

LEARNING DISORDERS



Harvard Medical School
Child Neurology 2017

Florence Lai, M.D.

Massachusetts General Hospital
Division of Child Neurology
September 8, 2017



LEARNING DISORDERS

- I have no disclosures.



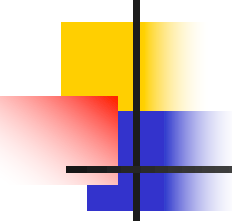
Learning Disorders

- Definition
- A case study
- Dyslexia
- Dyscalculia
- Dysgraphia



Learning Disorder - Definition

- Normal intelligence, educ. access
- An **aptitude deficit** with problems in processing information or generating output
- A non-talent (*e.g.* language, reading, math, visual motor)



Case study – 15 y.o. boy ⁽¹⁾

Med Hx: Normal pre/perinatal dev't

Freq ear infections (12-18 mo)

Late talker – 18-24 mos

Misarticulations, gestures

Fam Hx: Father & relatives –

poor readers/spellers

Right & Left Hemisphere Dysfunctions

Left

1. Speech-Sound

2. Dyslexia

3. Language
Impairment



Right

1. ↓ Social
Skills

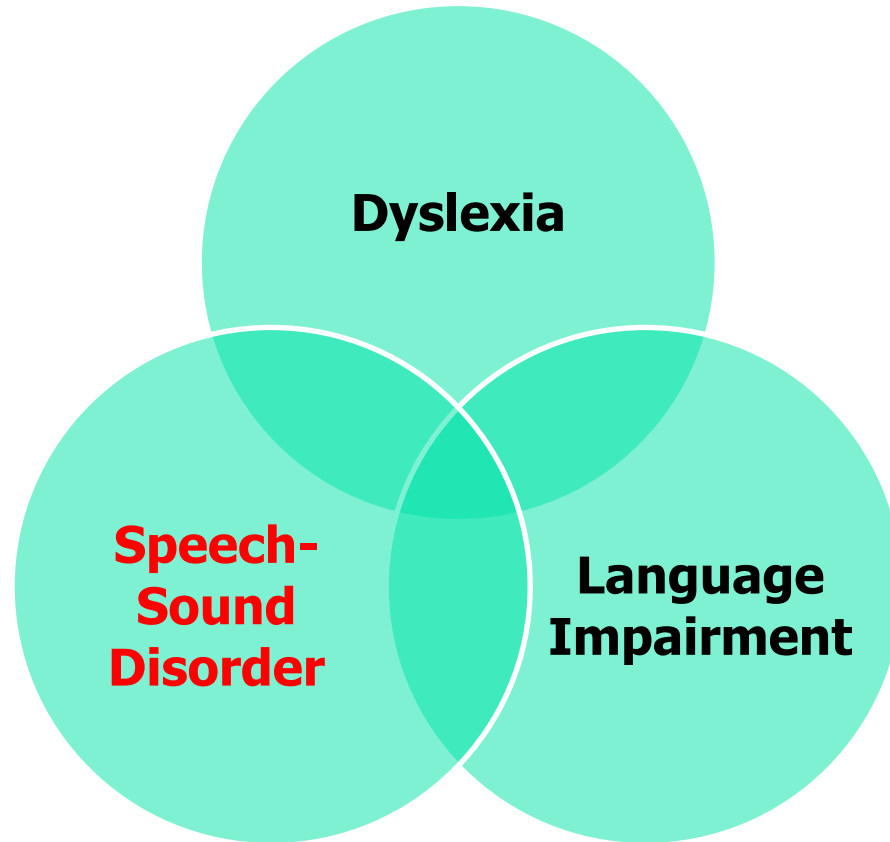
2. In-coord'n

3. Dysgraphia

Dyscalculia



Language Learning Disorders





Speech-Sound Disorder

- Expressive speech delay
 - r/o hearing deficit
 - r/o global delay
- Receptive language may be normal
- Misarticulations vs. Oral motor apraxia
- Speech-Language therapy

