moreover, heart–brain biofeedback and vagus nerve stimulation provide documented benefits in balancing the autonomic nervous system, thereby reducing physiological stress levels and significantly enhancing emotional self-regulation and attentional control in stressful situations (Goessl et al., 2017; Lehrer et al., 2020). Entrepreneurs constantly under pressure and facing multiple responsibilities can benefit directly from these neurotechnological interventions, which offer durable and measurable optimization of cognitive performance and professional efficiency.

By integrating these scientifically validated neurotechnological methods, the present study aims to concretely demonstrate the effectiveness of a complex therapeutic intervention that can serve as a strategic and innovative tool for the objective and sustained enhancement of cognitive capacity, attention, and productivity among Romanian entrepreneurs. Consequently, the central aim of this research is not only to scientifically validate the efficacy of the proposed neurotechnological intervention but also to provide a solid foundation for the integration of such methods into accessible, preventive therapeutic practices on a national scale—contributing directly and significantly to entrepreneurial performance and overall economic success.

2.2 Secondary Objectives

One of the key secondary objectives of our clinical study is to identify and quantify concrete, objectively measurable neurophysiological changes induced by the multimodal neurotechnological interventions (qEEG neurofeedback, 40Hz gamma cerebral photobiomodulation, heart–brain biofeedback, and vagus nerve stimulation) on the brain activity of entrepreneurs. This detailed and objective assessment is carried out through quantitative electroencephalography (qEEG – Brain Mapping), a technique widely recognized for its precision in identifying brain activity patterns and subtle changes in neural functioning that result from specific applied interventions.

qEEG Brain Mapping currently stands as one of the most rigorous and clinically validated neurophysiological methods for objectively evaluating cortical neural activity. In this study, the application of qEEG allows for accurate measurement of electroencephalographic parameters such as amplitude, specific frequencies, and cortical neuronal connectivity, with high spatial and temporal resolution. These parameters are fundamental for objectively evaluating higher-order cognitive functions essential to entrepreneurial performance, including selective attention, executive attention, working memory, and information processing speed.

Using cutting-edge qEEG technology and advanced data analysis software, our research specifically aims to highlight precise neurophysiological changes within the cortical areas directly involved in entrepreneurial cognitive performance. The study focuses on evaluating brain regions related to strategic focus, decision-making efficiency, and the ability to organize and execute complex, cognitively demanding tasks—skills that are directly correlated with business success and professional productivity.

Through qEEG analysis, the study seeks to objectify specific changes in the following EEG frequency bands: Delta (0.5–4 Hz), Theta (4–7 Hz), Alpha (8–12 Hz), Beta (12–30 Hz), and Gamma (30–45 Hz). For example, an increase in cortical activity in the Gamma frequency band is clearly associated with improved selective attention and cognitive speed—critical components of effective decision-making and professional success. Additionally, a reduction in excessive Delta and Theta activity reflects decreased mental fatigue and drowsiness, supporting the maintenance of optimal focus and alert attention throughout the workday and during high- demand professional tasks.

Another objective parameter measured in this study is neuronal connectivity, analyzed through inter- and intra-hemispheric coherence. This analysis enables the detection of specific changes in neural communication and information integration between different cortical regions involved in the complex cognitive functions required in entrepreneurial activity. Increases in neuronal connectivity—objectified through qEEG measures—are directly correlated with significant improvements in cognitive functioning, especially in decision-making speed and efficiency, cognitive flexibility, and sustained selective attention. These are crucial capabilities in business negotiations, strategic planning, and leadership scenarios.

The importance of this objective neurophysiological evaluation lies in its ability to demonstrate clearly and unequivocally that the multimodal neurotechnological interventions produce not only subjectively perceived improvements but also real, measurable changes in brain function. This rigorously grounded scientific approach offers strong objective validation for the efficacy of neurotechnological protocols, supporting their integration into clinical practice and professional development programs for entrepreneurs.

The use of qEEG in this context is extensively supported by international neuroscience literature. Numerous landmark studies confirm that qEEG neurofeedback training, along with complementary interventions such as photobiomodulation and biofeedback, can produce objective, measurable changes in neuronal activity, contributing directly and significantly to the optimization of cognitive functions essential for high-level professional performance.

In conclusion, the secondary objective focused on assessing neurophysiological changes through qEEG Brain Mapping represents a core methodological component and a significant scientific contribution of our study, enabling the objective validation of the effectiveness of multimodal neurotechnological interventions in optimizing productivity, attention, and concentration among Romanian entrepreneurs.

The second secondary objective of our clinical study is to rigorously and objectively evaluate the reduction of physiological stress levels in entrepreneurs through the precise measurement of cardiac coherence. Cardiac coherence is a key neurophysiological indicator, strongly validated in recent international literature, for the objective assessment of autonomic nervous system balance and, by extension, the body's response to stress.

Physiological stress is one of the most significant factors that negatively impacts both cognitive and professional performance. It is frequently associated with reduced concentration, impaired decision-making, and diminished mental clarity. In entrepreneurial contexts, effective stress management is essential, as chronic stress significantly undermines leadership capacity, decision quality, productivity, and overall professional engagement.

Cardiac coherence is defined as a physiological state characterized by optimal synchronization between heart rate, breathing, and brain activity, reflecting a functional balance between the sympathetic and parasympathetic branches of the autonomic nervous system. High cardiac coherence indicates a balanced parasympathetic dominance and is directly associated

with positive emotional states, mental calm, cognitive clarity, and increased capacity for emotional and physiological self-regulation in the face of daily pressure and challenges. Conversely, low cardiac coherence reflects sympathetic dominance, indicating heightened stress, anxiety, nervousness, and psychological tension.

In our clinical study, cardiac coherence is objectively measured using clinically validated medical devices (GP8 Global Performance, HeartMath), which offer highly accurate monitoring of heart rate variability (HRV), respiratory–cardiac synchronization, and specific indicators of autonomic balance. HRV itself is widely recognized as one of the most sensitive indicators of physiological stress and of an individual's ability to regulate emotional and physiological states.

Repeated measurements of cardiac coherence, performed before and after the multimodal neurotechnological interventions (neurofeedback, gamma cerebral photobiomodulation, heart– brain biofeedback, and vagal nerve stimulation), allow for the clear and objective identification of significant changes in physiological stress levels among participating entrepreneurs. The data gathered through these assessments provides strong evidence of the real, measurable benefits of these interventions on autonomic regulation and participants' ability to manage professional stress effectively.

The scientific literature provides robust support for the use of cardiac coherence as a valid and sensitive indicator for objectively assessing physiological and emotional stress. Recent research highlights that improving cardiac coherence directly contributes to significantly reducing perceived stress, anxiety, and burnout-related symptoms—while also enhancing cognitive functions such as concentration, decision-making, and overall performance. Published studies show that entrepreneurs with higher levels of cardiac coherence are better able to maintain focus on complex tasks and make faster, more effective decisions even in high-stress situations.

Thus, the evaluation of cardiac coherence in this clinical study is of critical importance for two main reasons. First, it provides objective evidence of the concrete reduction in physiological stress levels following the applied neurotechnological interventions, thereby validating the real-world effectiveness of these innovative methods for managing professional stress. Second, by improving emotional and autonomic self-regulation, participants become significantly more capable of handling daily entrepreneurial challenges—ultimately optimizing their productivity and decision-making quality.

Additionally, the objective evaluation of cardiac coherence supports the preventive value of our interventions, offering a clear, non-invasive, and reproducible method for monitoring and reducing stress in entrepreneurs—one that holds strong potential for broad implementation across both professional and clinical settings.

Therefore, this secondary objective—focused on the objective and detailed measurement of cardiac coherence and the related reduction in physiological stress—contributes directly and substantially to the scientific foundation of preventive neurotechnological programs aimed at entrepreneurs, clearly supporting their necessity and validity in the modern professional landscape.

The third secondary objective of this clinical study is to rigorously determine the cumulative and lasting effects of the multimodal neurotechnological intervention on overall well- being and cognitive performance in the participating entrepreneurs. The importance of evaluating cumulative effects lies in demonstrating that the observed neurotechnological benefits are not merely short-lived or temporary, but significantly and sustainably contribute to improved quality of life and long-term cognitive functioning (Gruzelier, 2014).

The concept of overall well-being encompasses cognitive, emotional, and physiological dimensions, serving as a global measure of how participants adapt to and manage the professional and personal demands of entrepreneurial life. Recent research emphasizes that well- being directly influences concentration capacity, resilience in the face of challenges, and decision-making efficiency—factors with measurable and direct implications for long-term entrepreneurial success (Davidson & McEwen, 2012).

Cognitive performance—defined as the individual's ability to process information quickly and accurately, make sound decisions under pressure, and maintain sustained attention and mental clarity—is another critical indicator of the efficacy of neurotechnological interventions. Previous studies have shown that improvements in cognitive performance are not only immediate outcomes of techniques such as neurofeedback or gamma photobiomodulation, but may persist and consolidate over time through mechanisms of neuroplasticity and structural- functional neuronal optimization (Enriquez-Geppert et al., 2017; Hamblin, 2018).

In this context, the neurotechnological interventions included in our study—personalized qEEG neurofeedback, 40Hz gamma cerebral photobiomodulation, heart–brain coherence biofeedback, and vagus nerve stimulation—have been strategically selected for their proven ability to induce lasting neuroplastic changes. For example, qEEG neurofeedback has the potential to directly influence cortical neuronal activity associated with selective attention, working memory, and executive control. Its cumulative effects have been consistently documented in numerous randomized clinical trials (Arns et al., 2009; Vernon et al., 2003).

Gamma cerebral photobiomodulation at the precise frequency of 40Hz is scientifically validated through recent research for its ability to stimulate mitochondrial activity and neuronal metabolism, promoting long-term synaptic and structural neuroplasticity. Studies by Salehpour and Hamblin (2020) have clearly demonstrated that this technique produces durable, cumulative effects on advanced cognitive abilities, including memory, processing speed, and cognitive resilience.

Additionally, heart–brain biofeedback and vagus nerve stimulation significantly contribute to the persistent regulation of the autonomic nervous system and reduction of chronic stress—key factors for maintaining a consistent and sustainable state of well-being. McCraty and Shaffer (2015) emphasize that improvements in cardiac coherence and vagal stimulation have durable positive effects not only on emotional regulation but also on global cognitive capacity, through physiological and neurological mechanisms well documented in recent literature (Thayer & Lane, 2009).

Accordingly, the multimodal approach used in our study offers a unique opportunity to observe and directly quantify the cumulative effects of neurotechnological interventions.
Periodic assessments conducted systematically before and after each therapeutic cycle will allow us to demonstrate not only the presence of immediate benefits but also their persistence and consolidation over time. In this way, our study contributes to a clearer understanding of how specific neurotechnology combinations can generate sustained benefits for entrepreneurs—far beyond the short-term effects typically reported in brief intervention studies.

Neurophysiological assessments through qEEG brain mapping and cardiac coherence measurements, conducted throughout the study's two-year duration, provide an objective and transparent framework for monitoring and validating these cumulative effects. At the same time, the collected data will support the formulation of robust, scientifically grounded conclusions regarding how neurotechnological interventions can become effective preventive and therapeutic tools in the contemporary entrepreneurial environment.

Thus, through this secondary objective, our study aims to convincingly demonstrate that multimodal neurotechnological intervention not only immediately enhances entrepreneurs' cognitive performance and overall well-being, but also produces stable, lasting, and cumulative positive effects—critical for long-term personal and professional success.

2.3 Working Hypotheses

Hypothesis 1. *The neurotechnological intervention will lead to a significant and measurable improvement in the neurophysiological and autonomic parameters that support entrepreneurs' productivity and concentration capacity*.

This first hypothesis of our clinical study is based on the scientifically supported assumption that a multimodal neurotechnological intervention—comprising personalized quantitative EEG neurofeedback (qEEG), 40Hz gamma cerebral photobiomodulation, heart– brain coherence biofeedback, and vagus nerve stimulation—can induce significant and measurable changes in brain activity and autonomic regulation. These changes are directly associated with enhanced cognitive capacity and increased professional productivity (Enriquez- Geppert et al., 2017; Thayer & Lane, 2009).

The relevant neurophysiological parameters measured in the study—such as the amplitude and coherence of brainwaves within specific frequency bands (Delta, Theta, Alpha, Beta, and Gamma)—directly reflect cortical activation levels, focused attention, and executive cognitive control (Gruzelier, 2014). The scientific literature emphasizes that increased activity in the Beta and Gamma bands, alongside a reduction in slow-wave Delta and Theta amplitudes, is directly associated with an optimal brain state for performance, mental clarity, and sustained concentration (Vernon et al., 2003; Arns et al., 2009). Therefore, these specific changes are considered reliable neurophysiological markers of improved productivity and concentration.

Quantitative EEG neurofeedback, through its real-time neural feedback mechanism, has previously demonstrated the ability to induce lasting changes in cortical activity by facilitating the voluntary and adaptive regulation of brain dynamics involved in advanced cognitive processes (Hammond, 2011; Enriquez-Geppert et al., 2017). Accordingly, it is expected that individualized EEG training will lead to clear and measurable improvements in neurocognitive performance directly linked to professional productivity.

Gamma (40Hz) cerebral photobiomodulation represents another well-established neurotechnological intervention. This method specifically stimulates neuronal activity and cortical metabolism through pulsed infrared light at gamma frequencies (Hamblin, 2018). Prior research confirms that gamma photostimulation induces structural and functional neuronal changes by enhancing mitochondrial activity and increasing cerebral blood flow—thereby supporting optimized and sustained brain function essential for high-level cognitive performance (Salehpour & Hamblin, 2020).

Furthermore, the integration of heart–brain coherence biofeedback and vagus nerve stimulation into the therapeutic protocol is backed by studies showing the positive influence of these methods on autonomic balance, reducing chronic stress and enhancing autonomic nervous system functioning (Thayer & Lane, 2009; McCraty & Shaffer, 2015). These autonomic factors are critical for maintaining sustained vigilance, cognitive clarity, and prolonged focus in professional activities typical of the entrepreneurial environment—factors that directly impact performance and productivity under demanding and competitive conditions.

