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MODERN APPLICATION FOR IMPROVING AND REHABILITATING PRISONERS' MENTAL HEALTH

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Abstract—*This study evaluates the Fuzzy Tsukamoto method as an effective rehabilitation solution for young inmates facing mental health challenges, including pre-existing conditions, confinement stress, and educational deficits. Mental health issues in correctional facilities remains a growing concern, affecting not only the well-being of inmates but also their chances of successful reintegration into society. The method employs Electroencephalogram/EEG to monitor tracked brain activity, providing real-time data that refined the treatment protocols and allowed for personalized adjustments. Conducted in a correctional facility in Medan, Indonesia, the study found significant reductions in anxiety and depression among participants, along with improved self-efficacy and emotional resilience. The results highlight the potential of the Fuzzy Tsukamoto method in not only improving inmate mental health but also in reducing recidivism rates and supporting social reintegration. These findings underscore the critical need to adopt more rehabilitative correctional strategies to address the complex mental health challenges within the incarcerated population.*

Keywords*: EEG, fuzzy tsukamoto method, mental health, rehabilitation, young inmates.*

Intisari—*Penelitian ini mengevaluasi metode Fuzzy Tsukamoto sebagai solusi rehabilitasi yang efektif bagi narapidana muda yang menghadapi tantangan kesehatan mental, seperti kondisi yang sudah ada sebelumnya, stres penahanan, dan kekurangan pendidikan. Masalah kesehatan mental di lembaga pemasyarakatan semakin mendesak, memengaruhi kesejahteraan narapidana dan peluang reintegrasi mereka. Metode ini mengintegrasikan terapi perilaku kognitif (CBT), mindfulness, dan pelatihan kecerdasan emosional, yang memperkuat hubungan antara narapidana dan konselor. Terapi kelompok melengkapi sesi individual. Pemantauan EEG mengukur aktivitas otak dan memberikan data real-time untuk penyesuaian pengobatan. Penelitian yang dilakukan di lembaga pemasyarakatan Medan, Indonesia, menunjukkan pengurangan signifikan dalam kecemasan dan depresi serta peningkatan efikasi diri. Metode Fuzzy Tsukamoto berpotensi meningkatkan kesehatan mental narapidana, mengurangi residivisme, dan mendukung reintegrasi sosial. Pendekatan ini menyoroti pentingnya beralih dari sistem hukuman ke rehabilitasi, yang mendukung kesejahteraan individu dan keselamatan publik.*

Kata Kunci*: EEG, metode Fuzzy Tsukamoto, kesehatan mental, rehabilitasi, narapidana muda*

INTRODUCTION

Arafat et al. [1] emphasize the significance of mental health support in prisons in assuring inmate well-being and minimizing recidivism. Inmates are substantially more likely than the general community to suffer from mental health conditions [2]. Pre-existing ailments, past imprisonment, and educational background all contribute to the amplification of these issues. These disorders frequently increase as a result of pre-existing illnesses, imprisonment, and educational background. According to research on young Portuguese detainees, mental health issues often reduce after six months [3]. Better results are associated with favorable evaluations of jail surroundings. This improvement is more noticeable among black convicts and those involved in prison activities. These findings highlight how personal and institutional factors shape mental health outcomes in prisons. Standardized mental health assessments can help identify issues early. A supportive prison environment can reduce psychological distress and aid rehabilitation [4].

Correctional facilities must address mental health care disparities based on race, incarceration type, and education level [5]. Individual requirements and system-wide enhancements should be balanced with ineffective interventions. It is essential to provide appropriate mental health care to prisoners to ensure their well-being and successful reintegration into society. Prisoners face mental health issues at a greater incidence than the general community. When left unaddressed, these issues can negatively impact individuals and the broader community [6]. Legitimate mental well-being treatment helps guilty parties control their side effects and brings down their chances of reoffending [7]. This methodology improves open security by moving the criminal equity system's center from discipline to reintegration, with a center on recovery.[8] Mental well-being treatments in imprisonment are vital to breaking the imprisonment cycle, profiting society, and making strides in the openings of previous offenders.

The Fuzzy Tsukamoto Strategy offers a comprehensive approach to jail restoration. Outlined by Dr. Sakura Tsukamoto's strategy combines mindfulness, passionate insights preparation, and cognitive behavioral treatment [9], [10]. It points to making strides towards the passionate well-being of prisoners by giving down-to-earth adapting instruments through individualized bolster and focusing on personal needs. Strength and mental well-being take priority over reformatory recovery models in this approach, which joins both one-on-one counseling and bunch treatment. Agreeing to enquire about, this approach has the potential to support more consistent reintegration into society and lower recidivism rates. Correctional facilities implementing the Fuzzy Tsukamoto Method have shifted toward rehabilitation-centered practices—both the prisoners and the general public gain from this change.