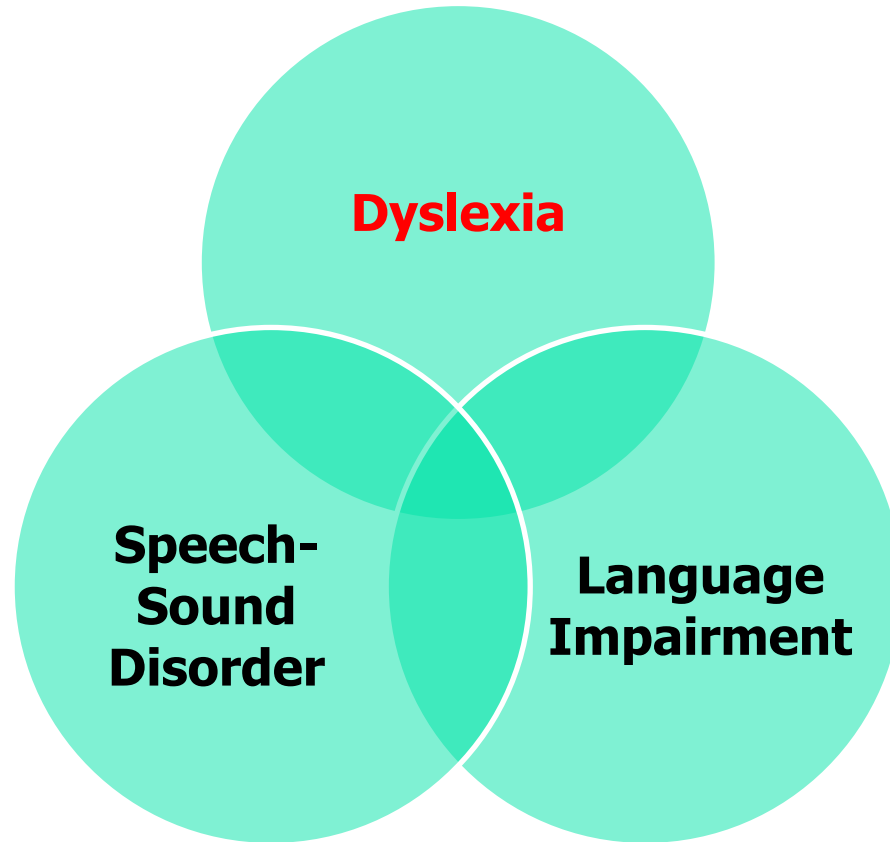


The "1-2-3" of Language Development

- **Single** words by **1** y.o.
- Combine **2** words - **2** y.o.
("Daddy car")
- Combine **3** words - **3** y.o.
("I want cookie.")



Language Learning Disorders





Dyslexia

Makes up 80 % of learning disorders

School reports of “learning disorder”
may actually be dyslexia

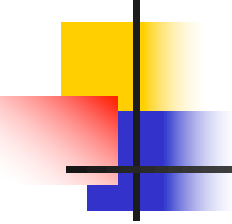
In 5-12 % of U.S. school children

- 2-5% have severe form



Case Study – Educ. Hx ⁽²⁾

- 1st grade – learning difficulties noted
- 2nd grade – IEP: pull-out reading & academic support till 4th grade
- Late 4th grade: diagnosed with dyslexia & ADHD



Dyslexia –definition

Int'l Dyslexia Assoc

2002

- A **specific learning disability** that is neurological in origin
- Characterized by **difficulties with accurate and/or fluent word recognition,**
- **Poor spelling & decoding abilities**
- Typically result from **deficit in the phonological component** of language
- **Unexpected** in relation to other cognitive abilities & provision of effective classroom instruction.



Dyslexia is NOT

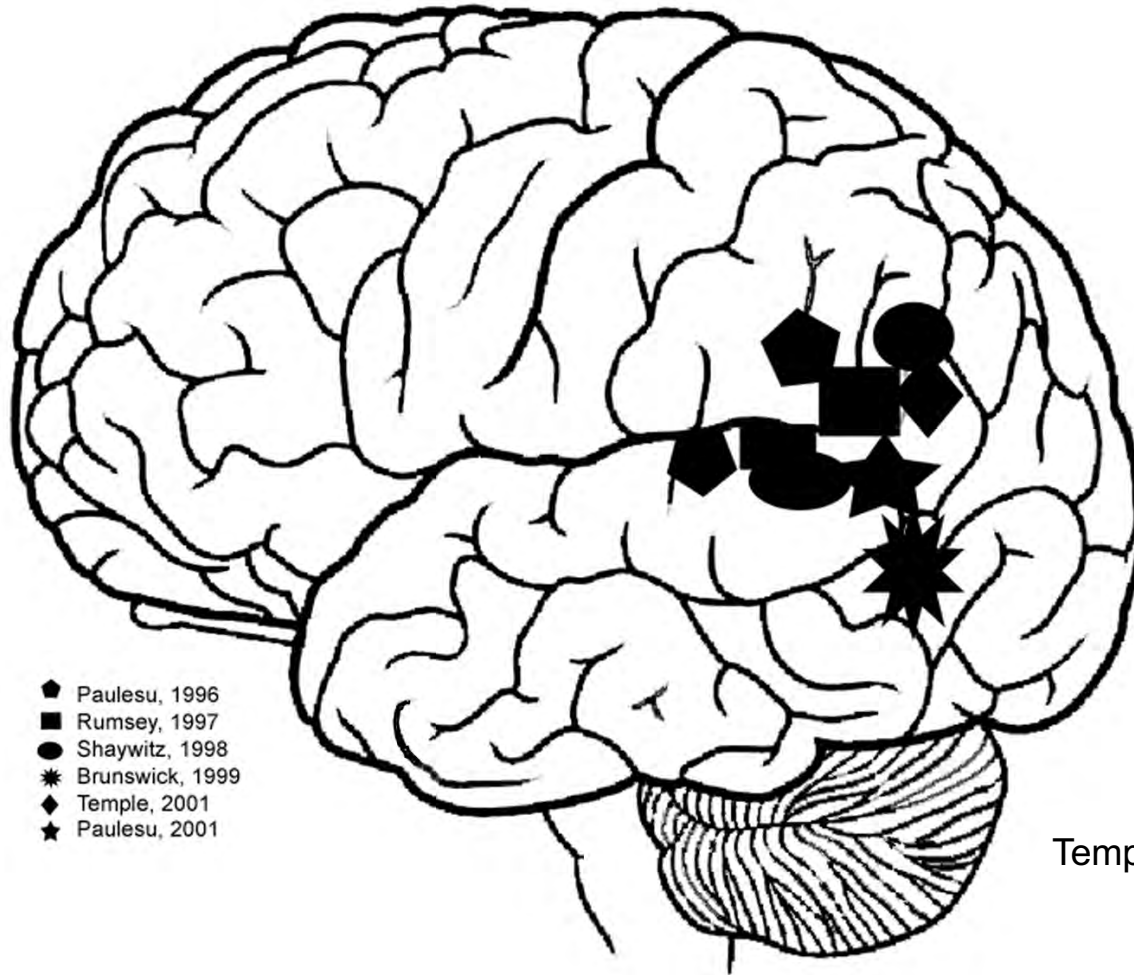
- Writing backwards or reversal of letters
(some reversal of letters/numbers can be normal up to 1st grade)
- A developmental lag – child with dyslexia will not “catch up” in reading without intervention



