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Preliminary Evidence for Efficacy of 4-Channel Live *Z*-Score Neurofeedback Training Among Individuals With Posttraumatic Stress Disorder

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Individuals with traumatic experiences may develop symptoms of posttraumatic stress disorder (PTSD) along with comorbid conditions like anxiety and major depressive disorders (Brunello et al., 2001; Kessler et al., 2017). Past studies utilizing amplitude training and alpha-theta training have demonstrated the efficacy of neurofeedback (NF) in alleviating trauma-related symptoms (Peniston & Kulkosky, 1991; van der Kolk et al., 2016). Despite symptom reductions, these studies often lacked an explanation of how targeted electrode sites were functionally related to PTSD symptoms. A potential solution to this issue is live *z*-score NF training (LZT), a state-of-the-art NF method that normalizes brain activity through real-time comparison to an age- and sex-matched normative database (Thatcher, 2013). Therefore, we conducted the first study to assess the acceptability and potential efficacy of LZT for treating PTSD. After a diagnostic interview using the MINI neuropsychiatric interview (Sheehan et al., 1998), 14 PTSD patients (8 females; mean age = 21.06, *SD* = 2.18) underwent 10 quantitative electroencephalogram (qEEG)-guided LZT sessions and three assessment sessions at pre-, mid-, and posttreatment. Each assessment session included self-report measures of trauma-related symptoms, acceptability, and safety concerns, as well as a 10-min eyes-open and eyes-closed resting-state EEG recording. Training sessions, lasting 20 min each, involved participants watching a video of their choice. Repeated measures ANOVAs indicated significant improvements in the symptoms of PTSD, anxiety, insomnia, and emotion dysregulation. Additionally, a significant correlation was found between beta (13–30 Hz) power in the parietal region (P3 and P4) and self-reported PCL-5 scores. Although these results are promising, we found that the treatment effects, including changes in the pattern of the qEEG map, were not uniform across the participants, which needs further investigation. While these results require replication in larger samples with active control groups, the study provides evidence that LZT holds potential as an effective treatment for PTSD.

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The Depression Network: A Neuroimaging Case Study of Acute Stimulation

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Depression is an intense feeling of sadness, irritability, worthlessness, hopelessness, and an overall empty mood. The human brain depression network is a combination of the default mode network, task positive network, cognitive control network, salience network, reward network, and affective network. The common areas amongst these networks are the amygdala, thalamus, hippocampus, cingulate cortex, and prefrontal cortex. In clinical depression there is a general imbalance of the above networks. There is excessive activation of the default mode network, as well as increased activity in the medial prefrontal cortex, amygdala, and hippocampus. The neuroanatomical structure of depression shows structural and functional differences in the brain. The hippocampus and prefrontal cortex often show atrophy in depression. The cortical-thalamo-striatal network and cortical-thalamo-amygdalar network show overconnection. Within these networks there is too little projection from the amygdala to the striatum and too much projection from the amygdala to the nucleus accumbens. This single-case investigation of active stimulation of the depression network first conducted a 19-channel qEEG recording of a standardized eyes-open baseline of this human brain network and then presented to the participant a commonly depressive video recording. EEGs were then carefully artifacted and a dependent-groups *t*-test comparison of the depressive challenge minus the baseline was conducted. A comparison table of network output and three-dimensional, colored, and Brodmann-area labeled differences were then displayed showing the statistically significant brain regions activated by the depressive stimulus. Heightened activity from pre–post scan was noted in the lower right occipital lobe for this visual stimulus and in the upper left and right temporal lobes. There was a significant increase in activity during the intervention in the left temporal lobe, which could be due to depressive ruminations. There was also a decrease in activity from pre–post scan in the middle temporal lobe and the upper occipital lobe. There was also heightened activity in the left amygdala area from the pre- to postintervention scans. As reported in previous research, exaggerated amygdala activation has been noted in depression and sadness. It has also been previously established that the amygdala has a large involvement in emotional states and emotional stress. Discussion is presented highlighting the depression network brain regions activated by this acute stimulation and implications for neurofeedback treatment are offered.

