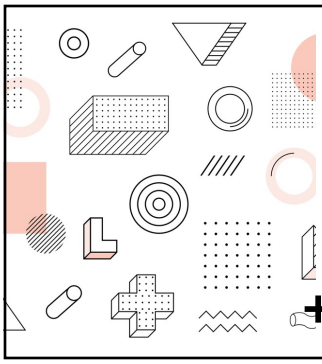

The Presentation, Neuroscience, and Diagnosis of Developmental Dyslexia

Jen Gale Psy.D.

1

Why is diagnosis important: Basic Stats

- Prevalence: One in 5 students or 15-20% of the general population has a language-based learning "disorder" and as many as 4.3 million Americans may have dyslexia.
- Dyslexia is the most common of the language-based learning disorders.
- NAEP ("Nation's Report Card") data from as recent as 5 years ago (2019) showed that more than 50% of 50 million school age children are NOT learning adequately.
- 36 percent of children were proficient in reading by 4th grade with only 37% of children showing to be proficient in reading by 12th grade.
- 2024 Literacy Statistics (National Literacy Institute) show that 20 percent of adults in the general population read below a 5th grade level and 54% of adults read below a 6th grade level

2

Why is diagnosis important: Basic Stats

- Family history is a significant risk factor for dyslexia. Molecular genetic linkage studies show that a child with an affected parent has a 40-60% risk (Stephenson).
- When one child in the family has dyslexia, there is an estimated 3-to-10-fold rate of increase for a sibling to have dyslexia
- In childhood, children with dyslexia have a 20-35% chance of also being diagnosed with ADHD. Clinically, the comorbidity is between 25 and 48%.
- ADHD, inattentive type is also the most common misdiagnosed neurodevelopmental disorder due to the shared or overlapping symptom set of the two diagnoses.
- 60% of children with a Reading Disability meet the criteria for at least one additional diagnosis (Willcutt & Pennington, 2000a, 2000b).

3

Why is diagnosis important: Basic Stats

- FALSE: Boys and Girls are equally affected (Sally and Bennett Shaywitz). Its also true that two thirds of the approximate 781 million illiterate adults are female.
- TRUE: While sex influence is controversial, more recent epidemiological studies show a twofold increase in risk for boys versus girls (differences in biological vulnerability)
- A mini-review of 40 years of epidemiological studies shows sex related or male-female related differences in reading abilities
- TRUE: Two-thirds of LD students are males (National Center for Learning Disabilities 2014)
- Affected individuals have a much lower educational level and higher rates of unemployment and psychosocial stress than would be expected by their level of intelligence. Those lacking literacy face severely restricted options, with even entry level, low skilled jobs posing challenges to secure.
- Entrepreneurs are over 5 times more likely to have dyslexia (Brock and Fernette Eide, The Dyslexic Advantage)

4

What Dyslexia is NOT

- Dyslexia is NOT reading words backwards
- IT is NOT a predominant disorder of visual perception
- It is NOT brain injury, or intellectual disability
- It is NOT illiteracy or an inability to read

- Aidan's Definition: "Dyslexia means that I am right brain dominant, which means that I read with my right brain, and that its harder to read and write and spell and do math than it is for the other kids in my grade."

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Right Hemisphere Theory

- fMRI shows that the dyslexic brain consistently employs more Right Hemisphere structures for reading and writing than left hemisphere structures
- Activates a broader field of meaning.
- Dyslexics are commonly strong visual spatial thinkers. They think and engage in 3D big picture thinking and overlook the detail. They are good at figurative meanings, themes; comprehension, jokes, use of contextual cues to figure out the information they missed. broader network of connections fostered by Right hemisphere can detect ambiguity. Reading with right brain dominance is compensatory.

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And what does the Left Hemisphere Do?

- The Left Hemisphere processes the most literal meaning of the word
- It quickly and efficiently produces language
- Narrow semantic fields
- Focuses on "rule-based procedures."

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What is Dyslexia?

- International Dyslexia Association –**deficits** in accurate and/or fluent word recognition, decoding, spelling, with secondary effects on reading comprehension.
- ICD-10- dyslexia is marked by reading achievement that falls substantially below what would be expected given the individual's chronological age, measured intelligence, and age-appropriate education.
- World Health Organization – a neurodevelopmental disorder hindering the acquisition of reading that cannot otherwise be explained by IQ, academic opportunities, motivation, or specific sensory acuity.

