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A Study on AI-Driven, Cloud-Based Neurofeedback Platform for Children with Developmental Disorders

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ABSTRACT

Developmental disorders present significant challenges for children's learning and overall well-being, necessitating innovative and effective support strategies. This study investigated the efficacy of a novel, AI-driven, cloud-based neurofeedback training (NFT) system in enhancing attention, speech development, and behavior among young children (aged 4-8 years) with developmental disorders in Malaysia. Adopting a qualitative quasi-experimental design with a pre-test/post-test framework, seven children participated in a structured NFT program involving a minimum of 72 sessions over at least six months. Data were gathered through comprehensive brainwave analysis using the specialized NFT system, supplemented by researcher observations and in-depth parental interviews. The findings revealed significant positive changes in brainwave patterns indicative of improved self-regulation. Correspondingly, participants demonstrated notable enhancements in attention, communication skills, and a reduction in behavioral problems. The integration of AI and cloud technologies in this NFT system allowed for personalized intervention protocols and suggests a pathway towards more accessible and scalable tech-driven solutions in developmental support. This research underscores the potential of advanced neurofeedback technology to provide a non-invasive and impactful intervention, offering valuable insights for practitioners, educators, and potentially shaping new avenues for entrepreneurial ventures in the EdTech and HealthTech sectors focused on child development.

Keywords: *Neurofeedback; Artificial Intelligence; Cloud Technology; Child Development; Developmental Disorders*

INTRODUCTION

The landscape of childhood development is increasingly marked by a growing concern for developmental disorders, conditions that cast long shadows on a child's ability to learn, interact socially, and navigate the path to their full potential. These challenges are not isolated; globally, an estimated 16% of the world's population, or roughly 1 in 6 individuals, live with significant disabilities, with approximately 317 million children and adolescents worldwide affected by health conditions contributing to developmental disabilities in 2019 (Olusanya et al., 2020). In Malaysia, the prevalence is also notable, with the National Health and Morbidity Survey (NHMS) in 2019 reporting that 4.7% of children experience functional difficulties, and special education programs have seen a consistent rise in enrollment, increasing by over 52% between 2016 and 2023 (Mukhriz et al., n.d.). Difficulties such as inattention, speech delays, and behavioral problems significantly impact children's academic journeys and personal growth. These difficulties will often be leading to enduring challenges.

In the early stages of treatment to address this developmental problem, psychostimulant drugs and several types of behavioral therapy have been introduced (Danielson et al., 2024). Although this approach has been successful in providing positive benefits, there are still shortcomings and limitations. Among the main concerns about the side effects of this traditional treatment are the long-term effects of the drugs taken (Deep, 2025). Among the long-term effects identified are reduced appetite, sleep disturbances, and drug dependence where the patient will experience symptoms again when the drug is not taken. In addition, the treatment of this child's developmental problem requires a high commitment from therapists and educators (Bellocchio et al., 2024). As a result, this puts pressure on the existing education system which is facing a shortage of therapists and special education teachers, in addition to limited class capacity and insufficient educational materials. Therefore, there is an urgent need to introduce other treatment alternatives for students who are facing developmental problems.

Among the proposed alternatives is neurofeedback training (NFT) which promises to treat students with developmental problems by adapting advanced technology in its treatment (Mitsea et al., 2025). Basically, neurofeedback is a non-pharmacological and non-invasive method that displays real-time displays of human brain activity(Diotaiuti et al., 2024). This display of brain activity helps researchers to understand and control human brain function. Brain function can be read using a tool called electroencephalography (EEG). When brain function is read and analyzed, researchers can provide feedback on the patient's brain wave patterns (through the NFT method) (Bajestani et al., 2024). Therefore, NFT aims to provide guidance through feedback to improve brain function such as attention, emotion and cognitive ability more optimally.

The concept of neurofeedback is not new. However, in line with the development of information technology and technological evolution, opportunities have opened for neurofeedback technology to improve its delivery results and effectiveness. This study focuses on the introduction of a new branch of innovation in the NFT system which will utilize Artificial Intelligence (AI) and cloud-based technology. The AI component facilitates personalized intervention protocols, tailoring the training to individual brainwave patterns, while the cloud-based infrastructure enhances accessibility and scalability, making it possible to deliver these advanced interventions more broadly ("anytime and anywhere"). This approach addresses some of the practical limitations of conventional therapies by offering a more adaptable and potentially more engaging method of support.

Therefore, the purpose of this paper is to present findings on the effectiveness of this specific AI-driven, cloud-based neurofeedback training system in a Malaysian context. This article evaluates the system's impact on enhancing attention, improving speech and communication abilities, and reducing behavioral problems in children aged 4-8 years diagnosed with various developmental disorders. Beyond the clinical outcomes, this paper will also explore the broader implications of such advanced technological interventions, considering their potential to reshape service delivery in child development and special education, and possibly open new avenues for entrepreneurial activity and business model innovation within the growing fields of educational and health technology.

LITERATURE REVIEW

The quest for effective interventions for developmental disorders has increasingly turned towards innovative, technology-driven solutions. Among these, neurofeedback training (NFT) stands out for its non-invasive approach to enhancing brain function and promoting self-regulation. This review will briefly outline the foundational principles of neurofeedback, discuss how contemporary technological advancements like Artificial Intelligence (AI) and cloud computing are revolutionizing its application, and explore the consequent implications for business and entrepreneurial activities in the health and educational technology sectors.