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The Human Pain Network: A Neuroimaging Case Study of Acute Stimulation

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Pain is described as an unpleasant sensory and emotional experience that sends threatening signals to the brain. Pain can be separated into two categories:

- Acute: caused by noxious environmental stimuli which dissipates after a few minutes, lasting < 6 months
- Chronic: pain persisting beyond the healing process, lasting > 6 months

Pain processing and modulation begin at the nociceptors (sensory receptors for painful stimuli) and send signals throughout the peripheral (PNS) and central nervous systems (CNS). Then the brain processes the pain through various neurological areas such as the amygdala, thalamus, hippocampus, and habenula. Painful stimuli produce an increase in activity throughout the human brain

pain network. The Brodmann areas identified as most active during a pain-inducing event are the pain network, comprised of areas 1, 2, 3, 4, 5, 13, 24, 32, 33, including the periaqueductal gray (PAG), the thalamus (Th), the primary somatosensory cortex (S1), the posterior parietal cortex (PPC), the insular cortex, the amygdala (Amyg), the prefrontal cortex (PFC), the anterior cingulate cortex (ACC), and the supplementary motor area (SMA). Modulating these pain sensations are more frontal areas including the ventromedial prefrontal cortex (vmPFC), the orbitofrontal cortex (OFC), the S1, the insula, the nucleus accumbens (NAc), the dorsal prefrontal cortex (dPFC), rostral anterior cingulate cortex (rACC), the thalamus, the amygdala, the periaqueductal grey (PAG), and the rostral ventromedial medulla (RVM). Quite obviously, many brain areas are involved in the sensation, perception, and processing/modulation of pain.

This single-case investigation of acute active stimulation of the human pain network first conducted a 19-channel EEG recording of a standardized eyes-open and eyes-closed baseline and then presented to the participant a commonly used, moderately pain-inducing stimulus, the cold pressor test of the right hand submersed in a bucket of ice water. EEG activity was recorded during this pain challenge in both eyes-opened and eyes-closed conditions. EEGs were then carefully artifacted and a dependent-groups *t*-test comparison of the acute pain challenge minus each respective baseline condition was conducted, exploring primarily connectivity (coherence) measures. A comparison table of network output and three-dimensional, colored, and Brodmann-area labeled differences were then displayed showing the statistically significant brain regions activated by the pain stimulus for each condition.

Results revealed that the eyes-open intervention produced significant hypocoherence connectivity between left Brodmann areas 1 and 4, S1, and primary motor cortex, respectively. The eyes-closed intervention resulted in hypocoherence in Brodmann area 1 only. Higher cortical activity was shown in the eyes-closed intervention when compared with the eyes-open intervention. Both interventions revealed that the prefrontal cortex, amygdala, thalamus, and habenula were highly active during the experience of acute pain.

These results suggest that 19-channel swLORETA deep-brain neurotherapy targeted at reduced prefrontal cortical, amygdala, thalamic, and habenula activity could offer a reduced perception of pain, even for chronic pain conditions. Certainly, more research is indicated on a group basis, but these single-case results are suggestive of potential treatment pathways to be pursued in further group studies.

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The Effectiveness of Neurofeedback for Refugees and Asylum Seekers With Trauma Symptoms: A Pilot Study

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The primary goal of the research is to assess the effectiveness of a neurofeedback protocol for refugees and asylum seekers with trauma symptoms. A growing amount of evidence supports the effectiveness of neurofeedback in reducing mental disorder symptoms (Micoulaud-Franchi et al, 2021; Russo et al., 2022). Neurofeedback is a noninvasive treatment that instructs individuals on

ways to control their brain functions by measuring brainwaves and sending audio or video feedback (Marzbani et al., 2016). Because it does not require talk therapy, neurofeedback holds the potential to serve refugees and asylum-seeking clients despite language barriers. Improving access to evidence-based mental health care treatment is critical, particularly as 31% of refugees experience posttraumatic stress disorder (PTSD), which is significantly higher than the general population (Blackmore et al., 2020). However, the efficiency of neurofeedback in treating PTSD symptoms for refugee clients is under-researched. Askovic and colleagues (2020) published one known study on this topic; however, their study utilized an average of 27 neurofeedback sessions. Not all refugees or asylum seekers have the social capital or resources to afford those treatments or participate for this duration of treatment. Thus, evidence to support the effectiveness of affordable and brief neurofeedback treatment for refugees or asylum seekers with trauma symptoms is necessary for mental health professionals and clients to make an informed decision about the treatments.