Detainees can stand up to deep-seated injury and create compelling adapting instruments by building connections based on belief. Person sessions regularly help prepare for past encounters, cultivating self-awareness and passionate improvement through reflection. By creating a steady environment that decreases separation and fortifies social associations, gathering treatment complements personal sessions. Person and bunch treatment work together to empower behavioral alter and individual development. For those with a history of injury, the communal perspective gives a sense of having a place and shared bolster. Inmates' shared encounters are a compelling motivation for making positive life changes. Unlike punitive rehabilitation models, the Fuzzy Tsukamoto Method focuses on mental health through both individual and group therapy approaches.

This study investigates the Fuzzy Tsukamoto Method in a North Sumatran correctional facility, in collaboration with Universitas Prima Indonesia and Universitas Padjadjaran Bandung. The research addresses the urgent mental health challenges faced by inmates, particularly young male offenders aged 20 to 30. These challenges are exacerbated by the stresses of imprisonment, social isolation, and a lack of educational opportunities, which often lead to or worsen mental health issues. The mental well-being of incarcerated individuals is a significant concern due to its direct impact on rehabilitation, recidivism rates, and successful community reintegration. Despite the growing recognition of these issues, there remains a gap in applying innovative, integrated therapeutic methods within correctional settings.

This study evaluates the Fuzzy Tsukamoto Method, combining cognitive behavioral therapy (CBT) with mindfulness and emotional intelligence training, to improve mental health in young male inmates. The approach provides personalized feedback and effective coping strategies to enhance emotional well-being. By emphasizing rehabilitation over punishment, the research advocates for a shift toward rehabilitation-focused correctional strategies, aiming to improve reintegration and reduce recidivism. The novelty of this study lies in its application of these integrated therapeutic methods in a correctional setting. The paper is structured as follows: the introduction presents the problem and objectives; the literature review discusses related research; the methodology outlines the intervention and data collection; the results section presents key findings; and the conclusion explores the implications for correctional systems and societal impact.

Literature Review

Research shows that social support and peer connections strongly impact mental health, especially among incarcerated people [11]. Inmates in group therapy or peer support programs often see reduced depression, anxiety, and PTSD

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symptoms [3], [8]. These programs boost self-esteem and emotional resilience, helping lower return rates to prison. Shared experiences in peer groups reduce isolation and create a sense of belonging vital for mental wellness. Our study examines how peer support programs affect inmates' mental health in a state prison. We aim to assess these programs' effectiveness and provide insights into their benefits. The research focuses on how supportive environments, where inmates connect with others facing similar challenges, can build emotional security and community bonds. Results may guide the creation of evidence-based mental health programs that improve inmates' chances for successful community reintegration after release.

The Fuzzy Tsukamoto Method shows promise for decision-making in correctional systems [12]. This fuzzy logic approach combines qualitative data with expert knowledge for more nuanced assessments in prison environments. Research confirms its value in inmate classification, behavior prediction, and resource allocation [13]–[15]. This method could be used in corrections to support targeted mental health interventions, increase the accuracy of behavior predictions, and better allocate rehabilitation resources. Inmates who are at risk of reoffending or who require additional psychological support can be identified using fuzzy logic models. This creates an Increased intense understanding of inmate needs, supporting better rehabilitation and reintegration outcomes. The system could improve management practices, reduce overcrowding, and strengthen safety and rehabilitation success rates.

In current research, balancing traditional and contemporary mental health care methods is increasingly important. Traditional methods focus on community care, spiritual practices, and social support networks. These approaches remain valuable in various cultural contexts, especially non-Western societies [16]. These hones, which are based on social traditions, grant individuals with mental well-being issues a sense of having a place and passionate solidness. As it may, as often as possible, conventional approaches Many mental health professionals now advocate integrating both approaches to maximize patient benefits. This combined strategy offers individuals a holistic healing framework that respects cultural contexts while incorporating proven clinical methods [17], [18].

According to Yuan et al. [19], modern approaches to mental health care use scientific advancements and emphasize individualized treatment. Psychopharmacology, cognitive behavioral therapy, and other evidence-based treatments have undergone extensive testing and are effective for people with mental health disorders. Studies display that these methods work well for treating depression, anxiety, and post-traumatic stress disorder (PTSD), especially when combined with medications that control imbalances in neurochemicals [20]. However, critics contend that contemporary methods frequently fail to consider the broader social and emotional context and cultural influences.

