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QEEG-GUIDED CLINICAL NEUROFEEDBACK: BOTTOM-UP APPROACH PROTOCOLS FOR BRAIN FOG SYMPTOMS

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Abstract:

This case report details the procedures for a client with brain fog symptoms using quantitative electroencephalograph (qEEG)-guided neurofeedback to alleviate or improve functionality. Based on the qEEG brain mapping assessment of the client, four different sets of clinical neurofeedback training protocols were designed and implemented in order to alleviate brain fog symptoms and improve his self-regulation skills in dealing with past trauma. Several measurements were administered pre- and posttraining as indicators of treatment outcome. These included pre- and post-qEEG brain mapping, Patient Health Questionnaire-9 (PHQ-9), General Anxiety Disorder-7 (GAD-7), and Cognitive Disturbance Scale (CDS) to determine the effectiveness of the interventions for the client. There was significant changes reported on the targeted bandwidth brainwaves after the clinical neurofeedback sessions. As a result, the clinical intervention of qEEG-guided neurofeedback was found to be effective for the client with brain fog symptoms in reducing the cognitive impairment.

Keywords:

Bottom-Up Approach, Brain Mapping Assessment, Brain Fog Symptoms, Qeeg-Guided Neurofeedback, Trauma

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Introduction

Traumatic stress, such as adverse childhood experiences (ACEs) can have lasting impacts on cognitive functioning and overall mental health (Karam et al., 2019; Westby, 2020). Individuals who have experienced chronic trauma or prolonged exposure to stress often report a higher prevalence of brain fog. Brain fog symptoms are subjective cognitive difficulties that affect daily functioning such as forgetfulness, difficulty in thinking or focusing, finding the right words, and mental confusion (Makhina, 2018). Repeated trauma and stress can narrow an individual's window of tolerance, thereby shrinking their capacity to manage stress leading to cognitive impairments. It could be potentially resulting from dissociative defense mechanisms triggered by ongoing trauma (International Society for the Study of Trauma and Dissociation, 2021). Hence, pertaining to the bottom-up somatic approach in Trauma Resiliency Model, the treatment prioritizes addressing emotional and survival-related brain regions with the aim of alleviating dissociative symptoms and improving brain fog symptoms. Clinical neurofeedback is a psychophysiological intervention that regulates brainwave activities to reinforce healthy brain function. This case report used four different sets of simultaneous neurofeedback training protocols to alleviate brain fog symptoms. This case report aims to study the effectiveness of bottom-up neurofeedback training protocol in alleviating brain fog symptoms.

Literature Review

Simultaneous neurofeedback training is the approach used in this case report, which involved designing four distinct neurofeedback training protocols. The first protocol focused on increasing alpha-theta brainwaves in the right temporal (T4) and parietal lobes (P4) with eyes-closed training. This type of training has been shown to reduce stress levels (Gruzelier, 2009), treat anxiety and depressive symptoms by rewarding alpha brainwaves (Green & Green, 1977). Enhancing alpha-theta brainwaves in these regions can help clients feel more relaxed and less emotionally triggered (Marzbani et al., 2016). Specifically, training the right parietal lobe is beneficial for depressive and anxiety symptoms (Li et al., 2018)., and right temporal lobe can help reduce the tendency to re-experience traumatic memories (Sherin & Nemeroff, 2011).

The second protocol focused on increasing SMR waves in Cz and Oz sites with eyes-open training. According to polyvagal theory (Porges, 1995), the neuroception process involves detecting cues of safety or danger, which helps in orienting and taking appropriate action. The Cz site corresponds to the postcentral gyrus and posterior cingulate gyrus, where high alpha brainwave levels can indicate emotional pain and numbness (Bester, 2020). The occipital lobe (Oz) can become hypersensitive to negative stimuli, leading to fatigue, stress, and anxiety (Novembre et al., 2019). Therefore, SMR-enhancement training on Cz and Oz sites aims to reduce these negative symptoms and improve cognitive functions such as information processing and memory.