This project serves as a pilot project to design an optimal neurofeedback protocol for refugees to alleviate trauma symptoms. We hypothesize that the trauma symptoms of refugees and asylum seekers who receive 10 neurofeedback sessions will be significantly decreased over time. We recruited 10 participants who identify themselves as refugees or asylum seekers and provided 10 neurofeedback sessions to each refugee client, primarily using the 4-channel *Z*-score Dynamix protocol. Measurement tools include the Posttraumatic Stress Disorder Checklist for DSM-5 (PCL-5) before and after their sessions each time. Results will indicate the decrease of the PCL-5 scores over time, suggesting the neurofeedback as an intervention to serve refugees and asylum-seeking clients with traumatic symptoms.

The significance of this study lies in its potential to provide evidence for the effectiveness of neurofeedback as a treatment for trauma symptoms in refugees, a group that often faces barriers to accessing traditional talk therapy due to language and cultural differences. By demonstrating the feasibility of a brief and affordable neurofeedback protocol, this research aims to inform mental health professionals and clients about viable treatment options, ultimately contributing to the advancement of mental health care for refugees. The findings from this study are expected to have implications for clinical practice and literature in neurofeedback.

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Effects of Interactive Brain Neurotherapy Based on fMRI-EEG-Neurofeedback on Structural Connectivity of Motor Cortex Networks in Stroke Patients

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Introduction. Structural connectivity is an indicator of the anatomical connectivity of brain regions and is analyzed by processing diffusion-weighted magnetic resonance imaging (DW-MRI). The method allows the visualization of the conductive pathways of white matter and investigation according to diffusion parameters. Neurofeedback (NFB) based on hemodynamic (fMRI) and EEG signals of the selected area of the of the cortex was used to assess effects of intervention in stroke.

Materials and Methods. Study recruited 14 patients (58 ± 7.5 years) with paresis in the upper extremity with less than 6 months poststroke. The patients underwent neurorehabilitation and were divided into two groups: NFB group (*N* = 7) and control (standard of care only, *N* = 7) groups. Treatment in the NFB group was complemented by six fMRI-EEG-NFB sessions. Before (T1), after the course (T2) of treatment, and 6 months later (T3), test sessions were conducted using DW-MRI. Anisotropy was analyzed in the ipsilesional and contralesional

hemispheres, and corpus callosum. The DW-MR-tractography analysis was carried out in the above areas and all pathways passing through these areas. Among the diffusion parameters there were analyzed fractional, kurtosis fractional and quantitative anisotropies; average diffusion capacity; and axial and radial diffusion coefficients. Depression of any of the anisotropy indices characterizes the processes of demyelination and loss of axons in the pathways; an increase, on the contrary, reflects tracts densification and an increase in the structural connections.

Results. All patients had changes of their structural connectivity in both hemispheres. During the pre–post period (T1-T2) in both groups the fibers of the ipsilateral tracts showed increased axial and decreased diffusion, and tended to loosen connectivity in the contralateral areas as indexed by decrease in kurtosis fractional anisotropy. The groups differed in changes in the corpus callosum connections. For the fMRI-EEG-NFB group, the fibers loosened in the projection of the premotor cortex showed increase in the radial diffusion and had consolidation in the projection of the primary motor cortex featured by decrease in the axial diffusion; whereas in the control group, there were noted the opposite effects. Six months later (T2-T3), both groups showed densification of fibers in a form of increased axial, radial, and middle diffusion coefficients, while the processes of demyelination and axon loss were still observed along the corticospinal tract in a form of decreased kurtosis anisotropy. There was a lower dynamic of axon loss ipsilaterally in the NFB group as compared to the control group. In the corpus callosum projection of the premotor cortex, the fibers showed increased fractional and quantitative anisotropies, and the same tendency was found in the projection of the primary motor cortex characterized by increased fractional anisotropy.

