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Sequential Memory in Developmental Dyslexia: Toward an Integrative Cognitive Framework

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Abstract

Developmental dyslexia refers to an unexpected difficulty with reading experienced by children and adults who otherwise possess the intellectual ability, motivation, and educational opportunities necessary to develop accurate and fluent reading skills. Traditionally, phonological processing deficits have been regarded as the primary cognitive mechanism underlying dyslexia. However, emerging evidence suggests that impairments in sequential memory and serial-order processing may also contribute substantially to reading problems. Sequential memory, the ability to remember information in the order in which it was presented, is crucial for reading and spelling, as both depend on the accurate sequencing of letters and sounds. Consequently, deficits in sequential memory may contribute to difficulties in literacy development and other daily cognitive activities among individuals with dyslexia. This article examines the role of sequential memory in developmental dyslexia. It also traces the historical development of dyslexia research from early descriptions of "word blindness" to contemporary multidimensional neuro developmental frameworks. Drawing upon evidence from cognitive psychology, neuroscience, and educational research, the article proposes that sequential memory may function as an important integrative mechanism linking perceptual, cognitive, linguistic, and learning processes. Conceptualising dyslexia within a broader framework of sequential memory dysfunction may help refine existing theoretical models and support the development of more targeted cognitive and educational interventions to improve academic performance and long-term functional outcomes.

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INTRODUCTION

Developmental dyslexia is a specific learning disorder marked by persistent difficulties in accurate and fluent word recognition, spelling, and decoding that occur despite normal intelligence, appropriate educational opportunities, adequate motivation, and intact sensory functioning (American Psychiatric Association, 2013). These reading difficulties occur in children and adults who otherwise possess the cognitive abilities and learning experiences typically required to develop accurate and fluent reading skills (Shaywitz, 2003). It is among the most prevalent learning disorders affecting literacy acquisition and academic performance across the lifespan (Snowling, 2000). Individuals with dyslexia commonly demonstrate impairments in phonological processing, reading fluency, verbal working memory, and orthographic processing, which can adversely affect reading comprehension, written language skills, and broader educational achievement (Vellutino et al., 2004). Although dyslexia was historically considered primarily as a reading disorder, contemporary research increasingly conceptualises it as a multidimensional neurodevelopmental condition arising from complex interactions among cognitive, linguistic, neural, genetic, and environmental factors (Pennington, 2006; Peterson & Pennington, 2015). The disorder is typically identified during the early school years when formal reading instruction begins; however, its cognitive, academic, and psychosocial consequences frequently persist into adolescence and adulthood (Shaywitz, 2003).

Origin Prevalence & Etiology

The scientific understanding of dyslexia emerged gradually through clinical observations made during the late nineteenth and early twentieth centuries. One of the earliest documented descriptions is often attributed to Adolf Kussmaul (1877), a German neurologist who used the term *"word blindness"* for individuals who could see normally but were unable to recognise written words. In 1896, W.P Morgan gave the first acknowledged clinical description of developmental dyslexia. He published a case report in the British Medical Journal describing a 14-year-old boy named "Percy," who was bright, intelligent, and capable in conversation, yet showed severe difficulty learning to read. Morgan referred to the condition as *"congenital word blindness."* A major advancement in the study of developmental dyslexia occurred through the work of Samuel Torrey Orton in the 1920s and 1930s. He proposed that dyslexia reflected atypical cerebral dominance and difficulties in integrating visual and linguistic information; these observations and theories significantly influenced subsequent research and educational approaches to reading disabilities. Although some aspects of his theory were later revised, Orton's work was highly influential because it framed dyslexia as a neurodevelopmental condition rather than a problem of motivation or intelligence. He also emphasised educational intervention and multidisciplinary approaches to treatment. By the late twentieth century, advances in cognitive psychology and neuroscience transformed the modern understanding of dyslexia, conceptualising dyslexia as a multifactorial neurodevelopmental disorder involving genetic, cognitive, neural, and environmental influences. This evolution reflects the progression of scientific understanding from early descriptions of "word blindness" to modern multidimensional theories integrating cognitive psychology, neuroscience, and education.