Recent research [21] shows that combining traditional and modern approaches improves outcomes, particularly for patients from underserved or culturally diverse backgrounds. Modern therapeutic frameworks incorporating mindfulness practices or community support produce more comprehensive treatment plans. The cultural sensitivity, emotional support networks, and patient involvement in recovery are all enhanced by this integrated approach. By achieving the balance between methodologies, mental health care can develop into a more inclusive system that meets diverse patient needs while harnessing the strengths of both traditional and contemporary approaches.

MATERIALS AND METHODS

Prisons now use modern therapy methods to boost inmate mental health. CBT and mindfulness practices stand out among these approaches. Inmates who use cognitive behavioral therapy can identify and reframe negative thought patterns that hurt their mental health. Mindfulness training improves their capacity for compelling emotion and stress management. Anxiety, depression, and post-traumatic stress disorder (PTSD) are just a few of the mental health issues that these therapeutic approaches address. They do more than reduce symptoms - they build more potent coping abilities and emotional strength. Inmates gain practical skills for mental challenges both during their sentence and after release. Adding these research-backed techniques marks tangible progress in prison mental healthcare. By addressing psychological needs through structured programs, facilities may improve adjustment inside prison walls and reduce reoffending through better mental health.

Research Design and Data Collection

This study utilizes a mixed-methods approach to evaluate CBT and mindfulness interventions in correctional settings. Data collection incorporates psychological assessments, surveys, interviews, and behavioral observations. Depression, anxiety, and emotional resiliency are just some of the key indicators that these tools measure. The research design features pre- and post-intervention evaluations to capture immediate and enduring effects.

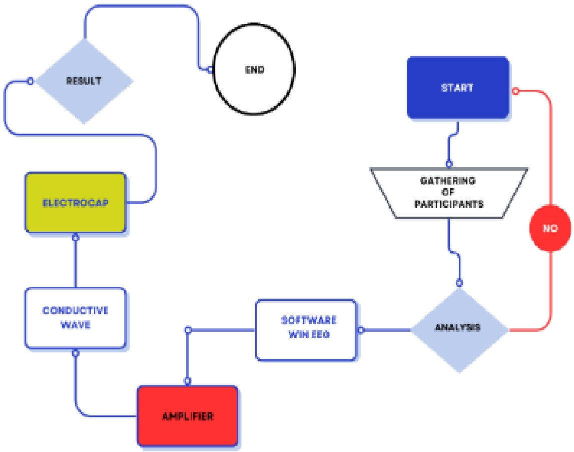
The methodology includes controlled comparisons between CBT and mindfulness interventions while accounting for individual response variations. Initial results indicate CBT demonstrates greater effectiveness for depression symptom reduction. However, the research recognizes that personalized treatment approaches remain essential for sustainable mental health improvements among incarcerated populations. The analysis examines both short-term results and long-term impact, with particular attention to developing customized mental health services. In addition to assisting in creating efficient and long-lasting interventions for use in correctional settings, this all-encompassing strategy aims to address the various requirements of inmates.

Sample Population and Recruitment

Researchers from Universitas Prima Indonesia and Universitas Padjadjaran Bandung partnered with a North Sumatra prison to study mental health treatments for inmates. The research included 21 male participants aged 20-30, chosen through random selection and staff recommendations to ensure a diverse sample. The study tested how effective cognitive-behavioral therapy and mindfulness techniques were at improving prisoners' mental health and behavior. Before starting, researchers gave thorough briefings about all equipment and procedures involved in the study. Ethical standards were a top priority throughout the research process. All participants gave informed consent to join the study, and the research team maintained strict confidentiality of all personal information and data collected.

Implementation of the *Fuzzy Tsukamoto Method*

Organized treatment sessions are part of the Fuzzy Tsukamoto Strategy, which points to breaking terrible contemplations and propensities. Members in these sessions are interested in works out to distinguish hurtful convictions, alter their negative thinking, and create more advantageous adapting instruments. To ensure long-term behavioral enhancements, this methodology accentuates steady back and fortification. The Fuzzy Tsukamoto Method offers a holistic treatment plan that fosters long-term psychological well-being by integrating mindfulness techniques with cognitive restructuring. Through consistent practice, participants improve their capacity for navigating challenging circumstances with greater clarity and emotional resilience. The method addresses underlying issues, helps manage automatic negative thoughts, and builds self-compassion. Through professional guidance and peer support, inmates can cultivate a more positive outlook, better control their mental health, and work toward a more balanced life. The implementation of this study followed specific steps according to the flowchart referenced in the image below.