Conclusions. Structural changes in stroke are occurring in both hemispheres, stimulating the long-term reorganization of the pathways. Complementing neurorehabilitation with neurotherapy based on fMRI-EEG-NFB as compared to standard of care neurorehabilitation resulted in a more pronounced decrease in the dynamics of axon loss along with their densification on the lesion side and an increase in interhemispheric structural connections. Acknowledgement: Supported by RFBR grant 20-015-00385.

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Single-Case Research Design: Exploring PTSD Protocols for Neurofeedback at a University Clinic

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Neurofeedback has emerged as a promising treatment for PTSD, with its roots tracing back to Peniston and Kulkosky's pioneering study in 1991 on alpha–theta neurofeedback for Vietnam veterans. Building on this foundation, Gapen et al. conducted a pilot study in 2016, revealing encouraging outcomes for chronic PTSD patients. Subsequent research by van der Kolk et al. in the same year further validated these findings through a randomized, waitlist-controlled study, demonstrating statistically significant results. These developments signal a potential shift in both the treatment and conceptualization of mental health disorders and PTSD.

Considering the complexity of PTSD and individual experiences, we aim to explore individual participant changes within their neurofeedback session data. While traditionally employed in educational research,

the methodology of single-case research designs (SCRDs) has garnered increasing interest across various disciplines in the past decade (Ganz & Ayres, 2018). Researchers turn to SCRDs when faced with numerous intervention data points and a desire to assess individual changes. Key characteristics of SCRDs include repeated measurement of the dependent variable over time, allowing for a nuanced understanding of the impact of interventions on individuals, organizations, businesses, or other groups (Kazdin, 2021). Our research questions are:

(a) Is there a change over time in participants' mean magnitude (i.e., band 1, band 2, and band 3 in BioExplorer) of their neurofeedback session-to-session data, based on their corresponding brain wave frequencies?, and
(b) How does participants' 1st neurofeedback intervention period (Phase B) compare to their 2nd neurofeedback intervention period (Phase C)?

Phase B is participants' first university semester of neurofeedback sessions and Phase C is their second intervention period. Our data will consist of retrospective neurofeedback data collected at a university clinic by student clinicians. We will be utilizing five to six participants receiving neurofeedback for PTSD and their corresponding session data. Our analysis will consist of nonoverlap of all pairs (NAP) which is not reliant on trend lines or means (Parker & Vannest, 2009) and simulation modeling analysis (SMA), a software program that considers autocorrelation, testing slope, and line trends of the neurofeedback session data and runs 5,000 simulation tests that determine the best fit model (i.e., trend line).

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Analysis of Runner's High Through Quantitative Electroencephalography and Computer-Brain Interface

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Runners' high is a short feeling of euphoria or bliss that occurs after running or physical exercise. These effects are typically felt after at least 45 min of running; however, it is not clear if its effect is enhanced with more strenuous running or longer times. In this study, the effects of runners' high will be examined and analyzed through quantitative electroencephalography, which entails both EEG recordings and further analysis by brain-mapping software. This study is currently ongoing, and will take approximately 6 weeks, divided into nine total sessions. Participants will first be recorded by a 19-channel EEG for an eyes-open and eyes-closed baseline. During the following interventions, participants will run various, set times then be recorded by EEG for 20 min directly after their runs. Before the interventions begin, participants will be given a questionnaire to assess their running capabilities, which will be used to create a running pace that they will follow during the runs. Participants will all run at a pace that allows them to exert effort in each run, but not too much to cause excess fatigue. The route that participants will run is going to be held constant, with the only thing changing being the time that they will run for. The participants will engage in the following runs as an intervention, where they will do one of these runs per week: a 15-min run, a 45-min run, two 55-min runs, a 75-min run, a 90-min run, then a final 60-min run. As said before, runner's high only takes effect after 45 min, however the 15-min run is in place to serve as a sort of extra baseline test. The runs following the 45-min runs will be used to measure any increasing effects of runner's high based on increased effort, and the final 60-min run is in place to examine if the effects of runners high dissipate as the runner becomes more adapted to longer runs. The EEG data will then be transformed into a three-dimensional view of the brain through low resolution electromagnetic tomography (LORETA), then a post minus preintervention *t*-test will be performed to analyze the results. The results will be analyzed based on the comparison of current source