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Definitions of Dyslexia

- IDEA (Individuals with Disabilities Education Act) - a **learning disability** is a basic **disorder** of a psychological process used in understanding oral, spoken, or written language, and may manifest in the imperfect ability to listen, think, speak, read, write, spell, or do math. It may include conditions such as dyslexia.
- DSM V – dropped the term learning disability and now uses the generic term of "specific learning disorder with impairment in….

9

Generally Accepted Definition of Dyslexia

- Dyslexia is a genetic, brain- based characteristic that results in **difficulty** connecting the sounds of spoken language to written words (from: Ben Foss, Dyslexia Empowerment Plan), leading to **difficulties** with accurate and/or fluent word recognition and poor spelling and decoding abilities.
- These difficulties typically result from a **deficit** in the phonological component of language that is often unexpected in relation to other cognitive abilities.
- Secondary **consequences** of dyslexia can include **problems** with reading comprehension, as the higher order capacity to comprehend is intact, but blocked by a deficit in the lower order function of phonological processing.

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Our description of Dyslexia

- Dyslexia as a Learning Style Variant
- An expression of a less common pathway to reading
- A result of a predominant right brain style of learning and reasoning
- A term for a set of strengths that lead to strong whole brain/big picture thinking and weaker language-based learning

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Strengths of the Dyslexic Brain

Weaknesses as Flip Side of Strengths

- Strong spatial sense
- Strong visual memory
- Strong contextual, personal or episodic element to memories
- Strong ability to see unusual connections
- Strong ability to make 3D connections
- Strong problem solving
- Strong narrative reasoning

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In all word languages studied to date, children with developmental reading disorders (dyslexia) primarily have difficulties in recognizing **and** manipulating phonological units at all linguistic levels (Goswami, 2007).

Lowest Incidence
- Italy 1-5%
- Slovakia 1-2%
- Italy 1-5%
- Czech Republic 2-3%
- Britain 4%
- Poland 4%
- Belgium 5%
- Greece 5%
- Japan 6%

Highest Incidence:
- China 5-8%
- **United States 5-10%**
- Russia 10%
- Israel 10%
- Finland 10%
- Nigeria 11%
- Australia 16%
- India 20%

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The English language is not a purely phonological language. In fact, one letter may map to as many as five distinct phonemes or sounds.

The English language includes over 1,100 ways of representing 44 sounds (phonemes) using a series of different letter combinations (Uhry & Clark, 2005).

Therefore, 25% of words are phonologically irregular (i.e. "debt", "yacht", "onion", etc..) or have one spelling but multiple meanings (i.e. "tear," "bass," "wind," etc.)

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Key Constructs in Reading and Potential Deficits in Dyslexia: "The Phonological Component of Language"

- Phonological Processing
  - Phonological Awareness
  - Phonological Memory (involves verbal working memory)
  - Rapid Automatized Naming +

- Orthographic Processing (involves visual components)
  - Reading Fluency

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The Role of Working Memory in Reading

- Working memory is known to be an essential component in the development of literacy skills
- The ability to retain verbal information in working memory is essential for reading specifically (and learning in general).
- Working memory includes a phonological loop that stores verbal information.
- Dyslexia involves deficits in both the phonological loop and central executive functioning (deJong 2006).
- Working memory also affects children's acquisition of phonics, or the ability to take apart and analyze sounds in words and reading comprehension.

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The Role of Working Memory in Reading

- Working memory capacity can influence both the duration that a fact remains in working memory and the probability that it is consolidated into long-term memory.
- A reader with more efficient working memory might have additional capacity and processing time to devote to rehearsal and to consolidate information.
- The poor or dyslexic reader would require all her processing capacity to perform the minimal amount of work on a given task.