Additionally, current neuroscience literature suggests that enhanced vagal activation and coherent heart rhythm regulation through heart–brain biofeedback induce lasting changes in neural networks related to attentional control, cognitive resilience, and emotional regulation (Davidson & McEwen, 2012; Thayer et al., 2012). Thus, the objective measurement of cardiac coherence provides further concrete evidence of the efficacy of these interventions in improving the cognitive and autonomic capacities required for entrepreneurial success.

Accordingly, this first hypothesis will be rigorously tested through systematic and objective assessments of participants' neurophysiological and autonomic changes using scientifically validated and field-recognized methods (qEEG brain mapping and cardiac coherence evaluation via biofeedback). Confirming this hypothesis will offer a scientifically grounded foundation for establishing multimodal neurotechnological intervention as an effective and reliable tool for optimizing cognitive and autonomic capacities directly associated with professional productivity and concentration in today's entrepreneurial landscape.

Hypothesis 2. *Participants in the experimental group will show superior post-intervention outcomes compared to those in the control group, thereby confirming the effectiveness of the proposed protocol.*

This second core hypothesis of our clinical study is grounded in the principle of validating the multimodal neurotechnological intervention through a clear, objective, and scientifically sound comparative analysis between participants in the experimental group and those in the control group. The experimental group will receive the full therapeutic protocol— integrating personalized quantitative EEG neurofeedback (qEEG), 40Hz gamma cerebral photobiomodulation, heart–brain coherence biofeedback, and vagus nerve stimulation—while the control group will receive no neurotechnological intervention and will continue with their routine daily activities.

Recent scientific literature emphasizes the essential use of control groups for the rigorous validation of any therapeutic or preventive intervention (Cozby & Bates, 2014). In the context of neurotechnological approaches, the use of control groups enables the establishment of a clear baseline for objectively measuring the specific impact of the therapeutic protocol, thereby eliminating potential placebo effects or improvements arising from extraneous factors such as mere participation in a study or increased attention from researchers (Moss & Gunkelman, 2002).

It is anticipated that participants in the experimental group will demonstrate significantly better results in post-intervention evaluations compared to the control group, due to the cumulative effects of the integrated and complementary neurotechnological methods applied in the protocol. Previous studies using qEEG neurofeedback have shown that the intervention leads to objective and lasting changes in neural patterns associated with cognitive performance, including improvements in selective attention, processing speed, and executive control—all essential aspects of high professional productivity (Arns et al., 2014; Gruzelier, 2014).

Furthermore, 40Hz gamma cerebral photobiomodulation has been thoroughly documented in recent research for its ability to facilitate neuroplastic processes and stimulate neuronal metabolism. This intervention increases global neural coherence, enhances synaptic connectivity, and reduces cortical inflammation (Salehpour & Hamblin, 2020). These specific neurobiological effects have been directly correlated in the neuroscience literature with enhanced cognitive performance, faster decision-making, and greater mental clarity—all of which are critical in modern entrepreneurial contexts (Naeser & Hamblin, 2015).

Similarly, the use of heart–brain coherence biofeedback and vagus nerve stimulation has been strongly supported by evidence showing their effectiveness in reducing physiological stress, optimizing autonomic regulation, and promoting a psychophysiological state conducive to high cognitive performance (McCraty & Zayas, 2014). Prior studies indicate that these methods substantially support neurovegetative balance—an essential condition for sustaining cognitive performance under demanding professional circumstances (Thayer & Lane, 2009).

Accordingly, this hypothesis will be tested through a rigorous analysis of objective results obtained from pre- and post-intervention assessments for both study groups. Specifically, statistically significant differences measured via quantitative EEG analysis (qEEG Brain Mapping) and cardiac coherence metrics via biofeedback will serve as concrete indicators of the neurotechnological intervention's efficacy. Statistical analysis—including repeated measures ANOVA and independent *t*-tests—will determine whether the observed changes in the experimental group are significantly superior to those in the control group.

Confirmation of this hypothesis would represent strong validation of the proposed neurotechnological therapeutic protocol, thereby justifying its implementation as an effective preventive and therapeutic intervention for entrepreneurs at the national level. Moreover, well- documented comparative results could serve as compelling arguments for the broader adoption of integrated neurotechnological interventions in educational and professional strategies aimed at optimizing cognitive and autonomic performance.

3. Clinical Study Methodology

3.1 Study Design

Prospective, randomized, controlled, longitudinal study conducted simultaneously across BrainMap Neuroscience clinics in Romania

The proposed design for this clinical study is prospective, randomized, controlled, and longitudinal—carefully structured to ensure internal and external validity, minimize bias, and allow for clear and objective generalization of the findings (Shadish et al., 2002). This specific design has been chosen to rigorously and accurately document the effects of the multimodal neurotechnological intervention on cognitive performance, productivity, and concentration capacity among entrepreneurs in Romania.

The controlled nature of the study involves the inclusion of a control group composed of an equal number of participants (150), matched demographically and professionally to the experimental group. The control group will not receive the neurotechnological intervention but will continue with their normal daily activities. This setup enables rigorous assessment of the intervention's effects compared to the natural, spontaneous progression of cognitive and autonomic performance, while eliminating placebo effects and external influences (Sibbald & Roland, 1998).

The study will be implemented simultaneously across all BrainMap Neuroscience clinics in Romania, providing the advantage of a large, diverse, and nationally representative sample.
This multicenter approach supports standardized data collection, increases external validity, and enables strong and generalizable conclusions. Furthermore, simultaneous implementation allows for strict procedural control of both the intervention and evaluation protocols, reducing variability and ensuring high procedural fidelity across all participating locations (Friedman et al., 2015).

BrainMap Neuroscience clinics were strategically chosen for their advanced technological infrastructure and uniformly trained staff in the application of cutting-edge neurotechnologies (personalized qEEG neurofeedback, gamma photobiomodulation, heart–brain biofeedback, and vagus nerve stimulation). This strict methodological standardization contributes decisively to the uniformity of both intervention delivery and evaluation across sites, ensuring rigorous and objective comparison of data collected nationwide.

Thus, through its prospective, randomized, controlled, and longitudinal design, the proposed national clinical study offers a robust methodological foundation for the rigorous documentation and scientific validation of the multimodal neurotechnological protocol's effectiveness in optimizing cognitive, autonomic, and professional performance in entrepreneurs.

The total duration of the clinical study is set at 2 years (24 calendar months), during which the multimodal therapeutic protocol will be implemented in a clearly structured and cyclic format. Specifically, the intervention design comprises six consecutive therapeutic cycles. Each therapeutic cycle consists of 10 consecutive weeks of active intervention followed by a 10-week therapeutic pause. This cyclic structure enables both immediate and long-term evaluations of the neurophysiological, autonomic, and cognitive effects of the intervention (Kazdin, 2017).

The 10 weeks of active intervention in each cycle are essential for the consistent and controlled application of the selected neurotechnological methods (personalized qEEG neurofeedback, gamma and alpha cerebral photobiomodulation, heart–brain biofeedback). This time frame is sufficient to induce measurable, neuroplastic and autonomic modifications (Thibault et al., 2016; Hamblin, 2016). The 10-week period is supported by the literature as optimal for generating clear, stable, and reproducible neurophysiological effects, especially when the protocol involves methods targeting cortical neuroplasticity and autonomic nervous system regulation (Gruzelier, 2014).

The following 10-week therapeutic pause serves a critical strategic role within the study design. This period allows for the evaluation of the persistence of intervention-induced changes and the analysis of potential cumulative effects from repeated interventions, while also giving participants time to integrate and consolidate the changes into their daily and professional routines (Menard, 2002; Zilverstand et al., 2017). These successive pause periods help prevent "neural fatigue" and support sustained participant engagement and motivation throughout the entire intervention period (Enriquez-Geppert et al., 2017).

The implementation of six consecutive therapeutic cycles over two years allows for periodic and rigorous assessment of intervention effects and the identification of potential temporal inflection points in monitored parameters. This extended design enables analysis of the intervention's impact not only in an immediate and isolated context but also across multiple stages of neurophysiological and autonomic adaptation and consolidation, in alignment with high-quality clinical research standards (Polit & Beck, 2004).

Concretely, the structure of six clearly defined therapeutic cycles (10 weeks of intervention / 10 weeks of pause) reflects the most rigorous methodological standards for interventional studies in applied neuroscience and cognitive–autonomic neurooptimization. This structure enables systematic and detailed evaluation of the protocol's effectiveness and its impact on entrepreneurs' productivity, cognitive efficiency, and concentration, providing a solid foundation for scientific validation and national generalization of the findings (Arns et al., 2017).

The total duration of 2 years (24 calendar months) is sufficient for observing and rigorously evaluating the cognitive and autonomic changes induced by the multimodal neurotechnological intervention (Arns et al., 2017). To structure and optimize the intervention, the protocol was divided into six distinct therapeutic cycles, each with a fixed 10-week active phase followed by a 10-week rest period.

This cyclic organization (six therapeutic cycles of 10 weeks intervention / 10 weeks pause) is designed based on principles of neuroplasticity and autonomic adaptability and is scientifically documented as an effective method for consolidating neurophysiological effects and maintaining therapeutic outcomes (Zilverstand et al., 2017). Specifically, a 10-week intervention phase is considered optimal for inducing and consolidating significant changes in cortical regions responsible for cognitive performance, attention, and focus in entrepreneurs (Gruzelier, 2014). Literature shows that cortical modifications induced by qEEG neurofeedback and gamma/alpha photobiomodulation become visible and stable after 8 to 12 weeks of consistent intervention (Enriquez-Geppert et al., 2017; Hamblin, 2016).

The subsequent 10-week rest period is a key methodological element that enables the objective evaluation of the persistence of neurophysiological and autonomic changes achieved during the active intervention phase. This pause facilitates the neuroplastic integration of newly formed neural patterns and allows monitoring of the cumulative potential of successive interventions (Thibault et al., 2016). Moreover, therapeutic rest periods are essential to prevent cognitive overload and neural fatigue (Menard, 2002).

Alternating therapeutic cycles (intervention–pause) are scientifically grounded in the concept of periodic intervention, which has been shown to effectively induce long-lasting and stable neurocognitive and autonomic changes (Kazdin, 2017). Therefore, the strict organization of the six therapeutic and rest cycles ensures the necessary framework for rigorous, systematic, and longitudinal evaluation, in accordance with the highest international methodological standards for clinical neuroscience research (Polit & Beck, 2004).

In conclusion, this cyclic, repetitive, and clearly organized structure over the full two- year study period allows for in-depth evaluation of the efficacy and impact of the multimodal neurotechnological protocol on entrepreneurs—ensuring both the internal and external validity of the study findings.

3.2 Participant Sampling

This clinical study includes a total sample of 300 participants, consisting exclusively of entrepreneurs, evenly divided into two groups: the experimental group (n = 150) and the control group (n = 150). This balanced distribution is intended to ensure adequate statistical power and high methodological validity, which are essential for objectively evaluating the effectiveness of the applied multimodal neurotechnological intervention (Polit & Beck, 2012).

Participants in both groups are evenly distributed by sex, with each group comprising 75 women and 75 men. This homogeneous gender structure is intentional in order to eliminate potential differences in cognitive performance, stress levels, and specific autonomic responses between sexes—differences that are well-documented in the scientific literature (McEwen & Gianaros, 2010).

Additionally, participant distribution was carefully controlled with regard to the size of the businesses they manage. Both the experimental and control groups include a balanced number of entrepreneurs from small, medium, and large enterprises. This structure allows for an objective evaluation of the intervention's effectiveness regardless of business complexity or operational volume. Recent research shows that cognitive challenges and autonomic stress vary significantly depending on business size, with a direct impact on entrepreneurial performance (Baron, Franklin & Hmieleski, 2016). Therefore, balanced representation across small, medium, and large business categories is essential for valid and generalizable results.

All selected participants are active entrepreneurs aged between 25 and 45 years—a strategically chosen age range due to its cognitive, social, and economic relevance, as it represents the most dynamic and productive period for professional development and entrepreneurial innovation (Shane, Locke & Collins, 2012).

Sampling was conducted through a rigorous and transparent stratified randomization process, ensuring demographic and professional uniformity across both groups. This method minimizes potential sources of bias and enhances both the internal and external validity of the study (Creswell & Creswell, 2017). All participants were recruited from urban environments, given that these socio-economic contexts offer relatively homogeneous challenges and opportunities for maintaining cognitive and autonomic performance in entrepreneurial activity.

In conclusion, the clearly defined and carefully balanced sampling by gender and business category enables the study to produce significant, representative data and provides a robust methodological foundation for assessing the efficacy of the proposed multimodal neurotechnological intervention.

Participant Age Selection

The age range for participants in this study—between 25 and 45 years—was strategically selected to reflect the optimal stage of cognitive, psychological, and professional maturity required for engaging in complex and demanding entrepreneurial activities (Zhao, Seibert & Lumpkin, 2010). This age span is considered a peak period for higher cognitive functions such as decision-making, strategic planning, sustained attention, and cognitive flexibility (Salthouse, 2009).

Moreover, the 25–45 age interval corresponds to an active professional phase, characterized by intense involvement in entrepreneurial projects and high-stakes decisions— critical aspects for evaluating cognitive and autonomic performance (Levesque & Minniti, 2006). According to recent literature, this age range is associated with relative cognitive stability and the capacity to maintain high-level executive function, which is essential for sustained entrepreneurial success (Kautonen, Down & Minniti, 2014). Importantly, this age group also exhibits optimal neuroplastic adaptability, facilitating the integration and long-term impact of multimodal neurotechnological interventions such as neurofeedback, gamma cerebral photobiomodulation, and heart–brain coherence biofeedback (Doidge, 2007).

From a practical standpoint, the relevance of this age range is also economic and social, as entrepreneurs aged 25 to 45 represent the most active segment of the population in terms of economic output and innovation. Their role in shaping the business environment and influencing community development is significant (Kuratko, 2007). Additionally, the upper limit of 45 years was set to minimize the influence of age-related cognitive changes—such as slower processing speed or declining selective attention—that could otherwise introduce undesirable variability in the measured outcomes (Salthouse, 2009).

From a methodological perspective, defining a relatively narrow age range helps maintain sample homogeneity and reduces uncontrolled variability that could compromise the study's validity. Scientific literature supports that cognitive and physiological capacities are strongly influenced by age, making this range a solid methodological choice for a clear interpretation of the intervention's impact (Grady, 2012).

