Neuroplasticity-Based Reading Interventions in Developmental Dyslexia

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Abstract

This literature review aims to explore the impact of neuroplasticity-based intervention on children with developmental dyslexia by examining existing research on interventions. Relevant studies were selected from academic journals and analyzed to assess different approaches, their effectiveness, and developmental factors. The review found that neuroplasticity-based intervention is specifically targeted through repeated practice that causes change in the brain. This suggests that neuroplasticity-based intervention is more beneficial as compared to traditional reading intervention as it can promote growth in reading skills among children when early intervention is taken. This also highlights the need for future research on whether neuroplasticity-based interventions can have sustainable long-term benefits for children throughout life.

Introduction

Developmental dyslexia (DDx) is a neurodevelopmental disorder that affects language-based skills, particularly reading, in 5-17% of children (International Dyslexia Association, 2014). This learning disorder is a result of multiple influences, including genetic factors, neurological factors including abnormal structure and function of the left hemisphere networks involved in reading and language, and environmental factors (Peterson & Pennington, 2015). In children with DDx, their brains are never fully capable of reading in the typical way due to difficulty in phonological awareness and grapheme-phoneme correspondence. While reading may require more effort from an individual with DDx, the brain can be trained to allow them to read more efficiently. This can be done by changing and adapting the structure and function of regions of the brain that face reading challenges (Shaywitz et al., 2001).

(Estévez Pérez, n.d.; Perdue et al.) ...Neuroplasticity, which is the brain's ability to adapt and change, is a process that occurs throughout life as a result of learning and experiences. This process causes the brain to react and adapt by building new connections (structural plasticity) and strengthening existing synapses in the brain (synaptic plasticity). By utilizing the brain's natural ability to change, children are able to improve reading skills by training phonological awareness and grapheme-phoneme correspondence. This can be utilized during specific critical periods where the brain is highly receptive to information. Additionally, children are able to train executive function and attention in order to have the key skills needed to learn.

Experts within the field of neurobiology have been investigating the potential impact of neuroplasticity on language skills. Current research is exploring the mechanisms and applications of neuroplasticity. This raises the consideration of the use of neuroplasticity in interventions to improve reading in children with developmental dyslexia because it may accelerate learning and the ability to retain new information to adapt better. By utilizing early intervention, we are able to better set up children for success while the young brain is plastic and is consequently able to quickly recover from injury and learn new skills (Johnston et al., 2009).

This paper will review scientific literature-based interventions in DDx that use neuroplasticity to facilitate skill training and strengthen neuron synaptic connections in reading. For this study, I reviewed seven scientific papers retrieved from the database Google Scholar to examine the efficacy of these interventions in improving reading.

Neuroplasticity-Based Intervention Approaches

Interventions, in the context of dyslexia, are targeted and intensive instruction intended to help children develop reading skills, including comprehension, vocabulary, and fluency, through individualized instruction, progress monitoring, and guidance. While different approaches target

different aspects of reading, the most significant improvements are seen in interventions that focus on foundational skills such as phonological awareness and decoding.

Phonological training programs, when delivered in an intensive and computerized manner, appear to be most effective. (Forné et al., 2022) found that students with reading difficulties following intensive computerized remediation (RDIR) showed a significant increase in reading performance through the phonics-based training that improves accuracy, speed, comprehension, and spelling. This approach is similar to a neuropsychological intervention program by Dorofeeva (2023) in which the structure and timing of neuroplasticity processes were used to achieve significant progress in enhancing cognitive skills and functions for reading. This was accomplished through training sessions with daily, repeated exercises to maximize the potential of the neuroplasticity processes to ensure long term benefits.

(Ahmad et al., 2012)...Integrating multimedia and multisensory interventions has also proven to be useful by enhancing engagement and motivation. Interactive multimedia application, which consists of a phonics reading technique and a multisensory approach, provides students with the necessary tools and support to overcome reading difficulty. Phonic reading helps children break down words into sounds using grapheme-phoneme correspondence, while the multisensory approach allows for visual, auditory, and kinesthetic stimulation to encourage interactivity and increase focus. Multimedia applications allow children to remain involved through the learning process, which can be an added benefit for children struggling with traditional intervention methods.