Dyslexia is brain-based

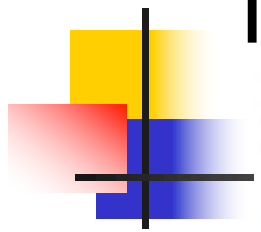
- Anat – loss of asymmetry of left planum temporale ; ectopias - migration defect
- FMRI - hypoactivation (L. temp, par., fusiform areas)
- White matter connectivity disturbances by diffusion tensor imaging studies
- PET – abn. Broca's area activation

Decreased Brain Activity in Dyslexic Readers

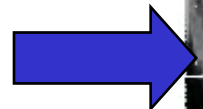


Temple, 2001, CONB

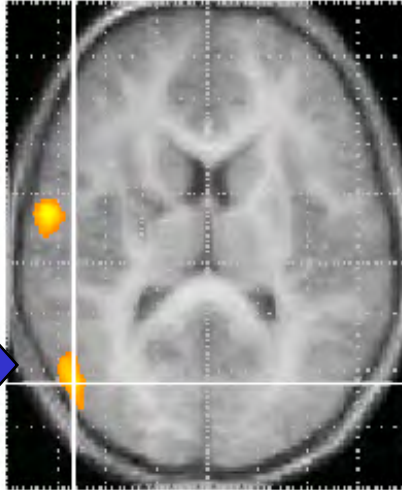
Phonological Processing in Normal Readers



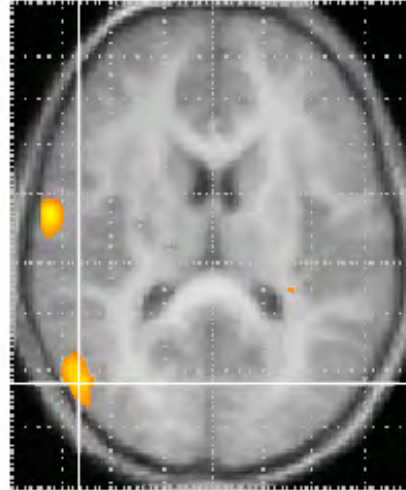
Left



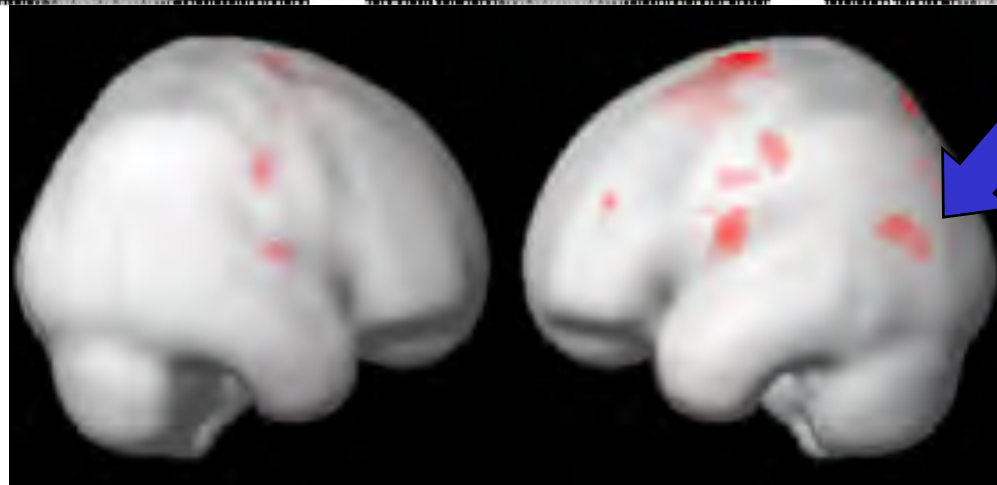
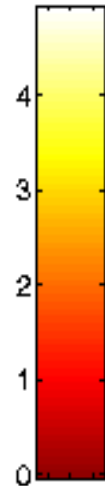
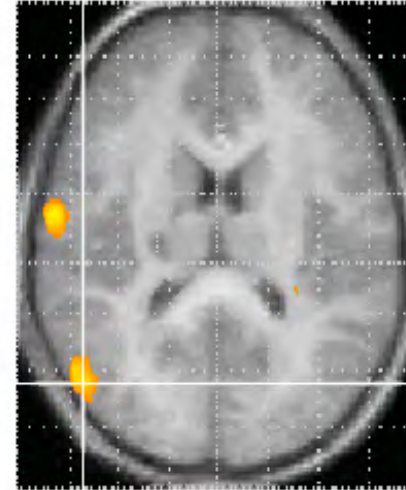
z = 14mm



z = 15mm



z = 16mm

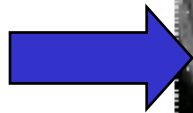


**Rhyme
versus
Match**

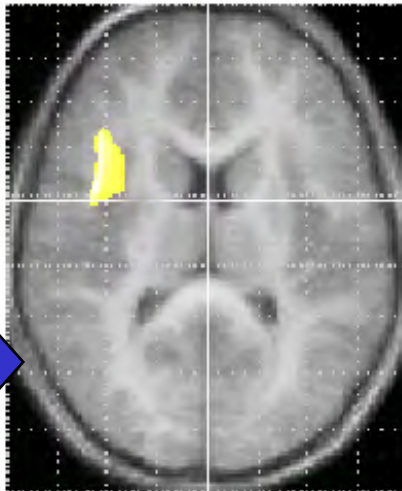
Phonological Processing in Dyslexic Readers