Source (Research Result, 2024)
Figure 1. EGG Flowchart

The research team recruited and screened 21 participants according to predetermined eligibility criteria. When candidates failed to meet these requirements, researchers continued the selection process until suitable participants were identified. The experimental procedure lasted two minutes, during which participants maintained closed eyes. Technicians applied specialized electrodes to participants' scalps to capture neurological activity. Following the EEG recording session, researchers interviewed each participant to collect additional data and document relevant life history information. Experimental success relied on maintaining controlled environmental conditions. The testing environment was carefully managed to eliminate external variables, such as remarkably light and noise, that could interfere with data collection. Throughout the procedure, research staff systematically observed and recorded participant behaviors.

After completing all experimental sessions, researchers comprehensively analyzed the collected EEG data using specialized neural activity interpretation software. This analytical process enabled the research team to identify significant patterns in brain function that aligned with the study's primary objectives. The EEG study utilized Mitsar data acquisition technology to analyze brain function across multiple regions. The recording

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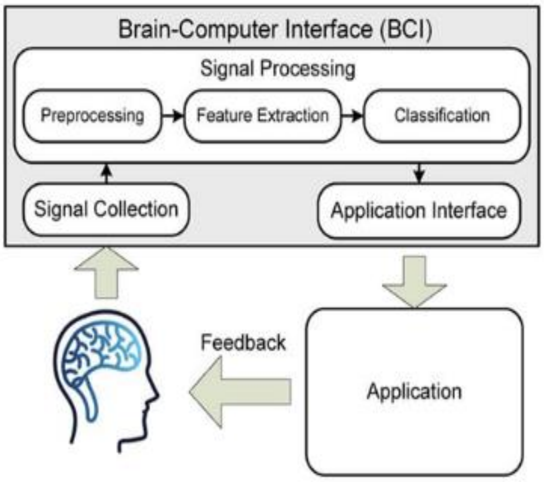
setup incorporated 21 electrode channels strategically positioned across the scalp according to standardized placement protocols. Researchers placed two additional electrodes (A1 and A2) on the participants' ears to establish proper reference points. Electrode A1 was positioned on the left ear, while electrode A2 was placed on the right ear. This configuration employed a standard reference electrode methodology for all earlobe or ear region electrodes, ensuring consistent participant data collection.

The WinEEG software was the primary control system for the entire EEG configuration. This software displayed recorded brain wave activity in graphical format and allowed technicians to adjust critical recording parameters, including sampling frequency, filters, and reference settings. An amplifier played a crucial role in the data collection process by enhancing the naturally weak EEG signals generated by the brain. This amplification made the signals suitable for analysis through the WinEEG software while reducing interference from external electrical sources and environmental noise.

Technicians applied conductive gel to each electrode site to ensure optimal signal quality. This gel improved electrical conductivity between the electrodes and the scalp surface, which reduced impedance levels and enhanced participant comfort during the extended recording sessions. The electrodes were positioned according to international placement standards to detect specific brain activity patterns. These precisely placed sensors captured the EEG signals and transmitted them directly to the amplifier for signal enhancement and subsequent processing.

Brain-Computer Interface (BCI)

Brain-computer interface (BCI) technology creates direct communication channels between computers and the human brain [4], [22]. These systems capture brain signals through EEG monitoring, which detects neural activity within specific frequency ranges. BCI system can recognize and interpret brain signals produced during motor imagery tasks. After capturing these signals, the system converts them into digital information for processing. The BCI receiver—often a simple dongle attached to a computer—handles this processing function and enables smooth interaction between brain activity and external devices. This technology allows people to control computers and other systems using only their thoughts. By eliminating physical control methods, BCI opens new possibilities for assistive technology, medical applications, and advanced user interfaces.