density (CSD). CSD is a method to estimate the location, intensity, and direction of brain activity and their connections, and any hypercoherence or hypocoherence will be analyzed. As runner's high is involved with feelings of sedation and anxiolysis, it is expected that the results will yield hypocoherence, specifically in areas such as the prefrontal cortex, the amygdala, thalamus, hippocampus, supplementary motor area, premotor area, primary motor cortex, the cerebellum, the ventral tegmental area, and the striatum.

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ISF Neurofeedback as an Adjuvant Treatment for Adults With Generalized Anxiety Disorders: A Randomized Controlled Pilot Study

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Anxiety disorders are among the most prevalent neuropsychiatric disorders in the world. Within that category, generalized anxiety disorder (GAD) is one of the most common disorders having a more significant functional impact (Giacobe & Flint, 2018). GAD is a disorder characterized by its chronicity, exacerbated anxiety, and a difficulty to regulating it underlying a feeling of uneasiness which impairs the health and quality of life of those suffering this condition (APA, 2013). A better understanding of the neurophysiological processes associated with anxiety has raised an increased interest for interventions that influence the brain's electrical regulation. Neurofeedback (NFB), a therapeutic intervention that involves a brain computer interface allowing to monitor and modulate real-time electroencephalographic (EEG) parameters is a method that has shown promising evidence in the treatment of diverse mood disorders (Abdian et al., 2021; Batail et al., 2019; Chen & Lin, 2020; Ribas et al., 2018). Recently, NFB prospective studies have also explored the regulation of the infra-slow brain's electrical signals (below 0.1 Hz). Previous studies have shown a regulation of autonomic nervous system (ANS) physiological measures suggesting that ISF NFB may influence brain networks involved with the ANS balance (Bekker et al., 2021; Leong et al., 2018; Perez et al., 2022). However, research on infra-slow fluctuations (ISF) NFB is still limited, and additional evidence is needed. The goal of the present study was to assess the adjuvant benefit of ISF NFB compared to group-based mindfulness for GAD in adults. The study was carried out with 22 participants and the groups were randomly assigned. Therefore, the experimental group received ISF NFB plus mindfulness-based stress reduction (MBSR), whereas the control group received MBRS alone. GAD-7, a validated scale to assess the severity of GAD symptoms and qEEG, the quantitative and normative analysis of the EEG were administered before and after the treatment. Our results indicate that neurofeedback with MBRS has a statistically significant greater effect on the reduction of GAD symptomatology in adults compared with MBRS alone. Psychophysiological findings are still being analyzed.

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Can Machine Intelligence Automation Assist in the Inspection of Clinical EEGs?

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We are teaching the computer how to “look at” an EEG and compare it with a large sample of others, to see how it compares. It is not “normative” in that it is compared with clinical samples, not “normals.” The purpose of our system is to prescreen EEGs that have not yet been inspected or artifacted, to determine how well they fit into a “typical” type of recording. This report can provide a heads-up of what to look for when proceeding to look at the EEG for purposes of clinical referral or to prepare the recording for qEEG analysis. This is therefore, a “pre-Q” or even a “pre-pre-Q.”

It gives you a heads-up of what the EEG is like, if you had looked at hundreds of them and knew what to look for, including having seen plenty of abnormal EEGs. You would do this before a qEEG analysis, to have an idea of what you might see. And, yes, it uses independent components analysis (ICA) to remove eye artifact, and it uses methods that are human-instructed (by our team) machine learning, not entirely artificial intelligence, to know what to do. This is not AI.

AI consists of methods where a computer attempts to learn to classify and respond to different information, by being presented with a vast amount of material, which it sorts through, and creates rules and so on. It may be guided or unguided, and can achieve remarkable capabilities (see, for example, the Score system1 which accurately detects and described important EEG features from preinspected EEG recordings). This is not qEEG.

