

The Influence of Neurolinguistic Intervention on the Development of Reading Ability in Children With Dyslexia: A Case Study Approach

Tammasse

Faculty of Cultural Sciences, Hasanuddin University, Makassar, Indonesia

Jumraini

Department of Neurology, Faculty of Medicine, Hasanuddin University, Makassar, Indonesia

Fathu Rahman

Faculty of Cultural Sciences, Hasanuddin University, Makassar, Indonesia

Abstract—Dyslexia is a learning disorder that affects reading, writing, and language comprehension skills. This condition often hinders a child's academic development despite having normal or above-average intelligence. This study focuses on the application of electroencephalography (EEG)-based neurolinguistic intervention to improve reading abilities in children with dyslexia. The research data were collected from a Special Needs School in Makassar using a case study approach to analyze changes in reading skills and neural activity before and after the intervention. The findings indicate that integrating EEG technology and neurolinguistic approaches in special education can be an effective solution for addressing dyslexia. Further studies are needed to evaluate long-term effects and expand the application of this therapy to a broader population.

Index Terms—dyslexia, neurolinguistic intervention, reading ability, theta-alpha brainwaves, electroencephalography

I. INTRODUCTION

Dyslexia is a developmental disorder that impairs an individual's ability to read, write, and spell correctly, despite having normal or above-average intelligence. As a condition affecting approximately 5-10% of the global population, dyslexia has a significant impact on the educational development and daily lives of affected children (Elliott & Grigorenko, 2024; Lachmann & Bergström, 2023; Tammasse et al., 2019). Understanding dyslexia has become increasingly important, especially with advancements in neuroscience that allow for the identification of brain mechanisms involved in the condition.

Children with dyslexia often face social stigma and struggle to adapt to educational environments dominated by conventional teaching methods. This situation is exacerbated by the lack of evidence-based intervention approaches to help these children overcome their challenges (Wilmot et al., 2023; Beckett, 2024; Tammasse et al., 2022). In this context, neurolinguistic-based therapy offers an innovative and scientifically grounded approach.

Neurolinguistics is a branch of science that examines the relationship between the brain, language, and behavior. Through technologies such as electroencephalography (EEG), researchers can map brain activity related to reading processes and identify areas that are impaired in children with dyslexia (Alduais et al., 2023; Arslanovna, 2024; Rahman et al., 2019). This study aims to explore the potential of neurolinguistic therapy, particularly brainwave therapy, in improving reading skills.

Brainwave therapy involves stimulating neural activity through techniques designed to enhance connectivity and synchronization between brain regions relevant to language processing. This approach has shown promising results in improving cognitive and linguistic abilities across various populations, including children with learning disabilities. However, further research is needed to specifically assess its effectiveness in children with dyslexia.

This study focuses on the use of EEG-based brainwave therapy to modulate neural activity and improve reading skills in children suspected of having dyslexia at SLB Negeri 2 Makassar. Using a case study approach, this research provides insights into the underlying neurolinguistic mechanisms and offers practical guidance for implementing this therapy in educational settings.

In an effort to address the urgent need for effective solutions, this research not only contributes to the theoretical understanding of dyslexia but also opens opportunities for the development of better intervention strategies. Through this approach, it is hoped that children with dyslexia can more easily adapt and reach their full potential in both academic and everyday life.

This research is to examine 1) the application of neurolinguistic intervention based on electroencephalography (EEG) to improve reading skills in children with dyslexia, and 2) to analyze changes in reading ability and neural activity before and after the intervention, focusing on enhancing the synchronization of theta and alpha brainwaves, which are important for language processing. The research explores the effectiveness of EEG-based therapy in improving reading accuracy and comprehension, while also investigating neural adaptations that support these improvements.

II. LITERATURE REVIEW

The theoretical framework for this research is based on several key concepts, including neuroplasticity theory, the dual-route model of reading processing, neurolinguistic approaches in education, and brainwave therapy. These concepts provide a foundation for understanding the neural mechanisms underlying language processing and the potential for intervention in children with dyslexia.

