= Dyslexia =

Dyslexia , also known as reading disorder , is characterized by trouble with reading despite normal intelligence . Different people are affected to varying degrees . Problems may include difficulties in spelling words , reading quickly , writing words , " sounding out " words in the head , pronouncing words when reading aloud and understanding what one reads . Often these difficulties are first noticed at school . When someone who previously could read loses their ability , it is known as alexia . The difficulties are involuntary and people with this disorder have a normal desire to learn .

The cause of dyslexia is believed to involve both genetic and environmental factors . Some cases run in families . It often occurs in people with attention deficit hyperactivity disorder (ADHD) and is associated with similar difficulties with numbers . It may begin in adulthood as the result of a traumatic brain injury , stroke , or dementia . The underlying mechanisms are problems within the brain 's language processing . Dyslexia is diagnosed through a series of tests of memory , spelling , vision , and reading skills . Dyslexia is separate from reading difficulties caused by insufficient teaching ; or either hearing or vision problems .

Treatment involves adjusting teaching methods to meet the person 's needs . While not curing the underlying problem , it may decrease the degree of symptoms . Treatments targeting vision are not effective . Dyslexia is the most common learning disability , affecting 3 ? 7 % of the population ; however , up to 20 % may have some degree of symptoms . While dyslexia is more often diagnosed in men , it has been suggested that it affects men and women equally . Dyslexia occurs in all areas of the world . Some believe that dyslexia should be best considered as a different way of learning , with both benefits and downsides .

= = Classification = =

Dyslexia is thought to have two types of cause , one related to language processing and another to visual processing . It is considered a cognitive disorder , not a problem with intelligence . However , emotional problems often arise because of it . Some published definitions are purely descriptive , whereas others propose causes . The latter usually cover a variety of reading skills and deficits , and difficulties with distinct causes rather than a single condition . The National Institute of Neurological Disorders and Stroke definition describes dyslexia as " difficulty with spelling , phonological processing (the manipulation of sounds) , or rapid visual @-@ verbal responding " . The British Dyslexia Association definition describes dyslexia as " a learning difficulty that primarily affects the skills involved in accurate and fluent word reading and spelling " and is characterized by " difficulties in phonological awareness , verbal memory and verbal processing speed " .

Acquired dyslexia or alexia may be caused by brain damage due to stroke or atrophy . Forms of alexia include pure alexia , surface dyslexia , semantic dyslexia , phonological dyslexia , and deep dyslexia .

= = = Definition = = =

There is some variability in the definition of dyslexia . Some sources , such as the U.S. National Institutes of Health , define it specifically as a learning disorder . Other sources , however , define it simply as an inability to read in the context of normal intelligence , and distinguish between developmental dyslexia (a learning disorder) and acquired dyslexia (loss of the ability to read caused by brain damage) . ICD 10 , the manual of medical diagnosis used in much of the world , includes separate diagnoses for " developmental dyslexia " (81 @.@ 0) and for " dyslexia and alexia " (48 @.@ 0) . DSM 5 , the manual of psychiatric diagnosis used in the United States , does not specifically define dyslexia , justifying this decision by stating that " the many definitions of dyslexia and dyscalculia meant those terms would not be useful as disorder names or in the diagnostic criteria " . Instead it includes dyslexia in a category called specific learning disorders .

= = Signs and symptoms = =

In early childhood , symptoms that correlate with a later diagnosis of dyslexia include delayed onset of speech , difficulty distinguishing left from right , difficulty with direction , and a lack of phonological awareness , as well as being easily distracted by background noise . The reversal of letters or words and mirror writing are sometimes seen in people with dyslexia , but are not considered to be defining characteristics of the disorder .

School @-@ age children with dyslexia may exhibit signs of difficulty in identifying or generating rhyming words , or counting the number of syllables in words ? both of which depend on phonological awareness . They may also show difficulty in segmenting words into individual sounds or may blend sounds when producing words , indicating reduced phonemic awareness . Difficulties with word retrieval or naming things is also associated with dyslexia . People with dyslexia are commonly poor spellers , a feature sometimes called dysorthographia or dysgraphia , which depends on orthographic coding .

Problems persist into adolescence and adulthood and may accompany difficulties with summarizing stories , memorization , reading aloud , or learning foreign languages . Adults with dyslexia can often read with good comprehension , though they tend to read more slowly than others without a learning difficulty and perform worse in spelling tests or when reading nonsense words ? a measure of phonological awareness .

A common myth about dyslexia is that its defining feature is reading or writing letters or words backwards , but this is true of many children as they learn to read and write .

