

# Dyslexia: Part 1

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NICHD P50 HD52120

# Background

- Began with a master's degree in school psychology at Akron U.
- Year of internship in Cuyahoga Falls.
- Clark County (Las Vegas) school psychologist for 2 years.
- Back to graduate school and then to FSU.

# NIH Centers

- National Institute for Child Health and Human Development (NICHD) funds 4 research centers on learning disabilities.
- Dyslexia is major focus of our Center.
- <http://www.fsuld.org/>

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# Two Goals for Today

- 1. Help you become most knowledgeable person in your school and community about dyslexia.
- 2. Help you with some resources and skills that will help you keep up with a rapidly advancing knowledge base.

# Dyslexia Laws!

- First one in Texas (1995)
- Most recent in California (2015).
- 16 states and more on the way.

# Dyslexia Laws in Ohio

- 3301.0711 Administration and grading of assessments
  - ...as having a condition that impairs performance, such as **dyslexia**, dyscalculia,...

# Dyslexia Laws in Ohio

- 3319.80 Engagement of dyslexia specialist to train teachers
  - ...governing board of any educational service center may engage the services of a **dyslexia** specialist to provide training.....



# Dyslexia Laws in Ohio

- 3323.01 Education of children with disabilities definitions
  - ...a specific learning disability (including **dyslexia**), deaf-blindness.....

# Dyslexia Laws in Ohio

- 3323.25 Pilot project to provide early screening and intervention services for children with risk factors for **dyslexia**, including low phonemic awareness.
  - Goal of the project is to demonstrate and evaluate the effectiveness of early reading assistance programs for children with risk factors for **dyslexia** and to evaluate whether those programs can reduce future special education costs.

# Dyslexia Laws in Ohio

- 5.2294. **Dyslexia** Awareness Month
  - ...The month of October is designated as “**Dyslexia** Awareness Month...”

# Four Learning Objectives

- 1. Distinguish between fundamental truths and common myths about the nature of dyslexia.
- 2. Identify problems with common approaches to identification of individuals with dyslexia.

# Learning Objectives

- 3. Identify best practices for early, reliable, and valid identification of individuals with dyslexia.
- 4. Identify best practices for prevention, intervention, and accommodation.

# Guiding Philosophy of the Florida Learning Disabilities Center: Healthy Skepticism

- “The greatest enemy of the truth is not the lie—deliberate, contrived, and dishonest, but the myth—persistent, pervasive, and unrealistic.”

—

--John F. Kennedy

Learning Objective 1:  
Distinguishing Between  
Fundamental Truths and  
Common Myths

# Reversal Errors

- Reversal errors (b for d, was for saw, and 53 for 35 for my cousin Kurt) are commonly considered to be the defining feature of dyslexia.



# Congenital Word Blindness

- Scottish surgeon James Hinshelwood provided first description of dyslexia (1905).
- He called it congenital word blindness.
- He identified 2 characteristics:
  - 1. It runs in families.
  - 2. Underdeveloped cerebral dominance is common.

# Cerebral Dominance

- Brain becomes asymmetric with development:
  - Raise your hand if you write with your right hand?
  - Raise your hand if you write with your left hand?
  - Can you write well with the opposite hand?



# Cerebral Dominance

- Being right-handed or left-handed is caused by one hemisphere becoming dominant.
- Language becomes carried out mostly in one hemisphere (the left hemisphere for most people).

# Samuel Orton (1920s-1960s)

- Dyslexia caused by slow development of brain asymmetry.
  - Left hemisphere sees letter as “b.”
  - Right hemisphere sees letter as “d.”
- Result is reversal errors.

# Reversal Errors

- Belief is validated by a real observation.
  - Find a struggling reader in a second grade classroom and they will make reversal errors.

# Why Make Reversal Errors?

- Several plausible reasons.
  - First has to do with how we are able to read.

# Reading is an Unnatural Act

- Reading and writing are too recent to be selected for by human evolution.
  - Human language emerged roughly one million years ago.
  - Cave paintings date from roughly 50,000 years ago. Earliest known writing system developed only around 6,000 years ago.



# If We Haven't Evolved for Reading, How do We Do It?

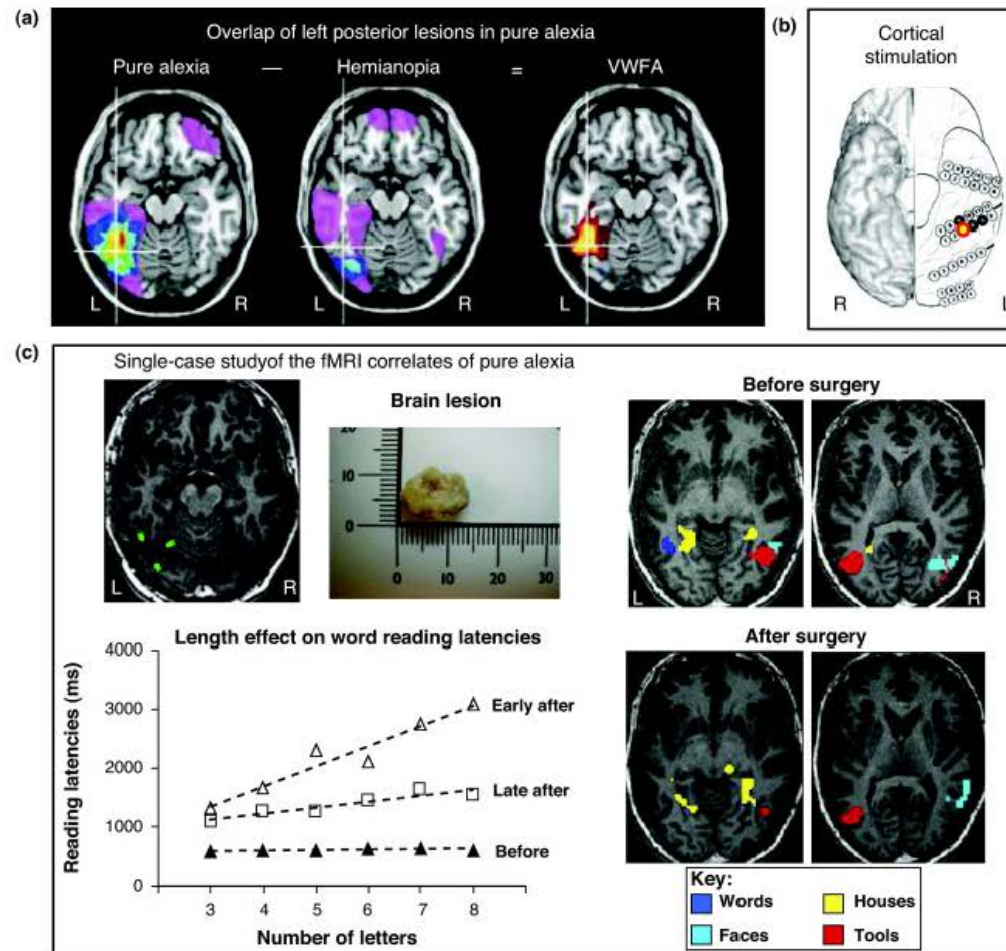
- By recruiting abilities that have evolved over time, primarily language and vision.