Affecting approximately 5–10% of the population, dyslexia remains one of the most extensively studied learning disorders in cognitive psychology and educational neuroscience (Peterson & Pennington, 2012; Shaywitz, 2003). Although dyslexia is most visibly expressed as a reading impairment, contemporary research increasingly suggests that its underlying mechanisms extend beyond literacy-specific deficits and involve broader cognitive and neurodevelopmental processes. Substantial empirical evidence supports the importance of phonological impairments in dyslexia (Ramus, Rosen, Dakin, Day, Castellote, White, & Frith, 2003). However, the phonological account alone has proven insufficient to explain the heterogeneity of dyslexia or the broad range of associated cognitive difficulties observed across individuals. Dyslexia occurs across cultures, socioeconomic groups, and languages, suggesting that it reflects a universal neurocognitive vulnerability rather than a culturally specific educational phenomenon. Although dyslexia has historically been diagnosed more frequently in males than in females, population-based studies indicate that sex differences may be smaller than previously assumed and may partly reflect referral bias (Shaywitz, Shaywitz, Fletcher, and Escobar, 1990). Cross-linguistic research further suggests that the manifestation of dyslexia differs across orthographies, with transparent languages often showing relatively preserved reading accuracy but persistent deficits in fluency and reading speed (Ziegler & Goswami, 2005). Dyslexia is widely regarded as a multifactorial neurodevelopmental disorder arising from the interaction of genetic, neurobiological, cognitive, and environmental influences. Family and twin studies demonstrate substantial heritability, indicating a strong genetic contribution to reading difficulties (Peterson & Pennington, 2012). Neuroimaging research further identifies atypical activation patterns within left-hemisphere reading networks, particularly in temporoparietal and occipitotemporal regions associated with phonological and orthographic processing (Shaywitz & Shaywitz, 2005). Environmental factors such as literacy exposure, instructional quality, and early intervention may influence developmental outcomes, although they are not considered primary causes of dyslexia.

Key Theoretical Perspectives Influencing Contemporary Dyslexia Research

Several major theoretical and empirical developments have shaped contemporary research on developmental dyslexia, progressively transforming the field from a narrow reading-disability framework into a multidimensional neurodevelopmental model. Five major strands of research have significantly influenced the modern understanding of dyslexia: phonological deficit theories, temporal processing perspectives, studies of working memory and executive functioning, neurobiological and genetic research, and multifactorial integrative frameworks. The most influential research strand shaping dyslexia research has been the phonological deficit hypothesis, which proposes that dyslexia arises primarily from impaired phonological representations and inefficient phonological processing (Snowling, 2000). According to this account, difficulties in mapping graphemes to phonemes disrupt reading acquisition and the development of fluent decoding skills. This framework shifted the field away from earlier visual theories of “word blindness” and established language-based processing deficits as central to reading impairment, with empirical evidence supporting the central role of phonological deficits (Ramus et al., 2003). The phonological perspective became the dominant explanatory model for several decades and continues to strongly influence research and intervention approaches. Another major strand emerged through temporal processing and auditory timing theories. Early work by Paula Tallal suggested that dyslexia and related language impairments may involve deficits in processing rapidly changing auditory information required for speech perception (Tallal, 1980). More recently, rhythmic and neural timing theories, including the temporal sampling framework (Goswami, 2011), have proposed that developmental dyslexia arises from impaired neural synchronisation to slow temporal fluctuations in speech. According to this model, deficits in auditory cortical disrupt the phonological processing mechanisms necessary for language development and reading acquisition. These approaches expanded dyslexia research beyond static phonological representations toward broader mechanisms involving neural timing, rhythmic synchronisation, and temporal organisation. A third influential strand focused on working memory, attentional control, and executive functioning. Building upon cognitive models proposed by Alan Baddeley and colleagues. Building on Baddeley’s (2000) framework, subsequent research has shown that many individuals with developmental dyslexia experience deficits in verbal working memory and serial-order retention, suggesting that difficulties extend beyond phonological processing alone and may involve broader impairments in the maintenance and organisation of sequential information (Smith-Spark & Fisk, 2007; Gathercole & Alloway, 2008). This research challenged purely phonological explanations and contributed to broader domain-general accounts of dyslexia. In particular, studies on sequential and serial-order memory suggested that difficulties in maintaining temporally ordered representations may play a critical role in reading impairment (Szmalec, Loncke, Page, and Duyck, 2011).

