Dyslexia

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Dyslexia is a learning disability that makes itself manifest primarily as a difficulty with written language, particularly with reading. It 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.[1] suggests that dyslexia results from differences in how the brain processes written and spoken language. Although dyslexia is thought to be the result of a neurological difference, it is not an intellectual disability. Dyslexia is diagnosed in people of all levels of intelligence.[2] Dyslexia is a learning difficulty which holds no simple definition; psychologists continue to have difficulties providing clear cut answers as to what it is or how it is actually caused.

Part of a series on
Dyslexia

and related disorders
Education · Neuropsychology

RELATED CONDITIONS

Acquired dyslexia · Alexia
Auditory Processing Disorder
Dyscalculia · Dysgraphia
Dyslexia · Dyspraxia

THEORIES

Double deficit · Magnocellular
Perceptual noise exclusion
Phonological deficit

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History

Identified by Oswald Berkhan in 1881, [3] the term 'dyslexia' was later coined in 1887 by Rudolf Berlin, an ophthalmologist practicing in Stuttgart, Germany.[4] He used the term to refer to a case of a young boy who had a severe impairment in learning to read and write in spite of showing typical intellectual and physical abilities in all other respects.

In 1896, W. Pringle Morgan, a British physician, from Seaford, East Sussex, England published a description of a reading-specific learning disorder in a report to the *British Medical Journal* titled "Congenital Word Blindness". This described the case of a 14-year-old boy who had not yet learned to read, yet showed normal intelligence and was generally adept at other activities typical of children of that age.[5]

During the 1890s and early 1900s, James Hinshelwood, a British ophthalmologist, published a series of articles in medical journals describing similar cases of congenital word blindness, which he defined as "a congenital defect occurring in children with otherwise normal and undamaged brains characterised by a difficulty in learning to read." 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.[6]

An early researcher in dyslexia was Samuel T. Orton, a neurologist who worked primarily with stroke victims. In 1925 Orton met a boy who could not read and who exhibited symptoms similar to stroke victims who had lost the ability to read. Orton began studying reading difficulties and determined that there was a syndrome unrelated to brain damage that made learning to read difficult. Orton called the condition strephosymbolia (meaning 'twisted signs') to describe his theory that individuals with dyslexia had difficulty associating the visual forms of words with their spoken forms.[7] Orton observed that reading deficits in dyslexia did not seem to stem from strictly visual deficits.[8] He believed the condition was caused by the failure to establish hemispheric dominance in the brain.[9] He also observed that the children he worked with were disproportionately left- or mixed-handed, although this finding has been difficult to replicate.[10] Orton's hypothesis concerning hemispheric specialization was borne out by post-mortem studies in the 1980s and 1990s establishing that the left planum temporale, a brain area associated with language processing, is physically larger than the corresponding right area in the brains of non-dyslexic subjects, but that these brain areas are symmetrical or slightly larger on the right for dyslexic subjects.[11] FMRI imaging studies of children and young adults reported in 2003 provide further support, demonstrating that increases in age and reading level are associated with a suppression of right hemispheric activity.[12] [13]

Influenced by the kinesthetic work of Helen Keller and Grace Fernald, and looking for a way to teach reading using both left and right brain functions,[14] Orton later worked with psychologist and educator Anna Gillingham to develop an educational intervention that pioneered the use of simultaneous multisensory instruction. The Orton-Gillingham approach to remedial reading instruction is still widely used and forms the basis of many reading intervention programs. [15]

In contrast, Dearborn, Gates, Bennet and Blau considered a faulty guidance of the seeing mechanism to be the cause. The data collected in 1931 by Tinker and Goodenough (The J.Educ. Psych.)(26) seemed to support this thesis. 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. To this end the authors asked four adults to read a text reflected in a mirror for ten minutes a day for five months. In all subjects, the words were not perceived in their globality but required a meticulous analysis of the letters and syllables. They also demonstrated total or partial inversions even sometimes affecting the order of the words in a sentence. They revealed a curious impression of not just horizontal but also vertical inversions. These are

errors that exist amongst dyslexics and they suffer from the aggravating circumstance inherent in all learning. What remained to be demonstrated was that there exists a preference amongst dyslexics, without sensory deficiency, or mental retardation, or any backwardness in speech or language, towards scanning with the eyes from right to left. Proof of this was provided in a work conducted under Clement Launay in 1949 (thesis G. Mahec Paris 1951). In adult subjects the reading of a series of 66 tiny lower-case letters, 5 mm high, spaced 5 mm apart, first from left to right and then from right to left was more easily and quickly done in the left to right direction. For former dyslexic children, a substantial number read a series of 42 letters with equal speed in both directions and some (10%) read better from right to left than from left to right. 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. This reading test can also be used to diagnose serious cases of dyslexia.