# Word Form Area

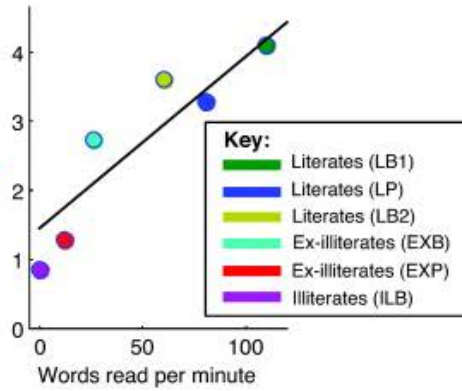
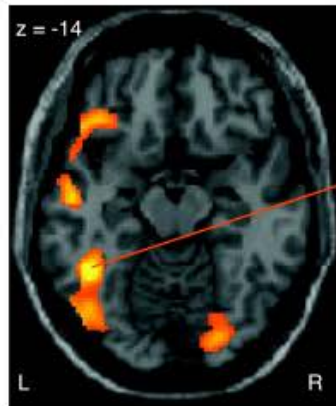
- Where visual images are stored, including images of letters and words.
- Also where actual visual images are processed for things that mattered a lot for survival—like an image of a mountain lion.

# Some Imaging Studies of the Visual Word Form Area

- Dehaene, S., & Cohen, L. (2011). The unique role of the visual word form area in reading. *Trends in Cognitive Science*, 15, 254-262.



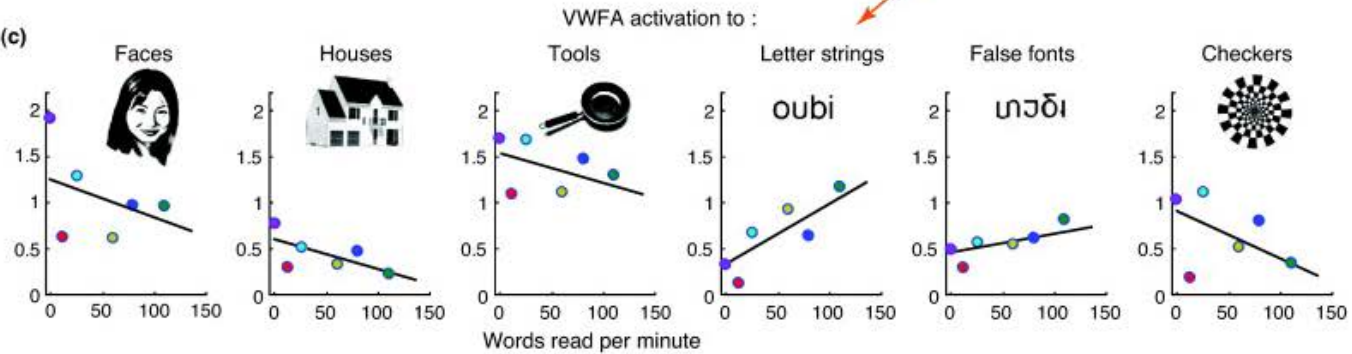
(a) Written sentences



(b) Letter strings



(c)



9-year-old  
good readers

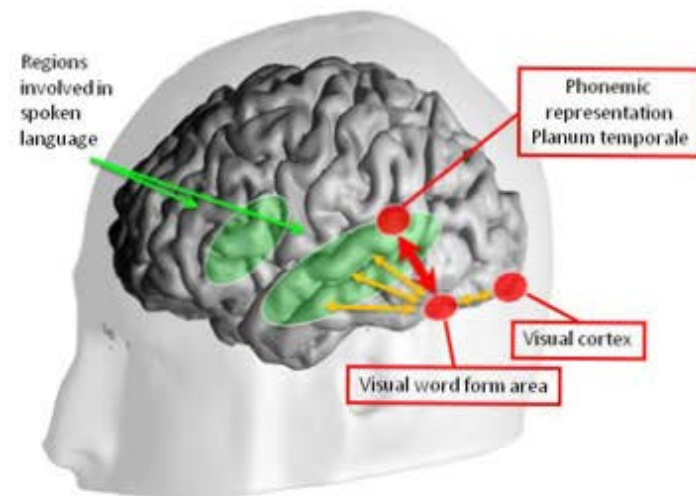


9-year-old  
dyslexics



Greater activity in good  
readers than in dyslexics  
in response to words  
for faces





# Does This Mean We Found the Cause of Dyslexia?

- Is an impaired visual word form area the neurological cause of dyslexia?