An Overview of Literature Review

A literature review surveys books, scholarly articles, and any other sources relevant to a particular issue, area of research, or theory, and by so doing, provides a description, summary, and critical evaluation of these works in relation to the research problem being investigated. Literature reviews are designed to provide an overview of sources have explored while researching a particular topic and to demonstrate to readers how this research fits within a larger field of study.

Understanding Neurofeedback and its Neuroplastic Foundations

Neurofeedback is a form of biofeedback that focuses on the electrical activity of the human brain (Tosti et al., 2024). Also often referred to as EEG biofeedback, this process involves measuring brain wave patterns in real time using electroencephalography (EEG) (Diotaiuti et al., 2024). The brain wave patterns are then given immediate feedback to the individual, usually in the form of auditory or visual signals (Dos Anjos et al., 2024). The main purpose of this process is to train individuals to understand how the brain wave work. By understand this, the user will be able to control their brain wave patterns more effectively. Training needs to be done regularly by the patient to train the brain to strengthen its natural capacity. This will increase the flexibility and cognitive control of the patient's brain (Sachse &

Widge, 2025). The assumption in this training is that individuals can change and control neural activity to improve specific brain functions through targeted feedback and conditioning.

The scientific basis of neurofeedback is known as neuroplasticity. Neuroplasticity explains that experience can change the brain's ability to adapt and reorganize itself (Puderbaugh & Emmady, 2023). The concept of neuroplasticity was first discussed by William James (Grafman, 2000). James explains that the brain is not a static organ but a dynamic system that is capable of structural and functional changes throughout a person's life. Neurofeedback then takes advantage of this principle by creating an environment in which the brain can learn new patterns (Davidson & Mcewen, 2012). When individuals receive feedback about their brain wave activity such as theta, alpha, beta, and gamma waves (Antara et al., 2024), their brains learn to produce patterns conducive to better attention, reduced impulsivity, and better emotional stability (Rai et al., 2024). These waves are usually produced naturally when individuals are in different mental states such as relaxation, focused attention, or deep sleep (Chen & Li, 2025). Previous studies have shown that wave activity in the beta range can enhance human brain wave frequencies to a level that may improve a person's attention and cognitive performance (Astuti et al., 2024; Li et al., 2024; Mohammadi et al., 2024).

AI and Cloud-Computing in Neurofeedback

For decades, the principles of neurofeedback have existed, yet there's still room for improvement. What is now being looked at is how the latest technologies, like artificial intelligence (Dias et al., 2024) and cloud computing (Shiwlani et al., 2024) can be adopted into neurofeedback studies to create a new field of study. One of these latest studies, which was done with these new technologies, is called " BrainSC." This is the name of the state-of-the-art brainwave scanning system that was developed in tandem by the Korea Research Institute of Brain Science and the BrainScience Academy Sdn. Bhd. (BrainScience Academy, 2025). It's said that this system uses an assessment tool that is both scientific and innovative. Moreover, it allows for human intervention that is supposedly cloud-based. That means this things should be able to access the technology anytime and anywhere.

Neurofeedback systems are becoming more personalized due to AI (Jiao, 2025). Traditional methods of analyzing brainwave data were not as accurate and, therefore, not as good at identifying the kind of subtle patterns that make each person's neural profile unique (Priyadarshani et al., 2024). Now, with AI, the kind of deep analysis necessary to really understand and "know" an individual neural profile is being done (Amiri et al., 2024). And at a speed that guarantees "real-time" updates and adjustments to training protocols as each individual progresses through their own unique kind of neurofeedback journey.

In addition, cloud computing fundamentally solves important problems concerning accessibility and scalability. Traditional neurofeedback often necessitates the use of very specialized equipment and trained professionals working in clinical environments (Chaudhary, 2025). A cloud-based neurofeedback system could allow for the remote monitoring of brain activity, storage of massive amounts of data, and even delivery of certain training components (Corrado et al., 2024), thus reducing the number of times the user needs to visit the clinic and making the whole operation much more feasible for a lot more people (Morrissey et al., 2024), especially those in rural and understaffed facilities. This research model (Farrow et al., 2025), in which is discussed a "cloud-based data-driven assessment tool" and "cloud-based technology that can be used anywhere and anytime (Xia et al., 2024)," illustrates how minimal the access requirement to a cloud-based system is.

Emerging Opportunities in HealthTech and EdTech

The convergence of neuroscience, technology, and the growing demand for effective developmental interventions creates fertile ground for innovation within the HealthTech and Educational Technology (EdTech) sectors (Basri et al., 2024). The development and deployment of sophisticated neurofeedback systems, such as the AI-driven, cloud-based platform evaluated in the primary research, exemplify a broader trend towards personalized and technology-enhanced care.

