Dyslexia is a learning disability that impairs a person's ability to read, and which can manifest itself as a difficulty with phonological awareness, phonological decoding, orthographic coding, auditory short-term memory, and/or rapid naming. Dyslexia is separate and distinct from reading difficulties resulting from other causes, such as a non-neurological deficiency with vision or hearing, or from poor or inadequate reading instruction. It is estimated that dyslexia affects between 5 and 17 percent of the population.

There are three proposed cognitive subtypes of dyslexia: auditory, visual and attentional. Although dyslexia is not an intellectual disability, it is considered both a learning disability and a reading disability. Dyslexia and IQ are not interrelated, since reading and cognition develop independently in individuals who have dyslexia.

**Classification**

Spoken language is a universal form of man made communication. The visual notation of speech, written language is not found in all cultures and is a recent development with regard to human evolution.

There are many definitions of dyslexia but no official consensus has been reached.

The World Federation of Neurology defines dyslexia as "a disorder manifested by difficulty in learning to read despite conventional instruction, adequate intelligence and sociocultural opportunity".

MedlinePlus and the National Institutes of Health define dyslexia as "a reading disability resulting from the inability to process graphic symbols".

The National Institute of Neurological Disorders and Stroke gives the following definition for dyslexia:

"Dyslexia is a brain-based type of learning disability that specifically impairs a person's ability to read. These individuals typically read at levels significantly lower than expected despite having normal intelligence. Although the disorder varies from person to person, common characteristics among people with dyslexia are difficulty with spelling, phonological processing (the manipulation of sounds), and/or rapid visual-verbal responding. In adults, dyslexia usually occurs
after a brain injury or in the context of dementia. It can also be inherited in some families, and recent studies have identified a number of genes that may predispose an individual to developing dyslexia”.

Other published definitions are purely descriptive or embody causal theories. Varying definitions are used for dyslexia from researchers and organizations around the world; it appears that this disorder encompasses a number of reading skills, deficits and difficulties with a number of causes rather than a single condition.

Castles and Coltheart describe phonological and surface types of developmental dyslexia by analogy to classical subtypes of alexia (acquired dyslexia) which are classified according to the rate of errors in reading non-words. However, the distinction between surface and phonological dyslexia has not replaced the old empirical terminology of dysphonetic versus dyseidetic types of dyslexia. The surface/phonological distinction is only descriptive, and devoid of any aetiological assumption as to the underlying brain mechanisms. In contrast, the dysphonetic/dyseidetic distinction refers to two different mechanisms; one that relates to a speech discrimination deficit, and another that relates to a visual perception impairment.

### Signs and symptoms

The symptoms of dyslexia vary according to the severity of the disorder as well as the age of the individual.

#### Preschool-aged children

It is difficult to obtain a certain diagnosis of dyslexia before a child begins school, but many dyslexic individuals have a history of difficulties that began well before kindergarten. Children who exhibit these symptoms early in life have a higher likelihood of being diagnosed as dyslexic than other children. These symptoms include:

- delays in speech
- slow learning of new words
- difficulty in rhyming words, as in nursery rhymes
- low letter knowledge
- letter reversal or mirror writing—(for example, “Я” instead of “R”)

#### Early primary school children

- Difficulty learning the alphabet or letters order
- Difficulty with associating sounds with the letters that represent them (sound-symbol correspondence)
- Difficulty identifying or generating rhyming words, or counting syllables in words (phonological awareness)
- Difficulty segmenting words into individual sounds, or blending sounds to make words (phonemic awareness)
- Difficulty with word retrieval or naming problems
- Difficulty learning to decode written words
- Difficulty distinguishing between similar sounds in words; mixing up sounds in polysyllabic words (auditory discrimination) (for example, “aminal” for animal, “bisghetti” for spaghetti)
Older primary school children

- Slow or inaccurate reading (although these individuals can read to an extent).
- Very poor spelling which has been called dysorthographia (orthographic coding)
- Difficulty reading out loud, reading words in the wrong order, skipping words and sometimes saying a word similar to another word (auditory processing disorder)
- Difficulty associating individual words with their correct meanings
- Difficulty with time keeping and concept of time when doing a certain task
- Difficulty with organization skills (working memory)
- Children with dyslexia may fail to see (and occasionally to hear) similarities and differences in letters and words, may not recognize the spacing that organizes letters into separate words, and may be unable to sound out the pronunciation of an unfamiliar word (auditory processing disorder).