# Does This Mean We Found the Cause of Dyslexia?

- Problem is that it is a correlate. Might be the **cause** of dyslexia, or the **effect** of it.
  - In fact, when reading problems are remediated successfully through intervention, reading networks observed in imaging normalize.

# One Reason for Reversal Errors then....

- Evolutionary history of the region of the brain that figures prominently in reading individual words—the visual word form area.

## Other Reasons for Reversal Errors in Reading

- b and d look alike.
- b and d sound alike—both stop consonants.

# Chinese Text

但那種事在這裏  
但我們不這樣做  
器可以用來作為武  
可以烘乾趾甲剪報  
和烘乾趾甲剪報  
核心有兩個粗糙  
一個循環蘋果的

## Other Reasons for Reversal Errors in Reading

- b and d look alike.
- b and d sound alike—both stop consonants.
- confusing was for saw reflects arbitrary aspect of English that it is read left to right.

# Digit Span Task

- I'll say a series of digits. You write them down in order when I finish reading the list.
- Easy one to start. Then a more difficult one.

## Other Reasons for Reversal Errors in Reading

- b and d look alike.
- b and d sound alike—both stop consonants.
- confusing was for saw reflects arbitrary aspect of English that it is read left to right.
- Item vs. order information.
  - Order is more difficult than item information.

# What's the Story about Reversals?

- Yes, children in 2<sup>nd</sup> grade with reading problems make reversal errors.
- But so do reading-age matched younger normal readers!
  - Reversals are routine in K and 1<sup>st</sup> grade.



# What's the Story about Reversals?

- Children in 2<sup>nd</sup> grade with reading problems are reading at an early 1<sup>st</sup>-grade level, making routine 1<sup>st</sup>-grade errors.
- They just stand out because their peers are no longer making them.

# Summary About Reversals

- An easy error for all of us to make.
- Reasons why reversal errors are easy to make in reading are known (VWFA, visual similarity, same category of letter, item vs. order information).

# Summary About Reversals

- Individuals with dyslexia do not make more reversal errors than do reading-matched younger readers.
  - A 2<sup>nd</sup> grade student with dyslexia makes reversal errors because reading is at beginning 1<sup>st</sup>-grade.
- They stand out because their age-matched peers make fewer reversal errors.

Are Faulty Eye-Movements the  
Problem?

# Let's Try an Observational Study

- Find a partner.
- Read something holding the material in front of you low enough so your partner can watch your eyes when you read.
- Note what you observe if you are the observer. Then switch roles and do it again.

# Are Faulty Eye-Movements the Problem?

- Have your neighbor hold something in front of his or her face and read it so you can look over what they are reading and into their eyes.
- Watch their eyes carefully and note what you see. Then reverse roles and have your neighbor observe you read.