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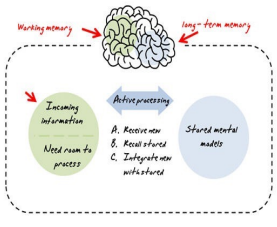
The phonological component of language includes phonological awareness, phonological memory (the ability to hold onto speech-based information in short term memory), the rapid retrieval of phonological information from working memory, orthographic processing (orthographic coding, involves visual processing), the efficient retrieval of phonological information from long term memory (how fast you can scan the array of visual symbols and encode a phonological response...and... procedural learning



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The Problem with English Orthography

– If the GH Sound in ENOUGH is pronounced /F/ and the O sound in WOMEN is /i/ and the TI in NATION is /SH/ then the word

"GHOTI"

is pronounced like "FISH."

"Welcome to the English Language"

(Steven G. Feifer, D.Ed, ABSNP, Learning and The Brain)

Ghoti or Fish?

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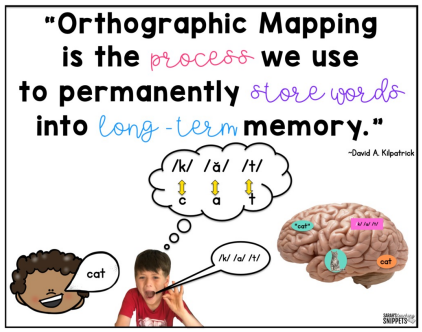

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Specific neuroimaging techniques have demonstrated that phonological processing and orthographic processing are a by-product of the functional integrity of the temporal-parietal junctures in the left hemisphere of the brain (Pugh et al., 2000, McCandliss & Noble, 2003; Shaywitz, 2004; Sandak et al., 2004).

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Phonological Processing: Phonological Awareness

– Knowledge of, and ability to manipulate, the sound structure of words
– Phonemic Awareness
– Individual phoneme skills
– Phoneme Deletion, Addition, Substitution

– Example Tasks
Elision: Say *gate* without the /g/ The new word is *ate*
Individual Phoneme Blending: What word do these sounds make? /s/ - /i/ - /t/
Rhyming: Name a word that rhymes with *star*

- Comprehensive Test of Phonological Processing (CTOPP-2)
- Phonological Awareness Test (PAT-2)

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Phonological Processing: Phonological Memory

Coding information phonologically for temporary storage in working or short-term memory.

– Example Tasks
– Digit Span
– Nonword Repetition

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Phonological Processing: Rapid Automatized Naming (RAN)

Speed with which a series of familiar stimuli can be named aloud, reflecting efficient visual-verbal connections

– Example Tasks
Rapid naming of letters, numbers, colors or objects from a 10X5 stimulus array under a time constraint

Rapid Automatized Naming–Rapid Alternating Stimulus Tests (RAN-RAS)

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Phonological Processing: Reading Fluency

– Ability to read single words and connected text with sufficient accuracy and speed so as to support efficient comprehension

– Example Tasks
- Decoding Fluency: Read aloud a list of common words or pseudowords as quickly and accurately as possible
- Orthographic Fluency
- Oral Reading Fluency: Read aloud, quickly and accurately, paragraphs of increasing complexity

- Test of Word Reading Efficiency (TOWRE-2)
- Gray Oral Reading Test (GORT-5)
- WIAT V Reading related battery

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Phonological coding	The ability to put together the phonemes and then verbally express words which have never been previously read or heard. This ability is tested through reading of pseudowords
Orthographic coding	Orthographic coding refers to the assumed process of recognizing a word by its holistic form. Orthographic coding is measured by a pseudo-homophone task where an orally presented word has to be compared with a visual presentation of two phonologically indistinguishable words, of which one may be orthographically correct
Rapid naming	Rapid naming is a measure of the speed of processing. The naming of objects, numbers, letters and colors is typically measured

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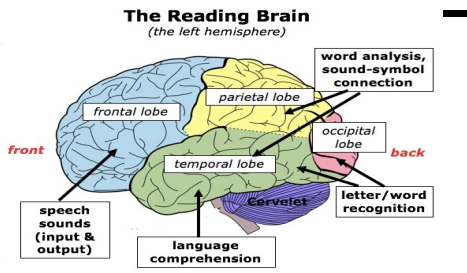

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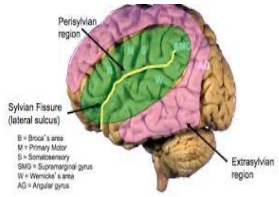
Proficient reading entails the convergence of phonological and orthographic processing systems onto a common network of neural structures dominated by the left perisylvian regions of the brain.