The third protocol targeted the right frontal lobe (F8) and temporal lobe (T4) to increase SMR brainwaves with eyes-open training. SMR enhancement has shown benefits in mood regulation, helping to reduce fear associated with past experiences (Gruzelier, 2014). The right frontal lobe plays a crucial role in emotional regulation and higher-order cognitive functions (Firat, 2019; McRae et al., 2012), while the right temporal lobe is associated with emotional and memory processes linked to trauma (Jo et al., 2019). This training aims to improve calmness and reduce performance anxiety by enhancing SMR brainwaves.

The fourth protocol involved increasing beta waves at F7 and SMR waves at F8 with eyes-open training. The left frontal region (F7) is crucial for inhibiting irrelevant information from

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short-term memory, with hyperactivity in this region being linked to rumination and depressive symptoms (McCurry et al., 2020; Galecki & Talarowska, 2017). Enhancing beta waves at F7 aims to reduce these negative thought patterns and improve cognitive functions. The right frontal region (F8) showed hypoactivity due to slow brainwaves (delta), affecting the ability to inhibit inappropriate responses (Penfold et al., 2015). Enhancing SMR waves at F8 aims to improve emotional regulation and reduce anxiety triggered by past traumas.

Overall, these protocols are designed to address various cognitive and emotional challenges associated with trauma, leveraging neurofeedback to enhance brain function and reduce symptoms of brain fog. The linkage among these protocols lies in their combined aim to stabilize the client's arousal level and emotions before gradually moving towards enhancing cognitive functions, consistent with the bottom-up approach in trauma treatment.

Methods

The qEEG Brain Mapping Assessment involves the use of technology in the functional neuroimaging field that used to detect and analyze brainwave activities (Marzbani et al., 2016). The qEEG brain mapping assessment is a reliable and valid method used in assessing various psychological disorders (Hannesdóttir et al., 2010; Linardakis & Pardell, 2018). The case report used TQ7 Trainer's qEEG to conduct the brain mapping assessment, and a protocol of six categories (i.e., disconnected, hot temporal lobes, reversals, blocking, locking, filtering and processing) was utilized in the assessment. TQ7 Trainer's qEEG system-based neurofeedback training was found to be beneficial in improving attention levels in individuals with depressive issues (Ribas et al., 2017). The qEEG brain mapping assessment was used in pre-intervention to design customized protocols for T, and also used in post-intervention to track his progress.

Three questionnaires were administered to T at three intervals during the course of treatment to track his progress. The Patient Health Questionnaire (PHQ-9) was used to assess T's progress on depressive symptoms (Kroenke et al., 2001)., while the Generalized Anxiety Disorder Scale (GAD-7) was used to assess his anxiety state over the past two weeks (Spitzer et al., 2006). The Cognitive Disturbance Scale was used to describe symptoms of brain fog (Ross et al., 2013). The questionnaires contained several items that were scored on a Likert scale and were used to calculate total scores. Higher scores on the PHQ-9 and GAD-7 indicated the severity of depressive or anxiety symptoms, respectively. The Cognitive Disturbance Scale examined the severity and frequency of brain fog symptoms.

Intervention

The qEEG-Guided Neurofeedback

In this case report, qEEG-guided neurofeedback was utilized to address T's brain fog symptoms. The clinical neurofeedback training was designed based on the qEEG brain mapping assessment and conducted using the Spectrum Brain Trainer machine. This machine allows for unipolar, bipolar, or simultaneous mode training and measures brainwaves from delta to hi-beta frequency range. The Fast Fourier Transform (FFT) algorithm in the machine converts the recorded brainwave reading from time domain to frequency domain and back to time domain, providing real-time qEEG readings. During the training sessions, brainwave activities were monitored on a laptop screen connected to the machine, and the practitioner adjusted the threshold of brainwaves based on real-time feedback