Another significant perspective involved neurobiological and genetic research. Advances in neuroimaging techniques transformed dyslexia into a biologically grounded neurodevelopmental disorder. Functional neuroimaging studies identified atypical activation patterns within left-hemisphere reading networks, particularly in temporoparietal and occipitotemporal regions associated with phonological and orthographic processing (Shaywitz & Shaywitz, 2005). Genetic studies further demonstrated substantial heritability and identified susceptibility genes associated with neuronal migration and cortical development (Peterson & Pennington, 2012). This body of research helped establish dyslexia as a disorder rooted in atypical neural development rather than poor instruction or reduced motivation. Finally, contemporary dyslexia research has increasingly been shaped by multifactorial and integrative models. Rather than attributing dyslexia to a single core deficit, researchers such as Pennington (2006) proposed probabilistic frameworks in which multiple interacting cognitive, neural, genetic, and environmental risk factors contribute to reading impairment. This model integrates phonological deficits, temporal processing difficulties, working memory impairments, attentional regulation difficulties, processing speed, and sequential learning into a broader, multidimensional account. Current research, therefore, increasingly emphasises heterogeneity, developmental trajectories, cross-domain interactions, and individualised cognitive profiles, reflecting a shift toward more comprehensive and mechanistic understandings of dyslexia.

Together, these frameworks have remarkably shaped modern research on dyslexia by expanding explanatory models beyond isolated reading deficits to encompass broader cognitive, neurodevelopmental, and neurobiological mechanisms underlying reading impairment. Despite substantial advancements in our understanding of the phonological, temporal, attentional, and working-memory correlates of dyslexia, recent evidence suggests that sequential memory may be a critical cognitive mechanism linking these diverse theoretical philosophies. There is a need to examine how deficits in sequential memory contribute to the cognitive profile of individuals with developmental dyslexia. Accordingly, the present article aims to synthesise current theoretical and empirical evidence concerning the role of sequential memory in dyslexia

The Importance of Sequential Memory in Contemporary Dyslexia Research

Sequential memory is the ability to encode, maintain, and reproduce information in its accurate temporal order. Evidence suggests that individuals with dyslexia exhibit disproportionate difficulties in tasks involving serial-order retention, including digit span, serial recall, nonword repetition, and order-reconstruction paradigms (Gathercole & Alloway, 2008; Szmalec et al., 2011; Martinez Perez, Majerus, Mahot, and Poncelet, 2012; Hachmann, Cashdollar, and Engle, 2014). Notably, these impairments frequently persist even when memory for individual items remains relatively preserved, suggesting that dyslexia may involve a selective disruption in temporal-order encoding rather than a generalised memory deficit. On the other hand, reading is fundamentally a sequential activity because letters, sounds, words, and sentences must be processed and integrated in the correct order over time. Therefore, efficient reading depends on the ability to encode, maintain, and manipulate sequential information, as letters must be processed in the correct order, phonemes must be blended sequentially, and orthographic representations must remain stable over time to support fluent decoding and comprehension. Difficulties in sequential processing may therefore contribute to problems in decoding, word recognition, reading fluency, and comprehension, which are commonly observed in individuals with developmental dyslexia (Ehri, 2005; Snowling, 2000; Szmalec et al., 2011). Thus, impairments in sequential memory may contribute to hallmark features of dyslexia, including transposition errors, slow decoding, impaired fluency, and reduced verbal working-memory performance (Smith-Spark & Fisk, 2007; Szmalec et al., 2011; Martinez Perez et al., 2012). Sequential memory depends upon several interacting mechanisms, including temporal encoding, binding of items to serial positions, attentional control, and resistance to interference. A growing body of research has studied the role of sequential memory in developmental dyslexia. Ample of studies have documented that individuals with dyslexia experience difficulties in tasks requiring the retention and recall of information in its correct serial order. These impairments have been observed across a range of paradigms, including digit-span tasks, serial recall tasks, nonword repetition measures, and order-reconstruction procedures (Smith-Spark & Fisk, 2007; Gathercole & Alloway, 2008; Martinez Perez et al., 2012). Importantly, several studies have found that difficulties in serial-order retention may persist even when memory for individual items remains relatively intact, suggesting that dyslexia may involve specific impairments in temporal-order encoding rather than a generalised memory deficit (Szmalec et al., 2011; Majerus, 2016). Proof from nonverbal and cross-modal studies further indicates that these difficulties are not restricted to linguistic material, supporting the view that sequential memory impairments may reflect broader cognitive mechanisms underlying dyslexia. Collectively, these findings suggest that deficits in sequential memory constitute an important component of the cognitive profile of developmental dyslexia and may contribute to difficulties in reading, spelling, language processing, and working-memory functioning. Despite growing evidence linking sequential-memory impairments to developmental dyslexia, several important gaps remain. First, it remains unclear whether sequential-memory deficits represent a core characteristic of dyslexia or a secondary consequence of reduced reading experience and phonological difficulties. Second, many existing studies rely on verbal tasks that conflate phonological processing with serial-order demands, making it difficult to determine whether observed impairments reflect genuine sequential memory deficits or broader language-related difficulties. Third, relatively few studies have employed nonverbal and cross-modal paradigms to examine whether sequential-memory impairments extend beyond the linguistic domain. Fourth, the neurobiological mechanisms underlying sequential memory dysfunction in dyslexia remain poorly understood, particularly with respect to neural timing, oscillatory synchronisation, and large-scale network coordination. Finally, there is limited evidence regarding the effectiveness of interventions specifically targeting sequential memory, temporal-order processing, and related cognitive mechanisms. Addressing these gaps may provide a clearer understanding of the role of sequential memory in dyslexia and facilitate the development of more precise assessment tools and targeted intervention strategies.