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Reading is a complex and slowly learned skill requiring the integration of multiple visual, linguistic, cognitive, and attentional processes.

– **Neuroimaging methods** including functional magnetic resonance imaging (fMRI), electroencephalography (EEG, and event-related potentials or ERPs), and magnetoencephalography (MEG), **have revealed the brain regions most consistently involved in single word reading**.

– In typically reading adults, these regions **are lateralized to the language-dominant left hemisphere**, and include inferior frontal, superior and middle temporal, and temporo-parietal regions.

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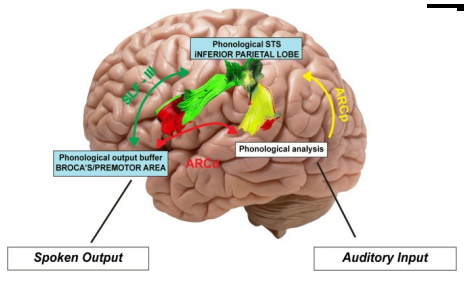

30

The Visual Word Form Area (VWFA)

In addition, experienced readers recruit an area of the left fusiform gyrus, which becomes preferentially engaged for orthographic (print) processing with reading experience. This reading network develops over years as children gain both specific reading skills and other abilities relevant to reading.

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The Neuroscience of Poverty

From: Family Income, Parental Education and Brain Structure in Children and Adolescents by Kimberly G Noble et al. in Nature Nauroscience Vol 18 May 2015

- Brains (MRI data n=1099) of those with higher family income and more parental education had larger surface areas than their poorer, less educated peers, Noble et al. 2015.
- The strongest correlation came in brain regions associated with language and executive functioning, Noble et al. 2015.
- By age 3, it is believed that children growing up in poor neighborhoods or from lower-income families may hear up to 30 million fewer words than their more privileged counterparts, Fernald, 2015.

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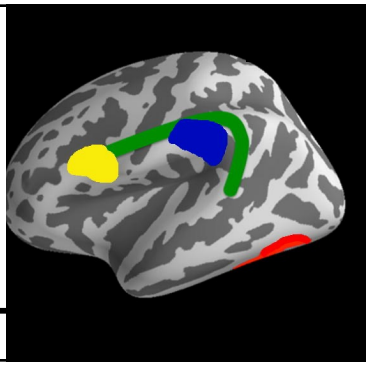
Brain Based Models of Dyslexia

Schematic of the aspects of the reading brain in the left hemisphere. The inferior frontal gyrus (yellow) and the inferior parietal area (blue) are connected by the arcuate fasciculus (green). The fusiform gyrus, which includes the visual word form area, is in red. These regions are the most commonly found to be atypical in function or structure in dyslexia.



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Cognitive components involved in reading and writing

Visual processing

The magnocellular system responds to moving stimuli and stimuli of low spatial frequency and low contrast. Impaired perception of moving stimuli and the neurophysiological correlates of this have been found repeatedly in individuals with dyslexia.

Later research shows that reduced MT activation for visual motion in dyslexia is a consequence, not a cause, of dyslexia.

MT hypoactivation in dyslexia reflected reading experience

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Phonological awareness	The ability to perceive, segment and manipulate the sounds of spoken words. Phonemes are the smallest meaningfully distinct sounds from which an acoustic speech flow can be constructed. The word dog, for example, consists of three phonemes /d/, /o/, /g/. The capacity for phonological awareness is often tested through a phoneme deletion task
Verbal short-term memory/Phonological Memory/ "Phonological Loop"	Various aspects of memory are required for reading. Many known words are no longer dissected into their phonemes but are recalled directly from memory. Processing of unknown words into their phonemes occurs in short-term memory. Short-term memory is often examined by a digit span task

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Procedural Learning Theory of Dyslexia

- Structural variations in the left temporal lobe cause deficits in the phonological component of language

However, it is also true that:

- 50% of dyslexics also have procedural learning deficits, or impaired *procedural learning* in language networks, pointing to the role of the cerebellum (rule learning/motor learning)
- They are slower to master skills that should become automatic through practice

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Procedural Learning Theory of Dyslexia

– "Procedural Learning Theory of Dyslexia" – challenges with motor control and coordination (low processing speed, slow work output, rote memory, syntax and language and sequencing and poor time awareness and estimation); memorizing sequences and writing conventions; spacing evenly between words; difficulty with learning by copying others; low implicit learning; Poor rule-based learning (long division, alphabet, days of year; carrying over/borrowing; and motor rules for forming letters the same way every time when writing by hand;
– They learn better when rules and procedures are broken down into small steps. They require explicit learning.