From a business perspective, companies like " BrainScience Academy Sdn. Bhd." (as a developer of the system) represent a growing niche of specialized service providers. These entities often operate at the intersection of research and commercial application, translating scientific advancements into marketable products and services. The business model for such enterprises can involve direct-to-consumer offerings (Ali et al., 2024), partnerships with schools or clinics, or the development of licensable technology platforms (Wider et al., 2024). The study finding that neurofeedback can be a "cost-effective alternative" also has business implications, suggesting market viability.

From an entrepreneurial perspective, technological advances such as AI and cloud technology are opening up new business opportunities in the field of neuroscience, especially in wearable sensor technology and live data analysis (Sanabria-Z et al., 2025). With the use of technology, entrepreneurs can create a tool or platform that integrates neurofeedback with other digital therapeutics such as gamification, virtual reality with a more user-friendly interface, developing specific applications for specific disorders (Reddy, 2025). The creation of this new product aims to improve operational efficiency for practitioners in this field. This business opportunity is seen as very positive given the growing world population, thus the need to improve the quality of life can be done with the current technological capacity (Morrissey et al., 2024), especially in the field of social entrepreneurship (Sanabria-Z et al., 2025).

Furthermore, continuous improvements and innovations guaranteeing the continuity of the field of neurofeedback can be ensured through the collection and analysis of large data sets from cloud-connected neurofeedback devices (Ling et al., 2024). With the availability of big data, further research, training of AI algorithms and the creation of a research, development and commercialization ecosystem can be carried out (Wider et al., 2024). In addition, the spillover from this development will also be seen through the need for training and skilled labor.

Thus, while neurofeedback has a strong foundation in neuroscientific principles such as neuroplasticity, there is still potential for further development in this field, particularly through advances in AI and cloud technologies. This includes not only advances in methods for addressing developmental disorders but also opportunities for innovation, business development and entrepreneurship in the rapidly evolving health and education technology landscape.

METHODOLOGY

This study used a quasi-experimental qualitative research design. This study used a pre-test/post-test framework to evaluate the effects of a neurofeedback training (NFT) intervention as show in Figure 1. This research focused on understanding changes in attention, speech development, and behavioral problems among children with developmental disabilities through an NFT program.

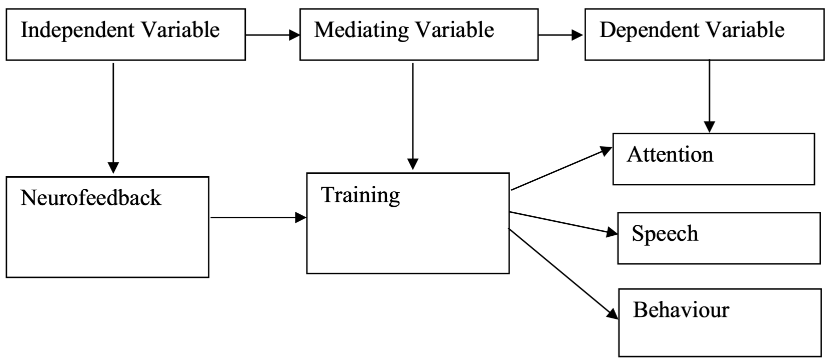


Figure 1. Proposed Conceptual Framework

Participants

The study involved seven child participants aged between 4 and 8 years. These participants were also patients who were actively receiving neurofeedback training at several research centers in Malaysia. The age range of 4-8 years was chosen because this is a critical period for cognitive development and the minimum age for the initiation of a specific NFT program for four years. The participants who participated had a spectrum of different developmental challenges, including autism spectrum disorder (ASD), Global Developmental Delay (GDD), speech and language delays, attention deficits and symptoms associated with Attention Deficit Hyperactivity Disorder (ADHD). The study used convenience sampling and combined with multiple sampling due to the suitability of the current situation. This hybrid approach ensured that the researchers obtained participants who met the specific criteria including participants who had developmental disorders with challenges related to attention, speech or behavior and were already involved in the NFT program. Input from the parents of these children was also taken with their views being collected through interviews.

The Neurofeedback Intervention and Technology

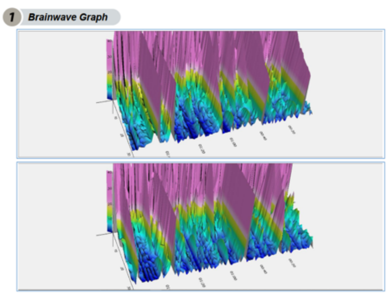
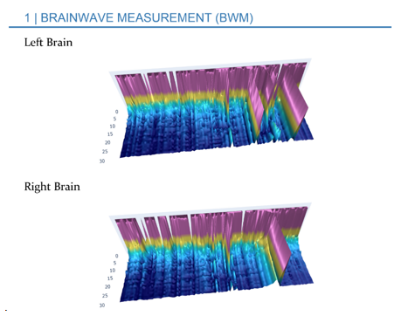
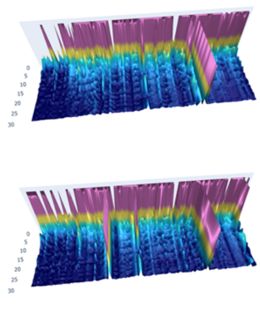
The core intervention in the assessment is a structured neurofeedback training program using an advanced system developed by the Korea Research Institute of Brain Science and the BrainScience Academy Sdn. Bhd. The system features BrainSc, brainwave scans through an EEG-based assessment tool that captures brainwave activity in real time. These waves are then processed and displayed in the form of 3-D brainwave diagrams. The results of these results are then combined with AI-driven techniques to enable personalized intervention protocols. All of these results will ultimately be supported by cloud-based technology for easy data management and accessibility.