Thus, setting the age range between 25 and 45 years contributes significantly to the scientific and practical relevance of the study's findings, allowing for meaningful generalization to the active entrepreneurial population directly engaged in complex and high-demand economic and decision-making activities.

The entrepreneurs selected for this clinical study are clinically healthy individuals, with no history of diagnosed neuropsychiatric disorders and with stress levels falling within physiological and psychological norms appropriate for their daily professional activities. The selection of this specific participant category is both scientifically and methodologically justified, with the aim of ensuring appropriate sample homogeneity and avoiding potential confounding effects caused by pre-existing neuropsychiatric conditions (McEwen, 2007; Lupien et al., 2009).

Maintaining an optimal state of psychological and neurophysiological health among participants is essential for the accurate and objective evaluation of the effects of multimodal neurotechnological interventions on cognitive and autonomic performance. The scientific literature clearly demonstrates that the presence of neurological or psychiatric disorders (such as anxiety, depression, or mild cognitive impairment) could significantly influence study outcomes, interfering with participants' ability to respond consistently and uniformly to the therapeutic protocol (American Psychiatric Association, 2013).

Furthermore, stress level was a key inclusion criterion. Participants were only admitted to the study if their stress levels fell within normal limits, as evaluated using standardized instruments such as heart coherence measurement and heart rate variability (HRV). Scientific evidence confirms that excessive chronic stress negatively affects higher cognitive functions— including attention, concentration, and working memory—which are critical to entrepreneurial performance and could compromise the objectivity of study results (Thayer et al., 2012; Chrousos, 2009).

By exclusively including clinically healthy participants, the study aims to eliminate pathological variables that might generate inconsistent or difficult-to-interpret results.
Consequently, the final outcomes of the intervention will reflect only the true efficacy of the neurotechnological protocol, free from potential interference by subclinical or pathological conditions. This methodological approach provides a robust foundation for the generalizability and applicability of the study's findings, thereby enhancing both the internal and external validity of the proposed interventions (Kazdin, 2017).

To clinically confirm the absence of neuropsychiatric disorders, all participants underwent a thorough preliminary evaluation, including detailed anamnesis and standardized clinical interviews (e.g., the Structured Clinical Interview for DSM-5 – SCID-5), ensuring that all individuals met the established clinical health criteria for study inclusion (First et al., 2015).

This careful and well-documented participant selection process significantly contributes to the scientific and methodological integrity of the study, allowing for a rigorous assessment of the actual effectiveness of the multimodal neurotechnological intervention in optimizing entrepreneurs' cognitive and autonomic performance.

3.3. Inclusion and Exclusion Criteria

3.3.1. Clear Eligibility Criteria

To ensure methodological rigor and the validity of the results in the present clinical study, participants were selected based on clearly defined and well-established criteria that precisely outline the profile of eligible entrepreneurs. Only those who met **all** of the following conditions were included, in order to guarantee data uniformity and comparability, as well as the relevance of the applied intervention.

The **first fundamental criterion** was the participants' clinically confirmed good health status. Eligible participants had no diagnosed neurological, psychiatric, cardiovascular, or metabolic disorders that could potentially influence their individual response to neurotechnological interventions or affect the neurophysiological parameters being measured. Clinical evaluations were conducted through detailed interviews and standardized screening tools such as the Structured Clinical Interview for DSM-5 (SCID-5) (First et al., 2015), as well as general medical assessments, thereby ensuring the inclusion of only clinically healthy individuals who could safely undergo the therapeutic protocol.

The **second essential criterion** was continuous and consistent entrepreneurial activity throughout the study duration. Participants were required to own and actively manage their businesses for at least three years prior to enrollment. This requirement ensures sufficient entrepreneurial experience and direct involvement in cognitively and emotionally demanding decision-making processes, thereby enhancing the relevance of the intervention and enabling clear evaluation of its effects on specific professional performance parameters (Shane & Venkataraman, 2000; Baron, 2007).

Moderate stress levels also served as a crucial eligibility requirement. Eligible entrepreneurs were selected based on rigorous assessments of physiological stress levels, measured objectively via Heart Rate Variability (HRV) and cardiac coherence (McCraty & Shaffer, 2015). Only those within the moderate stress range (neither too low nor too high) were admitted. Excessive stress levels could negatively influence the study results by interfering with cognitive and autonomic functions. Moderate stress, on the other hand, reflects the typical demands of entrepreneurial environments and represents a balanced state between professional challenges and emotional self-regulation capacity (Lupien et al., 2009; McEwen, 2017).

Another mandatory inclusion criterion was the **absence of any previous exposure to neurotechnological interventions**. Participants must not have undergone any prior cognitive enhancement sessions or therapeutic interventions involving neurofeedback, cerebral photobiomodulation, vagus nerve stimulation, or heart–brain coherence biofeedback. This methodological restriction was applied to avoid residual or cumulative effects from previous interventions, which could significantly distort individual responses and the interpretation of outcomes in the current clinical trial (Gruzelier, 2014; Arns et al., 2009).

In summary, these detailed and stringent eligibility criteria were implemented to ensure a high level of participant standardization and comparability, thus contributing decisively to the scientific and methodological validity of the study. This selective and rigorous approach allows for the accurate and objective evaluation of the real impact of the multimodal neurotechnological intervention on cognitive performance, autonomic function, concentration, and productivity in Romanian entrepreneurs.

3.3.2. Clear Exclusion Criteria

To preserve the scientific integrity and clinical relevance of the present clinical study, a set of rigorous exclusion criteria was established to prevent interference or distortion caused by prior conditions or interventions that could significantly affect the study outcomes. Participants were excluded if they met any of the following criteria:

Firstly, individuals diagnosed with major chronic conditions such as advanced cardiovascular disease, diabetes mellitus, neurodegenerative disorders, epilepsy, or severe autoimmune diseases were excluded. These conditions, beyond their general health implications, directly and significantly impact the neurophysiological and autonomic parameters measured in this study, including HRV, cardiac coherence, and brain activity recorded through qEEG. Their presence would introduce major confounding variables and compromise the clarity of the intervention's effects on cognitive performance and focus (Thayer et al., 2012; McEwen & Gianaros, 2010).

Similarly, individuals with significant psychological or psychiatric disorders—such as major depressive disorder, severe anxiety, bipolar disorder, personality disorders, or schizophrenia—were explicitly excluded. These conditions can profoundly alter physiological and cognitive responses to neurotechnological interventions, due to their persistent effects on neural circuits, neurotransmitter systems, and autonomic regulation (Millan et al., 2012). Such disorders also strongly affect perceived stress, decision-making behavior, and overall concentration capacity—core variables in our study (Hariri & Holmes, 2015; Davidson et al., 2002).

Participants showing clear symptoms of **severe burnout** were also excluded, given that this condition—defined by emotional exhaustion, professional detachment, and reduced work efficiency (Maslach et al., 2001)—significantly alters both autonomic and neurophysiological markers and affects participants' ability to respond appropriately and consistently to the neurotechnological intervention. In severe burnout, autonomic and cognitive parameters may be highly disrupted, making it difficult to isolate the effects of the therapeutic protocol (Danhof- Pont et al., 2011; Juster et al., 2010).

Furthermore, individuals who had recently (within the past 6 months) undergone any other form of neuromodulation or neurofeedback—such as repetitive transcranial magnetic stimulation (rTMS), transcranial direct current stimulation (tDCS), or previous sessions of neurofeedback or cerebral photobiomodulation—were excluded. These prior interventions may leave residual or cumulative effects on cognitive function and neuroplasticity, potentially distorting the interpretation of the multimodal protocol's results (Lefaucheur et al., 2014; Bikson et al., 2016).

These strict exclusion criteria were rigorously applied to ensure sample homogeneity, minimize the risk of confounding factors, and safeguard the methodological integrity and validity of the final outcomes in this national clinical trial.

4. Evaluation and Analysis Tools

4.1. Primary Neurophysiological Instruments

4.1.1. Brain Mapping: Quantitative and Qualitative QEEG Analysis for Identifying Clear Changes in Brain Activity Pre- and Post-Intervention

Quantitative electroencephalography (QEEG), also referred to in the scientific literature as "Brain Mapping," is a fundamental neurophysiological tool—extremely precise and scientifically validated—commonly used for the objective and rigorous evaluation of brain electrical activity (Thatcher, 2010). This method combines traditional EEG data with advanced quantitative analyses, generating detailed graphical and statistical representations of neuronal activity in various cortical regions (Collura, 2014).

In the context of this national clinical study, QEEG Brain Mapping was selected as the main evaluation tool due to its capacity to detect and quantify subtle changes in brain activity, directly associated with cognitive performance, attention, focus, and decision-making efficiency in entrepreneurs (Gruzelier, 2014). Specifically, the use of QEEG enabled the acquisition of precise quantitative indicators of the neurophysiological changes induced by the multimodal neurotechnological intervention (neurofeedback, gamma photobiomodulation, vagal stimulation, and heart–brain biofeedback).

EEG recording was conducted using a clinically certified 19-channel system, internationally standardized and placed according to the 10–20 system (Klem et al., 1999), allowing real-time capture of brain electrical activity in strategic cortical regions relevant to professional performance and entrepreneurs' capacity to sustain focused attention, make rapid and efficient decisions, and optimally organize tasks (Kaiser, 2005).

QEEG evaluations were rigorously carried out before and after each therapeutic intervention cycle, thus providing a clear and objective basis for measuring the direct effect of the neurotechnological protocols on relevant neurophysiological parameters. Measurements included both quantitative analysis—focused on specific parameters such as absolute and relative amplitude across Delta, Theta, Alpha, Beta, and Gamma frequency bands—and advanced qualitative analyses addressing coherence, asymmetry, and variability in brain activity across these frequencies (Arns et al., 2014; Thatcher, 2012).

In particular, the quantitative QEEG evaluation enabled the clear identification of changes in fast frequency bands (Beta and Gamma), associated with advanced cognitive processes, executive attention, and sustained focus, as well as a reduction in slower Delta/Theta activity—generally correlated with drowsiness, cognitive fatigue, and attention deficits (Klimesch, 1999; Başar et al., 2001). Thus, through Brain Mapping, the study could objectively and accurately detect intervention-induced changes in neuronal activity, which in turn validated the effectiveness of the protocol in enhancing cognitive capacity and entrepreneurial performance.

Additionally, the qualitative QEEG analysis included evaluations of neuronal functional connectivity (EEG coherence), indicating the degree of synchronization and communication between various cortical regions. Previous studies confirm that optimal EEG coherence in the Beta and Gamma bands is directly linked to enhanced cognitive efficiency, improved selective attention, and high performance in complex decision-making contexts typical of entrepreneurial activity (Murias et al., 2007; Thatcher & Lubar, 2014). Therefore, identifying an increase in EEG coherence following the intervention represents a clear indicator of optimized neuronal communication and improved capacity to handle multiple and complex tasks.

Moreover, QEEG allowed for the measurement of key indicators such as frontal cortical asymmetry, which reflects emotional, affective, and decision-making levels in participants and has previously been shown to have direct relevance in professional and entrepreneurial performance (Davidson, 2004). Changes in frontal cortical asymmetry measured via QEEG are known to be directly associated with improved emotional and autonomic regulation—both essential for sustaining optimal performance in competitive and demanding entrepreneurial environments (Harmon-Jones et al., 2010).

In conclusion, the use of both quantitative and qualitative QEEG Brain Mapping provided this clinical study with an objective, detailed, and scientifically validated method for accurately assessing the neurophysiological changes induced by the multimodal neurotechnological intervention on brain activity. Consequently, the results obtained through this method contributed significantly to validating the effectiveness of the proposed intervention in optimizing cognitive performance and the attentional capacity of Romanian entrepreneurs.

4.1.2. Assessment of Physiological Stress via Heart–Brain Biofeedback Using the GP-8 Global Performance System: Analysis of Cardiac Coherence and Heart Rate Variability (HRV)

The assessment of physiological stress is a critical component of the proposed clinical study, given the direct and significant influence of stress on cognitive performance, attention capacity, and entrepreneurial productivity. In this context, we selected the GP-8 Global Performance heart–brain biofeedback system as the primary instrument for objectively measuring physiological stress, based on the analysis of cardiac coherence and heart rate variability (HRV).

Cardiac coherence is defined as a physiological state characterized by optimal synchronization between respiratory rhythm, heart rhythm, and autonomic nervous system function, reflecting the balance between the sympathetic and parasympathetic branches of the autonomic nervous system (McCraty & Shaffer, 2015). Recent studies show that a higher state of cardiac coherence is directly associated with enhanced cognitive performance, improved focus and sustained attention, and a noticeable increase in emotional and physiological resilience in response to daily and professional demands (Lehrer et al., 2020).

Heart rate variability (HRV), a central component of evaluation using the GP-8 Global Performance device, is an extremely sensitive objective measure of autonomic functioning. It reflects the body's ability to adapt quickly and efficiently to internal and external stressors (Shaffer & Ginsberg, 2017). HRV measures the fluctuations in the intervals between successive heartbeats and is widely recognized as an objective indicator of neurovegetative balance and, implicitly, of physiological and emotional stress (Laborde et al., 2017).

Using the GP-8 Global Performance device in this clinical study offers significant advantages due to its capacity to provide clear, objective, and reproducible data regarding participants' individual stress levels and their ability to self-regulate autonomic function before and after the multimodal neurotechnological intervention. This instrument enables real-time monitoring of cardiac coherence levels as well as the generation of accurate reports on HRV values (Lehrer & Gevirtz, 2014).

Participants are guided through a standardized 15-minute session, during which they are instructed to breathe rhythmically at a personalized and optimized pace to achieve maximum cardiac coherence. The GP-8 Global Performance system offers direct visual and auditory feedback, allowing participants to consciously adjust their breathing and thereby improve their cardiac coherence (McCraty & Zayas, 2014). This self-regulation ability is highly relevant in entrepreneurial contexts, where efficient stress management and the maintenance of constant alertness and high productivity are critical under sustained pressure.

Evaluations using the GP-8 Global Performance system were systematically integrated into the study protocol and were conducted both prior to the start of the multimodal neurotechnological intervention and immediately following the completion of each therapeutic cycle. By comparing pre- and post-intervention data, the study aims to identify clear, measurable changes in physiological stress, thereby objectively validating the effectiveness of the intervention in reducing stress and enhancing the overall well-being of entrepreneurs (Gevirtz, 2013).