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Dyslexia and Developmental Motor Coordination Disorder/Dyspraxia

– Some studies report a 50% co-existence of developmental coordination disorder with dyslexia (Ramus et al., 2003; Crispiani & Palmieri, 2017)
– Fundamental sensory motor skills including gross motor, fine motor, balance, coordination, vestibular, ball skills, and timing of movement should be assessed.

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Procedural Learning Theory of Dyslexia (Roderick Nicholson and Angela Fawcett)

– Because individuals that struggle with procedural learning have trouble mastering rule-based learning automatically, they must perform the same skills using "conscious compensation," or focused attention and active working memory.
– When sequences are not rote and mastered, or too many parts of a complex task must be performed consciously then WM resources are likely to be overwhelmed.
– Dyslexics often experience WM overload and are therefore more error prone; they need more repetitions to master complex rules; appear to forget skills that seemed previously mastered without repetition.

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Development of Dyslexia: The Delayed Neural Commitment Framework, Roderick Nicholson and Angela Fawcett
Frontiers in Behavioral Neuroscience, 21 May 2019

"In earlier work, we proposed that developmental dyslexia (DD) is well-characterized in terms of **impaired procedural learning within the language networks, with the cerebellum being the key structure involved.**"

"Here, we deepen the analysis to include the child's **developmental process** of constructing these networks."

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Development of Dyslexia: The Delayed Neural Commitment Framework, Roderick Nicholson and Angela Fawcett
Frontiers in Behavioral Neuroscience, 21 May 2019

The "**Delayed Neural Commitment** (DNC)" framework proposes that, in addition to slower skill acquisition, dyslexic children take longer to build (and to rebuild) the neural networks that underpin the acquisition of reading.

This framework provides an important link backwards in time to the development of executive function networks and the earlier development of networks for language and speech."

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MRI shows brain differences before reading experience

– In MRI, pre-reading kindergartners with familial risk for dyslexia exhibited reduced bilateral occipitotemporal and left temporo-parietal activations for PA and also bilaterally reduced grey matter volumes in similar posterior cortical regions.
– Decreased grey-matter volumes in prefrontal and parieto-temporal regions were also found in 5- and 6-year-olds with maternal histories of reading difficulty.
– In a heterogeneous sample of kindergartners, pre-reading children exhibited a positive correlation between measures of PA and both the size and microstructural white-matter organization of the left arcuate fasciculus.
– Although it is not yet known which of these children will develop dyslexia, these studies support the idea that the most commonly observed functional and structural brain differences characterizing dyslexia are present before significant reading experience and therefore are more likely causes rather than consequences of dyslexia.

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MRI shows brain differences before reading experience

The most commonly observed functional and structural brain differences characterizing dyslexia are present before significant reading experience and therefore are more likely causes rather than consequences of dyslexia.

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Brain Basis of Executive Function Networks

- Word recognition and oral language ability are insufficient to fully explain differences in reading achievement.
- A mini review of current and preliminary findings on the behavioral and neurobiological relationship between executive function and reading suggests that EF plays a supportive and perhaps indirect role in reading achievement
- EF-related brain regions interface with the reading and language networks revealing the complex role that EF plays in reading development.

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Brain Basis of Executive Function Networks

Why is this important?

Executive Function Skills have been shown to be better predictors of academic outcomes than both intelligent quotient (IQ) and socioeconomic status (SES) (Blair & Razza, 2007: Pascual et al. 2019).

Executive Function predicted math and reading in higher grade levels (Ribner et al., 2018, Magalhães et al, 2020).

Students must be able to maintain an "alert state of calm", pay attention, successfully avoid distractions, remember and apply academic knowledge, and manage social-emotional responding in order to succeed (Kenney, 2020).

