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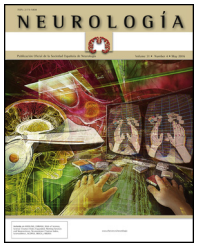

REVIEW ARTICLE

A review of the neurobiological basis of dyslexia in the adult population☆

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KEYWORDS
Dyslexia;
Adulthood;
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Abstract
Introduction: Adult dyslexia affects about 4% of the population. However, studies on the neurobiological basis of dyslexia in adulthood are scarce compared to paediatric studies.
Aim: This review investigates the neurobiological basis of dyslexia in adulthood.
Development: Using PsycINFO, a database of psychology abstracts, we identified 11 studies on genetics, 9 neurostructural studies, 13 neurofunctional studies and 24 neurophysiological studies. Results from the review show that dyslexia is highly heritable and displays polygenic transmission. Likewise, adult neuroimaging studies found structural, functional, and physiological changes in the parieto-occipital and occipito-temporal regions, and in the inferior frontal gyrus, in adults with dyslexia.
Conclusion: According to different studies, aetiology in cases of adult dyslexia is complex. We stress the need for neurobiological studies of dyslexia in languages with transparent spelling systems.

PALABRAS CLAVE
Dislexia;
Adultez;
Genética;
Neuroimagen

Una revisión de las bases neurobiológicas de la dislexia en población adulta

Resumen
Introducción: La dislexia en la edad adulta afecta a alrededor del 4% de la población. Sin embargo, la investigación acerca de los sustratos neurobiológicos de la dislexia en población adulta es relativamente escasa en comparación con la realizada en niños.
Objetivo: El presente estudio ofrece una revisión de las bases neurobiológicas de la dislexia en población adulta.

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Desarrollo: A partir de una búsqueda bibliográfica en la base de datos del *Psychological Abstracts: PsycINFO*, se identificaron 11 trabajos sobre las bases genéticas, 9 estudios que emplearon técnicas de neuroimagen estructural, 13 artículos que emplearon técnicas neurofuncionales, y 24, neurofisiológicas. Los resultados de la revisión señalan la gran heredabilidad de la dislexia, así como la implicación de diferentes genes. Asimismo, los estudios de neuroimagen muestran diferencias estructurales, funcionales y fisiológicas en regiones temporoparietales y occipitotemporales, y en el giro frontal inferior en los adultos con dislexia.
Conclusión: Las investigaciones muestran la gran complejidad etiológica de la dislexia en población adulta. Se destaca la necesidad de realizar estudios neurobiológicos en diferentes lenguas transparentes.

Introduction

Over the years, many terms have been used to name developmental dyslexia, including congenital word blindness, familial congenital word blindness, amnesia visualis verbalis, analphabetia partialias, bradylexia, congenital alexia, constitutional dyslexia, psycholexia, congenital typholexia, congenital dyslexia, developmental reading backwardness, primary or specific reading retardation, and strephosymbolia. In summary, from a cognitive and behavioural viewpoint, developmental dyslexia is a heterogeneous syndrome characterised by unexpected failure to recognise words, leading to the inability to attain a fluid, effortless reading style.[1–4] In addition to difficulty recognising words completely and/or fluently, patients also have problems with spelling, reading comprehension, and mathematical reasoning.[5]

The prevalence of dyslexia is between 5% and 15% of all school-age children, depending on the language and culture.[5] Prevalence estimates for Spain range from 3.2% to 5.9% in primary education,[6] and from 3.2% to 5.1% in secondary education.[7] Although prevalence in adulthood has not been studied, it is thought to be around 4%.[5]

Several longitudinal studies have shown that reading difficulties are chronic since they tend not to resolve in the long term. Therefore, evidence of reading difficulties persisting into adolescence and adulthood has led to considerable advances in research into the manifestations and neurobiological substrate of dyslexia in adulthood. In fact, research in adult subjects represents 5.82% of all research on learning difficulties conducted between 1998 and 2003.[8]

Regarding cognitive deficiencies, the meta-analysis conducted by Swanson and Hsieh[9] shows that specific cognitive and language processes in adults with dyslexia differ from those in adults with no reading disabilities due to difficulties in phonological processing persisting since childhood, as well as deficits in verbal memory, vocabulary, and naming speed. In addition, as stated by Swanson,[10] deficiencies in adults with dyslexia are more severe in those with higher IQs. As a consequence, both children and adults with dyslexia devote less time to reading, resulting in more limited vocabulary and severely impaired reading comprehension. Adults with reading disabilities have considerable difficulty understanding complex texts and making inferences.[11] Therefore, adolescents and adults with reading disabilities are frequently unable to keep up with academic demands; the knowledge they exhibit is limited, and this may severely impact their performance on reading tasks. In addition, difficulty reading has a negative effect not only on academic and cognitive performance but also on the personal and motivational levels. Klassen et al.[12] conducted a meta-analysis of 171 articles and concluded that such internalising problems as anxiety and depressive symptoms are frequent among adults with dyslexia. Self-esteem is also lower in adolescents and adults with dyslexia.[13]

Neuroimaging techniques provide neurological evidence about the neural networks involved in reading and its associated difficulties. Thus, the left hemisphere has been found to host neural networks involved in reading: an anterior network located in the inferior frontal gyrus (Broca's area), linked to articulation, silent reading, and naming,[14] and 2 posterior regions in the left hemisphere, one surrounding the parieto-temporal region which is responsible for word processing, and the other in the parieto-occipital region, responsible for word formation.[15–18] On the other hand, numerous studies have shown that dyslexia is highly heritable.[19,20] Other studies have also showed the influence of genetics on different reading disabilities.[20,21] Likewise, advances in molecular genetics have made it possible for researchers to locate several genes on chromosomes 1, 2, 3, 4, 6, 11, 15, 17, 18, and X which are involved in transmitting reading disabilities and various reading-related skills.[15,22] However, research on the neurobiological substrate of dyslexia in adults is relatively scarce compared to research conducted in children.

Objective

Based on the above, the present study aims to offer a general perspective on the neurobiological substrate of developmental dyslexia in adults based on a selective review of articles addressing this topic published in the past years. We aimed to summarise, analyse, and discuss findings reported in the last 10 years on the genetic basis of dyslexia, and