Implications and Future Directions

Research on sequential memory has substantial importance for the assessment and intervention of developmental dyslexia. Existing diagnostic methods rely primarily on phonological awareness and reading-based measures, which frequently identify difficulties only after formal reading instruction has begun. Although a growing body of evidence suggests that sequential memory impairments may contribute to reading difficulties, the precise nature and role of these deficits remain poorly understood. Precisely, it remains unclear whether sequential-memory impairments represent an independent cognitive marker of dyslexia or reflect broader difficulties in phonological processing, working memory, and language development. Addressing this issue is essential for improving theoretical models of dyslexia and developing more sensitive methods of early identification. Sequential-memory paradigms, particularly those employing nonverbal and cross-modal stimuli, may offer earlier and less language-dependent indicators of risk. Such approaches have the potential to identify vulnerable children before severe reading difficulties become established, thereby facilitating earlier intervention. However, relatively few studies have examined sequential-memory performance using nonverbal tasks, making it difficult to determine the extent to which these deficits extend beyond the linguistic domain. Further research is therefore needed to clarify whether sequential-memory impairments reflect domain-specific or domain-general cognitive difficulties. Traditional interventions for dyslexia have primarily focused on phonics-based instruction designed to improve phonological awareness, decoding skills, and grapheme–phoneme correspondence. Considerable evidence demonstrates that structured, explicit, and systematic literacy instruction can significantly improve reading outcomes, particularly when implemented early in development (Snowling & Hulme, 2012). Nevertheless, current multifactorial models of dyslexia suggest that phonological intervention alone may not fully address the diversity of cognitive difficulties associated with the disorder. If dyslexia involves impairments in temporal organisation and serial-order processing, interventions targeting sequential learning, rhythm perception, attentional control, and working-memory functioning may provide additional benefits alongside conventional literacy instruction. Rhythm-based auditory training, temporal sequencing activities, serial recall exercises, and executive function interventions have increasingly been studied as complementary approaches to reading intervention (Goswami, 2011; Smith-Spark & Fisk, 2007). Although evidence supporting some of these approaches remains preliminary, they represent an important shift toward mechanism-based interventions that target underlying cognitive processes rather than reading symptoms alone.

Future research should prioritise methodological refinement in the investigation of sequential memory in developmental dyslexia. Many existing paradigms conflate phonological processing with serial-order demands, thereby limiting the ability to isolate pure sequential memory deficits. Greater use of nonverbal, cross-modal, and experimentally controlled tasks will therefore be essential for clarifying the specificity and underlying mechanisms of these impairments. In addition, studies should incorporate larger, more diverse samples across age groups, languages, and orthographic systems to improve the generalisability of findings. Longitudinal investigations are particularly important for determining whether sequential-memory deficits precede reading difficulties or emerge as secondary consequences of reduced reading experience. Such research may help establish whether sequential memory impairments constitute an early cognitive marker of dyslexia and, therefore, contribute to earlier identification and prevention efforts. Future intervention studies should also examine whether training temporal-order processing, working-memory updating, attentional control, and rhythmic sequencing can produce meaningful improvements in reading and language outcomes.

CONCLUSION

Currently, developmental dyslexia is being recognised as a multifaceted neurodevelopmental disorder that extends beyond phonological difficulties. Accumulating evidence also suggests that sequential memory plays an important role in reading and may contribute to the cognitive profile of individuals with dyslexia. Difficulties in serial-order processing have been linked to impairments in reading, spelling, working memory, and temporal organisation, highlighting the potential significance of sequential memory as a unifying construct across multiple theoretical accounts of dyslexia. Although further research is needed to clarify its developmental origins, specificity, and neural basis, current findings suggest that sequential memory represents a promising avenue for advancing our understanding of dyslexia. Enhanced emphasis on sequential memory processes may ultimately improve theoretical models, facilitate earlier identification of the disorder, and support the development of more targeted and effective interventions for individuals with developmental dyslexia.