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Brain Basis of Executive Function Networks

- Executive Function Skills are a better predictor of school readiness than IQ or foundational math and reading skills
- Executive Function skills lead to educational success: EF increases math and reading competence throughout the school years
- Students must be able to maintain an "alert state of calm," pay attention, successfully avoid distractions, remember and apply academic knowledge, and manage social-emotional responding in order to succeed (Kenney, 2020).
- It is estimated that 30% of those with dyslexia have coexisting ADHD (primarily inattentive type). Source: IDA

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Brain Basis of Phonological Awareness Deficits

- Impaired PA in dyslexia could reflect either a deficit in *representing* phonetic sounds and/or a deficit in *access* to and *manipulation* of those sounds (e.g., for mapping phonemes to print).
- Findings from neuroimaging favor the interpretation of dyslexia as being characterized by weakness in access to otherwise intact phonetic representations. Consistent with this conclusion is the finding that children with dyslexia exhibited reduced prefrontal activation when engaging in an auditory PA task, but no difference in temporal-lobe activation, as compared with both age- and ability-matched children

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Brain Basis of Rapid Automatized Naming (RAN) Deficits

- RAN (Rapid Automatized Naming) refers to **the skill of quickly accessing presumably rote information (numbers, letters, colors, or objects.)** Students slower than average with RAN typically struggle with word-level reading
- A large structural MRI study of typical adult readers of Chinese found that phonological decoding ability was related to gray matter volume in the left perisylvian cortex, whereas naming speed was related to volume in a more distributed network across all four lobes
- Activation in left inferior parietal lobule showed a gradient associated with PA ability, whereas activation in right cerebellar lobule VI showed a gradient with RAN ability

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Brain Basis of Basic Perceptual Processes

- Neuroimaging findings have reported neural correlates of atypical basic perceptual processes in dyslexia.
- Reduced entrainment, or synchronization of neural firing, to the 30 Hz frequency range in dyslexia, as well as reduced left-hemisphere specialization for such oscillations may impede the efficient transfer of acoustic information into more abstract phonemic representations.
- Individuals with dyslexia also exhibited reduced neural entrainment in response to linguistic stimuli differences in EEG signals that reflect integration of auditory and visual stimuli, and greater variability of auditory brainstem responses to speech sounds

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Brain Basis of Basic Perceptual Processes

- Animal research has linked dyslexia-associated genes such as KIAA0319 with atypical neural migration and impaired speech sound discrimination, suggesting that the mechanism by which cortical abnormalities result in behavioral deficits is through the disruption of synchronous firing in response to oral language.
- In humans, variation in KIAA0319 and two other dyslexia susceptibility genes has been associated with variation in left-hemisphere white matter and reading skill.
- Such research may integrate findings from the genetic, cellular, cognitive, and behavioral levels in understanding the core deficits in dyslexia.

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3 Subtypes of Dyslexia

(1) Dysphonetic Dyslexia – impairment in phonological awareness or difficulty sounding out words based on phonics.

(2) Surface Dyslexia – impairment in orthographic processing, or a deficiency in rapid and automatic recognition of words in print. Poor phonological memory

(3) Mixed Dyslexia ("Double Deficit Dyslexia")–reading deficits characterized by impaired phonological and orthographic processing skills. Most severe form of dyslexia.

Comprehension Deficits – mechanical side of reading is fine, but difficulty persists in deriving meaning from print.

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(1)Dysphonetic Dyslexia :
- Phonemic Awareness Deficits
- Phonological Processing Deficits
- Phonological Working Memory Deficits
- Tendency to "guess" on words

(2) Surface Dyslexia:
- Orthographic Processing Deficits
- Slower Rapid Naming Skills
- Poor Reading Fluency
- Inaccurate Reading of "Irregular Words"

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(3) Mixed Dyslexia:
- Both Phonological and Orthographical Deficits
- Significantly Below Grade Level
- Failure to Respond to Interventions

Comprehension Deficits:
- Poor Attention
- Poor Executive Functioning
- Limited Verbal Working Memory
- Lower Verbal IQ

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Mild/Moderate/Severe Distinction

Dysphonetic Subtype - great difficulty using phonological route in reading, so visual route to lexicon is used. These readers do not rely in letter to sound conversions, but rather over-rely on visual cues to determine meaning from print.

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Mild/Moderate/Severe?