A. Neuroplasticity Theory

Neuroplasticity refers to the brain's ability to adapt and reorganize itself in response to experiences and learning. In children with dyslexia, neuroplasticity is central to correcting disrupted neural pathways through targeted interventions, such as EEG-based brainwave therapy (Öner, 2024; Zeine et al., 2024). This theory offers scientific support for the idea that modifying neural activity can enhance reading abilities. Studies have shown that neuroplasticity enables the brain to form new connections and strengthen existing ones, facilitating improvements in cognitive functions, including reading (Norsiah & Amira, 2017; Jumiati & Widiastuty, 2024; Voss et al., 2017). This adaptability provides a promising approach for overcoming the difficulties faced by dyslexic children in learning to read.

B. Dual-Route Model in Reading Processing

The dual-route model posits that reading involves two primary routes: the phonological route and the visual route. The phonological route is associated with recognizing letter sounds and words, while the visual route focuses on recognizing whole words directly. Children with dyslexia often experience disruptions in the phonological route, which can be remediated through targeted exercises and neural stimulation. According to research, Coltheart (2006), strengthening the phonological pathway through specific interventions can significantly improve reading skills in dyslexic children. This model supports the idea that improving neural processing in both routes is essential for enhancing reading ability.

C. Neurolinguistic Approaches

Neurolinguistics combines the fields of linguistics and neuroscience to understand how the brain processes language. By utilizing technologies like EEG, neurolinguistic approaches investigate how patterns of brain activity influence language acquisition and comprehension. In the context of reading, this approach examines how different regions of the brain interact during reading tasks and how these interactions can be modified to improve linguistic abilities. According to Friederici (2011), neurolinguistics offers valuable insights into the cognitive processes involved in language learning, making it a powerful tool for developing interventions aimed at improving language skills in children with learning disabilities.

D. Brainwave Therapy

Brainwave therapy involves modulating neural activity by stimulating specific brainwave frequencies, such as theta and alpha waves. These brainwaves are crucial for attention, information processing, and learning. Previous research has demonstrated that brainwave therapy can improve cognitive and linguistic abilities by enhancing the brain's ability to focus and process information more efficiently (Hammond, 2005; Milbocker et al., 2024; Cidral-Filho et al., 2024). In the context of dyslexia, stimulating neural synchronization can help to reorganize brain networks and promote better reading and comprehension skills. Studies by Norsiah and Amira (2017) have shown that brainwave therapy, especially when combined with other interventions, can lead to significant improvements in children's cognitive performance, including language processing.

In conclusion, this theoretical framework integrates neuroplasticity, the dual-route model of reading, neurolinguistic approaches, and brainwave therapy to provide a comprehensive understanding of how dyslexia can be addressed. Each of these theories contributes to the understanding of how targeted interventions can modify brain activity to improve reading and language abilities in children with dyslexia.

III. RESEARCH METHODS

A. Research Design

This study employs a case study design, allowing for an in-depth exploration of the effects of neurolinguistic intervention on children with dyslexia. This approach provides flexibility in evaluating various aspects of individual participants, including changes in reading abilities, morphological processing, and neural activity patterns. This design is suitable for understanding the mechanisms of change resulting from the therapy while offering a detailed context that supports the generalization of findings on a broader scale.

As part of the research design, data collection is conducted in three stages: before the intervention (baseline), during the intervention (monitoring), and after the intervention (post-test). These stages are designed to evaluate the short-term effectiveness of brainwave therapy and provide comprehensive empirical data.

B. Participants

A total of 30 children diagnosed with dyslexia, aged 11-14 years, were recruited from SLB Negeri 2 Makassar. These children were selected through a rigorous selection process based on neurological and psychological assessments conducted by an expert team. Additionally, participants come from diverse socioeconomic backgrounds to ensure the research findings have broad relevance. All participants and their guardians provided written consent before participating in the study. As part of ethical research practices, the research team also provided detailed explanations of the intervention procedures, research objectives, and potential benefits or risks to all participants.

C. Intervention Procedure

The intervention program lasted for eight weeks, with two sessions per week. Each session lasted one hour, during which children underwent brainwave therapy using an EEG device designed to monitor and modulate neural activity. The therapy focused on synchronizing theta and alpha waves, which have been shown to play a role in language processing and cognitive learning.