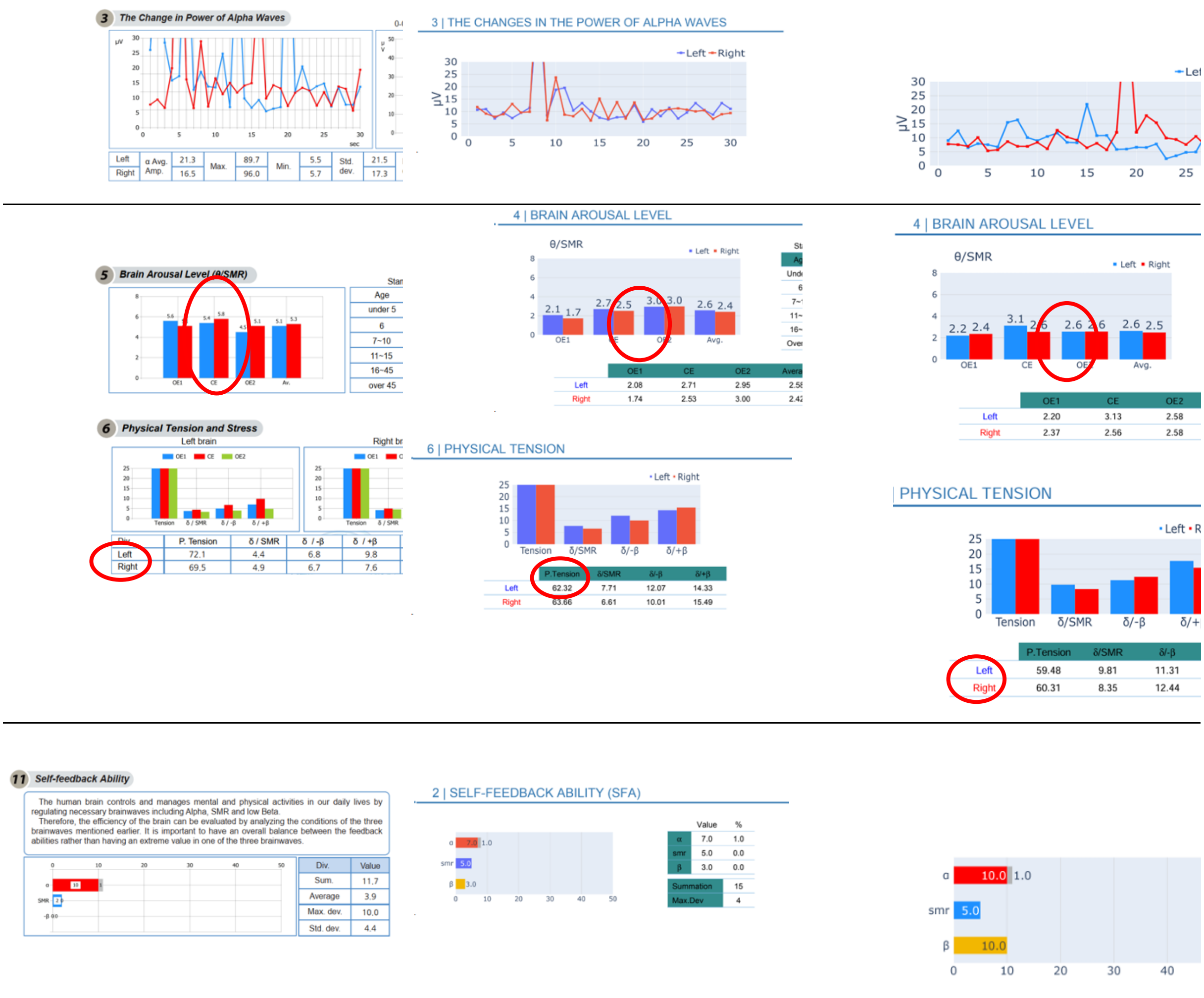
Each child is required to participate in at least 72 NFT sessions. Each session lasts 45 minutes. These sessions occur at a frequency of 12 times a month. The average duration of time taken by participants is a minimum of six months, but some participants have completed these sessions for up to three years. The training aims to help children self-regulate their brainwave patterns in addition to improving program development and research.