Secondary school children and adults

Brighter dyslexics are able to disguise their weaknesses (even from themselves) and often do acceptably well - or better - at GCSE level (U.K. - at 16 years old). Many students reach higher education before they encounter the threshold at which they are no longer able to compensate for their learning weaknesses.

One common misconception about dyslexia is that dyslexic readers write words backwards or move letters around when reading. In fact, this only occurs in a very small population of dyslexic readers. Dyslexic people are better identified by writing that does not seem to match their level of intelligence from prior observations. Additionally, dyslexic people often substitute similar-looking, but unrelated, words in place of the ones intended (what/want, say/saw, help/held, run/fun, fell/fall, to/too, etc.)

Comorbidities

Several learning disabilities often occur with dyslexia, but it is unclear whether these learning disabilities share underlying neurological causes with dyslexia. These disabilities include, but are not limited to:

- Cluttering—a speech fluency disorder involving both the rate and rhythm of speech, resulting in impaired speech intelligibility. Speech is erratic and nonrhythmic, consisting of rapid and jerky spurts that usually involve faulty phrasing. The personality of people with cluttering bears striking resemblance to the personalities of those with learning disabilities.
- Dysgraphia—a disorder which expresses itself primarily through writing or typing, although in some cases it may also affect eye–hand coordination direction or sequence oriented processes such as tying knots or carrying out a repetitive task. Dysgraphia is distinct from dyspraxia in that the person may have the word to be written or the proper order of steps in mind clearly, but carries the sequence out in the wrong order.
- Dyscalculia—a neurological condition characterized by a problem with learning fundamentals and one or more of the basic numerical skills. Often people with this condition can understand very complex mathematical concepts and principles but have difficulty processing formulas or even basic addition and subtraction.

Cause

The following theories should not be viewed as competing, but viewed as theories trying to explain the underlying causes of a similar set of symptoms from a variety of research perspectives and background.
Cerebellar theory

One view is represented by the automaticity/cerebellar theory of dyslexia. Here the biological claim is that the cerebellum of people with dyslexia is mildly dysfunctional and that a number of cognitive difficulties ensue.

Evolutionary hypothesis

This theory posits that reading is an unnatural act carried out by humans for an exceedingly brief period in our evolutionary history. It has been less than a hundred years that western societies promoted reading to the mass population and therefore the forces that shape our reading behavior have been weak. Many areas of the world still do not even have access to reading for the majority of the population.

Magnocellular theory

There is a unifying theory that attempts to integrate all the findings mentioned above. A generalization of the visual theory, the magnocellular theory postulates that the magnocellular dysfunction is not restricted to the visual pathways but is generalized to all modalities (visual and auditory as well as tactile).

Naming speed deficit and double deficit theories

The speed with which an individual can engage in the rapid automatized naming of familiar objects or letters is a strong predictor of dyslexia. Slow naming speed can be identified as early as kindergarten and persists in adults with dyslexia.

A deficit in naming speed is hypothesized to represent a deficit that is separate from phonological processing deficit. Wolf identified four types of readers: readers with no deficits, readers with phonological processing deficit, readers with naming speed deficit, and readers with double deficit (that is, problems both with phonological processing and naming speed). Students with double deficits are most likely to have some sort of severe reading impairment.

Distinguishing among these deficits has important implications for instructional intervention. If students with double deficits receive instruction only in phonological processing, they are only receiving part of what they need.