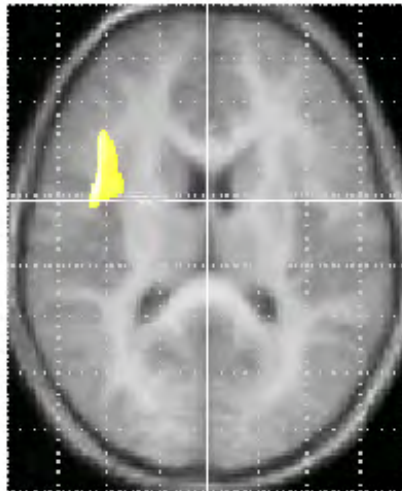
Left



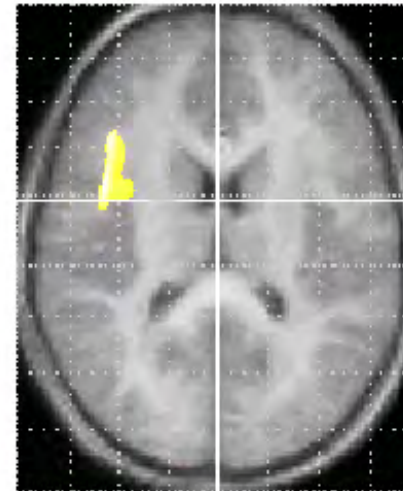
z = 14mm



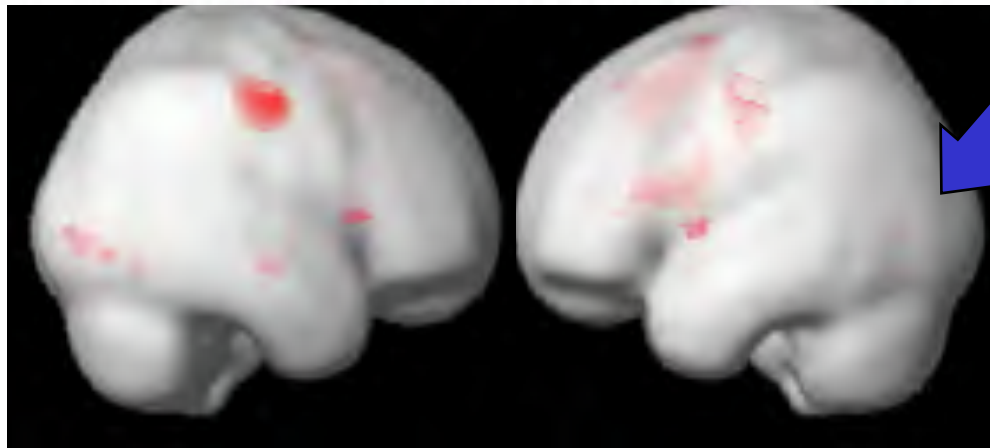
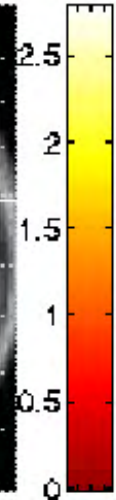
z = 15mm