Data Collection and Instruments

Several approaches were used throughout the data collection process to gain a comprehensive understanding of the effects of the study intervention. The main data collection tools used were the Brain Function Analysis Program software and the BrainSc EEG headband hardware. The use of this software and hardware played an important role in helping the program obtain detailed reports that included visual brain wave graphs, frequency appearance rate analysis, changes in the power of certain brain waves such as Alpha waves, assessment of brain arousal levels (indicated by the Theta/SMR ratio), and measures of physical tension and mental disturbance, in addition to self-feedback capabilities. The quantitative EEG data obtained offered an objective metric to track neurological changes from the pre-intervention stage to the post-intervention stage. The EEG signal correlation value at an average value of 0.942 ($p<0.01$) can be considered to have a high level of confidence. In addition to relying on the correlation value, to ensure that the results were reliable, a certified neuro-trainer also conducted systematic observations during the NFT session. Among the things that the trainer focuses on during the session are the visible changes in the participants' attention levels, their engagement with the training, their attempts at speech and communication, and their overall behavior patterns. All sessions conducted will be videotaped and field notes will be taken to ensure proper documentation. The quantitative data is then supported by qualitative data where semi-structured interviews are conducted with the parents. The interview structure is designed to gather the parents' perspectives on their child's progress during the intervention period. This includes matters regarding attention, speech and behavior in the home environment, their active involvement in the training regimen, and any challenges they face.

Table 1. Sample *Data Analysis in Pre-training, Sixth Month, March 2024 (One Year of Training)*

Date of Birth：28/5/2017 Problem：Premature, Inattentive, Speech Delay		
Before brain training Unable to sit for long time and listen to simple instructions	**After brain training (6 months)** Able to sit for long time and listen to simple instructions	**After brain training (until March 2024)** Able to sit for long time and take simple instructions
		



Data Analysis

The analysis results of the collected data, predominantly qualitative, sought to provide an intimate, contextual understanding of the impact of neurofeedback training on the participants. In addition, brainwave data from the Brain Function Analysis Report as show in Table 1, calculated before, during, and after the training sessions, were analyzed, as well. Among the waves considered were changes in alpha power, Theta/SMR ratio, and, of course, the impossibly significant critical wave—the one that indicates a participant may be deriving some actual benefit from the program! (I mention this wave with tongue in cheek but do take seriously the analytical strategy utilized here.) The brainwave data were dissected using an in-depth examination of various metrics EEG software calculates. Meanwhile, the qualitative data derived from the participants' and parents' observations were analyzed using thematic methods. The traits and themes emerging from these observations are staggering for both their richness and their importance. Among the participant progress traits described were significant strides in articulation and speech comprehension, developed social interaction and nearly adult emotional intelligence skills, and a reduction in challenging behaviors. Participants have become, in a profound way, able to self-regulate cognitively and emotionally. Analysis of the data appearances and triangulating the results among several ordinary and extraordinary scientific brains provides a nuanced, subtlety layered understanding of the program's power to perform all these as-yet seemingly impossible tasks.

RESULTS

This section outlines the main findings of the study and evaluation of the neurofeedback training (NFT) system. The results of this study will be presented in line with the four main research questions of the study. The first objective is to detail changes in brain wave activity. The second objective is to assess the effects on attention, speech and behaviour. The third objective assesses the role of parental involvement. The fourth and final objective is to look at the challenges faced during the intervention.

Changes in Rhythmic Brainwave Activity Post-Neurofeedback Training

The study analyzed changes in brainwave activity using the Brain Function Analysis Program, comparing pre-training assessments with post-training data collected after a minimum of six months, and for some participants, over more extended periods (up to three years).

1) Pre-Training Brainwave Profile: Prior to the NFT intervention, a consistent pattern was observed across most participants' brainwave assessments. The 3D brainwave graphs frequently indicated a predominance of 'pink' brainwaves, typically associated with elevated mental stress. Accompanying these were often 'artificial waves,' signifying excessive body movement, and an infiltration of 'light blue,' 'light green,' and 'yellow' waves into the fast wave region (beyond 18 Hz). These patterns suggested tendencies towards distraction, an inability to remain still, overthinking, and heightened emotional sensitivity. Furthermore, exceptionally high Alpha wave values and fluctuations in Alpha wave power were common, pointing to potential declines in prefrontal lobe functionality, which could manifest as wooziness, daydreaming, slow response times, and emotional volatility. Physical stress levels generally exceeded the threshold of 50, and mental distraction scores were significantly above the ideal level of 1, reflecting agitation and difficulty in information retention. Feedback ability assessments often showed low or absent Alpha, Sensorimotor Rhythm (SMR), and Low Beta activity, further corroborating profiles often associated with developmental disorders like ADHD.

2) Post-Training Brainwave Changes: Following the NFT intervention, notable shifts towards more regulated brainwave patterns were observed. After six months, a marked reduction in the atypical rapid appearance of pink brainwaves and the encroachment of other disruptive waves into the fast wave region was evident. This signified a stabilization of mental stress levels, leading to decreased excessive body movement and improved attention. Physical tension levels generally showed improved stress resilience, and while some mental distraction persisted, it was notably diminished. Alpha wave coordination between hemispheres often improved, suggesting better emotional regulation and cognitive comprehension. Brain arousal values typically indicated heightened awareness and engagement with surroundings. Participants who continued NFT for more extended periods, from one to three years, exhibited progressively greater brainwave stability. The initial improvements noted at six months were generally sustained and, in many aspects, enhanced, with a more significant decrease in brainwave patterns associated with stress and inattention. The synchronization between left and right alpha waves further improved, correlating with more stable emotional states and enhanced comprehension. Physical tension continued to decrease, and mental distraction levels, though sometimes still present, were considerably reduced from baseline, indicating improved sustained focus. Overall, the brainwave analysis suggested that the AI-driven NFT effectively facilitated a shift towards more typical and regulated neural activity, correlating with improvements in attention and a reduction in behavioral problem indicators.