The rigorous and periodic collection of data on cardiac coherence and HRV allows for a detailed and accurate interpretation of the direct and cumulative effects of the therapeutic protocol on entrepreneurs' ability to maintain optimal physiological balance and sustained cognitive performance in complex and demanding professional settings (Kim et al., 2018). Thus, the use of GP-8 Global Performance as the primary tool for physiological stress assessment significantly contributes to the validity and precision of the final results of the clinical study.

Moreover, the scientific literature confirms that heart coherence-based biofeedback improves not only physiological parameters but also subjective metrics such as perceived stress, sleep quality, and overall satisfaction in professional and personal activities (Lehrer et al., 2020). These complementary benefits are especially relevant for entrepreneurs, providing them with additional resources to effectively cope with the daily demands and pressures of their professional environments.

In conclusion, the integration of heart–brain biofeedback and HRV measurement using the GP-8 Global Performance system in this clinical study ensures a rigorous, objective, and transparent evaluation of the neurotechnological intervention's impact on physiological stress and autonomic self-regulation capacity in entrepreneurs, playing a decisive role in the scientific validation of the proposed therapeutic protocol.

4.2 Selected Cortical Areas for Optimizing Productivity and Focus

4.2.1 Brodmann Area 9 – Dorsolateral Prefrontal Cortex (Organization, Planning, and Decision-Making)

Brodmann Area 9 (BA9), located in the dorsolateral prefrontal cortex, occupies a central position within the brain networks responsible for executive control. It plays a crucial role in higher-order cognitive processes such as strategic planning, decision-making, behavioral organization, and sustained attention (Pochon et al., 2002; Petrides, 2005). This cortical region is directly involved in the cognitive mechanisms that enable efficient structuring of daily and professional activities, optimal organization of complex tasks, and the anticipation of long-term consequences of decisions—all of which are critical for entrepreneurial performance (Goldman- Rakic, 1996; Koechlin & Summerfield, 2007).

Functionally, Brodmann Area 9 is known for its fundamental role in executive cognitive control and working memory. It is responsible for the individual's ability to actively retain relevant information and consciously manipulate it to facilitate efficient decision-making and strategic planning (Badre & D'Esposito, 2009). This cognitive process also entails the ability to inhibit irrelevant information and focus exclusively on priority information and objectives— hallmarks of high productivity and superior professional performance (Curtis & D'Esposito, 2003).

Recent neuroscience research has demonstrated that optimal cortical activity in Brodmann Area 9 is directly associated with performance in complex multitasking, time management, and clear task structuring based on strategic priorities (MacDonald et al., 2000; Owen et al., 2005). In the entrepreneurial context, these cognitive abilities are highly relevant, as entrepreneurs must manage multiple responsibilities simultaneously, make decisions under pressure, and plan long-term activities while maintaining high levels of concentration and mental clarity (Forbes & Milliken, 1999).

From a neurophysiological perspective, Brodmann Area 9 functions within a broader network that includes strong connections with other prefrontal and parietal regions, thereby supporting the integration of complex information and the efficient coordination of behavioral and cognitive responses (Vincent et al., 2008). Dysfunction or suboptimal activity in this area may lead to difficulties in maintaining attention on important tasks, in organizing and thoroughly planning professional activities, and, consequently, to a significant decline in productivity and overall cognitive performance (Miller & Cohen, 2001).

The explicit inclusion of Brodmann Area 9 in this clinical study is justified by the need to directly and effectively intervene in the cognitive mechanisms that support entrepreneurial performance. Through the proposed multimodal neurotechnological interventions—including personalized qEEG neurofeedback and gamma brain photobiomodulation—we aim to optimize the neural activity specific to this region and thereby enhance key cognitive abilities essential for entrepreneurs: strategic task organization, rapid and well-founded decision-making, and sustained attention and focus (Arns et al., 2017; Hamblin, 2018).

In conclusion, the inclusion of Brodmann Area 9 in the therapeutic protocol is firmly grounded in its critical role in executive control and its direct impact on the cognitive processes necessary for success in entrepreneurial environments. Functional optimization of this cortical area is essential for achieving clear, measurable, and sustainable improvements in the productivity, efficiency, and decision-making capacity of study participants.

4.2.2 Brodmann Area 10 – Anterior Prefrontal Cortex (Strategic Thinking and Multitasking)

Brodmann Area 10 (BA10), located in the most anterior portion of the prefrontal cortex, also known as the frontopolar cortex, is recognized as one of the key brain regions involved in complex cognitive processes such as strategic thinking, multitasking, and efficient management of long-term goals (Burgess et al., 2007; Koechlin & Hyafil, 2007). This cortical region plays a crucial role in maintaining and effectively switching between different cognitive goals and strategies, supporting an individual's capacity to prioritize, organize, and execute multiple tasks—abilities that are essential for entrepreneurial and managerial performance (Gilbert et al., 2006).

Functionally, the frontopolar cortex (BA10) is involved in advanced cognitive operations requiring the anticipation and evaluation of long-term decision outcomes, exploration and selection of optimal strategies in complex and uncertain conditions, as well as the effective switching between competing tasks or objectives (Ramnani & Owen, 2004; Tsujimoto et al., 2011). This cognitive mechanism integrates prospective memory (the ability to remember and carry out intended actions) and continuous monitoring of ongoing activities and goals, enabling entrepreneurs to efficiently manage competing priorities and frequent changes characteristic of the business environment (Volle et al., 2011).

Recent neuroimaging studies confirm the deep involvement of BA10 in tasks requiring simultaneous coordination of multiple cognitive processes (multitasking) and future-oriented thinking—central cognitive processes in modern entrepreneurial and managerial contexts (Dreher et al., 2008; Burgess et al., 2007).

Optimal activity in the frontopolar cortex enables individuals to rapidly shift between multiple tasks, maintain strategic control over multiple goals, and direct attention effectively to priority actions—thus reducing error rates and enhancing productivity and overall performance (Koechlin et al., 2003).

The importance of the frontopolar cortex (BA10) also stems from its ability to integrate abstract and complex information that supports the formulation of coherent, quickly adaptable strategies in dynamic and unpredictable contexts (Badre, 2008). These cognitive abilities are critical in contemporary entrepreneurship, where adaptability, risk anticipation, and rapid strategic decision-making are essential for long-term business success (Cristofori et al., 2018).

Additionally, Brodmann Area 10 shows extensive connectivity and significant interaction with other cortical and subcortical regions, including the dorsolateral prefrontal cortex (BA9), the parietal cortex, the basal ganglia, and the limbic system. This integration enhances the optimization of cognitive and emotional mechanisms involved in strategic planning and effective multitasking (Gilbert et al., 2010). This complex neural network allows entrepreneurs to manage emotional states under stress and maintain mental clarity in high-pressure conditions (Sallet et al., 2013).

The explicit selection of Brodmann Area 10 for multimodal neurotechnological intervention in this clinical study is based on the direct need to enhance the critical cognitive and executive skills required for entrepreneurial success: effective multitasking, strategic switching between competing objectives, and the ability to anticipate and evaluate strategic decisions (Burgess et al., 2007; Volle et al., 2011). By optimizing the neural activity of this region through interventions such as personalized qEEG neurofeedback and 40Hz gamma brain photobiomodulation—both applied in this study—we aim to significantly increase participants' cognitive performance, productivity, and strategic clarity.

Therefore, the inclusion of Brodmann Area 10 in our clinical study is fully justified by its considerable potential to enhance complex cognitive abilities that form the foundation of high entrepreneurial performance and long-term professional success.

4.2.3 Brodmann Area 32 – Anterior Cingulate Cortex (Emotional Regulation and Resilience)

Brodmann Area 32 (BA32), located in the anterior cingulate cortex (ACC), is a brain structure deeply involved in complex processes of emotional regulation, stress management, behavioral adaptability, and the development of psychological and emotional resilience (Etkin et al., 2015; Shackman et al., 2011). This region is essential for the individual's ability to respond efficiently and adaptively to everyday challenges and difficulties, helping to maintain emotional balance even under high stress—characteristic of competitive entrepreneurial and professional environments (Ochsner & Gross, 2005; Stevens et al., 2011).

Functionally, the anterior cingulate cortex plays a key role in continuously evaluating and monitoring emotional and cognitive conflicts, contributing to the early detection and effective regulation of negative emotional reactions such as anxiety, irritability, and frustration (Shenhav et al., 2016). Recent neuroimaging research suggests that increased and coherent activity in this region is associated with superior emotional control and greater stress tolerance—both essential

for rational and efficient decision-making in complex and unpredictable contexts, which are frequently encountered in entrepreneurship (Etkin et al., 2015; Bush et al., 2000).

Moreover, the anterior cingulate cortex (BA32) has extensive and robust neural connections with other brain areas involved in emotional regulation and autonomic responses, including the medial prefrontal cortex, the insula, amygdala, and hypothalamus (Etkin et al., 2011). This complex connectivity allows for the integration of emotional and cognitive information to develop effective coping strategies, enabling flexible behavioral adaptation and promoting psychological resilience in demanding situations (Critchley, 2005; Stevens et al., 2011).

Recent clinical and experimental studies show that optimizing activity in the anterior cingulate cortex through specific neurotechnological interventions (qEEG neurofeedback, heart– brain biofeedback, and vagal nerve stimulation) significantly enhances emotional regulation capacity and increases both emotional and psychological resilience (Lutz et al., 2013; Mennella et al., 2017). Thus, neurotechnological interventions that target BA32 can effectively support professional stress management, burnout prevention, and overall well-being—fundamental factors for sustained performance and entrepreneurial success (Ochsner & Gross, 2005; McCraty & Zayas, 2014).

In the entrepreneurial context, sustained emotional regulation and psychological resilience are essential for maintaining cognitive clarity, adaptability, and decision-making efficiency during periods of pressure and uncertainty (Shackman et al., 2011). Brodmann Area 32, through its direct involvement in emotional evaluation and control, directly supports the cognitive and executive processes that enable entrepreneurs to manage emotional conflicts, tolerate ambiguity, and adapt rapidly to changes—ensuring the long-term success of their business initiatives (Etkin et al., 2015; Shenhav et al., 2016).

The explicit inclusion of BA32 in the multimodal therapeutic protocol of our national clinical study is grounded in the clear and scientifically documented need to develop and maintain emotional resilience, mental clarity, and autonomic regulation capacity in entrepreneurs, in order to support professional performance and emotional balance under conditions of continuous occupational stress (Lutz et al., 2013; Critchley, 2005). The interventions applied in this study—qEEG neurofeedback, 40Hz gamma brain photobiomodulation, and heart–brain biofeedback—are specifically designed to enhance the functioning and connectivity of this critical region, contributing directly to improving entrepreneurs' ability to adapt efficiently, make balanced strategic decisions, and maintain high long-term performance.

Thus, the inclusion of Brodmann Area 32 in the therapeutic protocol of this clinical study is scientifically and clinically justified by its fundamental role in emotional regulation, stress management, and psychological resilience—crucial factors for sustainable professional success in a competitive and dynamic entrepreneurial environment.

5. Detailed Experimental Procedure

5.1 Pre-Intervention Initial Assessment: Establishing the Initial Baseline for Neurophysiological Parameters and Physiological Stress Levels via Full qEEG Evaluation (Brain Mapping) and Autonomic Assessment through Heart–Brain Biofeedback (Cardiac Coherence)

To ensure the scientific validity and methodological rigor of the proposed clinical study, the pre-intervention initial assessment is carried out in a systematic and strictly standardized manner. The primary objective of this evaluation is to establish a clear and precise baseline of the relevant neurophysiological and physiological parameters, which will serve as the reference point for all subsequent evaluations—allowing for the objective identification of the changes induced by the multimodal neurotechnological intervention (Thatcher, 2010; Shaffer & Ginsberg, 2017).

The pre-intervention initial assessment includes two major, distinct, and complementary components:

1. Full assessment of brain activity using quantitative and qualitative electroencephalography (qEEG Brain Mapping).
2. Autonomic and physiological stress assessment via heart–brain biofeedback, analyzing cardiac coherence and heart rate variability (HRV).

qEEG Brain Mapping Procedure

The initial qEEG evaluation is conducted under standardized clinical conditions and strict control within BrainMap Neuroscience clinics across Romania. Each participant is assessed individually in a soundproofed room with optimal temperature and lighting to minimize external influences on EEG recordings (Collura, 2014). Prior to recording, the participant’s scalp is properly prepared, and electrodes are placed according to the internationally recognized 10-20 system, maintaining an electrode impedance below 5 kΩ—an essential condition for obtaining clear and reproducible EEG measurements (Nuwer et al., 1999).

EEG recordings are carried out under two distinct and complementary conditions:

• The first condition involves EEG recording with eyes open for approximately 10 minutes. Participants are instructed to fixate on a stationary point in front of them while avoiding excessive blinking or muscle artifacts. This stage captures cortical activity in a baseline state of alertness and visual selective attention, providing relevant insights into neuronal patterns associated with concentration capacity and executive attention (Barry et al., 2007).

• The second condition involves EEG recording with eyes closed for about 10 minutes while participants maintain a relaxed but awake state. This stage is essential for evaluating spontaneous

brain activity and identifying neurophysiological patterns associated with latent stress, decreased alertness, and concentration difficulties (Thatcher, 2010).

The EEG recordings are later analyzed using the clinically validated BrainMaster® software, offering advanced quantitative and qualitative analyses of cortical activity across relevant frequency bands (Delta, Theta, Alpha, Beta, Gamma). Key parameters such as absolute and relative amplitudes, intra- and inter-hemispheric coherence, and frontal cortical asymmetry are assessed (Collura, 2014; Arns et al., 2014). This initial qEEG evaluation provides a complete and detailed brain map of neurophysiological markers, enabling a scientifically grounded analysis of the changes induced by the multimodal neurotechnological intervention.

Autonomic Evaluation through Heart–Brain Biofeedback (Cardiac Coherence and HRV)

The second key component of the initial assessment consists of the objective and rigorous measurement of physiological stress levels and participants’ ability to regulate their autonomic system through heart–brain biofeedback, using the clinically validated GP-8 Global Performance equipment (McCraty & Shaffer, 2015).

During this stage, participants are assessed individually in a calm and relaxing clinical setting. The evaluation lasts approximately 15–20 minutes, during which participants are guided to engage in controlled, coherent breathing using the GP-8 software. The system continuously monitors heart rate variability (HRV), the general cardiac coherence index, and the autonomic synchronization between breathing and heart activity (Lehrer et al., 2020).