Each session began with a brief evaluation to identify the specific needs of each child. During therapy, children engaged in various language-based tasks, such as reading short texts, naming words, and forming words from syllables. These exercises were designed to simultaneously enhance phonological and morphological processing.

D. Research Instruments

This study utilized several tools to measure various cognitive and language aspects of the participants. First, Electroencephalography (EEG) was used to measure neural activity before and after the intervention. EEG data were analyzed to assess changes in relevant brainwave synchronization, providing insights into the intervention's impact on brain function.

Additionally, a Standardized Reading Test was used to assess improvements in reading ability, including accuracy, speed, and reading comprehension. This test provided an overview of the extent to which participants improved their reading skills. Finally, a Morphological Processing Task was designed to measure children's ability to understand word structures, including prefixes, suffixes, and root words—essential skills in language acquisition. These three instruments worked together to provide comprehensive data on participants' cognitive and linguistic development following the intervention.

E. Data Analysis

Quantitative data were analyzed using the latest version of SPSS software. Statistical analysis was conducted using a paired t-test to determine the significance of differences between pre- and post-intervention scores. This approach allowed for measuring significant changes in reading ability and neural activity among participants. The t-test was chosen because it is appropriate for dependent data sets, such as baseline and post-test results.

EEG data were analyzed using spectral analysis to identify neural activity patterns during therapy. Spectral analysis was conducted to evaluate the amplitude and frequency of theta and alpha waves, which are directly related to cognitive abilities, including language learning. Changes in amplitude indicated improvements in relevant neural connectivity.

In addition to quantitative analysis, this study also employed a qualitative approach through in-depth interviews with teachers and parents to understand how behavioral changes during therapy influenced children's daily learning experiences. These data provided additional insights that could not be directly measured through quantitative instruments. A summary of the in-depth interviews with teachers and parents is as follows:

TABLE 1
SUMMARY OF INTERVIEW RESULTS WITH PARENTS AND TEACHERS

No	Questions	Summary of Responses	Response by Teachers (T) or Parents (P)	
			(T)	(P)
1	Since when was this child suspected of having dyslexia?	We have observed these symptoms since school age.		✓
		After consulting with a doctor, we were advised to enroll the child in a special needs school.		✓
		Based on a medical certificate from the doctor.	✓	
2	What actions were taken after discovering that this child was suspected of having dyslexia?	Panic and ask why this happened.		✓
		Providing appropriate learning interventions	✓	
		At first, we didn't know that this was a learning disorder in children.		✓
3	What have you observed about a child suspected of having dyslexia in daily life?	Lack of confidence in social interactions and often complains.		✓
		We didn't know that he/she was suspected of having dyslexia.		✓
		Making efforts to adapt.	✓	
4	As a parent or teacher, what actions do you take to support children suspected of having dyslexia?	We didn't know what to do.		✓
		Discussing with parents to provide support and motivation to the child to stay enthusiastic about learning.	✓	
		Helping wisely to overcome difficulties in reading.	✓	
5	With this condition, what are your expectations?	Parents provide support and trust the school to assist the child in learning.		✓
		Teachers always help the child to stay motivated and learn well.	✓	
		I hope for continuous improvement.	✓	✓

The use of this mixed-method approach aims to provide a more comprehensive picture of the effects of the intervention. Qualitative data help validate quantitative results, while quantitative data provide strong empirical evidence to support the effectiveness of the therapy. The combination of both methods results in a comprehensive analysis that can serve as a foundation for future interventions.

Statistical analysis results indicate that the score changes between the baseline and post-test are significant at a $p < 0.05$ level. This finding reinforces the conclusion that brainwave therapy has a positive impact on reading skills and neural activity in children with dyslexia. EEG data support this result by showing a significant increase in theta and alpha wave synchronization in relevant brain areas.

This data analysis approach provides a strong foundation for understanding how neurolinguistic interventions can be effectively applied in special education contexts. With a holistic methodology, this study makes an important contribution to the development of evidence-based teaching strategies for children with dyslexia.