= = = Language = = =

The orthographic complexity of a language directly impacts how difficult learning to read the language is . English and French have comparatively " deep " phonemic orthographies within the Latin alphabet writing system , with complex structures employing spelling patterns on several levels : letter @-@ sound correspondence , syllables , and morphemes . Languages such as Spanish , Italian and Finnish have mostly alphabetic orthographies , which primarily employ letter @-@ sound correspondence ? so @-@ called shallow orthographies ? which for dyslexics makes them easier to learn . Logographic writing systems , such as Chinese characters , have extensive symbol use , and pose problems for dyslexic learners .

= = = Associated conditions = = =

Dyslexia is often accompanied by several learning disabilities , but it is unclear whether they share underlying neurological causes . These associated , or comorbid , disabilities include :

Dysgraphia ? A disorder which primarily expresses itself through difficulties with writing or typing , but in some cases through difficulties associated with eye ? hand coordination and direction or sequence @-@ oriented processes such as tying knots or carrying out repetitive tasks . In dyslexia , dysgraphia is often multifactorial , due to impaired letter @-@ writing automaticity , organizational and elaborative difficulties , and impaired visual word forming which makes it more difficult to retrieve the visual picture of words required for spelling .

Attention deficit hyperactivity disorder (ADHD) ? A disorder characterized by problems paying attention , excessive activity , or taking action without forethought . Dyslexia and ADHD commonly occur together . Either 15 % or 12 ? 24 % of people with dyslexia have ADHD . 35 % of people with ADHD have dyslexia .

Auditory processing disorder ? A listening disability that affects the ability to process auditory information . This can lead to problems with auditory memory and auditory sequencing . Many people with dyslexia have auditory processing problems , and may develop their own logographic cues to compensate for this type of deficit . Some research indicates that auditory processing skills could be the primary shortfall in dyslexia .

Developmental coordination disorder ? A neurological condition characterized by marked difficulty in carrying out routine tasks involving balance , fine @-@ motor control , kinesthetic coordination ,

difficulty in the use of speech sounds , problems with short @-@ term memory , and organization .

= = Causes = =

Researchers have been trying to find the neurobiological basis of dyslexia since the condition was first identified in 1881 . For example , some have tried to associate the common problem among dyslexics of not being able to see letters clearly to abnormal development of their visual nerve cells .

= = = Neuroanatomy = = =

Modern neuroimaging techniques such as functional magnetic resonance imaging (fMRI) and positron emission tomography (PET) have shown a correlation between both functional and structural differences in the brains of children with reading difficulties . Some dyslexics show less electrical activation in parts of the left hemisphere of the brain involved with reading , such as the inferior frontal gyrus , inferior parietal lobule , and the middle and ventral temporal cortex . Over the past decade , brain activation studies using PET to study language have produced a breakthrough in the understanding of the neural basis of language . Neural bases for the visual lexicon and for auditory verbal short @-@ term memory components have been proposed , with some implication that the observed neural manifestation of developmental dyslexia is task @-@ specific (i.e. functional rather than structural) . fMRIs in dyslexics have provided important data which point to the interactive role of the cerebellum and cerebral cortex as well as other brain structures .

The cerebellar theory of dyslexia proposes that impairment of cerebellum @-@ controlled muscle movement affects the formation of words by the tongue and facial muscles , resulting in the fluency problems that are characteristic of some dyslexics . The cerebellum is also involved in the automatization of some tasks , such as reading . The fact that some dyslexic children have motor task and balance impairments has been used as evidence for a cerebellar role in their reading difficulties . However , the cerebellar theory is not supported by controlled research studies .

= = = Genetics = = =

Research into potential genetic causes of dyslexia has its roots in post @-@ autopsy examination of the brains of people with dyslexia . Observed anatomical differences in the language centers of such brains include microscopic cortical malformations known as ectopias , more rarely , vascular micro @-@ malformations , and microgyrus . The previously cited studies and others suggest that abnormal cortical development presumed to occur before or during the sixth month of fetal brain development was the cause of the abnormalities . Abnormal cell formations in dyslexics have also been reported in non @-@ language cerebral and subcortical brain structures . Several genes have been associated with dyslexia , including DCDC2 and KIAA0319 on chromosome 6 , and DYX1C1 on chromosome 15 .

= = = Gene ? environment interaction = = =

The contribution of gene ? environment interaction to reading disability has been intensely studied using twin studies , which estimate the proportion of variance associated with a person 's environment and the proportion associated with their genes . Studies examining the influence of environmental factors such as parental education and teacher quality have determined that genetics have greater influence in supportive , rather than less optimal , environments . However , more optimal conditions may just allow those genetic risk factors to account for more of the variance in outcome because the environmental risk factors have been minimized . As environment plays a large role in learning and memory , it is likely that epigenetic modifications play an important role in reading ability . Animal experiments and measures of gene expression and methylation in the human periphery are used to study epigenetic processes ; however , both types of study have many

limitations in the extrapolation of results for application to the human brain .