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Figure 1 displays the results of T's qEEG brain mapping assessment prior to clinical neurofeedback. The brainwaves have been categorized according to their frequency range: delta (1–4 Hz), theta (4–8 Hz), alpha (8–13 Hz), sensorimotor rhythm (SMR, 13–15 Hz), beta (15–20 Hz), hi-beta (20–32 Hz), and gamma (32 Hz and above). The dominance of hi-beta brainwaves was observed in the right temporal and parietal lobes (i.e., T4 and P4), indicating trauma-related emotional arousal. Left frontal region (i.e., F7) also showed hyper-aroused hi-beta brainwave activity, possibly associated with higher cognitive demands. Right frontal region (i.e., F8) exhibited hypo-activation with dominance of delta brainwaves, potentially interfering with response inhibitory function that might impact on one's performance. Cingulate gyrus (i.e., Cz) and occipital lobe associated regions (i.e., Oz) were dominated by slow alpha brainwaves, indicating poor alpha-blocking and contributing to brain fog symptoms. Hence, one of the clinical neurofeedback training protocols were designed to reduce alpha brainwaves to deal with brain fog symptoms.

The qEEG-Guided Neurofeedback Training Protocols

A simul-training with active electrodes and auricular references was pasted using international 10-20 system. The reason for using this montage is based on the tradition in the field of neurofeedback for reducing anxiety symptoms (Dias & van Deusen, 2011). Four training protocols were implemented according to the bottom-up philosophy in stabilizing the arousal level and emotions before improving cognitive functions. Hence, the initial phase addressed brain stem and limbic system related areas (i.e., T4, P4, Cz, Oz), followed by cognition-related areas (i.e., F7 and F8).

Rewarding Alpha-Theta Brainwaves at T4 and P4 with Eyes-Closed State

Alpha-theta training was implemented to increase alpha and theta brainwaves in order to reduce stress and induce relaxation in T. Previous research showed that rewarding alpha brainwaves could alleviate anxiety and depressive symptoms (Green & Green, 1977). Training on the right parietal lobe (P4) in the eyes-closed state provided a healing process for T by increasing alpha-theta brainwaves, leading to relaxation and reduced processing of unnecessary emotion-triggering information (Marzbani et al., 2016). Training on the right temporal lobe (T4) aimed to reduce re-experiencing traumatic memories and hypervigilance state associated with high neural activity in this region (Sherin & Nemeroff, 2011), which further improve calmness and tolerance towards fear and stress arousal.

Rewarding SMR Brainwave at Cz and Oz with Eyes-Open State

Polyvagal theory (Porges, 1995) suggests that neuroception serves survival by activating adaptive behavior through listening, safety cues, and detecting danger. Vogt (2005) proposed pain sensations and negative emotions are processed in each subregion of the cingulate gyrus. Cz was postulated to be the scalp position to train the postcentral gyrus and posterior cingulate gyrus (Bester, 2020). T's qEEG brain mapping assessment showed high alpha brainwaves in the Cz site, causing T to shut down in response to emotional pain. The occipital lobe (Oz) processes visual information and can provoke negative feelings when exposed to uncomfortable stimuli. This activates a defense mechanism to prevent triggers (Porges, 1995), resulting in dominant alpha brainwaves that could indicate hypersensitivity in T's Oz site. To address this, SMR-enhancement training on Cz and Oz locations was conducted in eyes-open training to decrease numbness and sensitivity, as well as to and improve processing, memory, motivation, and energy.

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Rewarding SMR and Alpha Brainwaves at F8 and T4 with Eyes-Open State

Training of the right side of the frontal lobe (F8) and temporal lobe (T4) was conducted by increasing SMR brainwave through eyes-open training to improve T's calmness and reduce performance anxiety. SMR enhancement has been shown to impact mood and reduce fear feelings that is associated with unpleasant experiences (Gruzelier, 2014). Activation of the right frontal lobe is crucial for emotional regulation, improving T's ability to manage emotions in triggering situations. Meanwhile, the frontal lobe has always been granted to be the most prominent brain region that is responsible for higher-order cognitive functions (Firat, 2019), so increasing the activation level of F8 enhances T's ability to process emotions and prioritize essential information.