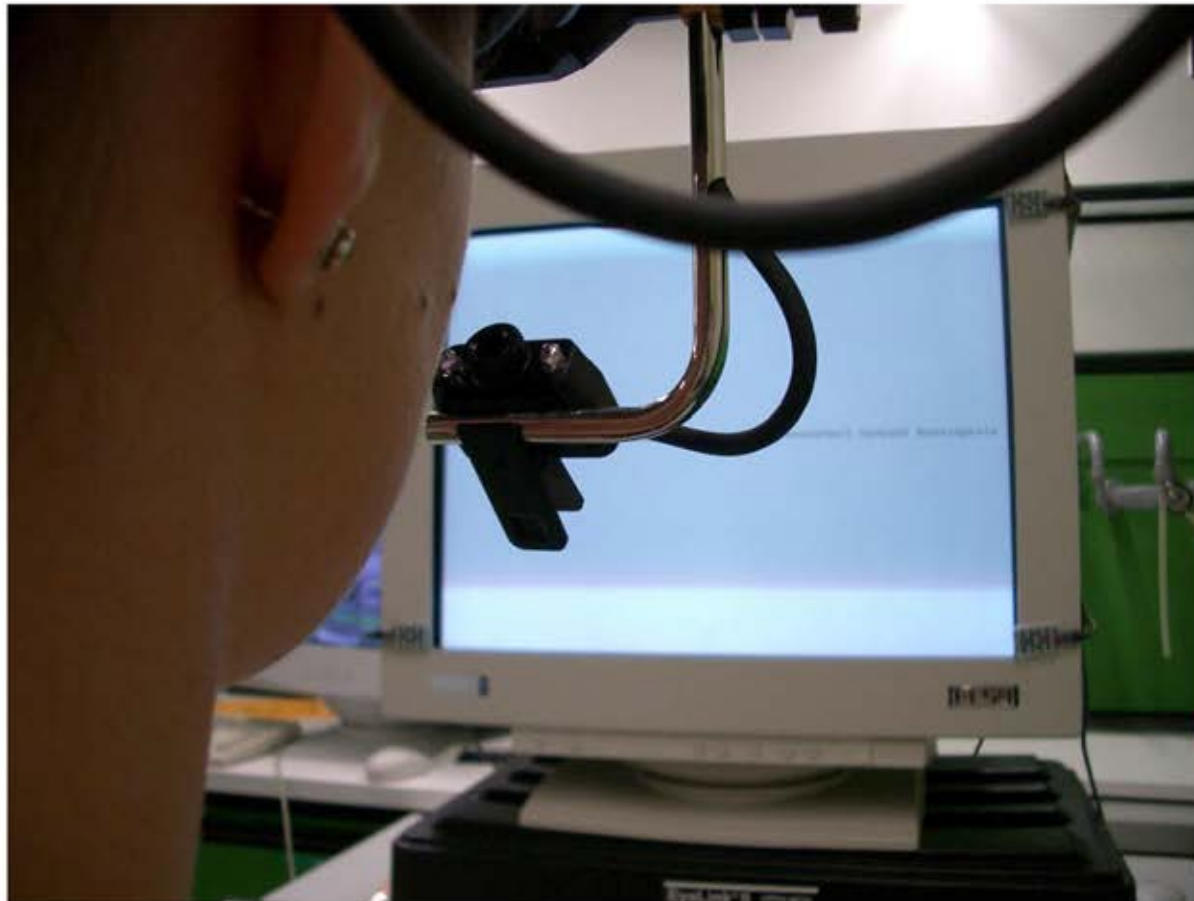
# Eye-Movements in Reading

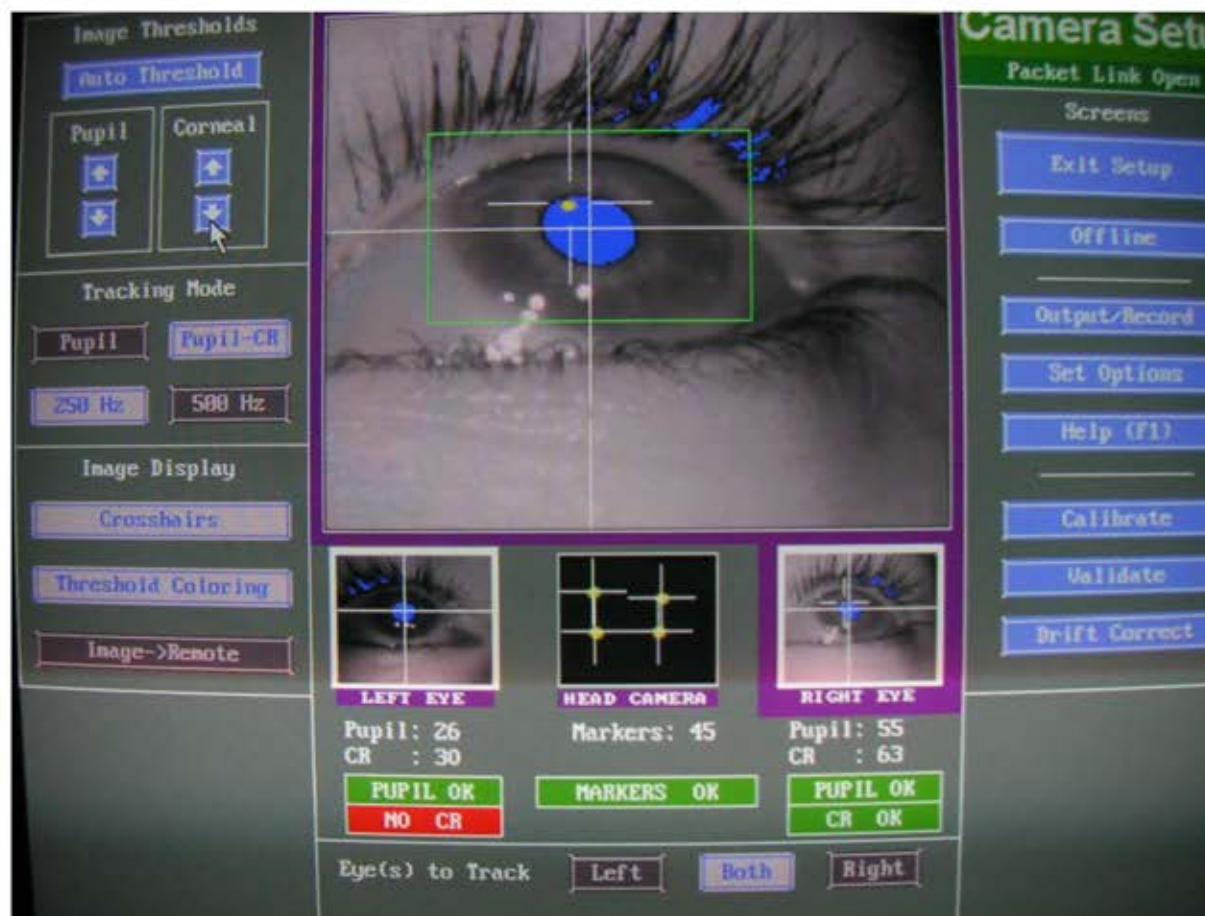
- Saccades initiated in 10-20 milliseconds and last from 20 to 80 milliseconds. A voluntary movement takes 200 milliseconds to initiate.
- They make up only about 5% of total reading time.

# Eye-Movements in Reading

- Fixations last between 70 to 500 milliseconds (half a second). They make up most of the reading time.







# Eye-Movements in Reading

- Saccades are the ballistic movements that bump the eyes across the page. They operate like cannons. Once fired, no voluntary control over movement is possible. Where the eyes land depend on how powerful of a saccade was used. Only during fixations can the eyes clearly see text and input information.

# Read the Following Paragraph

Eyes across the page once fired that saccades are over movement is possible. Only clearly see cannons no voluntary control and input information.

# Eye-Movements in Reading

- Skilled reading requires exquisite control of eye-movements!
- Not surprising that faulty eye-movements have been thought to be a likely cause of dyslexia.

# Eye-Movements in Reading

- Watch the eyes of an individual with dyslexia when reading and what do you see?
  - Eye-movements even bumpier:
    - More pronounced hesitations.
    - More common movements backwards (regressions).

# Are Faulty Eye-Movements the Problem?

- We saw that reading a paragraph is impossible if eye-movements don't work right.
- We know that individuals with dyslexia have affected eye-movements.
- Could this be their problem?

# Three Compelling Studies

- 1. Give normal readers difficult material to read—material that is so hard they read the text comparable to how a child with dyslexia reads grade-level material.
  - Their eye-movements look as jumpy and hesitant as the eye-movements of individuals with dyslexia!