= = Mechanisms = =

The dual @-@ route theory of reading aloud was first described in the early 1970s . This theory suggests that two separate mental mechanisms , or cognitive routes , are involved in reading aloud . One mechanism is the lexical route , which is the process whereby skilled readers can recognize known words by sight alone , through a " dictionary " lookup procedure . The other mechanism is the nonlexical or sublexical route , which is the process whereby the reader can " sound out " a written word . This is done by identifying the word 's constituent parts (letters , phonemes , graphemes) and applying knowledge of how these parts are associated with each other , for example , how a string of neighboring letters sound together . The dual @-@ route system could explain the different rates of dyslexia occurrence between different languages (e.g. the Spanish language dependence on phonological rules accounts for the fact that Spanish @-@ speaking children show a higher level of performance in non @-@ word reading , when compared to English @-@ speakers) .

Dyslexia disorder is not caused by mutation in one gene ; in fact , it appears to involve the combined effects of several genes . Studying the cognitive problems associated with other disorders helps to better understand the genotype @-@ phenotype link of dyslexia . Neurophysiological and imaging procedures are being used to ascertain phenotypic characteristics in dyslexics , thus identifying the effects of certain genes .

= = Diagnosis = =

There are tests that can indicate with high probability whether a person is a dyslexic . If diagnostic testing indicates that a person may be dyslexic , such tests are often followed up with a full diagnostic assessment to determine the extent and nature of the disorder . Tests can be administered by a teacher or computer . Some test results indicate how to carry out teaching strategies .

= = = Central dyslexias = = =

Central dyslexias include surface dyslexia , semantic dyslexia , phonological dyslexia , and deep dyslexia . ICD @-@ 10 reclassified the previous distinction between dyslexia (315 @.@ 02 in ICD @-@ 9) and alexia (315 @.@ 01 in ICD @-@ 9) into a single classification as R48.0. The terms are applied to developmental dyslexia and inherited dyslexia along with developmental aphasia and inherited alexia , which are considered synonymous .

= = = = Surface dyslexia = = = =

In surface dyslexia , words with regular pronunciations (highly consistent with their spelling , e.g. mint) are read more accurately than words with irregular pronunciation , such as colonel . Difficulty distinguishing homophones is a diagnostic used for some forms of surface dyslexia . This disorder is usually accompanied by surface agraphia and fluent aphasia . Acquired surface dyslexia arises when a previously literate person experiences brain damage , which results in pronunciation errors that indicate impairment of the lexical route .

= = = = Phonological dyslexia = = = =

In phonological dyslexia , sufferers can read familiar words but have difficulty with unfamiliar words , such as invented pseudo @-@ words . Phonological dyslexia is associated with lesions in the parts of the brain supplied with blood by the middle cerebral artery . The superior temporal lobe is often also involved . Furthermore , dyslexics compensate by overusing a front @-@ brain region called Broca 's area , which is associated with aspects of language and speech . The Lindamood Phoneme

Sequencing Program (LiPS) is used to treat phonological dyslexia . This system is based on a three @-@ way sensory feedback process , using auditory , visual , and oral skills to learn to recognize words and word patterns . Case studies with a total of three patients found a significant improvement in spelling and reading ability after using LiPS .

= = = = Deep dyslexia = = = =

Individuals with deep dyslexia experience both semantic paralexia (para @-@ dyslexia) and phonological dyslexia , which causes the person to read a word and then say a related meaning instead of the denoted meaning . Deep alexia is associated with clear phonological processing impairments . Deep dyslexia is caused by widespread damage to the brain that often includes the left hemisphere . The " continuum " hypothesis claims that deep dyslexia develops from phonological dyslexia .

= = = Peripheral dyslexias = = =

Peripheral dyslexias have been described as affecting the visual analysis of letters as a result of brain injury . Hemianopsia , a visual field loss on the left / right side of the vertical midline , is associated with this condition .

= = = = Pure dyslexia = = = =

Pure , or phonologically @-@ based , dyslexia , also known as agnosic dyslexia , dyslexia without agraphia , and pure word blindness , is dyslexia due to difficulty in recognizing written sequences of letters (such as words) , or sometimes even letters . It is considered ' " pure " because it is not accompanied by other significant language @-@ related impairments . Pure dyslexia does not affect speech , handwriting style , language or comprehension impairments . Pure dyslexia is caused by lesions on the visual word form area (VWFA) . The VWFA is composed of the left lateral occipital sulcus and is activated during reading . A lesion in the VWFA stops transmission between the visual cortex and the left angular gyrus . It can also be caused by a lesion involving the left occipital lobe or the splenium . It is usually accompanied by a homonymous hemianopsia in the right side of the visual field . Multiple oral re @-@ reading (MOR) is a treatment for pure dyslexia . It is considered a top @-@ down processing technique in which affected individuals read and reread texts a predetermined number of times or until reading speed or accuracy improves a predetermined amount .