IV. RESULTS

A. Improvement in Reading Ability

The results indicate a significant improvement in reading accuracy, reading speed, and reading comprehension. The average post-intervention score increased by 10.36% to 25% compared to pre-intervention levels. Children were able to read faster and more accurately while demonstrating better comprehension of the texts they read. This suggests that the therapy effectively enhanced neural connectivity that supports reading ability.

B. Neurological Adaptation

EEG analysis revealed an increase in theta and alpha wave synchronization in relevant brain areas, such as the angular gyrus and prefrontal cortex, which contribute to improved reading skills. Observed neural activity showed significant improvement in both phonological and visual pathways, which are key components in the reading process. Better synchronization between these areas allowed children with dyslexia to process information more efficiently.

C. Morphological Processing

Participants demonstrated significant improvements in morphological awareness tasks. Before the intervention, children often struggled to recognize and understand word structures, particularly words with prefixes or suffixes. After the intervention, they were able to identify morphological patterns more effectively, directly contributing to their improved reading ability. For instance, children could break down complex words into smaller components and process them more efficiently.

This improvement was observed not only in test tasks but also in daily contexts. Teachers and parents reported that children showed a greater interest in reading and were able to comprehend texts better in both formal and informal learning situations. This confirms that EEG-based interventions provide not only short-term benefits but also long-term positive impacts on learning.

Additionally, the study results indicate that children's ability to integrate phonological and morphological information improved significantly. This integration is crucial for word decoding and text comprehension, two essential aspects of reading. With this improvement, children demonstrated the ability to read a wider range of texts with higher levels of difficulty.

D. Therapy Participant Analysis

All participants (a total of 5 children) were confirmed to exhibit suspected dyslexia with specific characteristics. Linguistic assessments had been conducted, along with neurolinguistic testing using EEG. Below is an example of an EEG record:

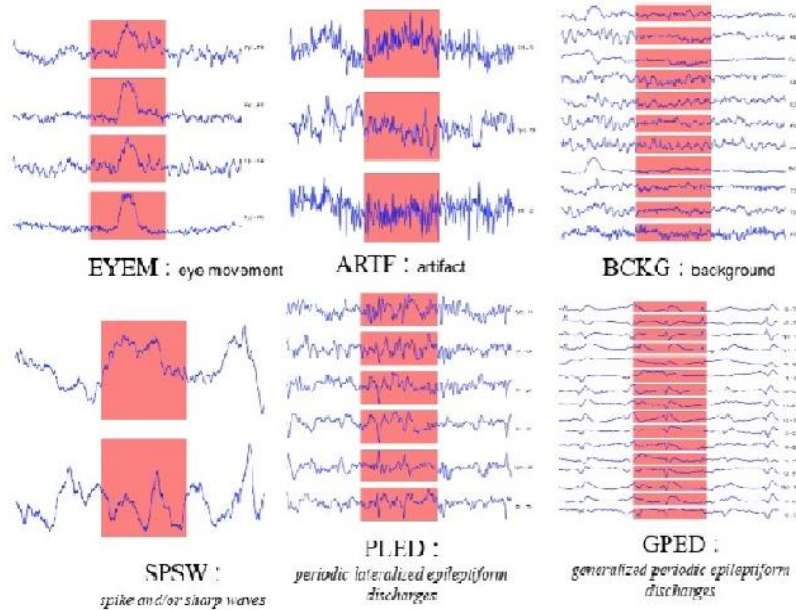


Figure 1. An EEG Record

Source: <https://www.its.ac.id/news/2023/09/06>

EEG recording data showing various human movements and the resulting sounds (top) and signals indicating brain disturbances (bottom).

Children suspected of having dyslexia also experience difficulties in writing words, such as inversion, mirror writing, upside-down letters, and so on. Look at the following handwriting transcription.