z = 16mm

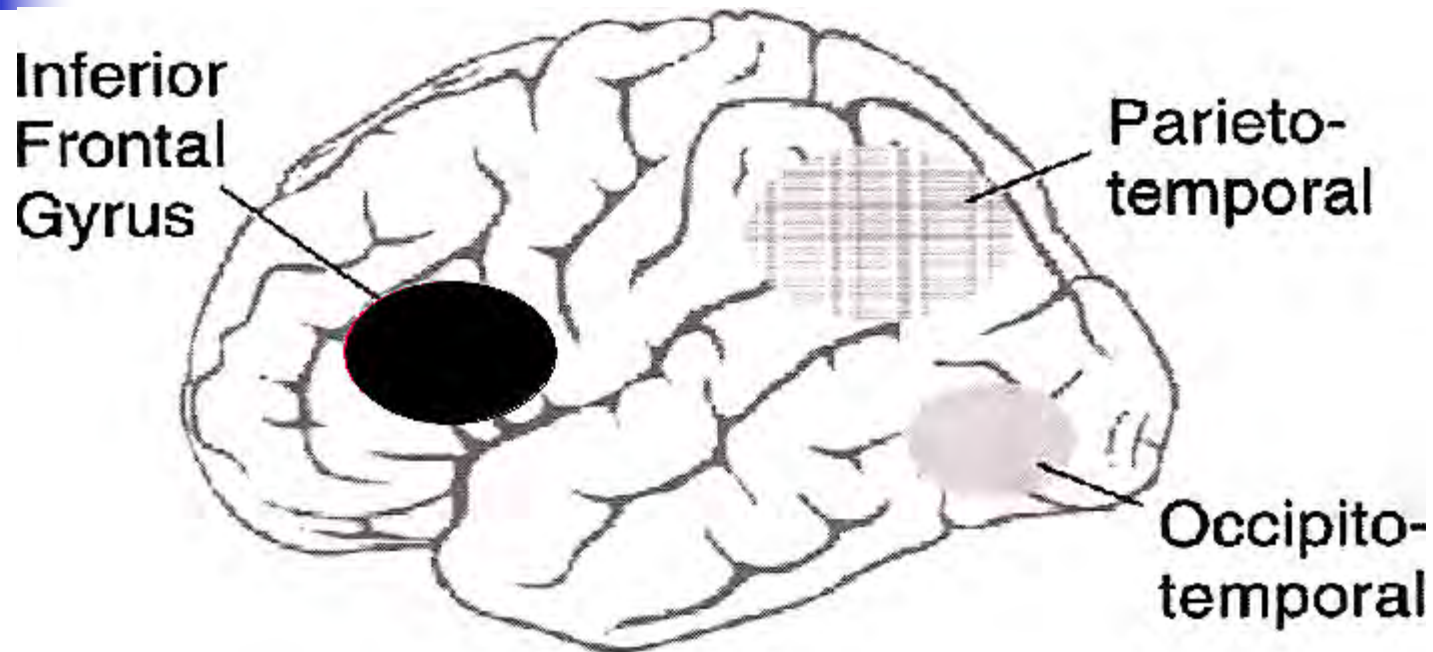


T value



**Rhyme
versus
Match**

Neuroanatomic Regions for Reading



Adapted from Sally Shaywitz, MD, 2002

Abn. white matter tracts in dyslexia



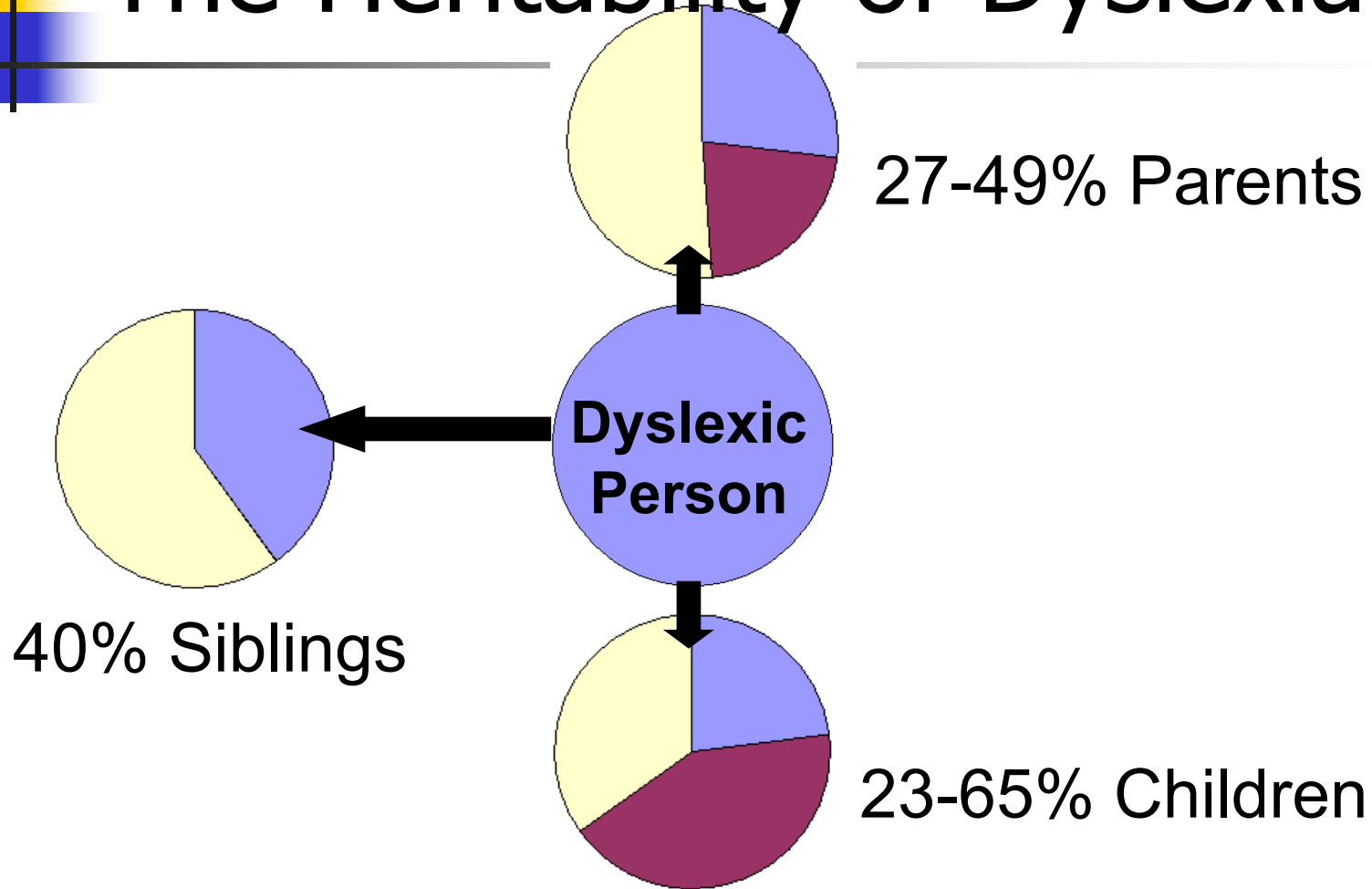
- Left arcuate/superior longitudinal fasciculus (Frontal <---> Temporal)
- Left inferior longitudinal fasciculus (Occipital <---> Temporal)
- Corona radiata (Cortex <---> Subcortex)



Dyslexia is genetic

- Polygenic - 9 risk loci (DYX1-DYX9) on 8 different chromosomes; 14 candidate genes
- Positive family history

The Heritability of Dyslexia





Gender differences in dyslexia

- Males > Females
- Study of > 491,000 beginning 2nd graders (Florida)
- Impaired reading fluency 2.4M:1F
- Impaired decoding 1.6 M:1F



Recognizable Deficits in Dyslexia

- Phonological awareness
- Rapid automatic naming
- Reading fluency



Phonological Deficit in Dyslexia

- Dyslexics have trouble
“breaking the reading
(alphabetic) code”
- Lack of phonemic awareness



The Reading Code

- Phoneme is smallest discernible segment of speech.
 - “c-a-t” has 3 phonemes
(“cuh”-“aah”-“tuh”)
- Syllables are made up of phonemes
- Words are made up of syllables



Decoding (reading)

- Symbol → Sound
- Grapheme → Phoneme
- Requires attention, working memory & sequencing skills



Encoding (spelling)

- Sound → Symbol
- Phoneme → Grapheme
- Requires attention, visual motor memory, sequencing skills



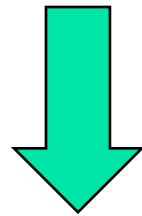
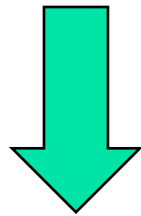
English Language is hard

- 26 letters in the alphabet, but 44 different sounds (eg call, cell)
- Inconsistent orthography
 - “F” sound in “Fan”, “Phone”, “Roughgh”
 - Different “ou” sounds in “our”, “thought”, “through”
- “Read the red book that we read earlier.”