The right temporal lobe also has been integrated in the current training protocol to reduce T's traumatic-based fear by decreasing hi-beta brainwave dominance. The right temporal lobe is integrated into the training protocol due to its connections with the limbic system, involved in emotion and memory processes (Jo et al., 2019). Hyperactivation of this region may reflect traumatic impacts of unpleasant memories (Heitmann et al., 2017; Shin & Liberzon, 2010). T's adverse experience of condemnation from parents during his developmental process resulted in being a perfectionist, making him vulnerable to experience anxiety. This was in line with the finding of Flett et al. (2004), in which perfectionistic individuals are more vulnerable to anxiety due to automatic negative self-talk about task demands. Therefore, the calming protocol was designed to improve T's ability to manage emotions and prioritize essential information when emotionally triggered.

Rewarding Beta Brainwave at F7 and SMR Brainwave at F8 with Eyes-Open State

The left frontal region (i.e., F7) of T exhibited hyper-aroused brainwave pattern due to hi-beta dominance, inhibiting irrelevant or negative information from short-term memory and memory retrieval. Based on past studies, a great activation in this region indicated suppression of emotions, highly associated with re-experience (McCurry et al., 2020) and rumination (Wang et al., 2019). Rumination is a common and stable coping style in response to depressive symptoms, but evidence suggests it exacerbates depressive symptoms and affects cognitive functions negatively, which may contribute to the manifestation of brain fog symptoms.

T's right frontal region (i.e., F8) demonstrated hypoactive brainwave pattern due to the dominance of the delta brainwave. With a central role in inhibiting inappropriate responses, past research demonstrated that low activation in this region may experience difficulty in inhibiting their responses under normal circumstances (Penfold et al., 2015). As a result, T experienced intense anxiety when expressing his opinion to an authoritative figure, due to past traumatic experiences and fear of criticism.

Results

Figure 2 displays T's qEEG brain mapping assessment after 60 neurofeedback sessions. The dominance of hi-beta brainwave decreased at emotion-associated regions (i.e., T4 and P4) under the eyes-closed state, with a reduction in relative percentage (T4: 11.6% to 9.2% ; P4: 6.8% to 5.8%) and amplitude (T4: 5.5μV to 3.9μV; P4: 5.1μV to 4.1μV). Similar changes were observed in the left frontal region (i.e., F7) under eyes open state, with a reduction in relative percentage (F7: 11.2% to 8.9%) and amplitude (F7: 4.3μV to 3.9μV). Improvements in these regions were linked to T's general calmness and rumination tendencies.

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Meanwhile, the slow-brainwave dominant pattern was reduced at the right frontal region (i.e., F8) across all three states of awareness. These changes can be observed from relative percentage (Eyes-closed: 22.3% to 11.0%; Eyes-open: 26.7% to 8.8%; On-task: 24.5% to 14.9%) and amplitude (Eyes-closed: 14µV to 5.5µV; Eyes-open: 14.5µV to 3.4µV ; On-task: 13.2µV to 6.7µV).

The dominance of idling brainwave (i.e., alpha brainwave) at the cingulate gyrus associated areas (i.e., Cz) was reduced particularly on the on-task state as observed from the relative percentage (Cz: 38.5% to 38.4%). At the same time, similar changes were also observed in the at the visual cortex associated region (i.e., Oz) under the on-task, with a reduction in relative percentage (Oz: 43.2% to 42.2%) and amplitude (Oz: 30.6µV to 23.2µV). The decrement of slow brainwaves (i.e., delta and alpha brainwaves) improved T's cognitive capability and reduced brain fog symptoms. Table 1 demonstrates the changes in relative percentage and amplitude of brainwave activities.

Apart from that, T's psychological well-being has shown significant improvement as demonstrated in Tables 2 and 3. The PHQ-9 and GAD-7 scores decreased throughout the intervention, while the Cognitive Disturbance Scale rating was reduced, significantly on the symptoms of annoying and cloudy.