In the 1970s, a new hypothesis, based in part on Orton's theories, emerged that dyslexia stems from a deficit in phonological processing or difficulty in recognizing that spoken words are formed by discrete phonemes (for example, that the word CAT comes from the sounds [k], [æ], and [t]). As a result, affected individuals have difficulty associating these sounds with the visual letters that make up written words. Key studies of the phonological deficit hypothesis include the finding that the strongest predictor of reading success in school age children is phonological awareness,[16] and that phonological awareness instruction can improve decoding skills for children with reading difficulties.[17]

The advent of neuroimaging techniques to study brain structure and function enhanced the research in the 1980s and 1990s. Since then, interest in the neurologically based causes has persisted. Current models of the relation between the brain and dyslexia generally focus on some form of defective or delayed brain maturation. More recently, genetic research has provided increasing evidence supporting a genetic origin of dyslexia [18].

Researchers are searching for a link between the neurological and genetic findings, and the reading disorder. There are many previous and current theories of dyslexia, but one that has much support from research is that, whatever the biological cause, dyslexia is a matter of reduced phonogical awareness, the ability to analyze and link the units of spoken and written languages. [19].

Subtypes of developmental dyslexia

Studies by Castles and Coltheart suggest that developmental dyslexia includes at least two prevalent and distinct varieties or subtypes of dyslexia. Subtypes include surface dyslexia and phonological dyslexia. Understanding these subtypes is useful in diagnosing learning patterns and developing approaches for overcoming impairments that may be visual perception impairments or speech discrimination deficits. These subtypes are based on differing patterns of underlying symptoms, as supported by a finding using large-scale data from comparative studies of reading patterns in dyslexic and normal readers [20]. In the study by Castles and Coltheart, 56 dyslexic boys and 56 non-dyslexic boys as a control group were tested. During the test, the boys read aloud words and non-words that were presented to them. The researchers found that surface dyslexics (subjects who have poor lexical skills, or can't make out irregular words well) had a mean difference of 14.4 words between reading regular words versus irregular words, however, the mean difference in subjects with phonological dyslexia (subjects who can't use sub lexical skills, or can't make out non-words) was only 7.75 words which was comparable to the control group [20]. The majority of their subjects showed signs of phonological dyslexia. Twenty-nine subjects showed that their non-word reading skills were poorer than their irregular word reading skills. However, sixteen subjects showed the opposite where their irregular word reading skills were poorer than their non-word reading skills and were called surface dyslexics [20].

Surface dyslexia

Surface dyslexia is characterized by subjects who can read known words but who have trouble reading words that are irregular [21]. Surface dyslexia is the outcome of an individual who cannot function using the lexical procedure for reading out loud. The lexical procedure includes sounding out a word through the use of a past word already known [20]. In Castles and Coltheart's study, both control and dyslexic subjects were shown a

card with a word that is irregular or that isn't pronounced as it looks. Fifteen of the 51 dyslexics were below the confidence limit set by the control subjects on ability to read irregular words. These subjects were then called surface dyslexics [22].

Phonological dyslexia

Phonological dyslexia is characterized by subjects who can read aloud both regular and irregular words but have difficulties with non-words and with connecting sounds to symbols, or with sounding out words [20]. Phonological processing tasks predict reading accuracy and comprehension. This subtype is the most predominant form of dyslexia [21]. In Castles and Coltheart's study, they had 56 dyslexic boys and 56 non-dyslexic boys read words and non-words given to them. The majority of the boys, 55%, showed a phonological dyslexic pattern [20].In Castles and Coltheart's study, dyslexic subjects and control subjects were asked to read non-words listed on a card, 17 out of 51 cases of dyslexics were below the confidence limit in non-word reading, which was derived by the control group of subjects their own age. These phonological dyslexics have a lower non-word reading level than expected by reviewing their irregular word reading level [22]. Phonological dyslexia is the outcome of a subject who cannot function using the sub lexical (pronunciations are constructed from smaller orthographic components) procedure for reading out loud [20] .In Castles and Coltheart's study, dyslexic and control subjects read words off a note card; the researchers found that while reading irregular words, the dyslexic subjects scored comparable to the control subjects because sub lexical skills were not involved in this test [20].

Double deficit dyslexia

Researchers have identified a deficit related to "naming speed", which relates to the ability of students to rapidly verbalize the names of symbols such as letters and numbers when tested [23]. In their study, Wolf and Bowers tested out naming speed by having their subjects name a symbol as quickly as possible when shown on a flash card. Difficulties in naming speed exist in conjunction with a phonological deficit, is characterized as double deficit dyslexia. Many parents who are dyslexic will have children who are dyslexic as well.[23].

Variations and related conditions

Dyslexia is a learning disability. It has many underlying causes that are believed to be a brain-based condition that influences the ability to read written language. It is identified in individuals who fail to learn to read in the absence of a verbal or nonverbal intellectual impairment, sensory deficit (e.g., a visual deficit or hearing loss), pervasive developmental deficit or a frank neurological impairment.