Surface dyslexia - an over-reliance on sound symbol relationships as the process of reading never becomes automatic. These children break every word down to its phonetic base, and read slowly due to poor orthographic processing

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Mild/Moderate/Severe?

- Mixed Dyslexia
- severely impaired readers with characteristics of both phonological deficits, as well as orthographical deficits. These readers have no usable key to the reading and spelling code. Very bizarre error patterns observed.

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Common Traits

- Appears bright, highly intelligent, and articulate but unable to read, write, or spell at grade level.
- Labelled lazy, dumb, careless, immature, "not trying hard enough," or "behavior problem."
- Isn't "behind enough" or "bad enough" to be helped in the school setting.
- High in IQ yet may not test well academically; tests well orally, but not written.
- Feels dumb; has poor self-esteem; hides or covers up weaknesses with ingenious compensatory strategies; easily frustrated and emotional about school reading or testing.
- Talented in art, drama, music, sports, mechanics, story-telling, sales, business, designing, building, or engineering.
- Seems to "Zone out" or daydream often; gets lost easily or loses track of time.
- Difficulty sustaining attention; seems "hyper" or "daydreamer."
- Learns best through hands-on experience, demonstrations, experimentation, observation, and visual aids.

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Common Traits

- AVOIDs reading
- Reads and rereads with little comprehension.
- Spells phonetically and inconsistently.
- Trouble with writing or copying; pencil grip is unusual; handwriting varies or is illegible.
- Poor memory for sequences, facts and information that has not been experienced.
- Often confuses left/right, over/under
- Thinks primarily with images and feeling, not sounds or words (little internal dialogue).
- Extremely disorderly or compulsively orderly.
- Can be class clown, trouble-maker, or too quiet.

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Common Traits

- Clumsy, uncoordinated
- Poor at ball or team sports
- Have difficulties with fine and/or gross motor skills and tasks
- Prone to motion-sickness.
- Can do arithmetic but fails word problems.
- Cannot grasp algebra or higher math.
- Will say they hate to read
- Prone to negative self beliefs about self as a learner (I'm dumb)
- Reading causes fatigue.

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Common Traits

- Had unusually early or late developmental stages (talking, crawling, walking, tying shoes).
- Prone to ear infections; sensitive to foods, additives, and chemical products.
- Can be an extra deep or light sleeper; bedwetting beyond appropriate age.
- Unusually high or low tolerance for pain.
- Strong sense of justice; emotionally sensitive; strives for perfection.
- Mistakes and symptoms increase dramatically with confusion, time pressure, emotional stress, or poor health.

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Early Identification

- A strategy for identifying brain differences that underlie dyslexia has been the study of pre-reading children, typically in kindergarten, for whom brain differences cannot be the consequence of altered reading experience.
- Although pre-reading children cannot have a formal diagnosis of dyslexia, children can be identified as at-risk for dyslexia because of either a family history of dyslexia, which increases their risk of dyslexia by four times or more or low performance on tests of pre-reading skills that tend to predict future reading difficulty

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Common signs: Preschool

- May talk later than most children
- May have difficulty pronouncing words: i.e., *busgetti* for *spaghetti*, *mawn lower* for *lawn mower, "C-P-P-O"*
- May be slow to add new vocabulary words
- May be unable to recall the right word
- May have difficulty with rhyming
- May have trouble learning rote facts and sequences (e.g., the alphabet, numbers, days of the week, colors, shapes,
- Struggle to learn how to spell and write his or her name

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Common signs: Preschool

- May have trouble interacting with peers
- May be unable to follow multi-step directions or routines
- Fine motor skills may develop more slowly than in other children
- May have difficulty telling and/or retelling a story in the correct sequence
- Often has difficulty separating sounds in words and blending sounds to make words

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Common signs: Kindergarten through fourth grade

- Has difficulty decoding single words (reading single words in isolation)
- May be slow to learn the connection between letters and sounds
- May confuse small words – *at/to*, *said/and*, *does/goes*
- Makes consistent reading and spelling errors including:
- Letter reversals – *d* for *b* as in, *dog* for *bog*
- Word reversals – *tip* for *pit*
- Inversions – *m* and *w*, *u* and *n*
- Transpositions – *felt* and *left*
- Substitutions – *house* and *home*

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Common signs: Kindergarten through fourth grade

- May transpose number sequences and confuse arithmetic signs (+ - x / =)
- May have trouble remembering facts
- May be slow to learn new skills; relies heavily on memorizing without understanding
- May be impulsive and prone to accidents
- May have difficulty planning
- Often uses an awkward pencil grip (fist, thumb hooked over fingers, etc.)
- May have trouble learning to tell time
- May have poor fine motor coordination

Excerpted from: ABC's of Dyslexia. (2000). International Dyslexia Association.