QEEG consists of processing EEG recordings to produce metrics useful in the interpretation of the frequencies and connectivity revealed in the EEG. QEEG requires that recordings be carefully inspected and artifacted, and that the age be noted when submitting the data to analysis. This is machine intelligence.

We equip the computer with a program that is designed to use digital signal processing in order to simulate what a doctor does when they do a visual inspection of an EEG. We pick the rules and do not allow the machine to make decisions about which metrics or derived computations are used. We define a set of reasonably informed metrics motivated by the concepts of the posterior dominant rhythms, amplitude foci and magnitudes, time course of various metrics, and so on. We then present the program with a number of EEGs (currently in the hundreds) and allow it to compute the population statistics of the input samples. In this regard it is similar to qEEG.

We do not select EEGs other than the fact that they were submitted and reported on by a board-certified clinical neurophysiologist/qEEG diplomate, in consultation with one or two board-certified qEEG diplomates. The purpose of the doctor’s report is to comment on the quality of the EEG submitted and make any relevant clinical observations regarding severe abnormalities or EEG quality problems.

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Resting-State Electroencephalography Complexity is Associated With Oral Ketamine Treatment Response: A Bayesian Analysis of Lempel-Ziv Complexity and Multiscale Entropy

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Subanesthetic doses of ketamine are a promising novel treatment for reducing symptoms of suicidality (Can et al., 2021; Ionescu et al., 2019; McIntyre et al., 2020); however, the evidence for prognostic biomarkers is sparse. Recently, measures of complexity, including Lempel-Ziv Complexity (LZC) and multiscale entropy (MSE), have been implicated in ketamine's therapeutic action (Murphy et al., 2023; Schartner et al., 2017). Moreover, these nonlinear indices of brain dynamics are associated with treatment response to both antidepressants and transcranial magnetic stimulation (Jaworska et al. 2017; Lebiecka et al., 2018; Méndez et al., 2012). We evaluated electroencephalogram (EEG)-derived LZC and MSE differences between responders and nonresponders to oral ketamine treatment (Can et al., 2021), hypothesizing that treatment responders would have higher neural complexity at baseline compared to nonresponders and that this would be attenuated posttreatment. Additionally, we predicted elevated complexity in the eyes open compared to the eyes-open condition, as observed in previous studies (Lord & Allen, 2023; Yang et al., 2023). Thirty-one participants (mean age = 45.64, *SD* = 13.95; 54% female) received six single, weekly (titrated) doses of oral racemic ketamine (0.5–3 mg/kg) and underwent EEG scans at baseline (week 0), posttreatment (week 6), and follow up (week 10). Resting-state (eyes closed and open) recordings were processed in EEGLAB, and complexity metrics were extracted using the Neurokit2 package. Participants were designated responders or nonresponders by clinical response (Beck suicide scale [BSS] score reduction of ≥ 50% from baseline to the respective timepoint or score ≤ 6) and then compared in terms of complexity across task types and time. Employing a Bayesian mixed effects model with timepoint, task, and response status as fixed effects and by-participant random effects (random intercepts and slopes). As hypothesized, there was evidence for a main effect of task for LZC, with higher eyes-open compared to eyes-closed values across timepoints and response status. Similarly, higher MSE values were observed in the eyes-open condition for scales 1–4, with the opposite observed from scales 6–10. Averaged over channels (global level), responders displayed elevated eyes-open baseline complexity (LZC and MSE scales 1–4) compared to nonresponders, with these values decreased at posttreatment (6 weeks) and follow-up (10 weeks) in responders only. Exploratory Bayesian analyses revealed the elevated baseline eyes-open LZC in oral ketamine responders was not reflective of a global increase in entropy, rather it was spatially localized to the left frontal lobe (electrodes F1, AF3, FC1, and F3). This is the first evidence showing EEG-complexity metrics may be sensitive biomarkers for evaluating and predicting oral-ketamine treatment response and highlights the left prefrontal cortex as a key region implicated in response among individuals living with chronic suicidality and depression.