The following conditions may also be contributory or overlapping factors, or underlying cause of the dyslexic symptoms as they can lead to difficulty reading:

- **Auditory processing disorder** is a condition that affects the ability to encode auditory information. It can lead to problems with auditory working memory and auditory sequencing. Many dyslexics have auditory processing problems including history of auditory reversals. Auditory processing disorder is recognized as one of the major causes of dyslexia.
- **Cluttering** is a speech fluency disorder involving both the rate and rhythm of speech, and resulting in impaired speech intelligibility. Speech is erratic and dysrhythmic, consisting of rapid and jerky spurts that usually involve faulty phrasing. The personality of the clutterer bears striking resemblance to the personalities of those with learning disabilities.[24]
- **Dyspraxia** is a neurological condition characterized by a marked difficulty in carrying out routine tasks involving balance, fine-motor control, and kinesthetic coordination. Problems with short term memory and organization are typical of dyspraxics. This is most common in dyslexics who also have attention deficit disorder.
- **Verbal dyspraxia** is a neurological condition characterized by marked difficulty in the use of speech sounds, which is the result of an immaturity in the speech production area of the brain.
- **Dysgraphia** is a disorder which expresses itself primarily during writing or typing, although in some cases it may also affect eye-hand coordination in such direction or sequence oriented processes 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** is 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 and even basic addition and subtraction.
- **Scotopic sensitivity syndrome**, also known as Irlen Syndrome, is a term used to describe sensitivity to certain wavelengths of light which interfere with proper visual processing. See also Orthoscopics and asfedia.
- High Functioning Speech Disorder Language is defined as the understanding and use of words and sentences to convey specific thoughts or meaning in connected speech. Higher-level language abilities include a person's ability to conceptualise, manipulate and judge the content and meaning of language. These skills allow a person to discuss, think and talk about language as an object that can be analysed.

The ability to use these skills requires an underlying understanding of all of the meaningful linguistic units in language e.g. phonology, syntax, semantics, morphology and pragmatics.

High-level language difficulties, such as High Functioning Speech Disorder, can often affect a person's ability to summarise information, make inferences, glean the main idea or predict outcomes from language. Quite often a person can seem quite rigid or concrete in their understanding or use of language, and often lack the flexibility required to understand humour, sarcasm, multiple meanings or non-literal meanings in language.

A person may have problems in the following areas: • Understanding or using ambiguity. • Understanding or using humour and sarcasm. • Using a variety of sentence forms to convey the same meaning. • Judging the appropriateness of words or language units. • Recognising language as a set of individual meaningful units. • Judging the correct use of grammar. • Segmenting language i.e. or words into sounds and sentences into words. • Summarising meaning and content either receptively or expressively • Not keeping up with his/hers peers either academically or socially.

The form of disability may be confused with autistic characteristics or with Asperger's Syndrome, especially if social relationships are difficult to make or maintain, or if responses do not appear immediately related to the question of the context.

Cross-Cultural Incidence Rate Comparison

Catherine McBride-Chang is a researcher in this area.

Scientific research

Theories of developmental dyslexia

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.

Evolutionary hypothesis

This theory posits that reading is an unnatural act, and carried out by humans for an exceedingly brief period in our evolutionary history (Dalby, 1986). It has been less than a hundred years that most western societies promoted reading by the mass population and therefore the forces that shape our behavior have been weak. Many areas of the world still do not have access to reading for the majority of the population. There is no evidence that "pathology" underlies dyslexia but much evidence for cerebral variation or differences. It is these essential differences that are taxed with the artificial task of reading. [25] The native reading hypothesis of dyslexia is another evolutionary theory which argues that because spoken language is naturally learned in the first few years of development, similarly, written language is best learned at the same early age. It suggests that many forms of dyslexia are therefore, to some extent, a result of introducing reading too late in

neurodevelopment. This means that the typically late reading of dyslexics might sometimes be the *cause* of dyslexia, rather than the other way around, and many cases of dyslexia might be prevented by the earlier introduction of reading instruction.[26]

Phonological hypothesis

The phonological hypothesis postulates that dyslexics have a specific impairment in the representation, storage and/or retrieval of speech sounds. It explains dyslexics' reading impairment 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. If these sounds are poorly represented, stored or retrieved, the learning of grapheme/phoneme correspondences, the foundation of reading by phonic methods for alphabetic systems, will be affected accordingly.[27]

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 dyslexics show poor performance on a number of auditory tasks, including frequency discrimination and temporal order judgment. Backward masking tasks, in particular, demonstrate a 100-fold (40 dB) difference in sensitivity between normals and dyslexics. [28] Abnormal neurophysiological responses to various auditory stimuli have also been demonstrated. The failure to correctly represent short sounds and fast transitions would cause further difficulties in particular when such acoustic events are the cues to phonemic contrasts, as in /ba/ versus /da/. There is also evidence that dyslexics may have poorer categorical perception of certain contrasts.[27]