Impact of Neurofeedback Training on Attention, Speech, and Behavior

The effectiveness of the NFT was further assessed through systematic researcher observations and parental reports on changes in participants' attention, speech and language abilities, and overall behavior.

1) Improvements in Attention: Across all participants, a consistent and positive trajectory in attentional capabilities was observed. Regarding eye contact and social responsiveness, initial states of absent, fleeting, or inconsistent eye contact with minimal responsiveness improved significantly. Following six months of NFT, eye contact became more frequent and sustained, and responsiveness increased. Over the longer term, typically one year and beyond, nearly all participants demonstrated consistent and appropriate eye contact and social engagement. Similarly, sitting tolerance and sustained focus saw considerable gains. Prior to NFT, most participants struggled to sit still, often requiring diversions or experiencing distress. After six months, all participants could generally sit through the 45-minute NFT sessions without external aids, an ability that remained consistent in long-term follow-ups.

In terms of prewriting and writing skills, initial significant challenges with fine motor control and eye-hand coordination gave way to gradual improvements. After six months, some participants began free handwriting, and by the one-year mark and beyond, most were capable of it, with some even writing within structured formats, reflecting enhanced precision and attention, though neatness could remain a challenge for those with co-occurring motor conditions.

2) Advancements in Speech and Language Abilities: Significant gains were documented in both receptive and expressive language domains. In receptive language, where many participants initially did not consistently follow instructions or recognize objects, improvements were seen within six months. Most demonstrated the ability to follow multi-keyword instructions, respond to multi-item requests, and identify objects and pictures. By one year, all participants generally showed consistent comprehension in these areas, including recognizing simple shapes and colors. In expressive language, participants progressed substantially from baselines where most were non-verbal or used only isolated single words. After six months, many began using two to three-word phrases, making requests, and imitating words. Echolalia, if present, tended to decrease over subsequent months, being replaced by more self-generated speech. By one year and beyond, most participants were using multi-word phrases more confidently, engaging in simple dialogues, and demonstrating clearer articulation.

3) Reduction in Behavioral Problems: Behavioral regulation showed marked improvement over the course of the NFT. For participants with ASD who initially displayed heightened sensory sensitivities, a gradual reduction in these issues was generally observed, particularly after approximately one year of consistent NFT. Among participants diagnosed with ASD and co-occurring ADHD characteristics, a decrease in hyperactivity and impulsivity was noted. After a year or more of NFT, impulsivity was often within an acceptable range, and aggressive behaviors, initially present in some, also decreased gradually, often becoming limited to situations of unfulfilled desires. Furthermore, frequent meltdowns and tantrums, which were common before NFT for most participants, significantly decreased in frequency and intensity over six months to one year, with long-term observations indicating minimal or substantially reduced occurrences, reflecting notable progress in emotional regulation.

The Role of Parental Involvement

Data gathered from parental interviews and questionnaires underscored that active and informed parental involvement was widely perceived as a significant contributing factor to the success rate of the NFT intervention. Parents who reported consistently engaging in structured home-based developmental activities, managing dietary factors—which included limiting sugar and, in some cases, using supplements like Omega-3 and Vitamin C—and maintaining regular, open communication with the staff at the brain training center, observed positive synergistic effects on their child's progress. Specifically, parents who actively sought and gained knowledge regarding neurofeedback principles, the nuances of special needs education, effective parenting strategies tailored to their child's unique challenges, and the intricate relationship between brain function and overall child development, reported feeling more empowered and capable in their supportive role. Their diligent participation in reinforcing learned skills, managing behavior in alignment with strategies discussed with the center's professionals, and cultivating a nurturing and stimulating home environment appeared to complement and amplify the direct therapeutic effects of the NFT sessions. This collaborative approach contributed to more robust and generalized improvements in their children's attention, speech development, and behavioral regulation.

Challenges Faced During Neurofeedback Training

Several challenges were identified through parental reports and researcher observations that could potentially temper the success rate of the NFT intervention. A primary practical challenge, especially for children with ASD and pronounced sensory sensitivities (affecting participants PN1, PN6, and PN7), was an initial resistance to wearing the MIT (Mighty Integration Technology) headphones. These headphones are integral to the home-based frequency and tone brain training component of the program. This resistance often translated into difficulties in completing the full 40-minute home sessions, particularly during the early phases of the intervention. However, families often managed this through strategies such as gradual desensitization or by facilitating these sessions within the more structured school environment with teacher assistance, typically resolving the issue within a few weeks. While most families successfully maintained the recommended frequency of center-based NFT sessions (12 times per month), occasional inconsistencies were noted for a couple of participants (PN3, PN6), primarily due to the demanding schedules associated with primary school.

