Visual-Spatial Attention Impairment in Reading-Challenged Kids

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Abstract

Although visual-attentional skills may have a causal role in the development of reading skills, developmental reading difficulties (developmental dyslexia) have historically been primarily linked to auditory-phonological abnormalities. The orthographic processing of the letter string and the graphemic parsing that come before the grapheme-to-phoneme mapping may include visuo-attentional mechanisms. Here, we measured visuospatial attention in a sizable sample of primary school children (n=398) using a straightforward paper and pencil activity made up of three labyrinths. Our labyrinth task, which also controls for sensorimotor learning, primarily evaluates dispersed and focused visuospatial attention in contrast to visual search tasks that require visual working memory. Children with reading difficulties (n=58) displayed obvious visuospatial attention deficits compared to regular readers (n=340), which did not appear to be related to the motor coordination and procedural learning abilities required for this paper and pencil exercise. An effective reading rehabilitation programme should incorporate both auditory-phonological and visuo-attentional therapies, as visual attention is defective in roughly 40% of children with reading difficulties.

Keywords: Motor coordination • Neuro-developmental disorders • Reading problems

Introduction

Despite having an average IQ, teaching experience, and the absence of any overt sensory deficits, developmental dyslexia is a distinct reading issue. Developmental dyslexia is included as a potential result of a particular learning impairment in the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5). Within the category of neurodevelopmental disorders, such as language disorder, attention deficit, and hyperactivity disorder, developmental coordination disorder, and autism spectrum disorder, the diagnosis of a particular learning disorder is frequently preceded or followed by additional diagnoses. According to the phonological core deficit theory, Reading Problems (RD) in kids with developmental dyslexia are caused by deficiencies in the ability to recognise and actively respond to spoken word sounds, which makes it difficult for them to learn the correct grapheme-to-phoneme mapping. Thus, the left temporoparietal junction, which is involved in auditory-phonological processing and recall of speech sounds, may be critical in the early stages of learning to read, when the development of the sub-lexical and lexical routes depends on grapheme-to-phoneme mapping. One of the best indicators of future reading ability is the amount of time it takes a prereading youngster to accurately and swiftly name a variety of well-known visual stimuli, or rapid automatized naming (RAN). In the same way that reading does, RAN tasks call for the following abilities: (i) attention to the stimuli; (ii) visual processes that are in charge of initial feature detection, discrimination, and stimuli identification; (iii) integration of visual information with stored orthographic and phonological representations; (iv) lexical processes, including access to and retrieval of phonological codes; and (v) organisation of articulatory output. Phonological awareness, visuospatial working memory, and RAN all appear to be reliable indicators of future reading development, according to longitudinal research. In the early stages of letter recognition and orthographic development, the frontoparietal network, which is engaged in visuo-attentional processing, may be extremely important. Stronger visual word form representations are possible thanks to effective visuospatial attentional extraction and selection skills. Scale-invariant gaze-centered letter detectors that jointly encode letter identification and letter location are the first step in the processing of orthographic data. These gaze-centered letter detectors respond in a manner that is concurrently influenced by visual acuity, crowding, and spatial attention. The right frontoparietal network is involved in attentional shifting (i.e., disengaging attentional focus) and scaling by combining signal-enhancing and noise-exclusion mechanisms (zoom-in and zoom-out of attentional focus). It is possible that the slow attentional shifting and altered perceptual noise-exclusion mechanisms that are frequently seen in children with developmental dyslexia are what cause the problems with quick stimulus-sequence processing. Graphemic parsing and letter-string processing require the following:(i)rapid and accurate deployment of visual attention along the letter strings; (ii) good abilities in global extraction and Spatio-temporal integration of visual information; (iii) a large visual-attention span; and (iv) a reduced visual crowding effect. Several longitudinal studies have confirmed that visuospatial attention abilities are good predictors of future reading skills. Importantly, visuo-attentional training seems to enhance reading abilities in kids with and without developmental dyslexia, supporting the idea that the frontoparietal attentional network is directly responsible for learning to read. The frontoparietal network is involved in many interactions with the environment, particularly in action recognition and action planning, in addition to attentional deployment, which is important for reading acquisition. It is interesting to note that visuo-attentional deficiencies are a hallmark of this neurodevelopmental illness, which affects children with developmental dyslexia at a rate of 16% to 70% comorbidity with a developmental coordination disorder. However, some longitudinal research on the potential connections between fine and gross motor skills and reading development have not produced consistent results, despite the evidence for the linkage between visuomotor and the attainment of reading and spelling skills. Particularly, when assessed with writing activities, some studies connected manual dexterity to upcoming reading abilities. A deficiency in sequential procedural learning (the capacity to learn a general task technique) has also been noted in children with developmental dyslexia, primarily in serial response time tasks. It's interesting to note that Lum and colleagues' meta-analysis revealed that the observed deficiency appears to be mostly related to a potential dysfunction in medial-temporal regions, which are involved in the processing of attentional spatiotemporal sequences. Additionally, children with developmental dyslexia display longer execution times while performing tasks that heavily require visuo-hand coordination, such as drawing a mirror. Although developmental dyslexia has been linked to visuomotor coordination impairments and procedural learning difficulties, a fundamental visuo-attentional deficit may also be a contributing factor.