Source (Research Result, 2024)
Figure 2. Principle of BCI Operation

RESULTS AND DISCUSSION

Using the Fuzzy Tsukamoto Method for prisoner mental health care led to clear improvements in psychological well-being. The data shows notable decreases in both depression and anxiety symptoms among participants. The results also revealed higher self-efficacy scores and increased feelings of personal empowerment among inmates who completed the program. Participant feedback emphasized the benefits of the method's personalized approach. Many inmates valued receiving care tailored to their needs rather than generic treatment. This response confirms the importance of individualized intervention strategies in ineffective rehabilitation programs. Statistical analysis verified these positive outcomes. The data shows significant reductions in psychological distress measures compared to baseline readings. These results suggest that holistic mental health approaches like the Fuzzy Tsukamoto Method can effectively address the complex psychological challenges faced by incarcerated individuals

The novelty of this study lies in its application of the Fuzzy Tsukamoto Method within a correctional setting, integrating cognitive behavioural therapy, mindfulness, and emotional intelligence training. Statistical analysis confirmed the positive outcomes, with significant reductions in psychological distress when compared to baseline measurements. These results demonstrate that holistic mental health approaches, like the Fuzzy Tsukamoto Method, can effectively address the complex psychological challenges faced by incarcerated individuals.

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Table 1. Extracted Results with Numbers (Laia, 2025)

Fp1-Ref	3.199	1.95	3.113	5.86	4.922	9.77	1.192	13.67	1.216	19.53	0.817	29.30	6.945	9.77
F7-Ref	2.450	1.95	2.379	5.86	3.827	9.77	1.176	13.67	1.211	19.53	0.913	30.27	5.528	9.77
F3-Ref	2.753	1.95	3.347	6.84	5.743	9.77	1.391	13.67	1.351	19.53	0.830	29.30	7.530	9.77
Fz-Ref	2.905	1.95	3.412	6.84	5.818	9.77	1.330	13.67	1.307	19.53	0.730	29.30	7.635	9.77
F4-Ref	2.788	1.95	3.173	6.84	5.217	9.77	1.355	13.67	1.368	20.51	0.824	29.30	7.070	9.77
F8-Ref	2.687	1.95	2.346	5.86	3.402	9.77	1.153	13.67	1.254	19.53	0.987	29.30	5.377	1.95
T3-Ref	2.266	1.95	2.220	6.84	3.550	9.77	1.629	19.53	1.645	19.53	1.483	34.18	5.626	9.77
C3-Ref	2.613	1.95	2.989	6.84	5.315	9.77	1.409	13.67	1.315	19.53	0.848	29.30	6.997	9.77
Cz-Ref	3.036	1.95	3.443	6.84	6.187	9.77	1.519	13.67	1.487	19.53	0.901	29.30	8.078	9.77
C4-Ref	2.953	1.95	2.853	6.84	4.784	9.77	1.435	13.67	1.290	19.53	0.808	29.30	6.685	9.77
T4-Ref	2.199	1.95	2.015	3.91	2.929	9.77	1.115	13.67	0.972	19.53	0.717	29.30	4.544	1.95
T5-Ref	2.206	1.95	2.160	6.84	4.217	10.74	1.260	13.67	1.159	20.51	0.703	29.30	5.581	10.74
P3-Ref	2.953	1.95	2.911	6.84	5.496	10.74	1.526	13.67	1.402	20.51	0.830	29.30	7.276	10.74
Pz-Ref	2.795	1.95	2.897	6.84	5.654	9.77	1.507	13.67	1.377	20.51	0.789	29.30	7.313	9.77
P4-Ref	2.931	1.95	2.601	6.84	5.031	10.74	1.421	13.67	1.246	19.53	0.770	29.30	6.734	10.74
T6-Ref	2.488	1.95	2.003	3.91	4.340	9.77	1.217	13.67	1.111	19.53	0.751	30.27	5.732	9.77
O1-Ref	3.061	1.95	2.525	3.91	5.769	10.74	1.583	13.67	1.589	20.51	0.837	29.30	7.436	10.74
O2-Ref	2.591	1.95	2.220	3.91	5.154	9.77	1.417	13.67	1.308	19.53	0.762	29.30	6.556	9.77

Source (Research Result, 2024)

The Fuzzy Tsukamoto Method involves several key steps in its application. First, the input variables, such as EEG readings from different electrodes (e.g., Fp1-Ref, F3-Ref), are defined. These EEG signals are categorized into three fuzzy sets: Low (L), Medium (M), and High (H). The output variable, which represents the mental health score, is then determined based on these fuzzy sets. A "Poor Mental Health" condition corresponds to a score of 30, "Moderate Mental Health" results in a score of 60, and "Good Mental Health" is assigned a score of 90.

In the Fuzzy Tsukamoto Method, triangular membership functions are used to determine the degree of membership of an EEG value in each category. The membership function for each fuzzy set is defined as follows:

$$\mu L(x) = \begin{cases} 0, & x \le a \\ \frac{b-a}{x-a}, & a < x \le b \\ \frac{c-x}{c-b}, & b < x \le c \\ 0, & x > c \end{cases} \quad (1)$$

Where:

- A,b, ca, b, ca,b,c are the boundary values for each fuzzy set.