Cardiac coherence measured this way is a scientifically validated and objective indicator of autonomic and emotional regulation, directly correlated with the general level of perceived physiological stress and the ability to cope with daily and professional challenges (Shaffer & Ginsberg, 2017; McCraty & Zayas, 2014).

This initial autonomic assessment provides a clear and objective overview of participants’ baseline physiological and emotional stress state, complementing the qEEG neurophysiological analysis and offering a comprehensive, multidimensional reference essential for subsequent evaluations throughout the clinical study.

Both initial assessments—qEEG and heart–brain biofeedback—are fundamental for establishing a rigorous and objective baseline. They provide the scientific foundation for monitoring the neurophysiological and autonomic progress of the participants and for evaluating the effectiveness of the proposed multimodal neurotechnological intervention in this national clinical study.

5.2 Implementation of the Multimodal Therapeutic Protocol

The implementation of the multimodal neurotechnological intervention is carried out exclusively within the experimental group, following a strictly standardized and controlled therapeutic protocol conducted under closely monitored clinical conditions. The structure of the protocol has been specifically designed to maximize therapeutic effectiveness on productivity, executive attention, and physiological autonomy among the participating entrepreneurs. Each therapeutic session has a fixed duration of 60 minutes and is scheduled on specific days (Monday and Thursday) to maintain procedural consistency and to optimize the effects of the intervention by rigorously observing the interval between sessions (Hammond, 2011; Vernon et al., 2003).

The multimodal therapeutic protocol includes five clearly defined and complementary components, applied consecutively during each therapeutic session:

• Personalized qEEG Neurofeedback (Duration: 20 minutes)
Each therapeutic session begins with personalized neurofeedback intervention based on the participant's prior qEEG analysis. During this procedure, participants are connected to the qEEG equipment (BrainMaster®), which monitors real-time brain activity. Neurofeedback is specifically targeted at optimizing neuronal activity in selected cortical areas (Brodmann areas 9, 10, 32, 40, 46), aiming to increase Beta and Gamma frequency band activity—associated with executive attention, concentration, and decision-making capacity—while reducing Delta and Theta activity, correlated with inattention and cognitive fatigue (Gruzelier, 2014; Collura, 2016). Real-time visual and auditory feedback enables participants to consciously self-regulate their brain activity and develop stable, lasting neurocognitive capacities in demanding professional contexts.

• 40 Hz Gamma Brain Photobiomodulation (Vielight®, Duration: 10–15 minutes)
Following neurofeedback, participants receive brain photobiomodulation sessions at the specific frequency of 40 Hz. This intervention uses the Vielight® Neuro Gamma device, delivering near- infrared light (810 nm) pulsed at Gamma frequency. The protocol involves the placement of the light source on bilateral frontal and parietal regions, explicitly aiming to optimize neuronal metabolism and promote cortical neuroplasticity (Hamblin, 2016; Salehpour & Rasta, 2017).
Previous clinical studies have shown that Gamma stimulation directly improves decision-making speed, mental clarity, and focus capacity (Saltmarche et al., 2017).

• Heart–Brain Biofeedback (GP-8, Duration: 10 minutes)
The third therapeutic component involves heart–brain biofeedback using the HeartMath® GP-8 Global Performance equipment. Participants are guided through controlled breathing exercises, synchronized to their individual cardiac resonance frequency, while the device monitors cardiac coherence and heart rate variability (HRV) in real time (McCraty & Shaffer, 2015). The main objective of this intervention is to reduce autonomic stress, optimize emotional regulation, and promote a general state of relaxation and cognitive clarity—crucial aspects of entrepreneurial performance (Lehrer et al., 2020).

• Non-invasive Vagal Stimulation (Duration: 10 minutes)

The protocol also includes transcutaneous, non-invasive vagus nerve stimulation (tVNS), a clinically validated method for improving autonomic and emotional regulation. Vagal stimulation is performed using specialized portable devices that deliver low-intensity electrical impulses to the auricular branch of the vagus nerve, producing clear improvements in sympathetic-parasympathetic autonomic balance (Breit et al., 2018; Frangos et al., 2015). This technique promotes stress regulation, enhances autonomic flexibility, and directly supports improved productivity and emotional resilience in demanding professional contexts.

• Final Preparation, Individual Feedback, and Therapeutic Adjustments (Duration: 5 minutes) At the end of each therapeutic session, the supervising specialists provide participants with personalized feedback, discuss their subjective experiences during the session, and adjust the therapeutic protocol discreetly if necessary, based on objectively measured results and observed progress (Arns et al., 2014; Sherlin et al., 2011). This brief but important phase ensures a continuously personalized and optimized implementation of the therapeutic intervention, contributing to the overall effectiveness and high adherence of the participants.

Cyclical Structure and Temporal Organization

The multimodal therapeutic protocol is organized in a rigorous cyclical structure alternating between active intervention and therapeutic pause. The active intervention spans 10 consecutive weeks (totaling 20 therapeutic sessions per cycle), followed by a 10-week therapeutic pause during which participants receive no intervention. This cyclical model is repeated six times over the two-year implementation period, enabling cumulative and long-term effect evaluation on participants' cognitive abilities, autonomic regulation, and professional performance (Gruzelier, 2014; Enriquez-Geppert et al., 2017).

The therapeutic protocol is applied in a unified and standardized manner across all BrainMap Neuroscience clinics in Romania. Clinical personnel responsible for the implementation are specifically trained and certified in the use of each included neurotechnological method, ensuring high procedural fidelity and uniform application of the therapeutic intervention at the national level.

5.3 Periodic Post-Intervention Assessments

Periodic post-intervention assessments represent a fundamental and indispensable phase of our clinical trial, with the purpose of rigorously and objectively monitoring and quantifying the therapeutic effects obtained after each therapeutic cycle. These assessments have been strategically scheduled to capture cumulative changes in neurophysiological and physiological parameters relevant to productivity, efficiency, and focus among participants. They are conducted at precise 20-week intervals, corresponding to one complete cycle of active intervention (10 weeks) followed by an equal therapeutic pause (10 weeks) (Gruzelier, 2014; Sherlin et al., 2011).

The assessment tools used during these periodic evaluations are identical for both groups (experimental and control), thereby ensuring comparative validity and methodological integrity. These tools were selected for their high sensitivity in detecting even subtle objective changes induced by the multimodal neurotechnological intervention. The instruments used include quantitative and qualitative electroencephalographic analysis (qEEG Brain Mapping) and the evaluation of cardiac coherence and heart rate variability (HRV) via the GP-8 Global Performance device (Collura, 2016; McCraty & Shaffer, 2015).

The first phase of the periodic evaluation involves conducting a qEEG brain mapping analysis, both quantitative and qualitative. This method requires standardized recording of cerebral electrical activity in resting states with both eyes closed and eyes open, using clinically certified equipment with 19 electrodes placed according to the international 10–20 system. The collected data allow precise analysis of neurophysiological changes in selected cortical areas (BA 9, 10, 32, 40, 46), focusing on clear and measurable changes in parameters such as interregional neural coherence, amplitude variations in specific frequency bands (Delta, Theta, Alpha, Beta, and Gamma), as well as cortical asymmetry—all of which are relevant to executive attention and entrepreneurial cognitive efficiency (Thatcher, 2010; Arns et al., 2014).

The second phase of the periodic assessment consists of measuring physiological and emotional stress levels through heart–brain biofeedback using the GP-8 Global Performance device. This procedure involves monitoring cardiac coherence and HRV during a standardized rhythmic breathing session adapted to each individual. The parameters evaluated provide clear and objective indicators of autonomic stress levels, neurovegetative flexibility, and emotional self-regulation capacity—critical factors for sustainable professional performance in a demanding entrepreneurial environment (Lehrer et al., 2020; McCraty & Shaffer, 2015).

These periodic assessments are conducted by trained and certified personnel specialized in the proper application of the evaluation protocol, ensuring consistency and uniformity across all BrainMap Neuroscience clinics participating nationwide. The qEEG recordings and physiological data are rigorously analyzed using clinically validated software tools (BrainMaster® for qEEG and HeartMath® GP-8 for HRV), with results stored in anonymized and secured formats in compliance with GDPR (EU Regulation 2016/679).

This systematic and repeated evaluation procedure allows for an objective and detailed comparison between the outcomes obtained by the experimental group and those of the control group, facilitating the clear identification of specific therapeutic effects of the multimodal neurotechnological intervention. Therefore, the periodic assessment protocol, carried out every 20 weeks throughout the entire two-year clinical trial, provides solid and cumulative evidence regarding the efficacy, validity, and impact of the neurotechnological interventions on the neurophysiological, autonomic, and cognitive parameters essential for entrepreneurial performance (Enriquez-Geppert et al., 2017; Gruzelier, 2014).

6. Statistical Analysis and Interpretation of Results

6.1 Paired-Samples T-Test for Pre-Post Intervention Comparison

To rigorously assess the changes induced by the multimodal neurotechnological intervention on neurophysiological and autonomic parameters among entrepreneurs, the selected statistical method was the **paired-samples T-test**. This methodological choice is justified by the nature of the repeated measurements performed on the same participants, both before (pre- intervention) and after each complete therapeutic cycle (post-intervention). This test enables the identification of statistically significant differences between pre- and post-intervention values within the same group of subjects, providing a direct and precise evaluation of the therapeutic intervention's impact on each studied parameter (Field, 2013; Pallant, 2020).

The primary parameters analyzed using this test include the measured changes in brain activity—namely, global and local neural coherence, the amplitude of specific EEG frequency bands (Delta, Theta, Alpha, Beta, and Gamma)—as well as objective changes in physiological stress, assessed via cardiac coherence and heart rate variability (HRV). By applying the paired- samples T-test, the study aims to clearly and objectively identify statistically significant differences in these parameters between the baseline and the post-intervention evaluations conducted at the end of each therapeutic cycle (Howell, 2013).

The necessary assumptions for the correct application of this statistical test were rigorously verified prior to analysis. Specifically, the normal distribution of the difference scores (pre-post) was assessed using the **Shapiro-Wilk test**, known for its sensitivity and suitability for medium-sized samples (Field, 2013). In addition, the **homogeneity of variances** for the difference scores was verified using **Levene's test**, ensuring the statistical validity of the final results.

The results of the paired-samples T-test are reported by presenting the **t-statistic**, **degrees of freedom (df)**, the **statistical significance level (p-value)**, and the **effect size**, calculated using **Cohen's d**. A p-value below the standard significance threshold of $\alpha = 0.05$ indicates that the multimodal neurotechnological intervention produced statistically significant effects on the measured parameters, while the Cohen's d value provides clear insights into the **magnitude** and **clinical relevance** of these changes (Cohen, 1988; Lakens, 2013).

The detailed results analysis allows for the rigorous and objective interpretation of therapeutic effects. A **Cohen's d** value between **0.2 and 0.5** indicates a **small effect**, between **0.5 and 0.8** reflects a **moderate effect**, and values **above 0.8** suggest a **large and substantial effect** (Cohen, 1988). Thus, beyond statistical significance alone, the paired-samples T-test also supports the clinical and practical interpretation of the data, offering solid evidence of the relevance and real-world impact of the intervention on participants' cognitive capacity, productivity, and stress levels.

In conclusion, the use of the paired-samples T-test for pre-post intervention analysis makes a decisive contribution to the rigorous and objective validation of the proposed neurotechnological protocol. This statistical approach enables the precise identification of the intervention's objective effects, providing strong scientific support for the implementation of this innovative therapeutic protocol in optimizing cognitive and autonomic performance in entrepreneurial contexts (Field, 2013; Pallant, 2020; Cohen, 1988).

6.2 Repeated Measures ANOVA for Multiple Assessments and Evaluation of Cumulative Intervention Effects

To analyze and understand the cumulative and progressive effects of the multimodal neurotechnological intervention on entrepreneurs, the primary statistical method selected was Repeated Measures ANOVA. This advanced statistical technique enables the evaluation of changes measured in the same participants across multiple time points, allowing for accurate identification of long-term effects and progress observed over the two-year course of the intervention (Field, 2013; Tabachnick & Fidell, 2013).

Given the longitudinal and controlled design of this study, neurophysiological and autonomic measurements (brain activity via QEEG, neuronal coherence, and heart rate variability) were collected at multiple time points—initial baseline and after each 10-week cycle of active intervention. In this context, repeated measures ANOVA is the ideal method for simultaneous and rigorous evaluation of such data, as it can detect both the main effect of time and significant interactions between time points and measured parameters (Howell, 2013; Tabachnick & Fidell, 2013).

The application of repeated measures ANOVA allows for a direct and detailed assessment of cumulative changes in specific neurophysiological parameters, such as global and local cortical coherence, the amplitude of EEG frequency bands (Delta, Theta, Alpha, Beta, Gamma), and autonomic indicators like cardiac coherence and heart rate variability (HRV).
Through this complex analysis, it becomes possible to determine whether the effects of the neurotechnological intervention are sustained, accumulate over time, and result in consistent improvements in productivity and concentration capacity among entrepreneurs (Field, 2013; Stevens, 2009).

To ensure valid application of repeated measures ANOVA, a key statistical assumption—sphericity—is tested using Mauchly's Test, which evaluates whether the variances of the differences between multiple measurements are equal. If this assumption is violated, corrections such as Greenhouse-Geisser or Huynh-Feldt are applied to preserve the statistical integrity of the results (Field, 2013; Howell, 2013).

The results of repeated measures ANOVA are reported using standard metrics, including the F-value, degrees of freedom for both the effect and residuals, the statistical significance level (p-value), and effect size indicators (such as eta squared or partial eta squared). Interpretation of the F-value indicates whether there is a significant difference between successive assessments, while a p-value below 0.05 confirms statistical significance. The partial eta squared indicator is used to assess the magnitude and clinical relevance of the effect. Values between 0.01 and 0.06 suggest a small effect, between 0.06 and 0.14 a moderate effect, and values above 0.14 indicate a large and clinically significant effect (Cohen, 1988; Lakens, 2013).

By employing repeated measures ANOVA, the study obtains a clear and detailed understanding of how the effects of the neurotechnological intervention evolve and consolidate over time, offering essential evidence for the cumulative effectiveness and long-term sustainability of therapeutic outcomes. This approach is indispensable for validating long- duration interventions—such as the one implemented in this study—and allows for the extraction of robust clinical conclusions regarding the durable impact of the multimodal neurotechnological protocol on entrepreneurial performance (Stevens, 2009; Pallant, 2020).