Perceptual visual-noise exclusion hypothesis

The concept of a perceptual noise exclusion deficit (impaired filtering of behaviorally irrelevant visual information in dyslexia or visual-noise) is an emerging hypothesis, supported by research showing that subjects with dyslexia experience difficulty in performing visual tasks (such as motion detection in the presence of perceptual distractions) but do not show the same impairment when the distracting factors are removed in an experimental setting. The researchers have analogized their findings concerning visual discrimination tasks to findings in other research related to auditory discrimination tasks. They assert that dyslexic symptoms arise because of an impaired ability to filter out both visual and auditory distractions, and to categorize information so as to distinguish the important sensory data from the irrelevant.
Phonological deficit theory

The phonological deficit theory postulates that people with dyslexia have a specific impairment in the representation, storage and/or retrieval of speech sounds. It explains the reading impairment of dyslexic persons on the basis that learning to read an alphabetic system requires learning the grapheme/phoneme correspondence, i.e. the correspondence between letters and constituent sounds of speech.

Rapid auditory processing theory

The rapid auditory processing theory is an alternative to the phonological deficit theory, which specifies that the primary deficit lies in the perception of short or rapidly varying sounds. Support for this theory arises from evidence that people with dyslexia show poor performance on a number of auditory tasks, including frequency discrimination and temporal order judgment.

Visual theory

The visual theory reflects another long standing tradition in the study of dyslexia, that of considering it as a visual impairment giving rise to difficulties with the processing of letters and words on a page of text. This may take the form of unstable binocular fixations, poor vergence, or increased visual crowding. The visual theory does not exclude a phonological deficit.

Effect of language orthography

The complexity of a language's orthography or spelling system – formally, its orthographic depth – has a direct impact on how difficult it is to learn to read that language. English has a comparatively deep orthography within the Latin alphabet writing system, with a complex orthographic structure that employs spelling patterns at several levels: principally, letter-sound correspondences, syllables, and morphemes. Other languages, such as Spanish, have alphabetic orthographies that employ only letter-sound correspondences, so-called shallow orthographies. It is relatively easy to learn to read languages like Spanish; it is much more difficult to learn to read languages with more complex orthographies, such as English. Logographic writing systems, notably Japanese and Chinese characters, have a purer direct relationship between the sound of a word and the representative visual symbols, which pose a different type of dyslexic difficulty.

From a neurological perspective, different types of writing system, for example alphabetic as compared to logographic writing systems, require different neurological pathways in order to read, write and spell. Because different writing systems require different parts of the brain to process the visual notation of speech, children with reading problems in one language might not have a reading problem in a language with a different orthography. The neurological skills required to perform the tasks of reading, writing, and spelling can vary between different writing systems and as a result different neurological deficits can cause dyslexic problems in relation to different orthographies.

Exacerbating conditions

Dyslexia is attributed to neurological factors that influence the individual's ability to read, write, and spell written language.
The following conditions may be contributory or overlapping factors, as they can lead to difficulties reading:

- **Aphasia** - The multiples issues which can cause alexia (acquired dyslexia).
- **Attention deficit hyperactivity disorder** - A disorder that occurs in between 12% and 24% of those with dyslexia.
- **Auditory processing disorder** - A condition that affects the ability to process auditory information. Auditory processing disorder is a listening disability. It can lead to problems with auditory memory and auditory sequencing. Many people with dyslexia have auditory processing problems including history of auditory reversals, and may develop their own logographic cues to compensate for this type of deficit. Auditory processing disorder is recognized as one of the major causes of dyslexia. Some children can acquire auditory processing disorder as a result of experiencing otitis media with effusion (glue ear, sticky ear, grommets) and other severe ear conditions.
- **Developmental dyspraxia** - A neurological condition characterized by a 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 are typical of dyspraxics.
- **Scotopic sensitivity syndrome**, also known as Irlen Syndrome - A term used to describe sensitivity to certain wavelengths of light which interfere with visual processing.
- **Specific language impairment (SLI)** - A developmental language disorder that can affect both expressive and receptive language. SLI is defined as a "pure" language impairment, meaning that is not related to or caused by other developmental disorders, hearing loss or acquired brain injury. A study by the Universities of Maastricht and Utrecht examined speech perception and speech production in 3-year-old Dutch children at familial risk of developing dyslexia. Their performance in speech sound categorization and their production of words was compared to that of age-matched children with SLI and typically developing controls. The results of the at-risk and SLI-group were highly similar. Analysis of the individual data revealed that both groups contained subgroups with good and poorly performing children. Their impaired expressive phonology seemed to be related to a deficit in speech perception. The findings indicate that both dyslexia and SLI can be explained by a multi-risk model which includes cognitive processes as well as genetic factors.

Experience of speech acquisition delays and speech and language problems can be due to problems processing and decoding auditory input prior to reproducing their own version of speech, and may be observed as stuttering, cluttering or hesitant speech.

### Management

There is no cure for dyslexia, but dyslexic individuals can learn to read and write with appropriate educational support.

Especially for undergraduates, some consideration of what 'reading' is and what it is for can be useful. There are techniques (reading the first sentence of each paragraph in a chapter, for example) which can give an overview of content. This can be sufficient for some purposes. Since stress and anxiety are contributors to a dyslexic's weaknesses in absorbing information, removing these can assist in improving understanding. When a dyslexic knows that not every reading experience must be onerous, it greatly helps their mental approach to the task.

The best approaches acknowledge that the objective in helping to improve a dyslexic's 'reading' is not to 'read-like-a-non-dyslexic-does', but to find a way of extracting information from text that works efficiently for someone who processes such information differently from the majority.

For alphabet writing systems the fundamental aim is to increase a child's awareness of correspondences between graphemes and phonemes, and to relate these to reading and spelling. It
has been found that training focused towards visual language and orthographic issues yields longer-lasting gains than mere oral phonological training.

The best form of approach is determined by the underlying neurological cause(s) of the dyslexic symptoms.

Context sensitive spell checkers combined with text-to-speech systems offer forms of assistive technology to dyslexia users, supporting reading and writing.