(Hornickel et al., 2012)...Reading skills are also linked to auditory processing, as one study found that utilizing assistive listening devices such as classroom FM systems help improve inconsistent auditory processing in children with dyslexia. In the study, FM systems were found

to improve auditory processing, which is linked to improvements in reading and phonological awareness. This highlights the importance of utilizing intervention that focuses on more than direct literary skills in order to enhance the brain's reading ability.

These interventions address the origin of this disorder, which is a network of regions in the left hemisphere of the brain. Specifically, these regions include the “occipito-temporal, temporo-parietal, and inferior frontal cortices” (International Dyslexia Association, 2015). By tackling these areas through intervention that is based in neuroplasticity, the brain is able to gradually reorganize itself to develop reading skills.

Efficacy of Interventions

These interventions were all able to show a significant improvement in reading skills, specifically in areas of fluency, decoding, and comprehension after each respective intervention. The effects of intervention can prove to be long-term if early intervention is taken to reorganize and strengthen weak connections, improving reading and executive function at an early age (Sabeghi et al., 2022).

The figure below presents two models of the brain. The control group, pictured on the left, indicates a greater amount of adaptation, while the dyslexia group, pictured on the right, indicates a lesser amount of adaptation (du Plessis, 2025).

This deficit in neural adaptation among sensory inputs in the dyslexia group can be argued to hinder the process of intervention rather than support it. However, neuroplasticity-based intervention trains specific regions of the brain using repetition and stimulates various sensory processes that increase neural adaptation. The argument also exists that interventions do not necessarily need to be based in neuroplasticity in order to successfully improve language-based skills. Yet, neuroplasticity-based intervention helps to reshape the brain

with developmental dyslexia while traditional remediation forces children to work around their brain differences rather than addressing the underlying issue.

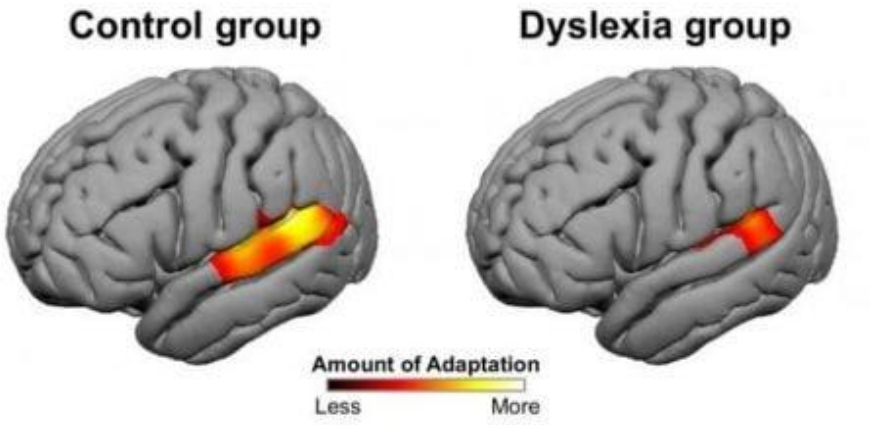

Figure 1. The image illustrates the difference in amount of adaptation in the control group as compared to the dyslexia group. *(du Plessis, 2025)*

(Dorofeeva, 2023)...Neuroplasticity-based intervention is proven to be highly efficient and can retain long-term effects by optimizing timing. One study examining the relationship between timing and neuroplasticity processes found that having brief training sessions followed by a 40-minute break was highly beneficial to helping the child retain information. The brief sessions resulted in a high level of CERB phosphorylation, which helps to activate genes needed for protein synthesis, which supports primary memory consolidation by strengthening and maintaining synapses. This encourages stable long-term memory and neuroplasticity. Additionally, a variety of tasks were used to target different types of processing in order to most effectively stimulate the regions of the brain needed to improve reading skill.

Developmental Considerations

(Colenbrander et al., n.d.)...Reading and writing abilities are essential skills necessary for every individual. Developmental dyslexia hinders these skills, causing “an inability to read accurately and fluently," which can lead to negative consequences in school, career opportunities, and overall health and well-being. This gap between the dyslexic individual and

peers will continue to widen over time, making it more difficult for the individual to catch up. In order to prevent this, it is crucial that reading difficulties are identified and addressed at an early age within schools. It is also important to note that support should continue even after the intervention, through follow-ups and progress tracking in order to ensure gains are not lost.