Visual theory

The visual theory (Lovegrove et al., 1980; Livingstone et al., 1991; Stein and Walsh, 1997) 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, but emphasizes a visual contribution to reading problems, at least in some dyslexic individuals. At the biological level, the proposed etiology of the visual dysfunction is based on the division of the visual system into two distinct pathways that have different roles and properties: the magnocellular and parvocellular pathways. The theory postulates that the magnocellular pathway is selectively disrupted in certain dyslexic individuals, leading to deficiencies in visual processing, and, via the posterior parietal cortex, to abnormal binocular control and visuospatial attention. Evidence for magnocellular dysfunction comes from anatomical studies showing abnormalities of the magnocellular layers of the lateral geniculate nucleus (Livingstone et al., 1991), psychophysical studies showing decreased sensitivity in the magnocellular range, i.e. low spatial frequencies and high temporal frequencies in dyslexics, and brain imaging studies.[27]

Cerebellar theory

Yet another view is represented by the automaticity/cerebellar theory of dyslexia. Here the biological claim is that the dyslexic's cerebellum is mildly dysfunctional and that a number of cognitive difficulties ensue. First, the cerebellum plays a role in motor control and therefore in speech articulation. It is postulated that retarded or dysfunctional articulation would lead to deficient phonological representations. Secondly, the cerebellum plays a role in the automatization of overlearned tasks, such as driving, typing and reading. A weak capacity to automatize would affect, among other things, the learning of grapheme-to-phoneme correspondences. Support for the cerebellar theory comes from evidence of poor performance of dyslexics in a large number of motor tasks, in dual tasks demonstrating impaired automatization of balance, and in time estimation, a non-motor cerebellar task. Brain imaging studies have also shown anatomical, metabolic and activation differences in the cerebellum of dyslexics.[27]

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). Furthermore, as the cerebellum receives massive input from various magnocellular systems in the brain, it is also predicted to be affected by the general magnocellular defect (Stein et al., 2001). Through a single biological cause, this theory therefore manages to account for all known manifestations of dyslexia: visual, auditory, tactile, motor and, consequently, phonological. Beyond the evidence pertaining to each of the theories described previously, evidence specifically relevant to the magnocellular theory includes magnocellular abnormalities in the medial as well as the lateral geniculate nucleus of dyslexics' brains, poor performance of dyslexics in the tactile domain, and the co-occurrence of visual and auditory problems in certain dyslexics.[27]

Perceptual visual-noise exclusion hypothesis

The concept of a perceptual noise exclusion (Visual-Noise) deficit is an emerging hypothesis, supported by research showing that dyslexic subjects 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.[29] 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.[30]

Research using functional brain scan technology

A University of Hong Kong study argues that dyslexia affects different structural parts of children's brains depending on the language which the children read.[31] The study focused on comparing children that were raised reading English and children raised reading Chinese. Using MRI technology researchers found that the children reading English used a different part of the brain than those reading Chinese. Researchers were surprised by this discovery and hope that the findings will help lead them to any neurobiological cause for dyslexia.[31]

Research also indicates

Genetic factors

A familial component to reading disorders was identified in the 1950s, and twin studies beginning in the early 1980s onward suggest that reading ability and disability is a heritable trait. Molecular studies have since linked several forms of dyslexia to genetic markers.[32] [33] [34].

Genetic research in families and twins with dyslexia have identified over nine chromosome regions as being associated with susceptibility to dyslexia. As is common in complex genetics, several of studies have not yet been replicated. [35]

However, several candidate genes have been identified, including at the two regions first related to dyslexia: DCDC2 [36] and KIAA0319 on chromosome 6, and DYX1C1 on chromosome 15.

Physiology

Modern neuroimaging techniques such as functional Magnetic Resonance Imaging (fMRI) and Positron Emission Tomography (PET) have produced clear evidence of structural differences in the brains of children with reading difficulties. It has been found that people with dyslexia have a deficit in parts of the left hemisphere of the brain involved in reading, which includes the inferior frontal gyrus, inferior parietal lobule, and middle and ventral temporal cortex.[37] [38]

Scientific studies of brains donated to medical research have revealed that there are anatomical differences in two parts of the dyslexic brain: the cerebral cortex and the thalamus. In 1979 Albert Galaburda of Harvard Medical School noticed anatomical differences in the language center in a dyslexic brain, showing microscopic differences known as ectopias and microgyria. Both affect the typical six-layer structure of the cortex. An ectopia is a collection of neurons that have pushed up from the lower layers of the cortex into the outermost one. A microgyrus is an area of cortex that includes only four layers instead of six. These differences affect connectivity and functionality of the cortex in critical areas related to auditory processing and visual processing, which seems consistent with the hypothesis that dyslexia stems from a phonological awareness deficit.