= = = = Hemianopic dyslexia = = = =

Hemianopic dyslexia is commonly considered to derive from visual field loss due to damage to the primary visual cortex . Sufferers may complain of abnormally slow reading but are able to read individual words normally . This is the most common form of peripheral alexia , and the form with the best evidence of effective treatments .

= = = Neglect dyslexia = = =

In neglect dyslexia , some letters , most commonly those at the beginning or left side of a word , are skipped or misread during reading . This alexia is associated with right parietal lesions . The use of prism glasses has been shown to substantially mitigate this condition .

= = = = Attentional dyslexia = = = =

People with attentional dyslexia complain of letter @-@ crowding or migration , sometimes blending elements of two words into one . Sufferers read better when words are presented in isolation rather

than flanked by other words and letters . Using a large magnifying glass may help mitigate this condition by reducing the effects of flanking from nearby words ; however , no trials of this or indeed any other therapy for left parietal syndromes have been published as of 2014 .

= = Management = =

Through the use of compensation strategies , therapy and educational support , dyslexic individuals can learn to read and write . There are techniques and technical aids which help to manage or conceal symptoms of the disorder . Removing stress and anxiety alone can sometimes improve written comprehension . For dyslexia intervention with alphabet @-@ writing systems , the fundamental aim is to increase a child 's awareness of correspondences between graphemes (letters) and phonemes (sounds) , and to relate these to reading and spelling by teaching how sounds blend into words . It has been found that reinforced collateral training focused on reading and spelling yields longer @-@ lasting gains than oral phonological training alone . Early intervention ? that done while the language areas of the brain are still developing ? is the most successful in reducing the long @-@ term impacts of dyslexia . There is some evidence that the use of specially @-@ tailored fonts may mitigate the effects of dyslexia . These fonts , which include Dyslexie , OpenDyslexic , and Lexia Readable , were created based on the idea that many of the letters of the Latin alphabet are visually similar and may therefore confuse dyslexics . Dyslexie and OpenDyslexic both put emphasis on making each letter more distinctive in order to be more easily identified . Font design can have an effect on reading , reading time , and the perception of legibility of all readers , not only those with dyslexia .

There have been many studies conducted regarding intervention in dyslexia . Among these studies one meta @-@ analysis found that there was functional activation as a result .

= = Prognosis = =

Dyslexic children require special instruction for word analysis and spelling from an early age . However , there are fonts that can help dyslexics better understand writing . The prognosis , generally speaking , is positive for individuals who are identified in childhood and receive support from friends and family .

= = Epidemiology = =

The percentage of people with dyslexia is unknown , but it has been estimated to be as low as 5 % and as high as 17 % of the population . While it is diagnosed more often in males , some believe that it affects males and females equally .

There are different definitions of dyslexia used throughout the world , but despite significant differences in writing systems , dyslexia occurs in different populations . Dyslexia is not limited to difficulty in converting letters to sounds , and Chinese dyslexics may have difficulty converting Chinese characters into their meanings . The Chinese vocabulary uses logographic , monographic , non @-@ alphabet writing where one character can represent an individual phoneme .

The phonological @-@ processing hypothesis attempts to explain why dyslexia occurs in a wide variety of languages . Furthermore , the relationship between phonological capacity and reading appears to be influenced by orthography .

= = History = =

Dyslexia was identified by Oswald Berkhan in 1881 , but the term dyslexia was coined in 1887 by Rudolf Berlin , an ophthalmologist in Stuttgart . He used the term to refer to the case of a young boy who had a severe impairment in learning to read and write , despite showing typical intelligence and physical abilities in all other respects . In 1896 , W. Pringle Morgan , a British physician from Seaford , East Sussex , published a description of a reading @-@ specific learning disorder in a report to the

British Medical Journal titled " Congenital Word Blindness " . The distinction between phonological and surface types of dyslexia is only descriptive , and without any etiological assumption as to the underlying brain mechanisms . However , studies have alluded to potential differences due to variation in performance .

= = Research and society = =

The majority of currently available dyslexia research relates to alphabetic writing systems , and especially to European languages . However , substantial research is also available regarding dyslexics who speak Arabic , Chinese , Hebrew or other languages .

As is the case with any disorder , society often makes an assessment based on incomplete information . Before the 1980s , dyslexia was thought to be a consequence of education , rather than a basic disability . As a result , society often misjudges those with the disorder . There is also sometimes a workplace stigma and negative attitude towards those with dyslexia . If a dyslexic 's instructors lack the necessary training to support a child with the condition , there is often a negative effect on the student 's learning participation . There is no evidence demonstrating that the use of music education is effective in improving dyslexic adolescents ' reading skills .