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Cognitive and Behavioral Traits Enhancement in AD Patients: A Substantial Impact of Binaural Beats Stimulation on Theta and Alpha Bands

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Alzheimer's disease (AD), a common neurological ailment, is characterized by a gradual decline of mental acuity resulting in dementia and adverse impact on an individual's behavioral performance, making AD patients incapable of performing normal daily tasks and activities independently. Currently, AD has afflicted about 50 million individuals worldwide. This research explored binaural beat stimulation's (BBS) potential for facilitating and enhancing AD patients' behavioral and neurological aspects, which were validated through analysis of brain's functional connections. There were 25 AD patients, who volunteered to participate in this study and receive 12 days of stimulation. These patients were divided into those who received BBS and others who received standard auditory stimulation (SAS). This study involved the employment of blessed dementia scale, Mini-Mental State Examination, and depression anxiety stress scale for a comprehensive behavioral analysis. The neural data was acquired through EEG. The neurological analysis was conducted by means of determining imaginary coherence, functional connectivity, and graph theory. The paired *t*-tests ($p < .05$) compared both groups' pre- and posttreatment outcomes. Findings of this study revealed that significantly improved ($p < .05$) results in the BBS group were observed for all behavioral scales. Coincidentally, functional connectivity results exhibited striking changes in AD post-ICH in the theta, alpha, and gamma bands. Specifically, in the theta band there was considerable increase in strong inter- and intraregional connectivity with occipital, parietal, and temporal brain regions being dominant, indicating a strong positive effect of BB on AD patients' working memory. Concurrently, the neurological analysis through graph theory also indicated a significant increase in cluster coefficient along with local efficiency in the theta and alpha band. These above-mentioned results of BBS group signify the efficacy of BB stimulation as a nonpharmacological intervention for the neurocognitive enhancement of individuals afflicted with AD, contributing to improvement in such patients' overall health.

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Addiction and Identity: Personality Insights and Experience Cultivate Difficult Perceptual Mechanisms in Populations of Inmates With Substance Abuse Problems

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Introduction. Understanding the intricate relationship between self-perception and experience, as underscored by Freud's psychoanalytic theory and Skinner's behaviorism, is crucial in exploring how adverse childhood experiences profoundly influence the development of substance use disorders (SUD) and associated psychopathology as well as their patterns in the

human brain (Barch et al., 2018; Cannon et al., 2008; Hawes & Allen, 2023; Lensch et al., 2021; Paulino et al., 2024).

Methods. This observational data consists of 111 individuals (40 female) with mean age 37.26, *SD* = 9.47. Participants completed initial screening and informed consent prior to neurofeedback training. Participants completed the self-perception and experiential schemata assessment (SPESA) and the personality assessment inventory (PAI; Morey, Lutz, FL) prior to LORETA neurofeedback procedures.

Results. Significant inverse correlations were found on most scales of the PAI with the total score on the SPESA. The results suggest an important relationship between negative experiences and experiences of psychopathology. Certain patterns of experience are present in this population with 64.5% reporting at least one prior treatment for SUD; 39.6% report a prior psychiatric diagnosis in childhood; 58.6% report violence was common in the home; 77.5% report alcohol and drugs were used in the home and 59.5% report abuse in the developmental periods. Linear regression results show the SPESA total score shows a predictive relationship: R^2 = .64, adjusted R^2 = .50, $F(31, 79)$ = 4.57, p = .000. The scales on the PAI identifying affective components of anxiety, traumatic stress, phobias, negative relationships, and antisocial behavior patterns were significant.

Discussion. The basic neural mechanisms of patterning behaviors and perceptions of past experiences and their influences on social, executive, and emotional processes are paramount when working with clients in any population. Additionally, the neural mechanisms of self-regulation are poorly understood; however, neurofeedback and neuromodulation data contribute to our understanding of these mechanisms and the potential to influence learning using neurofeedback or neuromodulation procedures (Downar et al., 2024; Fielenbach et al., 2017; Gabrielsen et al., 2022; Holland & Holbert, 2022). The data obtained in this study demonstrate significant correlations between the self, its experiences, and perceptions with psychological experiences in a heterogeneous population of inmates with substance use disorders. The importance of influencing currents and activity within the brain may represent the best potential toward integrative functioning relative to operant efficiency and improved self-regulatory mechanisms.