# Three Compelling Studies

- 2. Give individuals with dyslexia easy material they actually can read.
  - Their eye-movements look like those of normal readers!

# Three Compelling Studies

- The effects of eye-movement training programs.
  - Can train the ballistic saccades, so visual pursuit is trained. Results?
    - Visual pursuit can be improved with training, but training **doesn't generalize to actual reading**.

# What Should we Conclude about Role of Eye Movements in Dyslexia?

- Faulty eye movements not the cause of poor reading but a by-product of it!

Questions or Comments?

Enough Myths, How About Some  
Fundamental Truths?

# Dyslexia is a Latent Condition

- Latent means you can't observe it directly.
  - All we can do is infer its presence by its effect on things we can observe.

# Dyslexia is a Latent Condition

- Does that mean it isn't real or isn't as real as things we can observe directly?

# Dyslexia is a Latent Condition

- Not at all! Here are examples of other latent conditions:
  - Gravity
  - ADHD
  - Depression
  - Anxiety
  - Intelligence



# What is the Phenotype of Dyslexia?

- What are the main things we observe that indicate the presence of dyslexia?

# Inability to Sound Out New Words

- Commonly assessed by asking child to “read” nonwords:

Small Pool of Words Known by Sight

# What is the Phenotype of Dyslexia?

- Comprehension is affected secondarily.  
Because it is so hard to read the words on the page
  - Comprehension suffers.
  - Vocabulary can be affected long term.

# What is the Phenotype of Dyslexia?

- Unexpectedly poor reading that is due to a problem in language not in vision.
  - Language system implicated is the phonological system—used for processing speech sounds.

# Phonological Awareness

- Awareness of and access to the sound structure or phonology of one's language.
- So what is the sound structure of English?

# What is Sound Structure of English?

- Speech information can be represented at 4 levels.

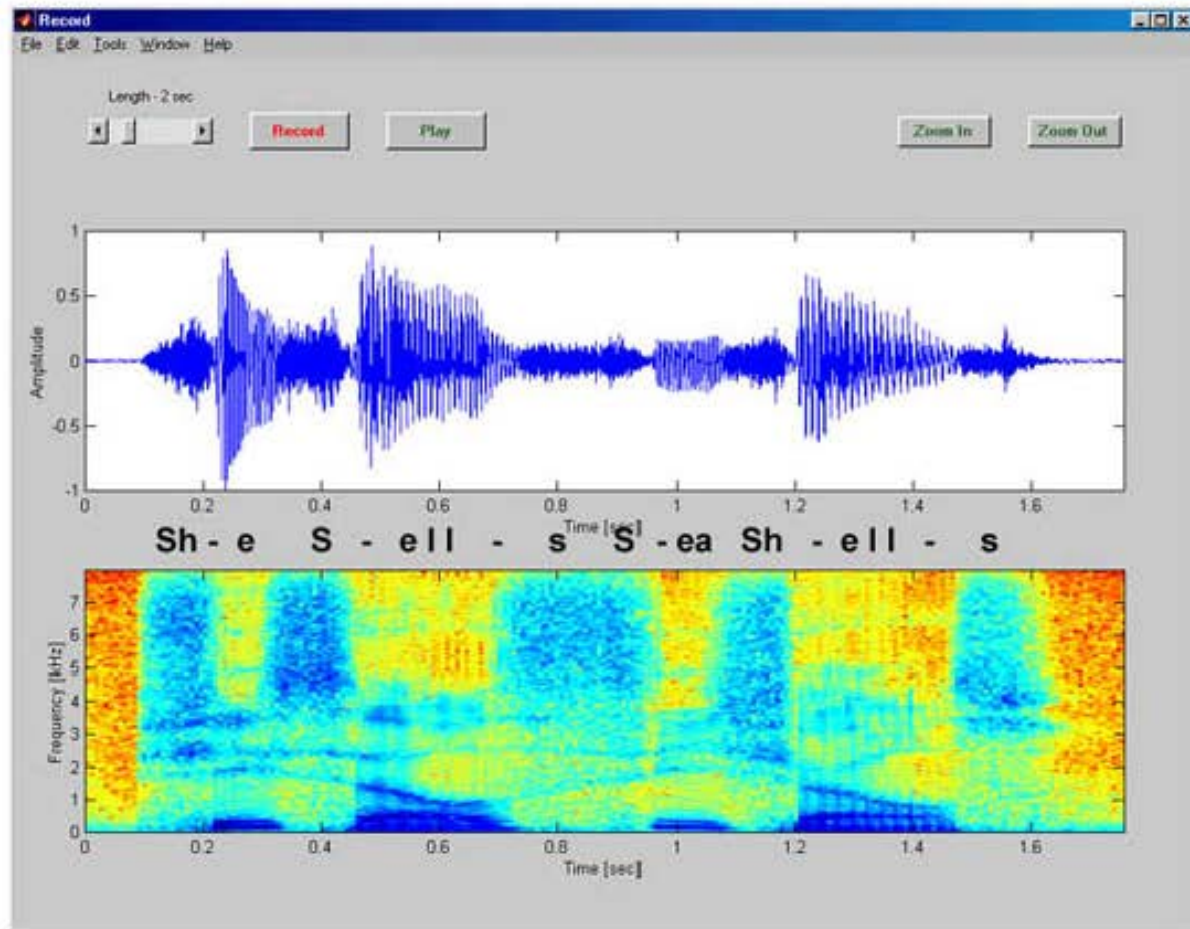
# What is Sound Structure of English?

- Speech information can be represented at 4 levels.
  - From lowest (least abstract) to highest (most abstract) levels they are:
    - Acoustic
    - Phonetic
    - Phonological
    - Morphophonological



# Acoustic Level

- Speech is represented by acoustic energy.
  - Can be observed in spectrogram.
    - Displays amount of energy at various frequencies.
  - Interesting observation: The spaces we hear between words and syllables are not represented in the acoustic stream.
    - Spaces are perceived because of perceptual and cognitive processing.