Beyond these direct intervention-related issues, parents also highlighted broader psychosocial and educational barriers. Negative public perception and social stigma surrounding developmental disorders were reported, sometimes leading to feelings of family isolation or public embarrassment. Systemic difficulties, such as challenges in accessing suitable and affordable educational placements for their children, and a perceived shortage of adequately trained educational staff specializing in special needs, were also cited. In addition, special or unique factors from the family or caregiver were also identified. Challenges such as the demands of managing a large family size, especially when more than one child in the family has special or unique needs (as in the PN7 family). In addition, issues such as parents or caregivers having many personal responsibilities (such as the PN1 mother caring for four school-aged children). Challenges or issues such as these add complexity or challenge to implementing all aspects of the recommended training and support at home consistently. Despite various obstacles in carrying out this training, on average the findings show that the NFT program is generally effective. This is with many families showing resilience in overcoming the challenges they face. In addition, these success factors are also supported by support from other family members or the training center itself.

DISCUSSION

The findings of this study indicate that the cloud-based and AI-driven neurofeedback training (NFT) system used in this study has great potential. These positive study results can be used as an indicator for this training system to be used as an effective intervention for children with developmental disorders, especially in Malaysia.

Interpreting the Efficacy of AI-Driven Neurofeedback

The brain wave profile from pre-training was persistently in line with the typical neurophysiological patterns seen in kids with developmental disorders such as autism spectrum disorder (ASD) and attention-deficit hyperactivity disorder (ADHD). The things researcher identified happening in the brain waves included indicators of stress, inattention, and emotional dysregulation. NFT's effect was toward more controlled brain wave activity, indicating the system's ability to facilitate neural self-regulation. This finding is critical in demonstrating that the use of technology impacts basic brain function. The documented functional improvements in attention, speech, and behavior are based on these neurophysiological changes. For instance, more stable arousal levels and better coordination of alpha waves. That makes attentional control and emotional stability a lot better, creating an internal state that is a lot more conducive to learning and social engagement for the patient.

The consistency of these improvements was particularly evident in participants who underwent training for a long period of time, over a year. This confirms that ongoing neurofeedback can enhance brain adaptability and the potential for lasting change. This supports previous literature that discusses and validates the role of NFT in restoring core deficits in attention, executive function, and emotional control (Astuti et al., 2024; Jiao, 2025; Reddy, 2025). This study demonstrates positive effects of systems specifically enhanced by AI for personalization and cloud technology for accessibility.

The Interplay of Technology, Parental Involvement, and Practical Challenges

The crucial role of parental involvement emerged as a significant theme, aligning with broader research on family-centered interventions. Parents who actively engaged in home-based activities, managed diet, and maintained communication with the training center perceived a greater positive impact. This suggests that the technological intervention, while powerful, achieves optimal results when embedded within a supportive and reinforcing ecosystem. Future iterations or business models around such NFT systems could benefit from incorporating structured parental training and support modules, potentially delivered via the same cloud-based platform, thus creating a more holistic and effective service.

Addressing the challenges encountered is also vital for the successful implementation and scaling of such technological interventions. The initial resistance to home-based components (MIT headphones) due to sensory sensitivities, particularly in children with ASD, highlights the need for user-centered design in therapeutic technologies. Innovations in hardware (e.g., more comfortable, less intrusive sensors) could represent an entrepreneurial opportunity. Furthermore, systemic issues like public stigma and difficulties accessing suitable educational support, while external to the technology itself, create an environment that can either support or hinder the overall progress of a child. This points to the need for integrated solutions where technological interventions are coupled with broader community awareness and educational reforms.

Implications for Technology, Business, and Entrepreneurship in Developmental Interventions

The findings from this research, particularly the successful application of an AI-driven, cloud-based NFT system, carry significant implications across the interconnected domains of technology, business, and entrepreneurship. From a technological standpoint, this study contributes valuable evidence to the understanding of how AI and cloud computing can revolutionize therapeutic interventions. The AI's capacity for personalization, enabling real-time adaptation of protocols to individual brainwave patterns, represents a shift away from generalized approaches towards more precise and potentially more effective outcomes focus on this innovative aspect. Simultaneously, cloud technology, as demonstrated in this research, substantially enhances the scalability and accessibility of such interventions, facilitating robust data-driven assessments and opening possibilities for remote support, thereby transforming traditional service delivery models. The specific system provided by " BrainScience Academy Sdn. Bhd." serves as a tangible example of this advanced technological integration.

These technological advancements directly translate into considerable business opportunities and the potential for new service delivery paradigms. Specialized centers, akin to the one where this research took place, can leverage such sophisticated NFT technology to offer premium, evidence-based services. Given the documented prevalence of developmental disorders and the recognized limitations of some conventional methods, a substantial market for these innovative interventions exists. If the "cost-effective alternative" nature of NFT, is further validated through comprehensive economic analyses, its appeal to both private consumers and public health systems could grow significantly. Businesses in this sector might explore varied service models, such as blended approaches that combine intensive center-based training with more accessible, cloud-supported home-based programs. Moreover, the rich datasets generated by these systems are in themselves a valuable asset, enabling continuous service improvement, personalized client management, and potentially new data-analytic products.