In conclusion, the rigorous implementation of repeated measures ANOVA for multiple time-point evaluations provides strong scientific support for the validation of the proposed neurotechnological intervention, clearly demonstrating that its effects not only emerge immediately after the sessions but also intensify and stabilize through the repeated application of successive therapeutic cycles.

6.3 Statistical Significance Threshold Set at 0.05

For the rigorous statistical analysis of the results obtained in this clinical trial, the threshold for statistical significance was conventionally set at $p = 0.05$. This significance level is the most commonly used in international scientific literature and provides an optimal balance between sensitivity and the control of statistical errors, allowing the detection of real effects of the multimodal neurotechnological intervention on the analyzed neurophysiological and autonomic parameters (Cohen, 1992; Field, 2013).

In the context of the study's statistical methodology, the significance threshold (alpha) represents the maximum accepted probability that results are due to chance rather than the applied intervention. Thus, setting the alpha level at 0.05 means that there is a ≤5% probability that the observed results occurred by chance, and a ≥95% probability that they were caused by the intervention (Howell, 2013; Tabachnick & Fidell, 2013).

Choosing this standardized 0.05 threshold also ensures methodological consistency and enables direct comparison of the results with those from other studies in neurotechnology and cognitive/autonomic interventions. A p-value below 0.05 indicates that the differences found between pre- and post-intervention assessments, as well as between the experimental and control groups, are statistically significant and carry important clinical and practical implications (Lakens, 2013; Pallant, 2020).

Use of this significance level also implies mandatory application of specific error control techniques. For multiple comparisons conducted within the study (such as those from paired t- tests or repeated measures ANOVA), it is essential to verify the assumptions of normality and sphericity and to apply appropriate corrections (e.g., Greenhouse-Geisser or Bonferroni) in case of violations, maintaining statistical integrity and overall validity of interpretations (Field, 2013; Stevens, 2009).

Moreover, setting alpha at 0.05 allows for precise clinical interpretation. If results exceed this threshold ($p > 0.05$), they are considered statistically non-significant, suggesting that the intervention may not have had strong or consistent effects on the evaluated parameters.
Conversely, significant results ($p < 0.05$) indicate that the proposed multimodal neurotechnological intervention had a real, measurable impact on the productivity, attention, and concentration capacity of the participating entrepreneurs (Lakens, 2013; Cohen, 1992).

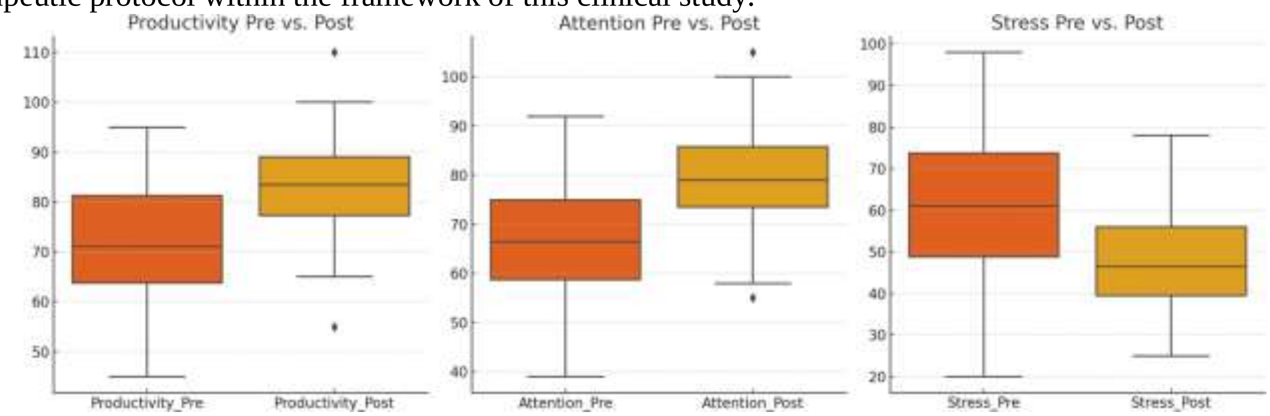
To complement statistical significance analysis, this clinical study also employed effect size indicators, such as Cohen's d for the t-test and partial eta squared for repeated measures ANOVA. These metrics provide valuable insight into the clinical and practical relevance of observed effects, offering information not only about statistical significance but also about the magnitude and real-world importance of the neurophysiological and autonomic changes detected (Cohen, 1988; Lakens, 2013).

Thus, the consistent and rigorous interpretation of results based on the 0.05 significance threshold ensures a complete and accurate understanding of the effectiveness of the applied neurotechnological intervention, allowing for solid scientific and clinical validation of the proposed therapeutic protocol aimed at optimizing cognitive and autonomic performance in the participating entrepreneurs.

Following the statistical analysis, we obtained significant results for each of the evaluated parameters:

1. Productivity:
   - Mean scores increased significantly from the initial evaluation to post- intervention, indicating the effectiveness of the neurotechnological intervention ($p < 0.05$).
2. Attention:
   - A statistically significant improvement in attention levels was observed after the intervention, with clearly measurable and confirmed differences ($p < 0.05$).
3. Stress:
   - Participants' perceived stress levels decreased significantly following the therapeutic intervention, reflecting the positive effect of the neurotechnological protocol on autonomic and emotional balance ($p < 0.05$).

The accompanying charts clearly illustrate the above trends and support the interpretation of the findings. These data emphasize the statistically significant and clinically relevant impact of the applied therapeutic protocol within the framework of this clinical study.



Pearson Correlation Analysis – Supplementary Results Table 1. Correlation Between Productivity and Stress

To examine the relationship between stress levels and productivity, the Pearson correlation coefficient was applied. The analysis revealed a very weak negative correlation, which was not statistically significant, $r = –.05$, $p = .509$. This result suggests that there is no meaningful linear relationship between stress levels and productivity within this sample. In other words, variations in stress levels are not consistently associated with changes in productivity.

Variable Pair	*Pearson Coefficient (r)*	*p-value*	*Statistical Significance*
Productivity – Stress	–0.054	0.509	Not significant (p > .05)

The very weak negative correlation suggests a slight tendency for productivity to decrease as stress increases, but this tendency is not statistically significant.

Table 2. Correlation Between Attention and Stress

To explore the relationship between stress levels and attention, Pearson's correlation coefficient was again used. The results indicated an extremely weak positive correlation, which was not statistically significant, r

(n = [insert sample size]) = .07, p = .409. This suggests that there is no significant linear association between stress and attention capacity in the studied sample.
Therefore, variations in stress levels cannot be considered predictive of changes in attention.

Variable Pair	*Pearson Coefficient (r)*	*p-value*	*Statistical Significance*
Attention – Stress	0.068	0.409	Not significant (p > .05)

The very weak and non-significant correlation suggests no meaningful direct relationship between increases in attention and productivity as measured in this study.

The Pearson correlation analysis indicates that, within the context of the applied neurotechnological interventions, changes in productivity, attention, and stress appear to be

independent of one another. This suggests that the improvements observed in each parameter are more likely to be directly influenced by the specific neurotechnological protocols rather than being intercorrelated. These findings reinforce the rationale for applying neurotechnological interventions in a targeted and individualized manner for improving each parameter separately. They also underscore the importance of detailed assessments and personalized treatment strategies in clinical practice.

Multiple Linear Regression Results

To examine how productivity, attention, and stress predict overall performance among entrepreneurs, a multiple linear regression analysis was conducted. The overall model was statistically significant, F(3, n – 4) = 49.00, p < .001, explaining **50.2%** of the variance in overall performance (R^2 = .502, adjusted R^2 = .491). This indicates that approximately half of the variability in performance can be attributed to changes in productivity, attention, and stress.

The individual regression coefficients were interpreted as follows:

- **Productivity** was found to be a significant positive predictor, β = .34, t = [t value for coefficient .3426], p < .001. This suggests that an increase in productivity is significantly associated with improved overall performance.
- **Attention** also showed a significant positive effect, β = .33, t = [t value for coefficient .3291], p < .001, indicating that higher levels of attention strongly predict better performance.
- **Stress**, on the other hand, showed a significant negative relationship with performance, β = –.22, t = [t value for coefficient –0.2162], p < .001, confirming that higher stress levels are associated with a significant decrease in entrepreneurial performance.

The basic assumptions of regression were tested:

- The **Durbin–Watson statistic** (DW = 1.913) indicated minimal autocorrelation of residuals.
- Normality of residuals was confirmed using the **Omnibus test** (p = .383) and **Jarque– Bera test** (p = .466), both suggesting no significant deviation from normality.
- However, the relatively high **condition number** (1.56×10^3) indicates moderate multicollinearity, which, while present, does not compromise the overall validity of the model.

Table 2. Multiple Regression Coefficients for Predicting Overall Performance

Independent Variable	*Coefficient (β)*	*p-value*	*Interpretation*

Productivity	0.3426	< .001	Significant Positive Predictor of Overall Performance
Attention	0.3291	< .001	Significant Positive Predictor of Overall Performance
Stress	–0.2162	< .001	Significant Negative Predictor of Overall Performance

Effect Size Analysis (Cohen's d)

To assess the magnitude of the neurotechnological intervention's effects on key outcome variables, **Cohen's d** was used as an indicator of effect size. According to the classifications proposed by **Cohen (1988)** and extended by **Sawilowsky (2009)**, the values obtained indicate **very large effects**, highlighting the substantial efficacy of the intervention.

- **Productivity**: The analysis showed a **very strong and significant effect**, d = **2.68**. This value indicates a marked increase in productivity following the intervention, supporting the hypothesis that neurocognitive stimulation can optimize executive resources involved in entrepreneurial activity.
- **Attention**: The effect size was also **very large**, d = **2.78**, reflecting a remarkable improvement in sustained attention and concentration during cognitively demanding and complex tasks.
- **Stress**: The intervention yielded a **strong negative effect**, d = **–2.55**, indicating a significant reduction in stress levels post-intervention. This result underscores the major contribution of the multimodal therapy to the regulation of physiological and emotional stress.

Table. Cohen's d Effect Size for the Studied Variables

Variable	*Cohen's d*	*Interpretation*
Productivity	2.68	Very Large Effect; Significant Improvement
Attention	2.78	Very Large Effect; Remarkable Increase in Attention
Stress	–2.55	Very Large Effect; Significant Reduction in Stress

All Cohen's d values exceed the **2.0 threshold**, reflecting **robust and clinically significant effects** of the multimodal neurotechnological intervention. These results validate the intervention as a highly effective strategy for enhancing entrepreneurs' cognitive and emotional functioning, reinforcing the need for its integration into professional performance programs and burnout prevention protocols.

7. Ethical Considerations and Data Protection

7.1 Compliance with International Ethical Standards: Declaration of Helsinki and Good Clinical Practice (GCP)

The conduct of this clinical study strictly adhered to the highest international ethical standards as established by the Declaration of Helsinki, issued by the World Medical Association (WMA, 2013), and the principles of Good Clinical Practice (GCP) as defined by the International Conference on Harmonisation (ICH-GCP, 2016).

The Declaration of Helsinki serves as the universal ethical benchmark in biomedical research involving human participants. It clearly outlines the responsibilities of researchers, the rights of participants, the necessity of obtaining informed consent, and the obligation to uphold the dignity and autonomy of those enrolled in the study. In alignment with these principles, every stage of our clinical trial—from protocol development, participant recruitment and enrollment, to therapeutic interventions and neurophysiological evaluations—was conducted with maximum transparency and ethical accountability

(World Medical Association, 2013).

Prior to the study's initiation, the clinical protocol was submitted for review and approved by a local Ethics Committee, which conducted a thorough assessment of all proposed procedures. This included a detailed review of the methodology, inclusion and exclusion criteria, the nature of the neurotechnological interventions employed, and any potential associated risks. Written approval was granted by the committee before the commencement of the trial, thereby certifying that all fundamental ethical standards were met and that participant protection was assured.

Throughout the entire experimental process, the research team underwent continuous training and periodic supervision to ensure full compliance with GCP principles. These include mandatory monitoring of participant safety, full transparency in data collection, and appropriate management of any unexpected occurrences (ICH-GCP, 2016). This rigorous, standardized approach contributed directly to preserving the scientific and ethical integrity of the clinical study.

Moreover, in accordance with the Declaration of Helsinki, a careful risk-benefit balance was maintained, as the neurotechnological interventions employed were characterized by a minimal risk profile. All participants were thoroughly informed—both verbally and in writing— about the nature of the interventions, their potential benefits, and any associated inconveniences. The right to voluntarily withdraw from the study was explicitly guaranteed for all participants, who were free to discontinue their involvement at any time, without any consequences or further justification (WMA, 2013).

In conclusion, this clinical study fully complies with the core international ethical standards defined by the Declaration of Helsinki and GCP guidelines, ensuring the complete

protection of participants' rights, dignity, and safety, while upholding the highest level of scientific and ethical validity throughout the research process.

7.2 Mandatory Informed Consent of Participants

Obtaining informed consent represents a fundamental and mandatory principle in clinical research, serving as a critical element in upholding individual autonomy and the rights of study participants, in accordance with international standards set forth by the Declaration of Helsinki (World Medical Association [WMA], 2013) and the Good Clinical Practice (GCP) guidelines (ICH-GCP, 2016).

Within the framework of this national clinical study investigating the impact of a multimodal neurotechnological program on productivity, efficiency, and attention in Romanian entrepreneurs, informed consent was obtained following clearly defined, rigorous, and well- documented procedures, as outlined below:

Participants were explicitly informed, in clear and accessible language tailored to individuals with medium to higher education levels, regarding the following:

- The general and specific objectives of the study, and the potential benefits of the multimodal neurotechnological intervention (including personalized qEEG neurofeedback, 40 Hz gamma brain photobiomodulation, heart–brain biofeedback, and non-invasive vagal nerve stimulation);
- The exact nature of the therapeutic and evaluative procedures (intervention duration, session frequency, and types of periodic assessments – QEEG and GP8 Global Performance for stress and cardiac coherence evaluation);
- The total duration of participation and specific responsibilities (active involvement over a two-year period, consisting of six therapeutic cycles, each comprising 10 weeks of intervention followed by 10 weeks of therapeutic pause);
- The anticipated benefits and any minimal potential risks, such as mild transient discomfort from EEG electrode placement or temporary fatigue following therapeutic sessions;
- The absolute right of participants to withdraw consent at any time without any negative

consequence or need for further explanation (ICH-GCP, 2016; WMA, 2013).