## Acoustic Level (cont.)

- When you listen to a foreign language you don't know, does it seem they talk very fast or very slow?
  - Very fast! The words run together.
- You sound the same to someone who doesn't know your language.

# Phonetic Level

- Speech is represented by phones—the universe of speech sounds actually made by the vocal tract.
- Experiment:
  - Are the sounds of the letter “t” in TAB, BAT, and STAFF identical or different?
    - Try this test: Hold your hand a centimeter in front of your mouth and say the three words.
    - What do you notice?

# Phonetic Level

- The “t” sound in TAB, BAT, and STAFF is different!
  - Most energy (air movement) for “t” in TAB.
  - Least energy for “t” in STAFF.
  - Energy for “t” in BAT is in between.

# Phonological Level

- Speech is represented by phonemes- differences in sound that signal differences in meaning.

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- Speech is represented by phonemes- differences in sound that signal differences in meaning.
  - The sound of “t” is different than the sound of “p.”
    - TAN has a different meaning than PAN.

## What Levels are Difficult for Individuals with Dyslexia?

- No problem at the acoustic level.
- Minor problem for some at the phonetic level.



## What Levels are Difficult for Individuals with Dyslexia?

- No problem at the acoustic level.
- Minor problem (if at all) at the phonetic level.
- Problem common at the phonological level.

## What Levels are Difficult for Individuals with Dyslexia?

- No problem at the acoustic level.
- Minor problem (if at all) at the phonetic level.
- Problem exists at the phonological level.
- Problems also exist at morphophonological level.

# Phonological Awareness Plays Causal Role in Learning to Read

- To a child who can hear similarities and differences among “cat,” “rat,” and “hat,” their spellings (cat, rat, hat) are sensible.
- Impaired phonological awareness is a common characteristic of individuals with dyslexia.

# Phonological Awareness can be Taught and Trained

- Every major reading series now includes lessons on phonological awareness.
- Training phonological awareness early can prevent or at least mitigate the severity of later word-level reading problems.
  - Early identification is critical to prevention.

# Measuring Phonological Awareness

- Common measures of phonological awareness include elision, segmenting, blending, sound matching, sound isolation, and phoneme reversal.

# Difficult Linking Phonemes to Graphemes

- A common view is that impairments in phonological processing prevent automatic coupling of letters and sounds.

# Difficult Linking Phonemes to Graphemes

- Letter sounds correspond roughly to phonemes.
  - That is why “bat” and “rat” have different first letters and identical second and third letters.

# Difficult Linking Phonemes to Graphemes

- Could explain difficulty in sounding out new words.
- Could explain why phonics is helpful for young readers at risk of developing reading problems.



Is Difficulty Linking Phonemes to Graphemes the  
Fundamental Problem in Dyslexia?

# One Test of the Linking Hypothesis

但那種事在這裏  
但我們不這樣做  
器可以用來作為武  
可以烘乾趾甲剪報  
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核心有兩個粗糙  
一個循環蘋果的

# Facts

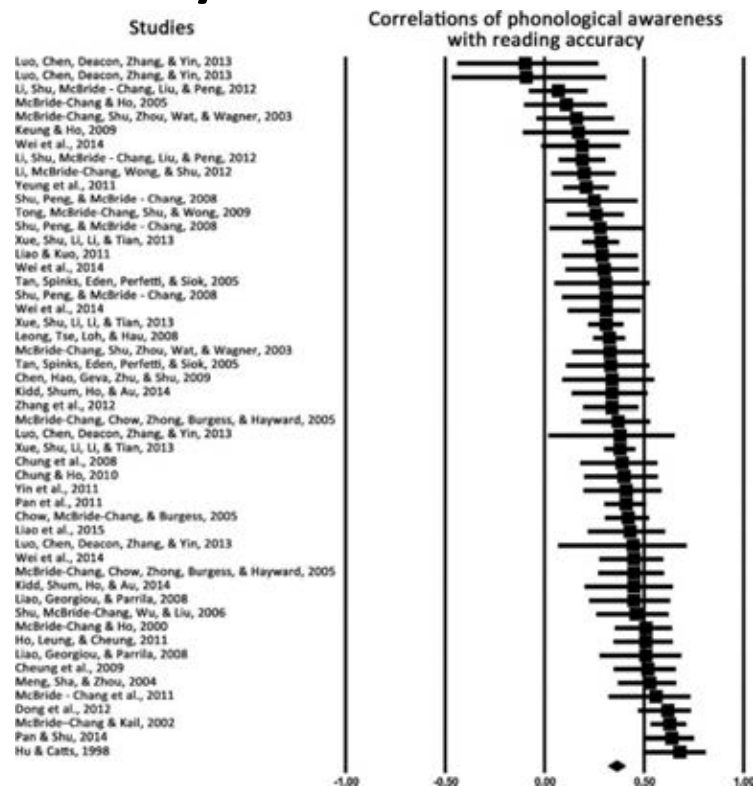
- Go to China and ask about dyslexia.
  - Parents and teachers say it doesn't exist.