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Diagnosis

- A comprehensive evaluation typically includes:
- intellectual and academic achievement testing (WISC V, WIAT IV)
- assessment of the critical underlying language skills that are closely linked to dyslexia. These include receptive (listening) and expressive language skills (CELF V)
- phonological skills including phonemic awareness, phonological memory and working memory, and rapid letter and number naming (CTOPP 2)
- Assessment of rapid non-symbolic naming (e.g., picture naming; CTOPP 2)
- Basic word reading, Nonsense word reading, decoding fluency (rapid pseudoword reading), orthographic (sight word) fluency (WIAT IV)

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Diagnosis

- Oral reading fluency (speed and accuracy in context; WIAT IV, GORT 5)
- Reading Comprehension (GORT 5, WIAT IV)
- Listening Comprehension (CELF V, WIAT IV)
- Written Expression (WIAT IV, TOWL)
- Verbal and Non-verbal Memory (NEPSY, CVLT C, ChAMP)
- Broader attention and EF (NEPSY, D KEFS, Conners' CPT, BRIEF 2)
- Sensorimotor functions (BOT 2)
- Social-emotional skills (test of social problem solving, Theory of Mind)
- Auditory Visual Integration (Auditory WM, Visual WM WISC V)

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Diagnosis (Qualitative)

- Assessment of reading habits (avoidance, reduced practice, deliberate practice)
- Beliefs about oneself as a reader, and as a learner in general
- Beliefs about one's own strengths and weaknesses
- Work arounds, compensatory tools, strategies to make reading easier
- Allies and Advocates

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Do Interventions Change the Brain?

Research is beginning to show two specific brain changes with LD kids as a result of reading interventions:

1. Hemispheric "normalization" – the left hemisphere begins to assert dominance after just four weeks of intervention.
2. Hemispheric "compensation" – children with reading difficulty also activate brain structures in the frontal lobe following intervention, suggesting greater text attention and working memory engagement (IFG), and enhanced error detection and EF skills (ACC).

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If a profile emerges that is characteristic of a reader with dyslexia, an individualized intervention plan should be developed that includes structured literacy intervention, and that is specific to the dyslexia subtype. It is not a one size fits all approach.

That said, intervention is critical. Neuroplasticity is most dynamic in young brains.

And when we improve these foundational competencies, we scaffold neuroplasticity and improve learning:

- Self regulation
- Phonemic awareness
- Fundamental movement skills
- Auditory-visual integration skills
- Executive Function

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Resources

- **Integrating Dyslexia:**
- https://www.dyslexia.com/about-dyslexia/understanding-dyslexia/guide-for-classroom-teachers/
- https://integratedlistening.com/blog/2016/11/01/the-pain-of-dyslexia/

- **Dyslexia as a Characteristic vs. a Diagnosis:**
- https://ortongillinghamonlinetutor.com/13-characteristics-of-dyslexia/
- https://www.dyslexia.com/about-dyslexia/signs-of-dyslexia/test-for-dyslexia-37-signs/

- **Identifying Learners Strengths and Weaknesses:**
- https://ortongillinghamonlinetutor.com/the-importance-of-identifying-the-strengths-of-dyslexia/
- https://www.beatingdyslexia.com/dyslexic-child.html

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Resources

- **Headstrong Nation (Mapping Your Child's Dyslexia):** http://headstrongnation.org/
- National Literacy Institute https://www.thenationalliteracyinstitute.com/post/literacy-statistics-2024-2025-where-we-are-now#
- National Center for Education Statistics https://nces.ed.gov/nationsreportcard/
- Brain Futures: Brain Fitness and Executive Function; Evidence Based Interventions that Improve Student Outcome https://www.brainfutures.org/wp-content/uploads/2020/02/Youth-Issue-Brief-November-2019.pdf

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