REFERENCES

American Psychiatric Association. (2013). Diagnostic and statistical manual of mental disorders (5th ed.). *American Psychiatric Publishing.*

Baddeley, A. D. (2000). The episodic buffer: A new component of working memory. *Trends in Cognitive Sciences, 4*(11), 417–423.

Cowan, N. (2005). Working memory capacity. *Psychology Press*.

Ehri, L. C., Nunes, S. R., Willows, D. M., Schuster, B. V., Yaghoub-Zadeh, Z., & Shanahan, T. (2001). Phonemic awareness instruction helps children learn to read: Evidence from the National Reading Panel's meta-analysis. *Reading Research Quarterly, 36*(3), 250–287.

Gathercole, S. E., & Alloway, T. P. (2008). Working memory and learning: A practical guide for teachers. *Sage*.

Goswami, U. (2011). A temporal sampling framework for developmental dyslexia. *Trends in Cognitive Sciences, 15*(1), 3–10.

Goswami, U. (2015). Sensory theories of developmental dyslexia: Three challenges for research. *Nature Reviews Neuroscience, 16*(1), 43–54.

Grainger, J. (2008). Cracking the orthographic code: An introduction. *Language and Cognitive Processes, 23*(1), 1–35.

Hachmann, W. M., Bogaerts, L., Szmalec, A., Woumans, E., Duyck, W., & Job, R. (2014)

Short-term memory for order but not for item information is impaired in developmental dyslexia

Annals of Dyslexia, 64, 121–136.

Howard, M. W., & Kahana, M. J. (2002). A distributed representation of temporal context. *Journal of Mathematical Psychology, 46*(3), 269–299.

Hulme, C., & Snowling, M. J. (2013). Learning to read: What we know and what we need to understand better. *Child Development Perspectives, 7*(1), 1–5.

International Dyslexia Association. (2002). *Definition of dyslexia*.

Majerus, S., Poncelet, M., Van der Linden, M., & Weekes, B. (2008). Lexical learning in bilingual adults: The relative importance of item and serial order information. *Memory & Cognition, 34*(4), 889–902.

Martínez Pérez, T., Majerus, S., & Poncelet, M. (2013). Impaired short-term memory for order in adults with dyslexia. *Research in Developmental Disabilities*, 34(7), 2211–2223

Pennington, B. F. (2006). From single to multiple deficit models of developmental disorders. *Cognition, 101*(2), 385–413.

Peterson, R. L., & Pennington, B. F. (2012). Developmental dyslexia. *The Lancet, 379*(9830), 1997–2007.

Peterson, R. L., & Pennington, B. F. (2015). Developmental dyslexia. *Annual Review of Clinical Psychology, 11*, 283–307.

Ramus, F. (2003). Developmental dyslexia: Specific phonological deficit or general sensorimotor dysfunction? *Current Opinion in Neurobiology, 13*(2), 212–218.

Ramus, F., Rosen, S., Dakin, S. C., Day, B. L., Castellote, J. M., White, S., & Frith, U. (2003). Theories of developmental dyslexia: Insights from a multiple case study of dyslexic adults. *Brain, 126*(4), 841–865.

Shaywitz, S. (2003). Overcoming dyslexia: A new and complete science-based program for reading problems at any level. *Alfred A. Knopf.*

Smith-Spark, J. H., & Fisk, J. E. (2007). Working memory functioning in developmental dyslexia. *Memory, 15*(1), 34–56.

Snowling, M. J. (2000). Dyslexia (2nd ed.). *Blackwell Publishing*.

Stanovich, K. E. (1988). Explaining the differences between the dyslexic and the garden-variety poor reader. *Journal of Learning Disabilities, 21*(10), 590–604.

Stein, J. (2001). The magnocellular theory of developmental dyslexia. *Dyslexia, 7*(1), 12–36.

Szmalec, A., Loncke, M., Page, M. P. A., & Duyck, W. (2011). Order or disorder? Impaired Hebb learning in dyslexia. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 37*(5), 1270–1279.

Tallal, P. (1980). Auditory temporal perception, phonics, and reading disabilities in children. *Brain and Language, 9*(2), 182–198.

Vidyasagar, T. R., & Pammer, K. (2010). Dyslexia: A deficit in visuo-spatial attention, not in phonological processing. *Trends in Cognitive Sciences, 14*(2), 57–63.