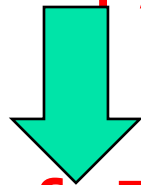
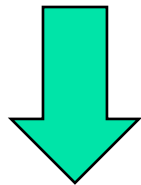


To Read a Word

See the word **Occip/Temp** **Visual form**
(Orthography)



Symbol → sound **Temp/par** **Phonol. proc.**



Pronounce word **Inf. Frontal** **Articulation**



Dysfluency in Dyslexia

Choppy (& slower) reader

Deficit in Rapid Automatic
Naming speed (→ affects
reading fluency)

Rapid digit & letter naming tests



Neuroanatomy of Dysfluency

Weak connectivity between pre-frontal lobes and cerebellum

White matter dysfunction (DTI studies)
→Lack of automaticity



Clinical Features of Dyslexia

- Slow to learn the alphabet
- Poor rhyming
- Mispronunciations
- Poor speller
- Choppy reader
- Slow naming speed



Clues for Dyslexia in K and 1st Grade

- Language delay
- Family history of dyslexia
- Poor knowledge of letter sounds
- Poor blending of sounds
- Trouble naming letters rapidly
- +/- left-handed



Dyslexia in later grades

- 2nd Gr.: oral reading fluency
- 4th Gr +: word recognition +/- comprehension
- [K-3 : **learning to read**]
- [Gr 4 +: **reading to learn**]



EARLY recognition and intervention is key

- Scary stat: (Florida study) Schools only recognized 1 in 4 boys and 1 in 7 girls who were reading impaired
- If intervention started in 1st grade, incidence of dyslexia drops from 5-12% to 1.5 – 6 %
- If intervention started in 3rd grade, 74 % have reading problems in HS



Remediation for Dyslexia

- Explicit, systematic, rule-based phonics instruction (Nat'l Reading Panel, 2000)
- Orton-Gillingham, Project READ, Wilson, Foundations, LindaMoodBell, RAVO
- Individual or small group instruction (< 3:1)
- Guided oral reading, vocab dev't



Sight word training in dyslexia

- Up to 1/3 of English words are irregular i.e. little correlation between grapheme and phoneme (eg. “Yacht”)
- Use in conjunction with phonological training



? Music training for dyslexia

- Common features of music and speech perception (timing, rhythm)
- Observation: musically-trained students have better reading & acad. perform.
- Left arcuate fasciculus –important for reading and for learning music
- Music & reading req. coord. (vis, audit & somatosensory and motor processes)



? Music training for dyslexia

- Study by Habib et al (2016)
- Intensive cognitive-musical training → better phoneme perception (*ba vs. pa*), auditory attention (by 20%), pseudoword repetition, phoneme fusion
- Improvement lasted beyond intensive training period



? Vision therapy for dyslexia

- Loss of visual fixation in those with dyslexia – Not due to oculomotor dysfunction but due to defect in visual processing of linguistic material
- No scientific proof that lenses, filters, eye-training exercises will correct dyslexia



Case Study – Educ. Hx ⁽³⁾

- 5th-6th grade – Language-based class
Orton-Gillingham instruction
5 X 42 min 1:1
- Priv tutor since 2nd grade;
O-G after 4th grade
- Reading level improved 21 months in
14 calendar months

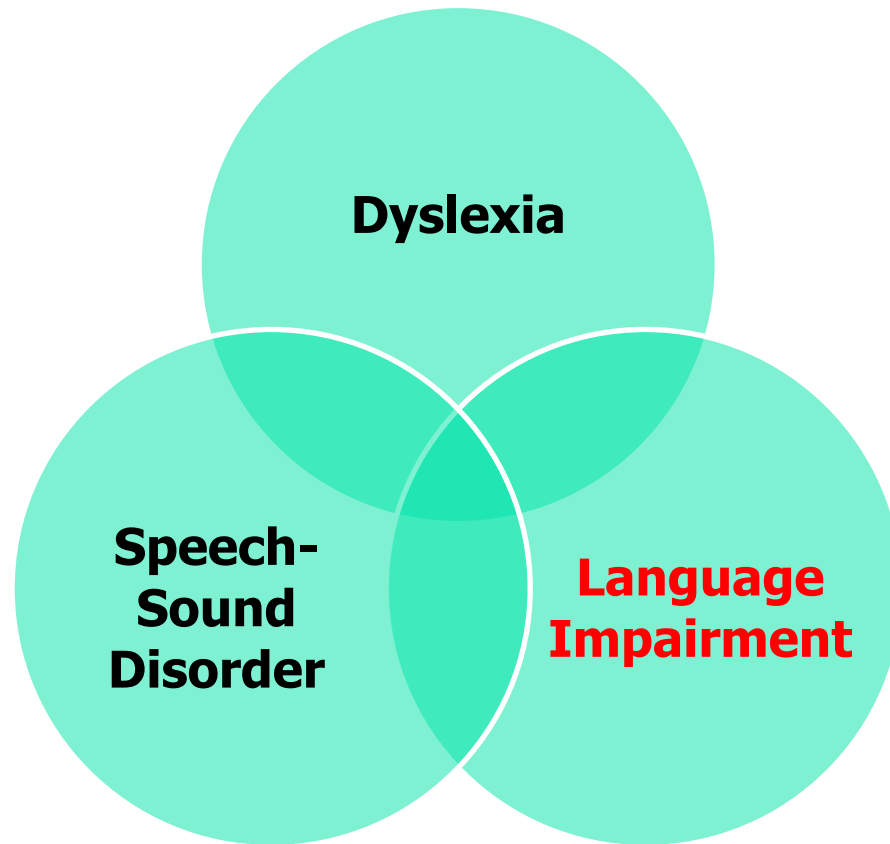


Case Study – Educ. Hx ⁽⁴⁾

- 7th - 8th grade: Inclusion classes & academic support
- 8th grade: concerns about following directions, reading fluency & comprehension, organization of expressive language, writing skills