Discussion

After 60 sessions of qEEG-guided neurofeedback training, there is an increased of alpha-theta brainwaves in the right parietal lobe (i.e., P4) and right temporal lobe (i.e., T4) under eyes-closed training, Due to high association with trauma-related experiences (Sherin & Nemeroff, 2011), right temporal lobe (i.e., T4) was trained under the same protocol with the aim to reduce stress effects and promote calmness. The training on the right parietal lobe (i.e., P4) aimed to promote healing process for T to feel relax and reduces emotional triggers (Marzbani et al., 2016), while the training on the right temporal lobe (i.e., T4) also designed to enhance calmness and tolerance towards traumatic-associated fear, resulting in reduced hypervigilance, improved stress tolerance, and sleep quality. As a results, T's emotional steadiness and calmness improved, leading to increased adaptation and efficiency during neurofeedback training.

The present study revealed that the reduction of alpha brainwaves in the cingulate gyrus associated region (i.e., Cz) and occipital lobe (i.e., Oz) reduced T's emotional pain and sensitivity to negative visual stimuli. Previous research highlighted that SMR enhancement training has an impact on mood and reduces fear associated with past unpleasant experiences (Gruzelier, 2014), allowing T to regulate emotions and engage effectively in daily routines without perceiving trauma-related cues as a threat. Moreover, the reduction in alpha brainwave dominance in both regions reduced T's brain fog symptoms and improved information processing, memory, motivation, and energy level.

Besides, the present study demonstrated that rewarding SMR brainwave at F8 and T4 with eyes-open training promoted the feeling of calmness and reduced performance anxiety. This training protocol increased the amplitude of SMR brainwave to retain the crucial activation level for T in terms of emotional and information processing, particularly by targeting the right frontal lobe (i.e., F8), which plays a vital role in emotion regulation and is recognized as the prominent brain region that serves for higher-order cognitive functions (Firat, 2019). The right temporal region (i.e., T4) was trained due to the aforementioned high association with traumatic-related experiences (Sherin & Nemeroff, 2011). The reduction of fast brainwaves

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(i.e, hi-beta brainwaves) and increased of SMR brainwaves would help to decrease performance anxiety associated with past traumatic experiences. Thus, T was able to manage and regulate his own emotions, focus on essential information, and improve his working performance.

Furthermore, the present study showed that rewarding beta brainwave at F7 and SMR brainwave at F8 in eyes-opened training improved T's coping skills and emotional regulation towards negative events and emotions. This was achieved by decreasing the hyperactivation of left frontal lobe's fast brainwaves (hi-beta brainwave) while maintaining its crucial activation level for higher-order cognitive functions, as the dominance of fast brainwaves in the left frontal lobe is highly associated with rumination (Kocsel et al., 2017). On account of this, T showed improvements in problem-solving skills, motivation, concentration, and memory retrieval, validated by the reduction of fast and slow brainwaves in F7 and F8 regions respectively.

Conclusion

In this report, the qEEG-guided clinical neurofeedback training protocols were effective in improving T's cognitive functions while preventing overarousal state. However, this study's results cannot be generalized to similar populations, and further research with larger sample size is needed to confirm the effectiveness of these bottom-up designed clinical neurofeedback training protocols in trauma-related cognitive care.

Acknowledgement

We would like to acknowledge deepest gratitude to all of the peers and colleagues for their encouragement, insightful discussions, and constructive feedback, which significantly contributed to the development of this work. We would also like to express my appreciation to the participant for their valuable contribution to this research, as well as to those who provided assistance and shared their knowledge, thereby enriching this study.