Studies of both autopsied brains and living brains using neuroimaging techniques have shown that the brains of dyslexic children are symmetrical, unlike the asymmetrical brains of non-dyslexic readers who had larger left hemispheres.[39]

Scientists do not claim that all people with dyslexia have these structural brain differences. However, the studies are evidence that some children's reading problems are brain based. The challenge for researchers is to determine how these structural differences affect reading acquisition. [40]

Effect of language orthography

Some studies have concluded that speakers of languages whose orthography has a highly consistent correspondence between letter and sound (e.g., Italian) suffer less from the effects of dyslexia than speakers of languages where the letter-sound correspondence is less consistent (e.g. English and French).[41]

In one of these studies, reported in Seymour et al.,[42] the word-reading accuracy of first-grade children of different European languages was measured. English children had an accuracy of just 40%, whereas among children of most other European languages accuracy was about 95%, with French and Danish children somewhere in the middle at about 75%; Danish and French are known to have an irregular pronunciation.

However, this does not mean that dyslexia is caused by orthography: instead, Ziegler et al.[43] claim that the dyslexia suffered by German or Italian dyslexics is of the same kind as the one suffered by the English ones, supporting the theory that the origin of dyslexia is biological. In a study by Paulescu et al. (Science, 2001) English, French, and Italian dyslexics were found to have the same brain function signature when studied with functional magnetic resonance imaging (fMRI), a signature that differed from non-dyslexic readers. However, dyslexia has more pronounced effects on orthographically difficult languages, e.g., dyslexics have more difficulty in English than Italian. Modern theories of some forms of dyslexia uses orthography to test a hypothesis of psychological causation

Characteristics

Formal diagnosis of dyslexia is made by a qualified professional, such as a neurologist or an educational psychologist. Evaluation generally includes testing of reading ability together with measures of underlying skills such as tests of rapid naming, to evaluate short term memory and sequencing skills, and nonword reading to evaluate phonological coding skills. Evaluation will usually also include an IQ test to establish a profile of learning strengths and weaknesses. However, the use of a "discrepancy" between full scale IQ and reading level as a factor in diagnosis has been discredited by recent research.[44] It often includes interdisciplinary testing to exclude other possible causes for reading difficulties, such as a more generalized cognitive impairment or physical causes such as problems with vision or hearing.

Recent advances in neuroimaging and genetics provide evidence that could potentially help identify children with dyslexia before they learn to read in the future. However, such tests have not yet been developed and more research is needed before such testing could be considered reliable.

Speech, hearing and listening

Speech delays may be an early warning sign of dyslexia. Many dyslexics may have problems processing and decoding auditory input prior to reproducing their own version of speech. Early stuttering or cluttering can also be warning signs of dyslexia.

Many dyslexics also can have problems with speaking clearly. They can mix up sounds in multi-syllabic words (ex: aminal for animal, bisghetti for spaghetti, hekalopter for helicopter, hangaberg for hamburger, ageen for magazine, etc.) They can also have problems speaking in full sentences. They can have trouble correctly articulating Rs and Ls as well as Ms and Ns. They often have "immature" speech. They may still be saying "wed and gween" instead of "red and green" in second or third grade. Many dyslexics might have speech therapy in special education. They may have fast speech, cluttered speech, or hesitant speech. [45] [46]

Reading requires the sounding out of words. Therefore, it makes sense that children with speech problems can end up having reading problems later. Many have problems with speech due to problems with auditory processing disorder issues.

Many dyslexics have problems with phonemic awareness. Phonemes are the smallest units in spoken language. The Auditory related underlying causes of dyslexia may be partially remediated by auditory therapy or speech therapy, which help with phonemic awareness. This may help to make sense of phonics which may help with phonological awareness, which is needed to sound out words.

Many acquire auditory processing disorder as an underlying cause of dyslexia from glue ear, otitis media.

Some shared symptoms of the speech/hearing deficits and dyslexia:

1. Confusion with before/after, right/left, and so on
2. Difficulty learning the alphabet
3. Difficulty with word retrieval or naming problems
4. Difficulty identifying or generating rhyming words, or counting syllables in words (phonological awareness)
5. Difficulty with hearing and manipulating sounds in words (phonemic awareness)
6. Difficulty distinguishing different sounds in words (auditory discrimination)
7. Difficulty in learning the sounds of letters
8. Difficulty associating individual words with their correct meanings
9. Difficulty with time keeping and concept of time
10. Confusion with combinations of words
11. Due to fear of speaking incorrectly, some children become withdrawn and shy or become bullies out of their inability to understand the social cues in their environment
12. Difficulty in organization skills

The identification of these factors results from the study of patterns across many clinical observations of dyslexic children. In the UK, Thomas Richard Miles was important in such work and his observations led him to develop the Bangor Dyslexia Diagnostic Test. [47]

Reading and spelling

- Spelling errors — Because of difficulty learning letter-sound correspondences, individuals with dyslexia might tend to misspell words, or leave vowels out of words.
- Letter order - Dyslexics may also reverse the order of two letters especially when the final, incorrect, word looks similar to the intended word (e.g., spelling "dose" instead of "does").
- Letter addition/subtraction - Dyslexics may perceive a word with letters added, subtracted, or repeated. This can lead to confusion between two words containing most of the same letters.
- Highly phoneticized spelling - Dyslexics also commonly spell words inconsistently, but in a highly phonetic form such as writing "shud" for "should". Dyslexic individuals also typically have difficulty distinguishing among homophones such as "their" and "there".
- Vocabulary - Having a small written vocabulary, even if they have a large spoken vocabulary.