Language Learning Disorders





Language Impairment

- Expressive +/- Recep. lang
- Higher order skills: Figurative lang.; Ambiguous lang.
- Listening/Reading comprehension
- Written expression
- Rx: S & L therapist



Co-Morbidities with Dyslexia

- 10% have Language impairment (listening/reading comprehension)
- 15 % have ADHD
- 35 % of those with ADHD have dyslexia
- 25% have both dyslexia & dyscalculia



Dyscalculia

- Difficulty understanding & learning number concepts /number facts
- Weak numerosity – understanding of sets
- Spatial working memory may be involved
- 5-6.5% school children; M=F
- Genetic predisposition
- Inefficient calculation methods
- Co-morbidities in 2/3: dyslexia, ADHD, language delay



Triple code in number processing

- Verbal – counting, recalling math facts
- Visual – processing Arabic number forms
- Approximate number sense



Math difficulties in dyslexia

- Counting
- Transcoding (reading & writing) numbers
- Math fact retrieval
- Deficits are milder than in those with dyscalculia or dyslexia-plus-dyscalculia



Math difficulties in dyscalculia

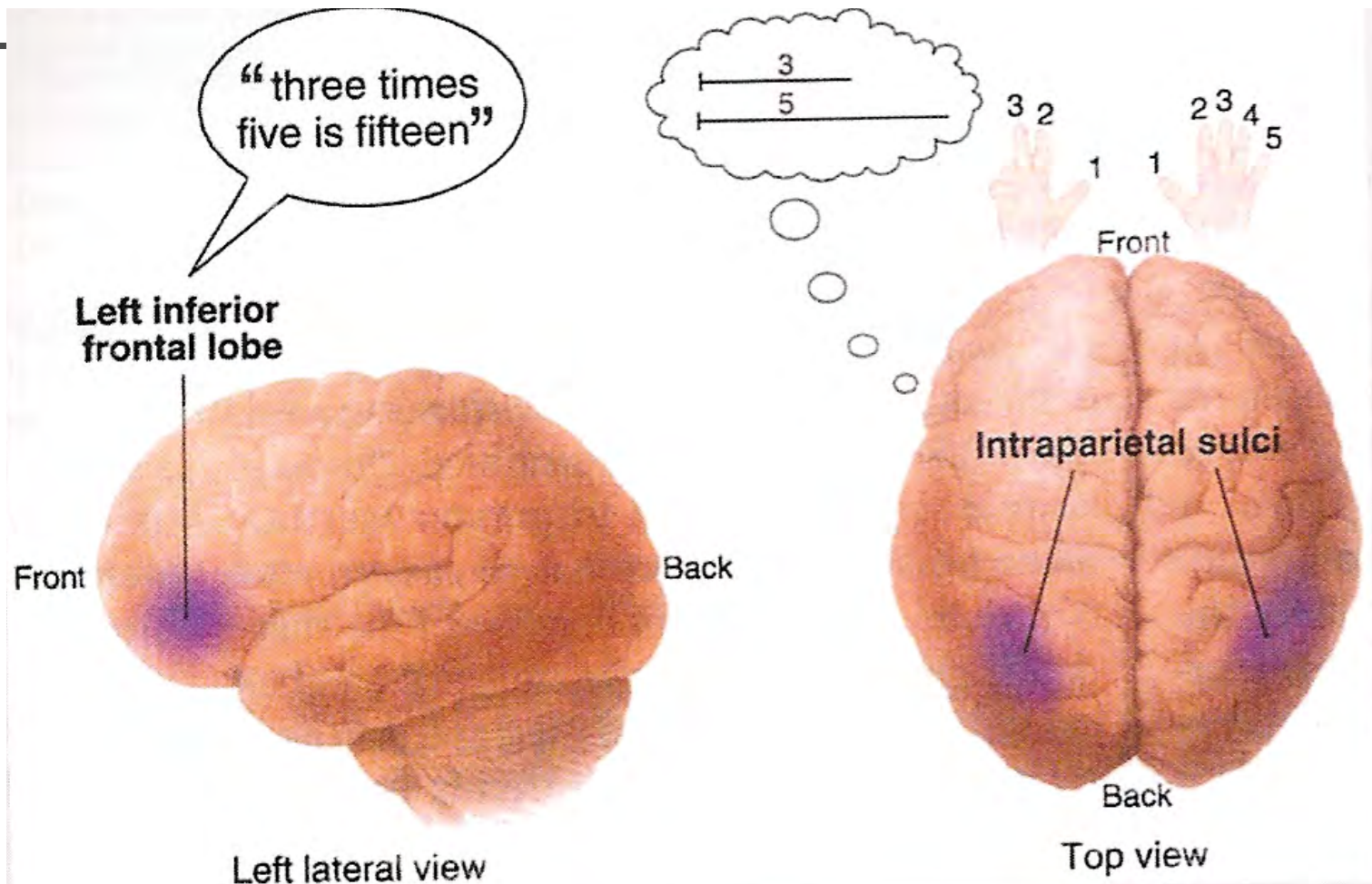
- Symbolic number comparison (bigger and smaller number)
- Counting
- Arithmetic operations (calculations)
- Approximate number sense (estimating quantity)