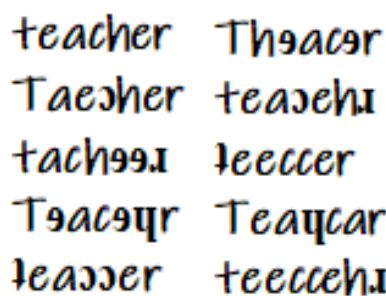


Figure 2. Handwriting Transcription

In the case of testing children suspected of having dyslexia, the EEG therapy concept shows an improvement in abilities. Observe the achievement results below:

TABLE 2
EEG THERAPY CONCEPT

No	Tested Identify	EEG Therapy		increase value
		Before	After	
1	Mr.01.G.13	74.5	83.7	9.2
2	Am.02.B.14	81.4	89.2	7.8
3	Bd.03.B.11	71.3	81.4	10.1
4	Rn.04.G.14	79.1	84.6	5.5
5	Wd.05.G.14	82.4	90.1	7.7
		388.7 (77.74)	429 (85.8)	Σ40.3

Thus, the value of 40.3 divided by 5 tested equals 8.06. This means that an average improvement of 8.06 was achieved using EEG therapy. In other words, this EEG therapy led to a 10.36% increase. This achievement can certainly be further enhanced periodically by applying various methods.

V. DISCUSSION

The findings of this study provide strong evidence of the effectiveness of neurolinguistic-based brainwave therapy in improving reading skills in children with dyslexia. These results align with the theory of neuroplasticity, which states that the brain has the ability to adapt through guided experiences.

This intervention offers new insights into the importance of interdisciplinary understanding between neurolinguistics and education. The integration of EEG-based therapy could serve as a foundation for developing more personalized and evidence-based teaching methods. However, this study has limitations, such as a small sample size and a relatively short intervention duration. Further research is needed to examine the long-term effects and to assess the application of this intervention to a broader population.

Beyond these limitations, there are significant opportunities to explore the effectiveness of this therapy in different age groups, such as adolescents or adults with dyslexia. Future studies could also integrate other therapeutic methods, such as phonological training or technology-based interventions, to create a more holistic approach.

The findings of this study also contribute significantly to existing literature by demonstrating how neurolinguistic-based therapy impacts specific neural activities, particularly in brain areas responsible for language processing. By utilizing EEG technology, researchers can directly map the changes that occur, providing quantitative evidence to support the effectiveness of the intervention.

From an educational perspective, these findings highlight the importance of evidence-based interventions in supporting children with special needs. By training teachers and educators on how to utilize EEG technology and neurolinguistic principles, schools can create a more inclusive learning environment.

Additionally, this approach can be adapted to various cultural and linguistic contexts, making it a global solution for dyslexia. The development of portable EEG-based devices could also facilitate access to and implementation of this therapy, particularly in resource-limited areas.

In the long run, collaboration between researchers, educational practitioners, and policymakers is crucial to ensuring that this innovative intervention method can be widely applied. Investing in further research and technological development will help improve the quality of life for children with dyslexia.

The findings of this study are not only relevant to the academic community but also have broad practical implications for parents, teachers, and policymakers. With a comprehensive approach, neurolinguistic-based brainwave therapy could become one of the primary solutions for addressing dyslexia on a global scale.

VI. CONCLUSION

This study reveals the significant potential of the neurolinguistic approach in addressing dyslexia challenges. EEG-based brainwave therapy has been proven to enhance reading skills and morphological processing in children with dyslexia. These findings strongly support the application of neurolinguistic technology in educational contexts, particularly for children with special learning needs. This approach not only offers short-term benefits but also has long-term positive implications for cognitive and academic development.

Beyond the immediate benefits in reading skills, this study demonstrates how EEG-based interventions can modulate relevant neural activity. Changes in theta and alpha wave synchronization provide empirical evidence that this therapy works at a neurophysiological level, repairing previously disrupted neural pathways in children with dyslexia. This opens opportunities for further research exploring the mechanisms of neuroplasticity in greater depth.

However, this study also highlights the need for further development to expand the scope and scale of intervention. By involving more participants from diverse backgrounds and testing the effects of this therapy over longer durations, the findings can further strengthen the scientific basis for its widespread application. Collaboration among researchers, practitioners, and policymakers is key to realizing the full potential of this neurolinguistic approach in addressing dyslexia globally.