# Facts

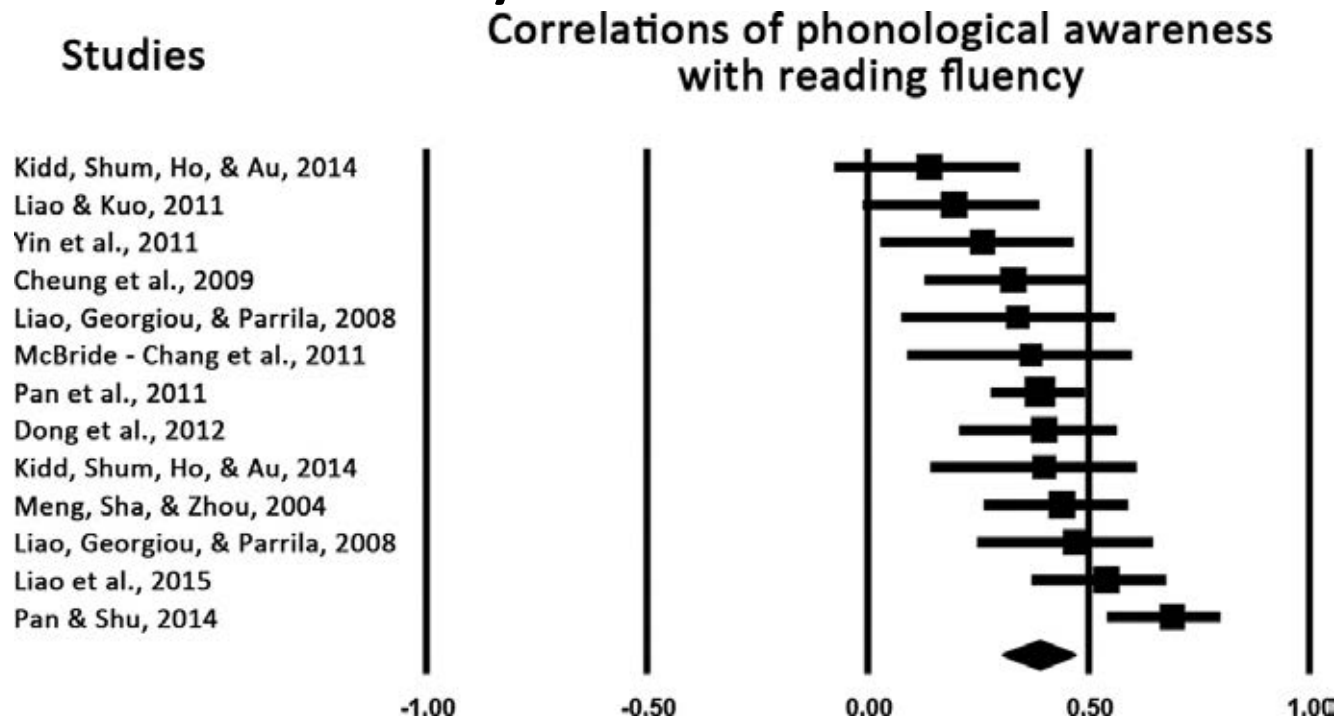
- Go to China and ask about dyslexia.
  - Parents and teachers say it doesn't exist.
- Researchers will tell you it does, and two recent studies support universality of reading predictors and problems.

- How Well Do Phonological Awareness and Rapid Naming Correlate with Chinese Reading Accuracy and Fluency? A Meta-Analysis
- *Scientific Studies of Reading*, 20, 99-123.

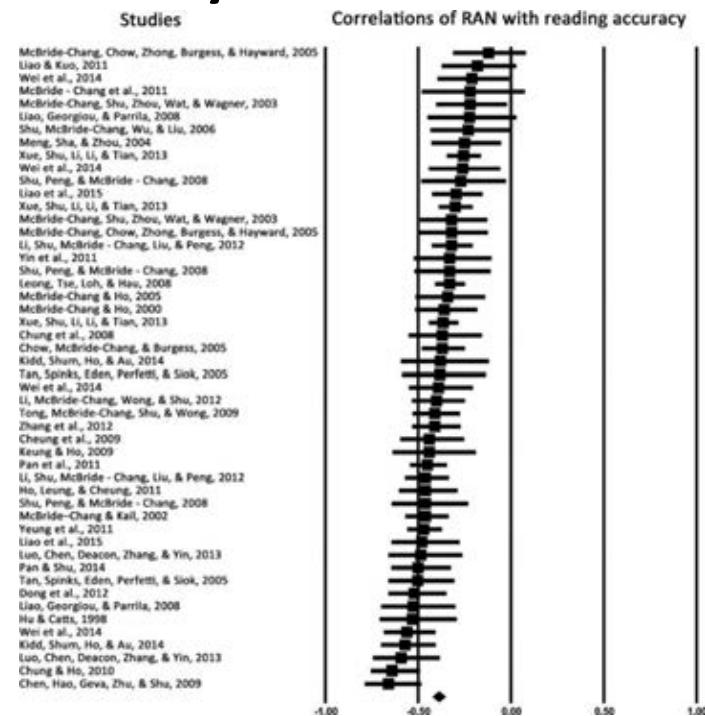
# Correlation between PA and Decoding Accuracy in Chinese is .4