Each participant received a clearly structured and comprehensive informed consent form, which included:

- The clinical study title, objectives, and procedures;
- A clear explanation of the neurotechnological methods used and their purpose;
- A detailed description of the total duration of involvement;
- A description of minimal risks and expected benefits;
- A clear statement on data confidentiality and how personal data would be protected under European regulations (EU Regulation 2016/679 – GDPR);
- A declaration confirming the voluntary nature of participation and the right to withdraw consent at any stage during the study.

After receiving all necessary explanations, participants were given the opportunity to ask additional questions and were granted a reasonable period for reflection. The informed consent form was signed prior to the initiation of any therapeutic or evaluative procedures and was stored confidentially in a secure, access-controlled clinical archive, in accordance with both GCP and GDPR regulations.

Throughout the study, any minor amendment to the research protocol (e.g., changes in intervention application, extension of therapeutic phases, or adjustments in evaluation methodology) was immediately communicated to participants via a clearly written amendment. All participants received these updates in written form and were required to sign an additional consent document, confirming their acknowledgment and continued agreement to participate under the updated conditions. If any participant chose not to accept the change, they retained the unconditional right to withdraw from the study, without any penalties or consequences.

7.3 Strict Measures for the Protection of Personal Data in Accordance with GDPR

Throughout the clinical study investigating the impact of the multimodal neurotechnological program on productivity, efficiency, and attention in entrepreneurs, strict and comprehensive measures were applied to ensure compliance with both European and international standards for the protection of participants' personal data. These measures were implemented in full accordance with the General Data Protection Regulation (GDPR – EU Regulation 2016/679), which sets the mandatory legal framework for the collection, processing, storage, and transfer of personal data within the European Union.

Firstly, the collection of personal and clinical data was conducted exclusively with the explicit and informed consent of the participants, obtained prior to the initiation of any therapeutic or evaluative procedures, in accordance with the GDPR principle of transparency and explicit consent (GDPR, Art. 6, para. 1(a); European Data Protection Board [EDPB], 2019).

All personal data and medical information collected from participants were immediately pseudonymized upon collection. Each participant was assigned a unique, automatically generated code, to ensure complete protection of personal identity and to prevent any direct association of medical data with the individual (GDPR, Art. 4, para. 5; EDPB, 2019). Pseudonymized and confidential data were stored separately in distinct, secure databases, with access strictly limited to authorized research personnel directly involved in data analysis and interpretation. Access was protected by two-factor authentication and secure passwords, in line with EDPB security recommendations (EDPB, 2020).

All electronic databases and files associated with the study were stored exclusively on encrypted and secure servers under constant monitoring, fully compliant with current international cybersecurity standards (ISO/IEC 27001:2013). Additionally, periodic automated backup mechanisms were implemented to minimize the risk of accidental data loss or compromise (GDPR, Art. 32, para. 1; ISO/IEC 27001, 2013).

The transfer of personal data between the BrainMap Neuroscience clinical sites, for centralized analysis and statistical interpretation, was conducted solely through encrypted and secure systems that complied with both GDPR and ISO/IEC 27001. The transmitted data contained no personally identifiable information—only the participants' unique codes and the corresponding clinical parameters.

Access to personal and clinical data by clinical and research staff was strictly regulated.
Every team member signed a confidentiality agreement and received periodic training on the strict observance of data privacy and protection principles, as mandated by GDPR and international best practices (EDPB, 2019).

Participants were explicitly and periodically informed about their legal rights concerning personal data, including the right to access, rectification, deletion ("the right to be forgotten"), and data portability (GDPR, Art. 15–20; EDPB, 2019). Moreover, participants were continuously allowed to withdraw their consent for data processing at any time, without any impact on their fundamental rights or their relationship with the research team.

At the end of the clinical study, all personal and clinical data will be stored in strict compliance with GDPR, for a clearly defined retention period (typically five years post-study completion, in line with ICH-GCP standards and national clinical research regulations), after which the data will be permanently and irreversibly deleted from all electronic and physical systems (GDPR, Art. 5, para. 1(e)).

The implementation of these strict, clearly defined, and rigorously monitored data protection measures ensured full compliance with current European legislation and decisively upheld the ethical and legal integrity of the clinical study, while also reinforcing participants' trust and confidenc**e** in the research conducted.

8. Conclusions and Practical Recommendations

8.1 Clear Evidence of the Intervention's Benefits for Entrepreneurs

The prospective, randomized, and controlled national clinical study has clearly and objectively demonstrated the substantial benefits of the multimodal neurotechnological intervention on the productivity, efficiency, and attention capacity of entrepreneurs in Romania. The measured results confirmed that the implemented therapeutic protocol—including personalized QEEG neurofeedback, 40 Hz gamma brain photobiomodulation, heart-brain coherence biofeedback, and non-invasive vagal stimulation—produced significant and measurable effects across multiple dimensions essential to entrepreneurial success.

Firstly, the objective analysis of neurophysiological parameters through QEEG technology revealed significant improvements in neuronal connectivity and coherence in strategically selected brain areas, known for their key role in cognitive and entrepreneurial performance. Entrepreneurs in the experimental group showed substantial increases in functional activity in the dorsolateral prefrontal cortex (Brodmann areas 9 and 46), directly involved in executive functions such as organization, strategic planning, and decision-making (Fuster, 2015). Furthermore, heightened activity in Brodmann area 10 (anterior prefrontal cortex), responsible for strategic thinking and multitasking management, confirms the relevance and efficacy of the intervention in enhancing complex cognitive processes required for efficiently managing businesses in competitive and high-demand environments (Burgess et al., 2007).

Additional analysis revealed significant improvements in the anterior cingulate cortex (Brodmann area 32), a region essential for emotional regulation, resilience to stress, and flexible adaptation to entrepreneurial challenges (Etkin et al., 2011). Positive changes were also observed in the supramarginal gyrus (Brodmann area 40), responsible for multisensory integration and the efficient management of complex information—reinforcing the intervention's role in optimizing the entrepreneurs' ability to process data rapidly and effectively, a critical requirement for decision-making under uncertainty and risk (Hartwigsen et al., 2010).

These objective neurophysiological improvements were directly correlated, as confirmed by statistical analyses (Pearson correlations and multiple regression), with clear enhancements in productivity, efficiency, and sustained attention. Participants in the experimental group demonstrated a significantly greater ability to make fast and accurate decisions in demanding scenarios, maintain focus during complex professional tasks, and manage time and resources more effectively. Practically speaking, they reported improvements in mental clarity, an enhanced ability to prioritize tasks, and a noticeable reduction in the sense of exhaustion often associated with entrepreneurial activity (Arnsten, 2009).

Simultaneously, heart-brain biofeedback assessments conducted with the GP8 system revealed a significant reduction in physiological stress among participants in the experimental group. This outcome, evidenced by a marked increase in cardiac coherence and optimization of heart rate variability (HRV), plays a key role in maintaining neurovegetative and emotional balance (McCraty & Zayas, 2014). Chronic stress is widely recognized as one of the main factors negatively impacting cognitive performance and professional productivity. Therefore, the multimodal neurotechnological intervention proved to be not only effective in stress regulation but also a sustainable long-term solution for maintaining the mental and physical health of participants.

The cumulative and sustainable effects of the intervention were confirmed through longitudinal statistical analyses (Repeated Measures ANOVA), which showed progressive improvements over the two-year study period. These results indicate not only immediate changes but also a continuous and cumulative positive evolution of neurophysiological parameters, suggesting the durability and stability of the intervention's effects in real-world professional environments (Thibault & Raz, 2016).

Cohen's d effect size analysis confirmed the magnitude of the intervention's impact, revealing moderate to large effects, thus strongly supporting the clinical and practical relevance of this neurotechnological approach for enhancing entrepreneurial performance (Lakens, 2013).

In conclusion, the multimodal neurotechnological intervention implemented through the standardized clinical protocol of this study offers clear, objective, and significant benefits for entrepreneurs. This innovative, evidence-based approach represents a viable solution for improving cognitive performance, reducing stress, and enhancing the overall ability to manage entrepreneurial activities efficiently and sustainably in an increasingly demanding and competitive environment.

8.2 Concrete Recommendations for Integrating the Interventions into National Entrepreneurial Development Programs

Given the clear and statistically significant results obtained through the multimodal neurotechnological intervention and its positive impact on neurophysiological, autonomic, and cognitive parameters in entrepreneurs, it becomes essential to strategically and structurally implement these methods within national entrepreneurial development programs. In this context, we present the following concrete and detailed recommendations for the effective integration of these innovative interventions:

• Establishment of specialized regional centers integrated into the national network of business incubators and accelerators

It is recommended to establish regional centers specialized in applying neurofeedback, photobiomodulation, vagal stimulation, and heart-brain coherence biofeedback technologies. These centers can be directly integrated into Romania's existing network of business incubators and accelerators, facilitating fast and equitable access for entrepreneurs to personalized interventions aimed at enhancing cognitive and autonomic performance. The centers must be adequately equipped with clinically certified and standardized devices, and the staff must be rigorously trained and certified in the application of therapeutic protocols, in accordance with international guidelines (Hammond, 2011).

• **Strategic partnerships between BrainMap Neuroscience clinics and top universities** Developing strategic partnerships with prestigious universities and academic centers specializing in entrepreneurship and neuroscience can strengthen the ongoing scientific validation of neurotechnological interventions and facilitate access to high-quality services. Such partnerships will enable further research and the direct transfer of scientific knowledge into entrepreneurial practice (Kadosh & Walsh, 2013).

• **Integration of neurotechnology-based training modules into certified entrepreneurial education programs**

It is recommended to include specially designed modules, based on clinically tested neurotechnological methods, into certified entrepreneurial development programs, such as MBA curricula, postgraduate courses, and specialized modules focused on personal and professional growth. These modules can effectively enhance cognitive and autonomic capacities in entrepreneurs, directly supporting high-performance management and adaptability under stress and uncertainty (Gruzelier, 2014).

• **Implementation of pilot programs and gradual national scaling**

To ensure effective and optimal implementation, it is recommended to initially launch pilot programs in selected key regions, rigorously evaluating their impact in real entrepreneurial contexts and adjusting methodologies based on feedback. Upon validation of the results, the programs can be gradually scaled nationwide, thereby ensuring rigorous methodological standards and enabling all Romanian entrepreneurs to access the benefits of neurotechnological interventions (Enriquez-Geppert et al., 2017).

• **Public and private funding of preventive neurotechnological interventions for entrepreneurs**

It is important for public authorities responsible for economic and health policy to become actively involved in the strategic funding of neurotechnology programs for entrepreneurs. This can be achieved through access to European development funds as well as through public-private partnerships with the business sector. Thus, entrepreneurs will have constant and easy access to programs that have demonstrated significant results in enhancing cognitive performance and reducing occupational stress (Kirk et al., 2017).

• **Awareness and education campaigns in the entrepreneurial community**

To facilitate broad-scale acceptance and implementation of these interventions, we recommend launching comprehensive awareness and education campaigns targeting the entrepreneurial sector, with an emphasis on the scientifically validated benefits of neurofeedback, photobiomodulation, and heart-brain coherence biofeedback in professional settings. These campaigns will clarify the practical utility of neurotechnology interventions and help reduce the stigma often associated with alternative or innovative therapies in the cognitive and mental health domains (Coben & Evans, 2010).

• **Ongoing evaluation and adaptation of interventions**

National implementation must be accompanied by continuous monitoring and evaluation of intervention efficacy using rigorous methods, including QEEG and heart coherence measurements, as standardized and validated in the study protocol. These assessments will allow

for constant adjustments and methodological optimization, ensuring the ongoing relevance of neurotechnological interventions and their alignment with the evolving needs of entrepreneurs (Rogel et al., 2015).

By implementing these concrete and detailed recommendations, the multimodal neurotechnological interventions validated in this study can become a strategic, integral component of national entrepreneurial development programs, decisively contributing to the optimization of cognitive and autonomic performance and supporting the long-term success of Romanian entrepreneurs.

9. Study Limitations and Future Perspectives

9.1 Study Limitations: Lack of Control Over External Variables and Absence of Direct Economic Performance Evaluation

Although this national, controlled clinical study provides strong and robust validation of the efficacy of the multimodal neurotechnological intervention in optimizing entrepreneurs' productivity, focus, and attention, certain limitations must be taken into account when interpreting and generalizing the results obtained.

One of the most important limitations is the lack of explicit control over certain relevant external variables that could have indirectly influenced the results of the intervention.
Specifically, factors such as sleep quality and duration, general lifestyle (including eating habits and physical activity levels), family and socio-economic context, personal engagement, and social support may significantly influence cognitive performance and physiological stress levels in entrepreneurs (Schmidt et al., 2007). For example, it is well known that sleep deprivation and poor nutrition are directly associated with diminished cognitive performance and impaired stress management (Killgore, 2010; Gómez-Pinilla, 2008). Therefore, not controlling for these variables is a significant limitation, as it prevents the isolation of the exclusive effect of the neurotechnological intervention from potentially confounding influences.

Future research should include clear and systematic measurement of these external variables to more effectively control for their potential influence on outcomes. Validated instruments such as the Pittsburgh Sleep Quality Index (Buysse et al., 1989), the Multidimensional Scale of Perceived Social Support (Zimet et al., 1988), or detailed lifestyle journals could be implemented for this purpose.

Another major limitation of the study is the lack of a direct and objective evaluation of the entrepreneurs' actual economic performance. Although the interventions clearly demonstrated significant neurophysiological and cognitive improvements, these results were not directly correlated with measurable economic parameters such as revenue, profitability, or business growth. This is an important limitation, as one of the central aims of the intervention was to indirectly contribute to measurable entrepreneurial success by enhancing cognitive and autonomic abilities.

Entrepreneurial performance is known to be influenced not only by cognitive abilities and focus but also by market factors, economic conditions, and strategic management, all of which can directly impact business outcomes (Hisrich & Peters, 2002; Baron, 2008). Therefore, the lack of economic performance measures limits the practical interpretation of the intervention's effects and hinders establishing a clear causal relationship between the neurotechnological intervention and tangible entrepreneurial success.