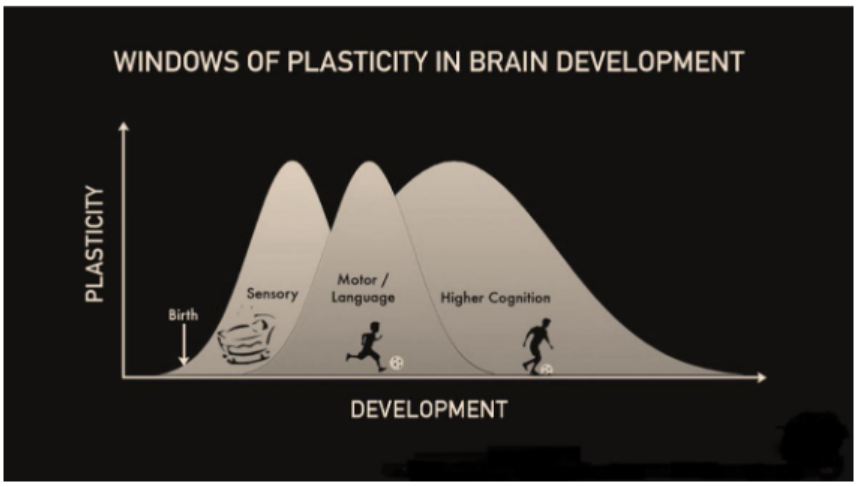

Figure 2. The diagram depicts the periods of brain plasticity through development *(Ayşegül Avşar Tuncay & Aydın Kızılaslan, 2023)*

Limitations

(Perdue et al., 2021)...When it comes to intervention, there is no single intervention that can be applicable to all. While taking intervention can influence change in brain activity and structure and boost reading skills, results vary between individuals. Certain programs can cause more benefits than others for some individuals, and even a combination of intervention can be worthwhile.

(Colenbrander et al., n.d.)...Across the studies shown, there is more than likely a variability in outcomes among the children. This is simply due to the fact that children with developmental dyslexia will have reading disabilities at a range of severity, affecting how impactful intervention is. Additionally, interventions may not be the most accessible nor affordable, especially later in schooling. There is also a lack of research as to how interventions

will be beneficial long-term after early intervention as it requires ongoing and possibly long-term support in order to remain effective.

It is also important to note the variability among methodologies in delivery, intensity and duration, and targeted skills of the shown studies demonstrating neuroplasticity-based interventions. Furthermore, publication bias should be taken into account as interventions with negative or inconclusive results tend not to have been published, contrasting with the reviewed sources in this review which all found to have concluded with positive or significant outcomes.

Future Direction

In the future, it would be favorable to utilize emerging technologies such as artificial intelligence and personalized learning platforms to create neuroplasticity-based interventions. Taking advantage of this will help to maintain relevance and an edge in modern day society, as well as to maximize resources. Furthermore, implementing more longitudinal and long-term studies would prove to be beneficial in order to truly experiment with the long-term benefits of these interventions. Further research should be conducted on whether neuroplasticity-based intervention offers a definitive advantage over traditional intervention in order to grasp a full understanding. Finally, by potentially using neuroplasticity-based interventions in school systems, implemented by school policies, a wider demographic of children would be able to access tools that are vital to their success.

Conclusion

Reading is one of the most vital factors of human development. Failing to take necessary measures to improve reading skills in children with dyslexia at an early age can severely affect children in their personal lives, career goals, and academics. Utilizing neuroplasticity-based

intervention allows for specific areas of the brain to be targeted through repeated practice that causes the brain to change.

Neuroplasticity-based interventions can prove to be efficient when measures are taken at an early age, and a variety of interventions that stimulate regions of the brain and sensory processes are utilized. Parents, educators, clinicians, and policy-makers are able to make a difference by taking advantage of tools that will promote reading in the lives of children struggling with developmental dyslexia, so that all kids can have the resources they need to succeed.

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