REFERENCES

- [1] Alduais, A., Alduais, A., Amidfar, M., & Alizadeh Incheh, S. (2023). Neurolinguistics: A scientometric review. *Cogent Arts & Humanities*, 10(1), 1-40.
- [2] Arslanovna, K. D. (2024). Importance of Neurolinguistics as a Science. *Pedagogical Cluster-Journal of Pedagogical Developments*, 2(4), 264-269.
- [3] Beckett, J. (2024). Dyslexia: 'The right diagnosis... The wrong treatment'. *Support for Learning*, 39(2), 71-84.
- [4] Cidral-Filho, F. J., Porter, P., & Donatello, N. N. (2024). An Integrative Review of Brainwave Entrainment Benefits for Human Health. *Applied Psychophysiology and Biofeedback*, 49(3), 331-337.
- [5] Elliott, J. G., & Grigorenko, E. L. (2024). Dyslexia in the twenty-first century: A commentary on the IDA definition of dyslexia. *Annals of dyslexia*, 74(3), 363-377.
- [6] Jumiaty, N., & Widiastuty, H. (2024, December). Exploring Neuroplasticity in Adult Language Learning: A Literature Review.

In International Seminar (Vol. 6, pp. 744-752).

- [7] Lachmann, T., & Bergström, K. (2023). The multiple-level framework of developmental dyslexia: the long trace from a neurodevelopmental deficit to an impaired cultural technique. *Journal of Cultural Cognitive Science*, 7(2), 71-93.
- [8] Milbocker, K. A., Smith, I. F., & Klintsova, A. Y. (2024). Maintaining a dynamic brain: a review of empirical findings describing the roles of exercise, learning, and environmental enrichment in neuroplasticity from 2017-2023. *Brain Plasticity*, 9(1-2), 75-95.
- [9] Norsiah, F., & Amira, N. A. (2017). The effects of neurotherapy (NFT) using Ayatul Kursi as stimulus on memory performance. *Journal of Islamic, Social, Economics and Development*, 2(4), 22-31.
- [10] Öner, K. (2024). The Role and Importance of Neuroplasticity in Developing Psychological Resilience. *Journal of Education and Research in Nursing*, 21(3), 250-253.
- [11] Rahman, F., & Amir, P., Tammasse. (2019). Trends in Reading Literary Fiction in Print and Cyber Media by Undergraduate Students of Hasanuddin University. *International Journal of Education and Practice*, 7(2), 66-77.
- [12] Tammasse, Jumraini, Rahman, F. (2019). Some difficulties in verbalizing English words and phrases: A case study of suspected dyslexic children. *Asian EFL Journal Research Articles*, 6(26), 73-85.
- [13] Tammasse, T., Tammasse, J., Utami, I. F., & Rahman, F. F. (2022). The Effectiveness of Using Kinect-Based Dyslexia Therapy in Improving Reading Ability in Dyslexic Children: A Linguistic Study. *ELS Journal on Interdisciplinary Studies in Humanities*, 5(3), 515-523.
- [14] Voss, P., Thomas, M. E., Cisneros-Franco, J. M., & de Villers-Sidani, É. (2017). Dynamic brains and the changing rules of neuroplasticity: implications for learning and recovery. *Frontiers in psychology*, 8(274878), 1-13. <https://doi.org/10.3389/fpsyg.2017.01980>
- [15] Wilmot, A., Pizzey, H., Leitão, S., Hasking, P., & Boyes, M. (2023). Growing up with dyslexia: Child and parent perspectives on school struggles, self-esteem, and mental health. *Dyslexia*, 29(1), 40-54.
- [16] Zeine, F., Jafari, N., Nami, M., & Blum, K. (2024). Awareness Integration Theory a Psychological and Genetic Path to Self-Directed Neuroplasticity. *Health Sciences Review*, 11(100169), 1-6. <https://doi.org/10.1016/j.hsr.2024.100169>

Tammasse is a chairman of Indonesian Post grade studies at Hasanuddin University. His research interest is Neurolinguistic and Psycholinguistic.

Jumraini is a Head of the Department of Neurology, Faculty of Medicine, Hasanuddin University, she is also a neurologist.

Fathu Rahman is a professor specializing in literature and culture at the Faculty of Cultural Sciences, Hasanuddin University, Indonesia. He is actively involved in research and publication, having written 35 articles over the years in several reputable international journals indexed by Scopus. Despite his numerous responsibilities, he remains dedicated to mentoring Ph.D. students in the fields of Literature, Linguistics, and English Language Teaching.