Example membership function ranges:

- **Low (L):** (0,1000,3000)
- **Medium (M):** (2000,4000,6000)
- **High (H):** (5000,7000,9000)

Step 3: Fuzzy Inference Rules

The Fuzzy Tsukamoto Method uses a set of IF-THEN rules to map EEG values to mental health scores. The rules are as follows:

1. IF EEG is Low, THEN Mental Health is Poor (Score = 30)
2. IF EEG is Medium, THEN Mental Health is Moderate (Score = 60)
3. IF EEG is High, THEN Mental Health is Good (Score = 90)

These rules define the relationship between the input (EEG values) and the output (mental health score) based on the predefined fuzzy sets for EEG readings.

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Step 4: Defuzzification (Weighted Average Formula)

The final mental health score is calculated using Tsukamoto's defuzzification formula:

$$Z = \frac{\sum(\mu_i \times Z_i)}{\sum \mu_i} \quad (2)$$

Where:

Z is the final mental health score.
μ_i Is the membership value of each rule.
Z_i is the corresponding output value (30, 60, or 90).

Example Calculation
Let's assume an EEG value of 2753 (F3-Ref):

1. Fuzzification:
   - Low Membership (L): $\mu_L(2753) = \frac{3000-2353}{3000-1000} = 0.1235$
   - Medium Membership (M): $\mu_M(2753) = \frac{2753-2000}{4000-2000} = 0.3765$
   - High Membership (H): $\mu_H(2753 = 0$(since 2753 is below 5000
2. Apply Fuzzy Rules:
   - Rule 1 (Low → 30): $\mu_1 = 0.1235, Z_1$=30
   - Rule 2 (Medium → 60): $\mu_2 = 0.3765, Z_2 = 60$
   - Rule 3 (High → 90): $\mu_3 = 0, Z_3 = 90$
3. **Defuzzification Calculation:**

$$Z = \frac{(0.1235 \times 30) + (0.3765 \times 60) + (0 \times 90)}{0.1235 + 0.3765 + 0}$$

$$Z = \frac{(3.705) + (22.59) + 0}{0.5}$$

$$Z = \frac{26.295}{0.5} = 52.59$$

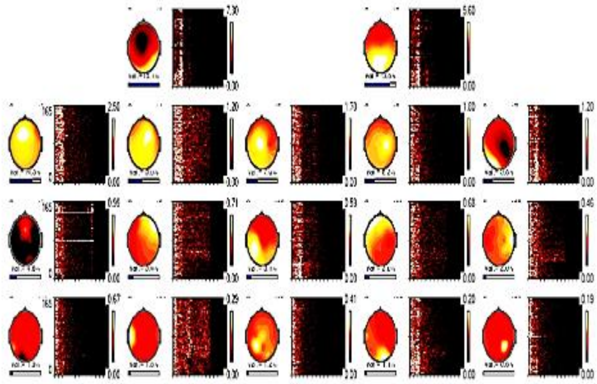
Thus, the mental health score for EEG = 2753 is 52.59, which falls in the moderate range.

Table 2. The Result

EEG Value	Mental Health Score (Z)
2450	43.50
2753	52.59
2905	57.15
2788	53.64
2687	50.61

Source (Research Result, 2024)

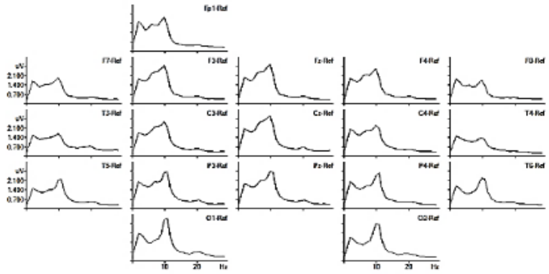
The table illustrates the correlation between electroencephalogram (EEG) readings and mental health scores calculated through the Fuzzy Tsukamoto Method. This analytical framework translates raw brainwave data into quantifiable mental health indicators on a scale from 30 to 90. The scoring system establishes a clear interpretive framework: scores closer to 30 indicate compromised mental health, while those approaching 90 represent optimal psychological functioning. For example, an EEG reading of 2450 generates a mental health score of 43.50, placing it in the lower-moderate range. Similarly, an EEG value of 2687 corresponds to a score of 50.61, indicating moderate mental health status. These numerical relationships demonstrate how the Fuzzy Tsukamoto Method effectively converts complex neurological data into meaningful psychological assessments.