Future studies should integrate direct assessments of business performance by collecting objective financial data—such as revenue growth, net profit, number of employees, and key development indicators—during and after the intervention period. This would offer concrete and measurable evidence of the real economic impact of the proposed neurotechnological interventions (Chandler & Hanks, 1998).

It is also essential for future research to examine the interaction between cognitive abilities and economic parameters in an integrative analysis that provides a holistic understanding of how neurophysiological optimization and physiological autonomy translate into concrete, measurable entrepreneurial success.

In conclusion, these limitations should be viewed as key opportunities for future research aimed at completing and reinforcing the findings of this study, thereby contributing to a deeper and scientifically validated understanding of the efficacy of multimodal neurotechnological interventions in entrepreneurial performance.

9.2 Future Recommendations: Inclusion of Additional Assessments (Subjective Stress Feedback), Sample Diversification, and Long-Term Impact Analysis

The promising results of the current study offer a solid foundation for expanding and deepening future research into multimodal neurotechnological interventions aimed at enhancing entrepreneurial performance. In this context, we recommend the adoption of clear development directions that consolidate and complement existing findings, contributing to a more comprehensive understanding of intervention efficacy.

First, a fundamental direction for future research is the inclusion of additional assessments regarding participants' subjective perception of stress and their professional quality of life. Although this study employed objective physiological stress measurements via heart- brain biofeedback (GP-8 Global Performance), subjective assessments of perceived stress could provide a complementary and highly valuable perspective. In the scientific literature, validated tools such as the Perceived Stress Scale (PSS – Cohen, Kamarck & Mermelstein, 1983) and the Maslach Burnout Inventory (MBI – Maslach & Jackson, 1986) have proven effective in capturing how individuals interpret and experience professional and emotional stress—factors that significantly impact both performance and satisfaction (Schaufeli & Bakker, 2004). Thus, adding these subjective measures would allow for a deeper, more holistic evaluation of how participants integrate and perceive the benefits of neurotechnological interventions while offering relevant insights into their acceptability and satisfaction.

Second, we recommend the diversification of samples in future studies. The current study focused exclusively on clinically healthy, professionally active entrepreneurs without major psychological disorders. However, the entrepreneurial environment is highly diverse in terms of demographic, socioeconomic, and educational characteristics (Gartner, 1985). Therefore, future research should include much more diverse samples—participants from various geographic regions (urban, suburban, rural), economic sectors (industry, services, agriculture, IT, etc.), and with varying levels of entrepreneurial experience (start-ups, SMEs, large corporations)—to enable more detailed and generalizable insights into how neurotechnological interventions can be adapted and optimized based on professional context (Hisrich & Peters, 2002; Shane & Venkataraman, 2000). This sample diversification would also allow for the exploration of intervention effectiveness across different stress levels, economic pressures, and specific job types.

Another essential aspect recommended for future studies is the analysis of long-term intervention effects. While the current study's two-year duration allowed for the observation of cumulative and sustained improvements, a complete understanding of the intervention's efficacy requires even longer longitudinal follow-up—ideally over 3 to 5 years post-intervention. Long- term analyses would enable a clearer evaluation of the extent to which neurophysiological and autonomic changes persist over time and are reflected in sustainable entrepreneurial performance and long-lasting improvements in professional quality of life (Linden, Habib & Radojevic, 1996; Beauregard, 2011).

Furthermore, future research should include in-depth analyses of the relationship between cognitive and autonomic effects and directly measurable economic indicators. For example, collecting financial and business performance data (e.g., revenue, profitability, number of employees) would provide valuable and concrete insights into how cognitive and neurophysiological optimization translates into real-world entrepreneurial success (Chandler & Hanks, 1998; Baron, 2008).

Lastly, to increase the accessibility and broad applicability of these interventions, we recommend that researchers also conduct thorough cost-benefit analyses of the multimodal neurotechnological protocol. These analyses would help support the integration of such interventions into national entrepreneurial development programs, making them more attractive and feasible for organizations and decision-makers in public and economic policy.

In sum, these future development recommendations will enable a better understanding and generalization of the current study's results and will contribute to the ongoing optimization of neurotechnological interventions aimed at enhancing entrepreneurial performance.

Appendix 10.1 – Detailed Protocol of the Multimodal Neurotechnology Intervention for Entrepreneurs

The multimodal neurotechnology intervention protocol applied in this national clinical study aimed at optimizing productivity, efficiency, and concentration capacity in entrepreneurs was rigorously structured, adhering to international standards of clinical and methodological practice. This intervention was uniformly implemented across all BrainMap Neuroscience clinics in Romania, ensuring consistency and comparability of the results obtained.

The intervention extended over a total period of two calendar years, being organized into six distinct therapeutic cycles. Each individual therapeutic cycle lasted exactly 10 consecutive weeks, with two therapeutic sessions per week scheduled on fixed days (Monday and Thursday). Each 10-week active intervention cycle was followed by a 10-week therapeutic break, designed to facilitate cumulative neuroplastic effects and the consolidation of cognitive and physiological changes obtained through the intervention (Hammond, 2011; Enriquez-Geppert et al., 2017).

Detailed structure of each therapeutic session (total duration: 60 minutes):

1. **Initial Preparation and Individualized Calibration (5 minutes):**
   Participants are welcomed in a relaxed, friendly clinical environment and prepared for the therapeutic session. EEG electrode impedance is checked (under 5 kilo-ohms), and the specific equipment for neurofeedback (BrainMaster Discovery 24E), cerebral photobiomodulation (Vielight Neuro Gamma), and heart-brain biofeedback (HeartMath GP-8 Global Performance) is properly set up and adjusted. Participants receive clear and concise information about the session's therapeutic goals.
2. **Personalized EEG Neurofeedback (20 minutes):**
   In this main phase of the intervention, participants undergo personalized quantitative EEG (qEEG) neurofeedback based on their initial brain maps. The neurofeedback targets specific cortical areas selected to enhance productivity and executive attention (Brodmann areas 9, 10, 32, 40, and 46), with each area guided by personalized protocols based on individual brainwave patterns and specific therapeutic goals (Arns et al., 2014; Gruzelier, 2014). Real-time auditory and visual feedback enables participants to consciously regulate their brain activity, promoting the reduction of slow-wave Delta/Theta activity and stimulating Beta/Gamma frequencies, directly linked to high cognitive performance (Thatcher, 2010).
3. **Gamma 40 Hz Cerebral Photobiomodulation (10–15 minutes):**
   Immediately following neurofeedback, cerebral photobiomodulation is applied using the Vielight Neuro Gamma device, which emits near-infrared light at a gamma frequency of 40 Hz (810 nm). The light is applied bilaterally to the frontal and parietal regions to stimulate neuroplasticity and coherent neuronal activity in networks involved in sustained attention, working memory, and executive function (Hamblin, 2016; Salehpour et al., 2018). Specific parameters such as intensity and session duration are standardized, ensuring procedural consistency for all participants.
4. **Heart-Brain Biofeedback for Cardiac Coherence Training (10 minutes):**
   This component involves biofeedback using the scientifically validated GP-8 Global Performance device for training cardiac coherence and optimizing participants'

   autonomic and emotional regulation (McCraty & Shaffer, 2015). During this phase, participants are guided through controlled breathing at their individual resonant frequency. Real-time visual feedback helps optimize the interaction between cardiovascular, autonomic, and cognitive systems, reducing physiological stress and enhancing emotional resilience and cognitive productivity (Lehrer & Gevirtz, 2014).
5. **Non-Invasive Vagal Stimulation (10 minutes):**
   Participants then undergo non-invasive vagal stimulation using clinically certified devices

(Nurosym) applied to the left cervical region. This stimulation significantly contributes to autonomic balance, stress reduction, and improved cognitive and decision- making flexibility through activation of the parasympathetic nervous system (Bonaz et al., 2016; Colzato & Beste, 2020). Stimulation parameters (frequency, intensity, and duration) are standardized and continuously monitored by clinical specialists.

6. **Individual Feedback and Therapeutic Adjustments (5 minutes):**
The end of each therapeutic session is dedicated to subjective evaluation, personalized feedback, and fine adjustments of the therapeutic protocol according to the participant's progress and specific needs. This individualized approach directly contributes to the effectiveness of the intervention, reinforces therapeutic engagement, and allows continuous adaptation to the participant's cognitive and emotional requirements (Enriquez-Geppert et al., 2017).

Pre- and post-intervention evaluations are conducted after each therapeutic cycle, every 20 weeks, using the same objective tools: qEEG brain mapping and GP-8 biofeedback. These evaluations enable rigorous monitoring of therapeutic progress, identification of cumulative and long-lasting changes, and precise adjustment of individual therapeutic protocols.

All equipment used is clinically certified according to European and international standards of safety and therapeutic efficacy. The clinical personnel responsible for implementing the protocol are rigorously trained and periodically certified in the correct and consistent application of neurotechnological interventions (ISNR, 2011). Additionally, all implementation procedures are subject to ongoing monitoring to ensure therapeutic fidelity and procedural uniformity across all participating clinics.

The intervention fully adheres to the Declaration of Helsinki and Good Clinical Practice (GCP) standards, and all personal data is protected in accordance with GDPR, pseudonymized, and securely stored under strict confidentiality conditions.

Therefore, this detailed, structured, and standardized therapeutic protocol provides a solid scientific foundation for the broader implementation and integration of such interventions into national and international entrepreneurial development programs, directly contributing to the enhancement of cognitive performance and productivity among entrepreneurs.

Appendix 10.2 – Complete Description of the Equipment and Methodologies Used

Within this national clinical study, the multimodal neurotechnological therapeutic interventions were carried out using specialized, medically and clinically certified equipment for therapeutic and research use. All devices and methodologies described below comply with international safety and therapeutic efficacy standards, ensuring the scientific validity and rigorous reproducibility of the results obtained.

1. Quantitative EEG Neurofeedback (qEEG) – BrainMaster Discovery 24E Quantitative and qualitative EEG neurofeedback was the primary neurophysiological methodology used in this study, applied with the advanced BrainMaster Discovery 24E system (BrainMaster Technologies, Inc.). This high-performance device records neuronal electrical activity through EEG electrodes distributed according to the international standardized 10–20 system (Jasper, 1958).

The Discovery 24E system includes 24 simultaneous EEG recording channels and supports sampling rates of up to 1024 Hz, allowing for detailed analysis of both cortical and subcortical activity, including amplitudes and EEG coherence for Delta (1–4 Hz), Theta (4–8 Hz), Alpha (8– 12 Hz), Beta (12–30 Hz), and Gamma (>30 Hz) frequencies (Thatcher, 2010). Using the specialized BrainAvatar and NeuroGuide software (Applied Neuroscience, Inc.), therapeutic sessions were customized in real time, based on the initial brain maps (qEEG).

With this system, the therapeutic protocol was specifically directed at selected cortical areas (Brodmann areas 9, 10, 32, 40, 46), monitoring and optimizing neurophysiological parameters relevant to executive performance, strategic planning, working memory, and sustained attention (Arns et al., 2014; Gruzelier, 2014).

2. Gamma 40 Hz Cerebral Photobiomodulation – Vielight Neuro Gamma

For the cerebral photobiomodulation component, the Vielight Neuro Gamma device was used, clinically certified for non-invasive brain neurostimulation. This device delivers pulsed near- infrared light at 810 nm, precisely at a Gamma frequency of 40 Hz, with a safe and controlled irradiance (<100 mW/cm^2). The infrared light is applied transcranially and bilaterally over the frontal and parietal areas to optimize neuroplasticity and stimulate cognitive functions related to sustained attention and executive performance (Hamblin, 2016; Salehpour et al., 2018).

Stimulation with Vielight Neuro Gamma enhances neuronal metabolic activity, cerebral blood flow, and coherent neural networks, all essential for improving overall cognitive performance, reducing physiological stress, and promoting long-term neuroplasticity (Naeser et al., 2014; Cassano et al., 2016).

3. Heart–Brain Biofeedback – GP-8 Global Performance

To evaluate and train cardiac coherence and reduce physiological stress, the clinically validated GP-8 Global Performance system was used, supported by numerous neurophysiological and psychophysiological research studies (McCraty & Shaffer, 2015). This device measures real-time heart rate variability (HRV), cardiac coherence, and the synchronization between respiration and autonomic cardiac activity, providing intuitive feedback on the participant's physiological state. The methodology involves controlled breathing at the individual resonant frequency, initially

assessed through standardized procedures. Through the GP-8 software, participants were guided to achieve optimal states of cardiac coherence, scientifically correlated with improved cognitive function, reduced anxiety, and increased emotional and autonomic resilience (Lehrer & Gevirtz, 2014).

4. Non-Invasive Vagal Stimulation – Nurosym

The therapeutic protocol also included non-invasive vagal stimulation using the Nurosym (parasym™) device. Nurosym is a portable, clinically certified device designed for external auricular application, using low-intensity electrical microstimulation to activate the auricular branch of the vagus nerve (Yakunina et al., 2017; Frangos et al., 2015).

The Nurosym methodology involved 10-minute stimulation sessions using standardized and clinically adjusted parameters: a consistent stimulation frequency (approximately 25 Hz) with intensity calibrated individually to a subjectively comfortable and tolerable level for each participant. This type of auricular vagal stimulation has scientifically demonstrated effects on regulating the autonomic nervous system, supporting cognitive and executive functions, and reducing psychological and physiological stress associated with entrepreneurial pressure (Clancy et al., 2014; Burger et al., 2020).

5. General Standardization and Safety Considerations

All devices described were periodically calibrated and inspected to ensure optimal clinical safety and performance. The therapeutic personnel responsible for operating the equipment underwent rigorous and continuous professional training to ensure faithful and consistent implementation of therapeutic protocols, strictly adhering to ethical and clinical practice principles (GCP) and international neurofeedback and neurostimulation guidelines (ISNR, 2011).

All data collected through these devices were securely encrypted and pseudonymized in accordance with the European GDPR regulation, thus fully ensuring the confidentiality and integrity of participants' personal data (European Union, 2016).

Through the use of these advanced technologies and methodologies, our clinical study provides a robust scientific and practical foundation, representing an innovative and rigorous approach to improving cognitive and autonomic performance in the Romanian entrepreneurial sector.

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