Writing and motor skills

Because of literacy problems, an individual with dyslexia may have difficulty with handwriting. This can involve slower writing speed than average, poor handwriting characterised by irregularly formed letters, or inability to write straight on a blank paper with no guideline.

Some studies have also reported gross motor difficulties in dyslexia, including motor skills disorder. This difficulty is indicated by clumsiness and poor coordination. The relationship between motor skills and reading difficulties is poorly understood but could be linked to the role of the cerebellum and inner ear in the development of reading and motor abilities.[48]

Mathematical abilities

Dyslexia should not be confused with dyscalculia, a learning disability marked by severe difficulties with mathematics. Individuals with dyslexia can be gifted in mathematics while having poor reading skills. However, in spite of this they might have difficulty with word problems (i.e., descriptive mathematics, engineering, or physics problems that rely on written text rather than numbers or formulas). Individuals with dyslexia may also have difficulty remembering mathematical facts, such as multiplication tables, learning the sequence of steps when performing calculations, such as long division, and other mathematics which involve remembering the order in which numbers appear. This may be exhibited by having a slow response in mathematical drills and difficulty with word problems.

Adaptive attributes

A study has found that entrepreneurs are five times more likely to be dyslexic than average citizens[49]. There also exists a movement concerning the idea that dyslexia can be a natural neurological variation and a useful set of traits when dealing with large and complex bodies of information. This was first described and promoted in Thomas G. West's 1991 book, *In the Mind's Eye: Visual Thinkers, Gifted People with Dyslexia and Other Learning Difficulties, Computer Images and the Ironies of Creativity.*

Management

See also: Dyslexia treatment

There is no cure for dyslexia, but dyslexic individuals can learn to read and write with appropriate education or treatment. There is wide research evidence indicating that specialized phonics instruction can help remediate the reading deficits. The fundamental aim is to make children aware of correspondences between graphemes and phonemes, and to relate these to reading and spelling. It has been found that training, that is also focused towards visual language and orthographic issues, yields longer-lasting gains than mere oral phonological training.[19]

Teachers are also using audiobooks as a way of teaching textbooks in an engaging way to those with dyslexia. In the UK, one of the biggest charities is Listening Books, offering members a streaming service over the internet. www.listening-books.org.uk An Australian company, ReadHowYouWant is working to make all published books available in audiobook form[50].

Accessible publishing, the method by which charities and companies work to provide books and textbooks in a variety of formats and fonts suitable for all readers, has long been focused on developing formats to improve dyslexia by use of word patterns, phonic symbols, highlighting mirrored letters (such as *b* and **d**), and increasing the font size as words move along[51].

Effective training is given by teachers at school or kindergarten. Meta-analysis evaluating the effects of phonological awareness instruction has shown that word reading skills of all children, those with a risk for reading problems as well as those developing typically, improved their reading in systematic phonics instruction, a method that encourages a word to be recognised through the building of its constituent sounds. Basic phonemic awareness instruction did not, however, improve spelling in disabled readers.[52] None of the

studies included measures of reading fluency.[53]

The core deficit of dyslexia is in learning to read at the word level [54], and individuals with dyslexia require more practice to master skills in their areas of deficit. In the circumstances where typically developing children need 30 to 60 hours training, the number of hours that has resulted in optimistic conclusions concerning the treatability of dyslexia is between 80 and 100 hours, or less if the intervention is started sufficiently early. Only approximately 20% of adults with early reading difficulties have acquired fluent reading skills in adulthood. [19]

Functional MRI (fMRI) studies have shown changes in the brains of dyslexic children and adults with phonics tutoring, along with improved performance on tests of phonemic awareness and text decoding.[55] [56] Functional MRI studies have also shown changes in the brain and spelling improvement of dyslexic children taught spelling phonetically in an orthographic manner. [57]

One factor that characterises the field of dyslexia treatment is the incessant flow of alternative therapies for developmental and learning disabilities. These controversial treatments include nutritional supplements, special diets, homeopathy, and osteopathy/chiropractic manipulation.[58]

Because dyslexia has often gone undiagnosed in children, many adults suffer from the condition without realizing it.

Facts and statistics

In the United States, researchers estimate the prevalence of dyslexia to range from three to ten percent of school-aged children though some have put the figure as high as 17 percent.[59][60] Recent studies indicate that dyslexia is particularly prevalent among small business owners, with roughly 20 to 35 percent of U. S. and British entrepreneurs being affected. Researchers theorise that many dyslexic entrepreneurs attain success by delegating responsibilities and excelling at verbal communication.[61]

Dyslexia is diagnosed more frequently in boys. However, this may not reflect the actual occurrence of dyslexia. Evidence based on randomly selected populations of children indicate that dyslexia affects boys and girls equally; that dyslexia is diagnosed more frequently in boys appears to be the result of sampling bias in school-identified sample populations. [62]

Dyslexia's main manifestation is a difficulty in developing word-level reading skills in elementary school children. Those difficulties result from reduced ability to associate visual symbols with verbal sounds. While motivational factors must also be reviewed in assessing poor performance, dyslexia is considered to be developmental. Most scientific criteria for dyslexia exclude cases that can be explained as arising from environmental factors such as lack of education or total sensory deficits.