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Table 1: Changes on the Brainwaves

Brain Sites	Targeted Brainwave Bandwidth	State of Awareness	Changes on Relative Percentage (%)		Changes on Amplitude (μV)	
			Pre	Post	Pre	Post
T4	Hi-beta	Eyes-closed	11.6	9.2	5.5	3.9
P4	Hi-beta	Eyes-closed	6.8	5.1	5.8	4.6
F7	Hi-beta	Eyes open	11.2	8.9	4.3	3.9
F8	Delta	Eyes-closed	22.3	11.0	14	5.5
		Eyes open	26.7	8.8	14.5	3.4
		On Task	24.5	14.9	13.2	6.7
Cz	Alpha	On Task	38.5	38.4	25.7	26.2
Oz	Alpha	Eyes open	43.2	42.2	30.6	23.2

Table 2: Scoring for Patient Health Questionnaire (PHQ-9) and Generalized Anxiety Disorder Scale (GAD-7)

	Before Intervention	During Intervention	After Intervention
Patient Health Questionnaire (PHQ-9)	7	8	4
Generalized Anxiety Disorder Scale (GAD-7)	7	7	2

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Table 3 Cognitive Disturbance Scale

	Self-rating on the severity of brain fog symptoms		
	Before Intervention	During Intervention	After Intervention
Confusion	70	15	0
Easily distracted	0	15	0
Forgetful	70	15	0
Annoying	100	0	0
Exhausted	70	15	0
Slow	70	15	0
Cloudy	100	15	0
Spacey	80	15	0
Lost	70	15	0
Detached	70	15	0
Thoughts shifted quickly	50	15	0
Mind went blank	80	25	0
Mental fatigue	70	25	0
Difficulty focusing	80	25	0
Difficulty thinking	90	30	0
Difficulty finding right words	90	25	0
Difficulty processing what others say	60	25	0
Difficulty processing words read	50	25	0
Difficulty finding your way	40	15	0
Trouble driving	0	15	0

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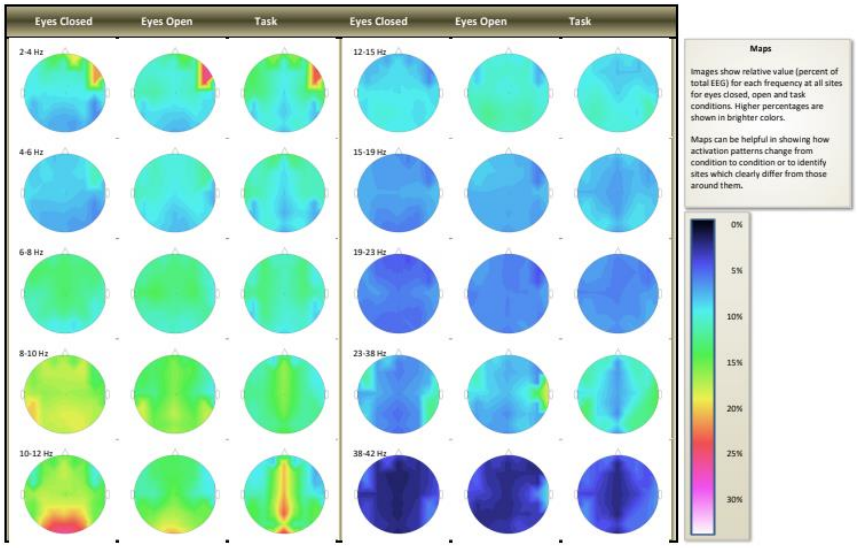