Materials and Methods

Participants

The children that participated in our study totaled 398. The children attended primary school from the second to the fifth grade, where they were partially evaluated in schools in various Italian areas. The vision of children was normal or corrected to normal. There were no documented neurological issues or hearing problems. Using standardised word and pseudoword reading exercises, clinicians assessed children's reading skills. They were labelled as normal readers (TRs) or children with RD based on how well they performed on standardised word and pseudoword reading tasks. A child was labeled as having RDs if they performed at least two reading tests (word and/or pseudoword reading) at speeds and/or accuracy that were at least two Standard Deviations (SDs) lower than the average scores determined for a normative sample.

Cs labyrinth task

There are three sheets of labyrinths in the assignment. Eight by eight Cs are arranged in a square grid on each sheet with the four cardinal directions. The beginning is denoted by a red C with a triangle inside and the ending by a yellow circle. The participant was instructed to use the opening of the black C to draw a straight line from the triangle to the last circle, stopping at the adjacent C. Before the test, the kid was shown a sample sheet on which the test's administrator demonstrated how to do it, and a second sheet on which the participant performed a practise test. We consistently administered the three labyrinths in the same order so that we could examine the procedural learning abilities. The double administration of the identical labyrinth path is expected to, in particular, result in an improvement in the second administration—an implicitly facilitative visuomotor impact at the core of the procedural learning mechanism. The attentional shifting index was similar between the first and second labyrinths, despite the fact that the first had 21 passages and the second had 36.

Discussion

A crucial factor in the growth of reading skills impeding orthographic processing is a visuospatial attention deficit. Using a straightforward paper-and-pencil activity that did not require auditory-phonological skills, we discovered a substantial difference in visuo-attentional ability between children with and without RDs. To attain the level of representation on which the grapheme-to-phoneme conversion process functions, computational models of reading presuppose a type of graphemic parsing. Visual information is divided into single letters and processed serially and one at a time. Regardless of how graphemic parsing is conceptualised, it necessitates first a focused visuospatial attention on each sublexical unit, followed by an efficient distributed visuospatial attention on the full letter-string. Visual search tasks also include concentrated and distributed visuospatial attention. Indeed, it has been shown that, in both shallow and deep orthographies, visual search abilities-without involving any phonological abilities-are good predictors of future reading skills. Additionally, visuospatial attention training through the use of action video games enhances both visual search efficiency and reading skills in both dyslexic and non-dyslexic children. Visual search tasks, on the other hand, necessitate not just distributed and concentrated visuospatial attention, but also working memory for the visual target and a precise match between the focused candidate item and the intended target. Children with dyslexia have poor visual working memory. Importantly, all of the components (Cs) that make up the visual paths in the labyrinth task are sequential targets that should be processed without using working memory, minimising the potential impact of visual working memory deficiencies on our visual task. Therefore, our results demonstrate that children with RD tend to have pure visuospatial attention impairments, regardless of visual working memory skills. Since reading experience may directly influence the development of visuospatial attention, Goswami has critically addressed the potential causal link between the acquisition of reading skills and visuospatial attention. The Cs labyrinth task required constant attentional reorientation in all directions, which ruled out the possibility that this difference was the result of a simple practise effect related to the habitual left-to-right attentional shifting trained during reading acquisition and consolidation. Instead, the reading direction in western orthographies is not exclusively left-to-right attentional shifting. Instead of a general speed of processing deficiency, the selective difference in execution durations between the two groups in the first and second labyrinth highlights the significance of strong visuospatial attention skills. Last but not least, individual data analysis revealed that approximately 40% of kids with RD had visuospatial attentional mechanisms that are compromised as measured by labyrinths 1 and 2, indicating that these kids have attentional dysfunction. It should be emphasised that increasing lateral visual noise and emphasising the particular orienting and zooming attentional mechanisms required during this straightforward paper and pencil task could improve the sensitivity of our labyrinth task to visuospatial attentional dysfunction. Therefore, the labyrinth task seems to be an effective method for identifying the presence of visuospatial attentional deficits in primary school students with RD and in kids with other neurodevelopmental disorders related to RD.

DD and developmental coordination problem frequently co-occur. The presence of a problem in this area may have an impact on performance in the Labyrinth task, which heavily relies on motor coordination abilities. However, the distinction between the first and third labyrinths could aid physicians in determining whether a particular challenge with visuospatial attention, motor abilities, or procedural learning may be present. The visuospatial attention deficit indexes, as demonstrated in the correlation section, regulate not only the procedural learning skills but also the visuomotor skills intrinsically captured in the performance of the third labyrinth (measured through the delta of the execution time between the first and second administration of the same labyrinth). Only having trouble with the first two labyrinths may signify a particular visual attentional problem. Finally, the potential contribution of IQ to the learning of reading was not taken into account in the current study. The correlation between IQ and reading progress in children with RD is contradictory, nevertheless. In conclusion, our research demonstrates that children with RD, as opposed to those who have conventional reading abilities, appear to have a visual attentional impairment that is unrelated to visual working memory or motor procedural learning. Our labyrinth test, in particular, highlights visual spatial attentional deficiencies that may affect both distributed and focused spatial attention in children with RD. The development of both lexical and sublexical reading pathways depends on these visual attentional mechanisms.

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