**History**

- **Identified by Oswald Berkhan in 1881, the term 'dyslexia' was later coined in 1887 by Rudolf Berlin, an ophthalmologist practising in Stuttgart, Germany.**
- **In 1896, W. Pringle Morgan published a description of a reading-specific learning disorder in the British Medical Journal titled "Congenital Word Blindness".**
- **During the 1890s and early 1900s, James Hinshelwood published a series of articles in medical journals describing similar cases of congenital word blindness. In his 1917 book Congenital Word Blindness, Hinshelwood asserted that the primary disability was in visual memory for words and letters, and described symptoms including letter reversals, and difficulties with spelling and reading comprehension.**
- **1925 Samuel T. Orton determined that there was a syndrome unrelated to brain damage that made learning to read difficult. Orton’s theory strephosymbolia described individuals with dyslexia having difficulty associating the visual forms of words with their spoken forms. Orton observed that reading deficits in dyslexia did not seem to stem from strictly visual deficits. He believed the condition was caused by the failure to establish hemispheric dominance in the brain. Orton later worked with the psychologist and educator Anna Gillingham to develop an educational intervention that pioneered the use of simultaneous multisensory instruction.**
- **In contrast, Dearborn, Gates, Bennet and Blau considered a faulty guidance of the seeing mechanism to be the cause. They sought to discover if a conflict between spontaneous orientation of the scanning action of the eyes from right to left and training aimed at the acquisition of an opposite direction would allow an interpretation of the facts observed in the dyslexic disorder and especially of the ability to mirror-read.**
- **1949 Research conducted under G. Mahec show that the phenomenon is clearly linked to the dynamics of sight as it disappears when the space between letters is increased, transforming the reading into spelling. This experience also explains the ability to mirror-read.**
- **1968 Makita suggested that dyslexia was mostly absent among Japanese children. A 2005 study shows that Makita’s claim of rarity of incidence of reading disabilities in Japan to be incorrect.**
- **In the 1970s a new hypothesis emerged: that dyslexia stems from a deficit in phonological processing or difficulty in recognizing that spoken words are formed by discrete phonemes. Affected individuals have difficulty associating these sounds with the visual letters that make up written words. Key studies suggested the importance of phonological awareness,**
- **1979 Galaburda and Kemper, and Galaburda et al. 1985, reported observations from the examination of post autopsy brains of people with dyslexia. Their studies reporting observed anatomical differences in the language center in a dyslexic brain, taken with the similar work of Cohen et al. 1989, suggested abnormal cortical development, which was presumed to occur before or during the sixth month of foetal brain development.**
- **1993 Castles and Coltheart describe developmental dyslexia as two prevalent and distinct varieties using the subtypes of Alexia, Surface and Phonological Dyslexia. Manis et al. 1996, concluded that there were probably more than two subtypes of dyslexia, which would be related to multiple underlying deficits.**
- **1994 From post autopsy specimens Galaburda et al., reported : Abnormal auditory processing in people with dyslexia suggests that accompanying anatomical abnormalities might be present in the auditory system. Supported the reported behavioral findings of a left hemisphere-based phonological defect in dyslexic individuals.**
- **The development of neuroimaging technologies during the 1980s and 1990s enabled dyslexia research to make significant advances. Positron emission tomography (PET) and functional magnetic resonance imaging (fMRI) studies have revealed the neural signature of adult normal reading (e.g. Fiez and Petersen, 1998; Turkeltaub et al., 2002 and phonological processing (e.g., Gelfand and Bookheimer, 2003; Poldrack**
et al., 1999). Employing various experimental approaches and paradigms (e.g., the detection or judgment of rhymes, nonword reading, and implicit reading), these studies have localized dysfunctional phonological processing in dyslexia to left-hemisphere perisylvian regions, especially for the alphabetic writing system (Paulesu et al., 2001; for review, see Eden and Zeffiro, 1998, ). However, it has been demonstrated that in nonalphabetic scripts, where reading places less demands on phonemic processing and the integration of visual-orthographic information is crucial, dyslexia is associated with under activity of the left middle frontal gyrus (Siok et al., 2004).

- **1999** Wydell and Butterworth reported the case study of an English-Japanese bilingual with monolingual dyslexia. Suggesting that any language where orthography-to-phonology mapping is transparent, or even opaque, or any language whose orthographic unit representing sound is coarse (i.e. at a whole character or word level) should not produce a high incidence of developmental phonological dyslexia, and that orthography can influence dyslexic symptoms.

- **2003** Ziegler and colleagues claimed that the dyslexia suffered by German or Italian dyslexics is very similar to the one suffered by English dyslexics (readers of different—shallow versus deep orthographic systems), supporting the idea that the origin of dyslexia is mostly biological.

- **2007** Lyttinen et al. Researchers are seeking a link between the neurological and genetic findings, and the reading disorder.

- **2008** S Heim et al. in a paper titled "Cognitive subtypes of dyslexia" describe how they compared different sub-groups of dyslexics in comparison with a control group. This is one of the first studies not to just compare dyslexics with a non dyslexic control, but to go further and compared the different cognitive sub groups with a non dyslexic control group.

- **2008** Wai Ting Siok et al. in a paper titled "A structural–functional basis for dyslexia in the cortex of Chinese readers" describe how dyslexia is language dependent, and especially between alphabetic and non-alphabetic writing systems.

- **2010** KK Chung et al. investigated the "Cognitive profiles of Hong Kong Chinese adolescents with dyslexia".