The developmental intervention landscape is a branch of business opportunities, especially in the sectors involving EdTech and HealthTech. These business opportunities cover a variety of possibilities starting from the development and refinement of AI algorithms tailored for neurofeedback and other neuro-therapeutics. Other businesses that can be explored include the creation of innovative hardware solutions such as more comfortable EEG sensors or more engaging feedback interfaces. This can be done by incorporating gamification or virtual reality into the interface or software. In addition, this field can also focus on building a secure and user-friendly cloud platform designed to manage NFT data. Furthermore, the development of training curricula and certification programs is also needed as the system becomes more widespread. All the challenges identified such as initial hardware barriers open up room for ideas to innovate. The successful use of AI in Malaysia shows the global potential for such technologies to be adopted everywhere. This encourages entrepreneurial efforts beyond the technology hubs that are currently in use.

Limitations of the Study

While the findings are promising, certain limitations inherent in the author research should be acknowledged. The qualitative quasi-experimental design, while providing rich, in-depth data, involved a small sample size of seven children from a single center. This limits the generalizability of the findings to broader populations or different cultural contexts. The absence of a randomized control group, a common feature of quasi-experimental designs chosen for practical or ethical reasons in such settings, means that observed changes cannot be definitively attributed solely to the NFT intervention without considering other co-occurring factors (though the pre-post design strengthens the inference). Furthermore, while parental reports and researcher observations provided valuable qualitative data, they may be subject to inherent biases. Future research employing larger, multi-center randomized controlled trials would be beneficial to further substantiate these findings and explore the impact of this technology across more diverse groups.

In essence, this study provides a strong indication of the positive impact of an AI-driven, cloud-based NFT system. It highlights a pathway for technological innovation to enhance traditional therapeutic approaches, opening new avenues for business and entrepreneurial endeavors aimed at improving the lives of children with developmental disorders.

CONCLUSION AND FUTURE DIRECTIONS

This study has provided a comprehensive evaluation of an innovative, AI-driven, cloud-based neurofeedback training (NFT) system aimed at supporting children with developmental disorders in Malaysia. The findings robustly demonstrate that this technologically advanced intervention can lead to significant positive changes in brainwave self-regulation. These neurophysiological improvements were consistently correlated with functional enhancements in critical areas such as attention, speech and communication abilities, and behavioral control among the young participants.

The integration of Artificial Intelligence for personalized training protocols and cloud technology for enhanced accessibility and data management appears to be a key contributor to the observed efficacy. This research underscores the substantial potential of such sophisticated NFT systems to serve as a non-invasive, impactful, and potentially transformative tool in the landscape of developmental interventions. The study contributes to the growing body of evidence supporting neurofeedback, particularly its technologically advanced iterations, as a viable and promising approach for improving the quality of life and developmental trajectories of children facing diverse challenges. The positive outcomes observed suggest that such systems offer a significant step forward from more conventional methods, paving the way for more personalized, data-driven, and accessible therapeutic options.

Future Directions

While the present study offers encouraging insights, it also opens several avenues for future research and development, particularly at the intersection of technology, business, and specialized healthcare.

First, there is a clear need for broader validation through larger-scale, multi-center studies, ideally incorporating randomized controlled trial (RCT) designs. Such research would enhance the generalizability of the current findings across more diverse populations and varied cultural or systemic contexts, providing more definitive evidence of efficacy. Longitudinal studies extending well beyond the current observation periods are also crucial to ascertain the long-term sustainability of the improvements achieved through this AI-driven NFT and to track its impact on academic achievements, social integration, and mental health outcomes as children transition into adolescence and adulthood.

From a technological innovation perspective, future research should continue to explore the optimization of AI algorithms used in NFT. This could involve developing more sophisticated machine learning models for even finer-grained personalization of training protocols and predictive analytics for outcomes. There is also considerable scope for innovation in hardware development, focusing on creating more user-friendly, comfortable, and less obtrusive EEG sensor technologies, which could address some of the sensory challenges noted in this study. Integrating NFT with other emerging technologies, such as virtual reality (VR) or gamified interfaces, could further enhance engagement and effectiveness, particularly for younger users. These technological advancements represent significant entrepreneurial opportunities for developing next-generation therapeutic tools.

In terms of business and service delivery model innovation, future studies could conduct thorough cost-effectiveness analyses of AI-driven, cloud-based NFT systems compared to traditional interventions. Such economic evaluations are vital for informing investment decisions by both private providers and public health systems. Research into a model that combines service delivery and center-based sessions with remote monitoring ensures a more optimal future model. This can be done with the support of cloud technology and a home-based training component that will increase scalability and market penetration. In addition, the system also requires the development of standardized training and certification for practitioners, which also opens up a business opportunity in the education business.

Next, the future research agenda suggests investigating the application of this similar AI neurofeedback protocol to a variety of other developmental disorders such as learning disabilities dyslexia or dyscalculia. In addition, studies on different age groups, including adolescents, are also possible in the future. The study also suggests exploring NFT for other conditions such as OCD, anxiety, and depression, or for cognitive enhancement in healthy populations. Finally, research focusing on effective implementation strategies and policy development is also suggested for future work. This includes examining how to integrate such technological interventions into existing education and healthcare systems in a country or region. This recommendation is important because there are varying levels of public awareness, stigma and equitable access in different locations. This finding will be key to ensuring that the benefits of this technology reach all children who may need it.

Thus, the convergence of neuroscience, AI and cloud technology offers a useful tool or methodology. Future research and entrepreneurial efforts should now focus on how to maximize the potential of this convergence to foster positive development outcomes globally.

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