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ERP Neuromarkers of PTSD Associated With Hawaii Red Hill Toxic Jet Fuel Exposure

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The jet fuel leak from the Hawaii Red Hill Underground Fuel Storage Facility began in November 2021 and created an ongoing public health crisis impacting hundreds of thousands of O'ahu residents. The health effects of jet fuel exposure have been shown to impact many aspects of human physiology including immune, gastrointestinal, cardiovascular, integumentary, and nervous systems. Scalp resting-state electroencephalogram (rsEEG) and event-related

potentials (ERPs) have been shown to be useful in the assessment of brain functioning in the context of toxic encephalopathy, epilepsy, anxiety, depression, OCD, ADD/ADHD, and posttraumatic stress disorder (PTSD). In this case series, rsEEG and ERP data of 31 subjects with self-reported cognitive and/or neurological changes following HRH were analyzed. Subjects completed at least 10 min of eyes open, 10 min of eyes closed, and 22 min of task EEG recording using a standardized cued Go-NoGo visual continuous performance task (VCPT) from the HBImed methodology for calculation of ERPs. Slowed alpha, unstable vigilance, focal and generalized slowing, and excessive beta activity were noted in the rsEEG across various symptom presentations. ERP group analysis of a subset of subjects (N = 18) constrained by age (18–50 years) showed two statistically significant (p < .01) differences when compared to a database of healthy controls (N = 200). The action suppression ERP component is generated in the supplementary motor cortex to inhibit a prepared action and was reduced in amplitude in the study group. The visual P1/N1/P2 ERP component complex is generated in the primary and secondary visual areas and reflects the process of visual object categorization and is modulated by the activation of the amygdala via the thalamus. This component was reduced in latency and increased in amplitude in the study group. Group comparisons were conducted by joint diagonalization of covariance matrices. These findings are consistent with the diagnosis of PTSD. Limitations of this study including subject sample bias are discussed. Possible reasons for PTSD diagnosis are discussed, including lack of medical care access, institutional disregard, displacement, loss of life, denial of care, and fear of retaliation.

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QEEG-Guided sLORETA Neurofeedback Effects on Event-Related Potentials and Cognitive Performance in a 7-Year-Old Moderate Concussion Patient: A Case Study

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A concussion can induce brain electrical activity alterations, detectable as anomalies on an electroencephalogram (EEG). These alterations typically signify disruptions in the brain's normal communication pathways, impacting various cognitive functions. Consequently, individuals may experience impairments in attention, memory, and executive functions. Additionally, behavioral manifestations of concussions often include increased irritability, fatigue, and difficulties in academic or social interactions.

The use of standardized low-resolution electromagnetic tomography analysis z-score neurofeedback (sLZNFB) represents a promising approach for targeting network disruptions in deep cortical regions. This study aimed to investigate the effects of sLZNFB on brain electrophysiology and cognitive performance in a 7-year-old girl who suffered from a moderate Grade II concussion while riding her bicycle without a helmet at the age of 6. The patient exhibited deficits in attention, processing speed, and memory.

The study used a pre-experimental design with pre–post comparison. To this end, LZNFB was applied to affected brain areas for 20 sessions. Baseline and posttreatment measurements were made on qEEG metrics, whole-brain event-related potentials (oddball and visual paradigms), attention, memory, executive function, reaction time, and cognitive flexibility. Clinical improvements were found in variables related to processing speed after 16 sessions of sLZNFB on computerized tasks. Significant changes in the eyes-closed resting-state z-score maps were found in lateral/central Delta frequency and connectivity variables in all frequencies in the eye-closed condition. An

increased inhibition of the Alpha Mu rhythm in the eyes-open condition was also observed. Event-related potentials on oddball auditory and visual tasks showed greater organization, significant changes in early components (N1 and N2), and less P300 latency. In addition, parents reported significant improvements in mood and reading throughout the sessions.

These findings suggest the potential effectiveness of LZNFB on cognitive performance improvement among pediatric concussion patients. Further studies with a larger number of patients and control groups may be required to evaluate the full potential of this type of training in concussion patients.

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