Dyslexia can be substantially compensated for with proper therapy, training, and assistive technology. Many coping strategies are developed subconsciously by the individual dyslexic.

Dyslexia has many variations dependent on the cultural choice of visual notation of speech. So the nature of the notation used in different cultures creates different types of problems for their groups of dyslexics. The differences between the English text and Chinese characters is a good example.

Dyslexia can also result in minor speech difficulties (i.e. switching around syllables, mispronouncing, inable to express their ideas because they can't find the words.)

Legal and educational support issues

In the English law case of *Skipper v Calderdale Metropolitan Borough School* (2006) EWCA Civ 238, the Court of Appeal applied *Phelps v London Borough of Hillingdon* (2001) 2 AC 619 as the landmark case on the failure to diagnose dyslexia, in accordance with duty of care in English law, and to hold that the appellant

could pursue her claim against her school for humiliation, lost confidence, and lost self-esteem, and for loss of earnings following its failing to diagnose and treat her dyslexia despite the fact that, as Latham LJ. The ruling states in paragraph 29:

> "The extent to which her dyslexia could have been ameliorated or provided for will always remain uncertain, as will the extent to which that would have affected her performance in public examinations; the evidence that we have includes material to suggest that she, not surprisingly, reacted adversely to the break-up of her parents marriage when she was 15, in other words at a critical time in her education. Whether any improvement in her examination results would have led to her life taking a significantly different course will also be a matter for some speculation."

Some charitable organizations like the Scottish Rite Foundation have undertaken the task of testing for dyslexia and making training classes and materials available, often without cost, for teachers and students.[63][64][65]

In England and Wales, the failure of schools to diagnose and provide remedial can help for dyslexia following the House of Lords decision in the case of Pamela Phelps has created an entitlement for students with dyslexia in Higher education to receive support funded via the Disabled Students Allowance. Support can take the form of IT equipment (software and hardware) as well as personal assistance, also known as non-medical helper support. Dyslexic students will also be entitled to special provision in examinations such as additional time to allow them to read and comprehend exam questions.

The British Disability Discrimination Act 1995 also covers dyslexia.

> *"In some cases, people have 'coping strategies' which cease to work in certain circumstances (for example, where someone who stutters or has dyslexia is placed under stress). If it is possible that a person's ability to manage the effects of the impairment will break down so that these effects will sometimes occur, this possibility must be taken into account when assessing the effects of the impairment."* — Paragraph A8, Guidance to the Definitions of Disability.

In Scotland, David Ballantine a member of the cross party group on dyslexia put forward a petition through the Scottish Parliament Petitions Website. The petition called:

"On the Scottish Parliament to urge the Scottish Government to consider the need for legislation to provide a standardised assessment of all schoolchildren by the age of 8 which will inform parents, pupils and educators as to whether the pupil is at risk of developing a specific learning difficulty."

The petition was contrary to the other view that children should not be identified with dyslexia as it was felt that a significant proportion of these children who were dyslexic and not identified did not have appropriate learning strategies in place and that it was the right of the child to know if they had a learning difficulty that would inhibit their education.

Controversy

Some disagreement exists as to whether dyslexia does indeed exist as a condition, or whether it simply reflects individual differences among different readers.

"The Dyslexia Myth" is a documentary that appeared as part of the *Dispatches* series produced by British broadcaster Channel 4.[66] First aired in September 2005, it claims to expose myths and misconceptions that surround dyslexia. It argues that the common understanding of dyslexia is not only false but makes it more difficult to provide the reading help that hundreds of thousands of children desperately need. Drawing on years of intensive academic research on both sides of the Atlantic, it challenged the existence of dyslexia as a separate condition, and highlighted the many different forms of reading styles.

The documentary only focused on the reading difficulties that dyslexics encounter. As discussed in previous headings, dyslexia is more than a mere reading disability, and commonly includes symptoms that extend beyond reading difficulties. However, these symptoms are not included in the DSM-IV list of symptoms by

which "Reading Disorder" is diagnosed in the USA.