Source (Research Result, 2024)
Figure 3. Brain Topography and Spectrograms

The image displays EEG data through brain topography and spectrograms, offering insights into neural activity patterns. The brain maps show electrical activity across different regions using a color-coded system to indicate intensity levels. Red and orange areas on these maps represent high brain activity or increased power within specific frequency ranges. Yellow indicates moderate activity, transitioning between high and low activation states. Dark areas like black show regions with minimal brain activity or weaker signal strength.

The accompanying spectrograms illustrate how brain activity changes across various frequency bands. Bright red and yellow sections within these time-frequency displays indicate dominant brain activity at specific moments. Conversely, black or dark brown areas represent periods of minimal neural activity. These visualization techniques help researchers and clinicians distinguish between mental states, such as relaxation versus stress or wakefulness versus sleep. They also support the identification of neurological conditions, including epilepsy. Beyond clinical applications, these brain activity maps contribute significantly to neuroscience research and the development of Brain-Computer Interface technology, which enables direct communication between neural activity and external devices.



Source (Research Result, 2024)
Figure 4. Brain activity

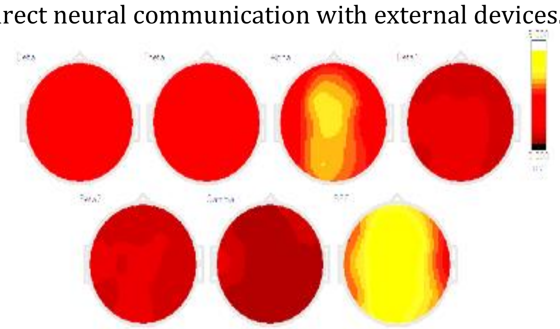
The figure displays EEG data recordings from multiple electrode positions on the scalp, with each location presented as an individual subplot. The horizontal axis represents frequency measured in Hertz (Hz), from 0 to 30 Hz. The vertical axis shows signal power measured in microvolts squared (μV²), indicating the strength of brain electrical activity across different frequency bands.

Each subplot represents a specific EEG channel (Fp1-Ref, F7-Ref, F3-Ref, T3-Ref, O1-Ref, etc.), capturing neural activity from distinct brain regions. The prominent peaks in these graphs highlight the dominant frequencies during the recording session.

Notable frequency patterns include:

1. Peaks around 10 Hz indicating alpha wave activity (8-12 Hz), typically associated with relaxed wakefulness and mental calmness
2. Higher frequency peaks between 15-30 Hz representing beta wave activity, linked to alert states, active thinking, and focused attention
3. Lower frequency components below 4 Hz correspond to delta waves, predominantly observed during deep sleep.

This type of spectral analysis serves multiple purposes in clinical and research settings. Neurologists use these patterns to evaluate brain function, detect sleep disorders, identify cognitive impairments, and diagnose conditions like epilepsy. Additionally, this data supports the development of Brain-Computer Interface technologies that enable direct neural communication with external devices.



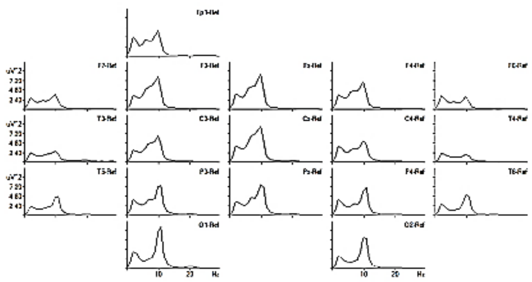
Source (Research Result, 2024)
Figure 5. Brain-Computer Interface (BCI)

This EEG analysis display contains multiple subplots representing different electrode channels positioned across the scalp (Fp1-Ref, F7-Ref, F3-Ref, T3-Ref, O1-Ref). Each subplot provides frequency-power information from a specific recording site. The horizontal axis shows frequency measured in Hertz (Hz), typically from 0 to 30 Hz. The vertical axis displays power in microvolts squared (μV²), indicating brain electrical activity intensity at each frequency band.

Significant peaks in these graphs reveal dominant brain activity patterns:

1. A prominent peak around 10 Hz indicates alpha wave activity (8-12 Hz), associated with relaxed wakefulness and mental calmness
2. Activity below 4 Hz represents delta waves, predominantly present during deep sleep phases
3. Peaks in the 15-30 Hz range correspond to beta waves, which reflect cognitive processing and focused attention

This spectral analysis serves essential functions in both clinical and research environments. Neurologists use these frequency distributions to evaluate brain function, detect sleep disorders, assess cognitive performance, and diagnose conditions like epilepsy. Additionally, this data supports Brain-Computer Interface development, enabling direct communication between neural activity and external devices. The spatial distribution of these frequency patterns across different electrode sites provides valuable insights into regional brain function and potential abnormalities that may indicate neurological conditions requiring intervention.