Figure 1: Result of Preintervention qEEG Brain Mapping Assessment of T

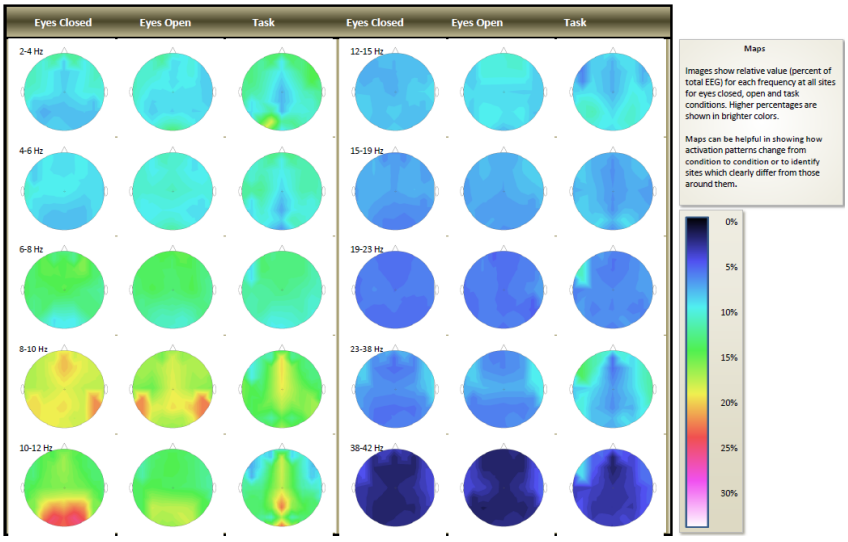

Figure 2: Result of Postintervention qEEG Brain Mapping Assessment of T

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Appendix

INFORMED CONSENT

Informed Consent to Participate in a Case Report Study

New Mind Brain Health Centre

Case Report Issue: Brain Fog Symptoms

Name of Principal Investigator: Hiro Koo Kian Yong, Loh Jun Ming, Lee Jia Wen, Gan Chi Kien

Phone Number of Principal Investigator: +6016-7154419

A. INFORMATION ABOUT THIS STUDY

PURPOSE AND BACKGROUND

Loh Jun Ming, Lee Jia Wen and Gan Chi Kien, the brain health specialists in New Mind Brain Health Centre, are conducting a case report study under the supervision of *Hiro Koo Kian Yong*. The purpose of the project is *to study how qEEG-guided clinical neurofeedback training help in alleviating the brain fog symptoms* as well as *to study how the application of cognitive behavioural hypnotherapy help in resolving the traumatic experiences that associated with the brain fog symptoms*.

PROCEDURES

The following will occur if you participate in this study:

- You will be asked your background information (i.e., age, gender, educational background, health conditions etc).
- You will be asked to explain the brain fog symptoms that you have experienced prior to the interventions and how did the symptoms affect your life.
- You will be asked to provide feedbacks and explain about the changes (if any) that you have experienced throughout and after the therapeutic process.
- You may be asked to attend an interview to share about the progress of your conditions (the interview would be recorded) or to provide a written testimonial as the evidence for the progress that you had reported.

Informed Consent (front)

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RISKS

Throughout the process, you might feel uncomfortable in sharing about your unpleasant life experiences that will trigger your emotions. However, you are free to withdraw yourself from this case report study at any time.

CONFIDENTIALITY

The data from this study will be kept confidential. No identities of participants will be used in any reports or publication resulting from this study. All audio recordings, and summaries will be given codes and stored separately from any names or other direct identification of participants. Research information will be kept in locked files at all times. Only research personnel will have access to these files and only those with an essential need to see names will have access to a particular file. All audio recording will be destroyed after the transcript done.

B. INFORMED CONSENT STATEMENT

I have spoken with the Principal Investigator about this study and have had any questions answered. If I have any further questions about the study, I understand that I can contact *Loh Jun Ming, Lee Jia Wen, Gan Chi Kien* or the supervisor of this project, *Hiro Koo Kian Yong* by calling 6016-7154419 or by physically visting to New Mind Brain Health Centre, 2-3A, 2nd Floor, Wisma Life Care, No5, Jalan Kerinchi, Bangsar South, 59200 Kuala Lumpur, Malaysia.

I have been given a copy of this consent form to keep.
I understand that PARTICIPATION IN THIS CASE REPORT STUDY IS VOLUNTARRY, that I am free to decline to participate in this research study, and that I may withdraw my participation at any time without penalty.

Signature: _____ Date: 1/8/2024
(Research Participant)

Signature: _____ Date: 18/8/2024
(Supervisor)

Informed consent (back)

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