Suspecting dyscalculia in K

- Impairments
 - Understanding quantity
 - Automatic understanding of small numbers (1, 2, 3) without counting (subtilizing)
 - Counting skills
 - Identification of Arabic numbers

Neuro-anatomical sites for calculations





Brain abnormalities in dyscalculia

- Increased brain activation in frontal (>parietal) areas
- Decreased gray and white matter volumes in the intraparietal sulci
- Deficit in superior longit. fasciculus connecting frontal & temporal areas



Remediation for dyscalculia

- Explicit instruction to improve number sense (multisensory, practical applic)
- More time to memorize facts (drills)
- Error analysis (understand why it is wrong)
- Mastery of each sequential skill
- Help with attention, visual perceptual problems, comprehension issues



Dysgraphia

- 2-5% of school children
- Types:
 - Dyslexic - weak orthographic spelling
 - Weak motor handwriting

Dysgraphia with Dyslexia (8th grade boy)

DATE	TIME	
1/20/07	9:44	I Like to Play Football. I like Go in Out Side. I like TV
		Blaind Sland girl / Fightin Brother head Puppe

“building” “sailing” “girl” “fighting” “brother” “head”
“puppy” □



Help for Dysgraphia

- Occupational Therapy
- Tape stories & essays (Scribe)
- Alpha-Smart/Laptop/iPAD in class
- Word-processing; spell-checker
- Vertically-lined or large graph paper for Math calculations



Final Thoughts

Studying the neurobiological substrates of learning disorders can elucidate basic brain developmental processes.

Early diagnosis / **specific** interventions
critical for better outcomes
(academically, emotionally, socially)



Case Study - Conclusion

Academic success

Honor Roll status in 9th grade !

Celebrate Success !





Learning Disorders – References F.Lai, MD

Learning Disorders – General

- Fletcher JM, Francis DJ, Morris RD et al. Evidence-based assessment of learning disabilities in children and adolescents. *J Child Adolesc Psychology* 2005; 24(3):506-522.
- Lagae L. Learning disabilities: definitions, epidemiology, diagnosis, and intervention strategies. *Ped Clinics N Amer* 2008;55(6):1259-68.
- Semrud-Clikeman M, Bledsoe J. Updates on Attention-Deficit/Hyperactivity Disorder and learning disorders. *Curr Psychiatry Rep* 2011;13:364-73.
- Willcutt EG, Pennington BF, Duncan L et al. Understanding the complex etiologies of developmental disorders:behavioral and molecular genetic approaches. *J Dev Behav Pediatr* 2010;31(7):533-544.

Dyslexia & Language Learning Disorders

- Eicher JD, Gruen JR. Imaging-genetics in dyslexia: connecting risk genetic variants to brain neuroimaging and ultimately to reading. *Mol Genet Metab* (2013); 110(3):201-12.
- Habib M, Lardy C, Disiles T, Commeiras C, Chobert J, Besson M. Music and dyslexia: a new musical training method to improve reading and related disorders. *Frontiers in Psychology* 2016;7(26):1-15.
- Handler SM, Fierson WM. Learning disabilities, dyslexia, and vision. *Pediatrics* 2011;127(3):e818-e856.
- Kere,J. The molecular genetics and neurobiology of developmental dyslexia as model of a complex phenotype. *Biochem Biophys Res Commun* (2014);452(2):236-43.
- Nicholson RI, Fawcett AJ. Dyslexia, dysgraphia, procedural learning and the cerebellum. *Cortex* 2011;47(1):117-27.
- Norton ES, Beach SD, Gabriela JDE. Neurobiology of dyslexia. *Curr Opinion Neurobiol* 2015;30:73-78.
- Peterson RL, Pennington BF. Seminar: Developmental dyslexia. *Lancet* 2012 May 26; 379(9830):1997-2007.
- Stoodley CJ, Stein JF. Cerebellar function in developmental dyslexia. *Cerebellum* 2013;12(2):267-76.



Learning Disorders — References F.Lai, MD

Dyslexia & Language Learning Disorders (cont'd)

- Vagge A, Cavanna M, Traverso CE, Iester M. Evaluation of ocular movements in patients with dyslexia. *Ann of Dyslexia* 2015;65:24-32.
- Zoccolotti P, Friedmann N. From dyslexia to dyslexias, from dysgraphia to dysgraphias, from a cause to causes: at look at the current research on developmental dyslexia and dysgraphia. *Cortex* 2010;46(10):1211-5.

Dyscalculia

- Butterworth B. Foundational numerical capacities and the origins of dyscalculia. *Cell* 2010;14(12):534-541.
- Butterworth B, Varma S, Laurillard D. Dyscalculia: from brain to education. *Science* 2011; 332:1049-1053.
- Jimenez-Fernandez G. How can I help my students with learning disabilities in Mathematics? *REDIMAT* 2016;5(1):56-73.
- Kucian K, von Aster M. Developmental dyscalculia. *Eur J Pediatr* 2015;174:1-13.
- Moll K, Gobel SM, Snowling MJ. Basic number processing in children with specific learning disorders: Comorbidity of reading and mathematics disorders. *Child Neuropsychology* 2015;21(3):399-417.
- Price GR, Ansari D. Developmental dyscalculia. *Handb Clin Neurol* 2013;111:241-4.
- Rapin I. Dyscalculia and the calculating brain. *Pediatric Neurology* 2016;61:11-20.
- Rotzer S, Loenneker T, Kucian K. Dysfunctional neural network of spatial working memory contributes to developmental dyscalculia. *Neuropsychologia* 2009;47(13):2859-65.