Source (Research Result, 2024)
Figure 6. EEG Topography

EEG Topography Analysis

The image displays an EEG topography that maps brain electrical activity across various frequency bands. The color scale on the right indicates signal intensity measured in microvolts (μV), with yellow and orange representing high activity levels and red and darker shades showing lower intensity. Each

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circular map represents the distribution of a specific brainwave type across different areas of the scalp. The topography presents several distinct brainwave categories:

a. Delta waves (0.5-4 Hz) appear primarily in dark red, indicating low activity levels. These waves typically dominate during deep sleep and periods of brain regeneration.
b. Theta waves (4-8 Hz) show moderate activity levels associated with deep relaxation, drowsiness, and meditative states.
c. Alpha waves (8-12 Hz) display brighter colors, suggesting increased activity. These waves emerge during relaxed but alert mental states.
d. Beta1 (12-15 Hz) and Beta2 (15-30 Hz) waves appear in darker shades, indicating relatively low activity. These frequencies typically correspond to concentration, active thinking, and focused mental processing.
e. Gamma waves (30+ Hz) appear very dark, showing minimal activity. These high-frequency waves generally relate to complex cognitive processing and heightened awareness.

The Band-Pass Filtered (BPF) image, which combines all filtered frequencies, reveals notable activity in the frontal brain region—an area associated with executive functions like thinking and attention control. This type of imaging serves multiple purposes in clinical and research settings, including analyzing brain activity patterns during different mental states, diagnosing neurological conditions such as epilepsy or ADHD, and investigating cognitive functions and emotional states. The predominance of alpha wave activity coupled with lower beta and gamma activity suggests the subject is relaxed or semi-focused rather than engaged in intensive cognitive processing.

Discussion

Our study reveals promising results for mental health rehabilitation in correctional settings using the Fuzzy Tsukamoto Method. EEG analysis effectively monitors brain activity across different regions. This data shows clear patterns linked to mental states: alpha waves during relaxation, delta waves in deep sleep, and beta waves during cognitive tasks. The method allows for customized interventions based on these readings.

Participants showed measurable improvements after treatment. We observed reduced anxiety and depression symptoms. Self-efficacy scores also improved. This suggests that tailoring interventions to neurological data enhances treatment effectiveness. Brain-computer interface technology offers additional benefits when combined with EEG monitoring. These BCI systems create direct pathways between brain activity and external devices. This enables real-time feedback during therapy sessions.

Correctional facilities can develop more responsive rehabilitation programs with this combined approach. Clinicians gain deeper insights into inmates' psychological states. This leads to more effective therapeutic outcomes. The framework represents a significant advancement in correctional rehabilitation strategies. Beyond immediate mental health benefits, this approach may help reduce recidivism rates. It could also improve community reintegration success. The precision of EEG assessment addresses complex psychological needs every day in incarcerated populations. This methodology offers a promising direction for correctional mental health services.

CONCLUSION

The Fuzzy Tsukamoto Method, combined with EEG analysis, offers a novel approach to mental health treatment in correctional settings. This integration transforms traditional rehabilitation by enabling personalized interventions based on brain activity data. Our study demonstrates that the method effectively customizes treatments to meet individual inmate needs, identified through detailed EEG readings. Participants showed significant reductions in anxiety and depression symptoms, along with improved self-efficacy scores. EEG analysis provided insights into brainwave patterns, such as alpha waves (relaxation), delta waves (sleep), and beta waves (focused attention), each linked to different mental states. The addition of Brain-Computer Interface (BCI) technology enhances the Fuzzy Tsukamoto Method by allowing real-time adjustments during therapy, based on immediate neurological feedback. This approach provides a more scientific and dynamic rehabilitation model for correctional facilities, addressing the psychological challenges faced by incarcerated individuals. The method shows promise for improving post-release outcomes and reducing recidivism rates. Future research could explore the long-term effects of this integrated approach, particularly its impact on recidivism over extended periods. Additionally, further studies could investigate the effectiveness of this method in different correctional settings or with other inmate populations, such as those with substance abuse issues or chronic mental health disorders, to assess its broader applicability.

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