Julian Elliot, a psychologist at Durham University in the United Kingdom, disputes the characterization of dyslexia as a medical condition, and believes it should be treated simply as a reading difficulty. According to Elliot, "[parents] don't want their child to be considered lazy, thick or stupid. If they get called this medically diagnosed term, dyslexic, then it is a signal to all that it's not to do with intelligence."[67] Elliot believes that children of all levels of intelligence may struggle with learning to read, and that all can be helped by educational strategies appropriate to their needs. He feels that resources are wasted on diagnosis and testing, and favors early intervention programs for all struggling readers.[68]

However, John Everatt of the University of Surrey, has suggested that dyslexic students can be distinguished from other children with low reading achievement by testing geared to assessing their strengths as well as weaknesses. Dyslexic children tend to score significantly better than other children, including non-impaired children, on tests of creativity, spatial memory, and spatial reasoning. Dyslexic children also perform better than other reading-impaired children on tests of vocabulary and listening comprehension. Everatt suggests that dyslexic children may be better served by educational intervention which includes strategies geared to their unique strengths in addition to skill remediation, and thus recommends more comprehensive evaluation and targeted interventions. [69]

Gerald Coles, an educational psychologist and formerly an associate professor of clinical psychiatry at Robert Wood Johnson Medical School and the University of Rochester, in the United States, who has written extensively on literacy and learning disabilities, asserts that there are partisan agendas behind the educational policy-makers and that the scientific research that they use to support their arguments regarding the teaching of literacy are flawed. These include the idea that there are neurological explanations for learning disabilities. Gerald Coles argues that school failure must be viewed and treated in the context of both the learning environment and the child's individual abilities, behavior, family life, and social relationships. He then presents a new model of learning problems, in which family and school environments are the major determinants of academic success. In this "interactive" paradigm, the attitudes and methods of education are more important than inherent strengths or deficits of the individual child.[70]

The experience of Sudbury model of democratic education schools

Sudbury model of democratic education schools assert that there are many ways to study and learn. They argue that learning is a process you do, not a process that is done to you; That is true of everyone. It's basic.[71] The experience of Sudbury model democratic schools shows that there are many ways to learn without the intervention of teaching (http://en.wikipedia.org/wiki/Response_to_intervention#Criticism_of_the_concept_of_preventing_academic_failure_through_intervention), to say, without the intervention of a teacher being imperative. In the case of reading for instance in the Sudbury model democratic schools some children learn from being read to, memorizing the stories and then ultimately reading them. Others learn from cereal boxes, others from games instructions, others from street signs. Some teach themselves letter sounds, others syllables, others whole words. Sudbury model democratic schools adduce that in their schools no one child has ever been forced, pushed, urged, cajoled, or bribed into learning how to read or write, and they have had no dyslexia. None of their graduates are real or functional illiterates, and no one who meets their older students could ever guess the age at which they first learned to read or write.[72][73] In a similar form students learn all the subjects, techniques and skills in these schools.

Dyslexia in literature, film, and television

Dyslexic characters have featured in a number of works of fiction. Notable works include Henry Winkler's Hank Zipzer series of children's books, and Jennifer Weiner's 2002 novel, *In Her Shoes* (which was adapted as the 2005 film, *In Her Shoes*). Toki Wartooth and Skwisgaar Skwigelf both from the TV show Metalocalypse claim to be dyslexic as they cannot read music. Shooting Fish features Dylan a dyslexic conman, who makes his living using confidence tricks to gain money from rich people, he attributes his lifestyle to his inability to get a job which he blames on his dyslexia. Additionally, there are three episodes of The Cosby Show which focus on dyslexia, all three having Theo as one of the major characters in the plot. Aamir Khan's famous

Bollywood film *Taare Zameen Par* tells the story of eight year-old Ishaan (Darsheel Safary) who suffers greatly until a teacher (Aamir Khan) identifies him as dyslexic. George Lopez from the hit TV show, also named George Lopez, has dyslexia in the storyline. Dr. Christina Yang from Grey's Anatomy is also dyslexic, although only two other characters know about her dyslexia. Perseus Jackson, the protagonist in the popular children's fictional series Percy Jackson and the Olympians, is immediately portrayed to be a dyslexic child in school. However, the answer to his dyslexia is described as being a part of his Demigod blood, which his brain is wired to understand Ancient Greek.

See also

- Child development
- Dysorthographia
- Foggy brain
- List of people diagnosed with dyslexia

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External links

Associations and Charities

- British Dyslexia Association (http://www.bdadyslexia.org.uk/)
- British Dyslexics (http://www.dyslexia.uk.com/)
- Dyslexia Action (http://www.dyslexiaaction.org.uk/)
- International Dyslexia Organization (http://www.interdys.org/)
- Valley of Chicago Learning Center (http://www.valleyofchicagolc.org/)

Historical

- Samuel T Orton and June L Orton Personal Papers and Manuscripts at the Columbia University Health Science Library collection (http://library.cpmc.columbia.edu/hsl/archives/findingaids/ortonpapers.html)
- help on dyslexia (http://www.4dyslexics.com)

Research papers, articles and media

- Auditory and visual automatic attention deficits in developmental dyslexia (http://www.utdallas.edu/~tres/neuroII/mehta.pdf)
- A Blog of Personal Experiences of Living with Dyslexia (http://charleyabel.wordpress.com)
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