# Correlation between PA and Decoding Fluency in Chinese is .4

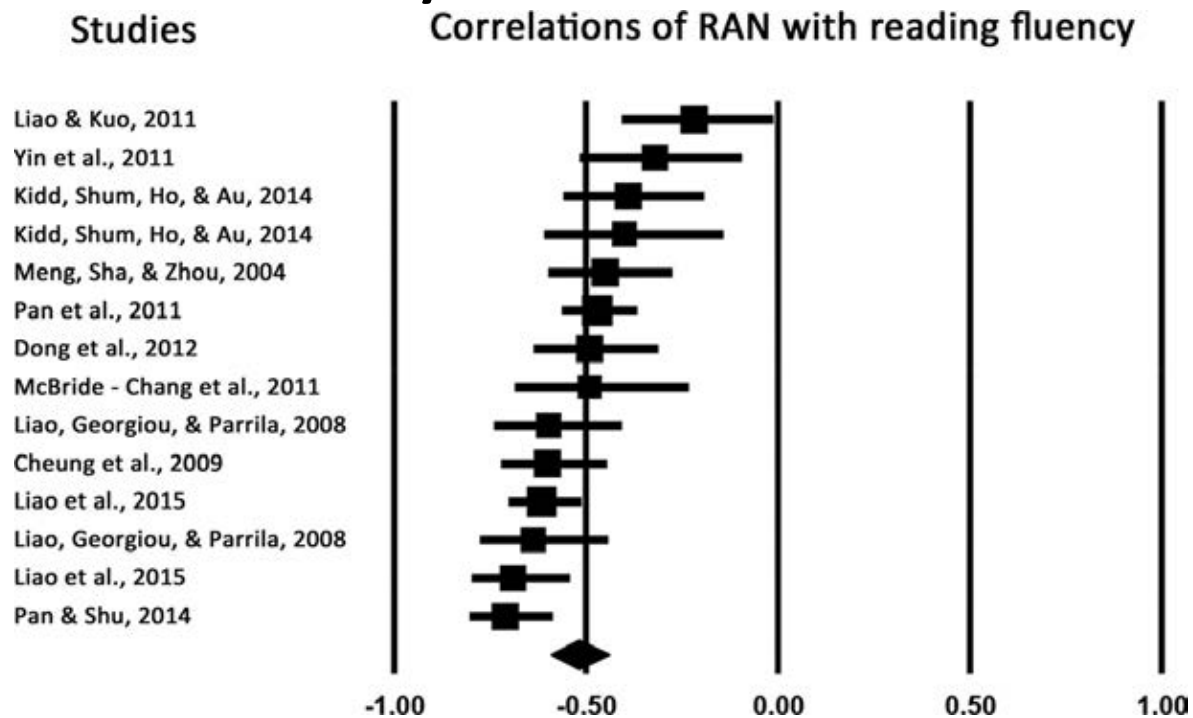


# Correlation between RAN and Decoding Accuracy in Chinese is .4





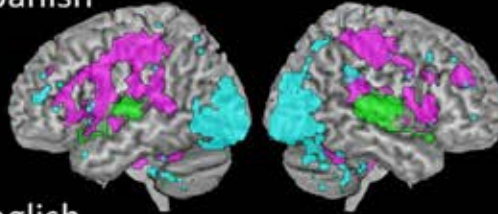
# Correlation between RAN and Decoding Fluency in Chinese is .5



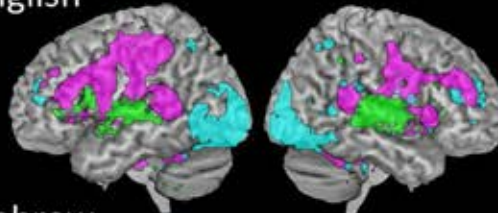
# **Comparing Activation Patterns in Spanish, English, Hebrew, and Chinese**

- **Jay G. Rueckl et al. PNAS  
2015;112:15510-15515**

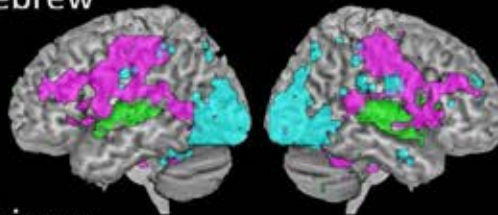
A Spanish



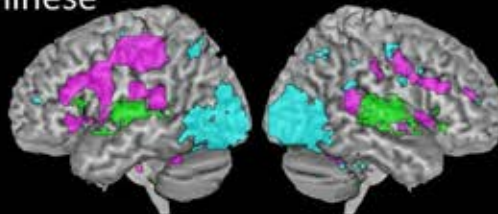
B English



C Hebrew



D Chinese



● Print only    ● Speech only    ● Overlap

# Facts

- Phonological processing problems are universal including in China.
- Problems in decoding, whether it is alphabetic script or Chinese characters, also are universal.

# Facts

- Explanation is that all written languages convey information about pronunciation as well as meaning.
- Dyslexia is not simply failing to connect letters and sounds, but this can be how the general deficit shows up in alphabetic scripts such as English.

# Phonological Memory

- What we use when we try to remember a number we want to use.

# Measuring Phonological Memory

- Digit Span
  - Best with rapid presentation of digits (e.g, 2 per second).
  - Minimizes rehearsal strategies and maximizes dependence on phonological processing.
    - Try your best to recall these two strings orally.

# Measuring Phonological Memory

- Nonword Repetition
  - Works best with “nonword-like” nonwords.
    - “tobraj” is better than “vellow.”
  - Has been used with children as young as 2 or 3 by having a puppet game with the puppets or dolls having nonword names.
    - “Put srismmuz on the horse.”



# Some Facts About Phonological Memory

- Tasks are simple cognitively compared to phonological awareness tasks.
- Before children learn to read, the correlation between phonological memory and phonological awareness approaches 1.0!

# Some Facts About Phonological Memory

- After children learn to read, measures of phonological memory and phonological awareness are now highly correlated (.8) yet distinguishable.

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- After children learn to read, measures of phonological memory and phonological awareness are now highly correlated (.8) yet distinguishable.
- Phonological memory measures do not correlate with reading as high as measures of phonological awareness.
  - But phonological awareness tasks are more similar to reading.

# Phonological Recoding for Lexical Access

- Words, including written form, pronunciation, and meanings are stored in a lexicon.
- Written forms and meaning forms can be recoded into pronunciations to access the correct lexical entry.

# Measuring Phonological Recoding for Lexical Access

- Rapid Naming Task
  - Items to be named can be colors, objects, digits, or letters.
  - Task can be latency to name a single object using a voice key or serial naming.

# Reading Comprehension is Worse than Listening Comprehension

- If your primary problem is an inability to read words on the page, you will understand more when someone reads text to you compared to when you have to read it yourself.

# Reading Comprehension is Worse than Listening Comprehension

- This criterion distinguishes individuals with dyslexia from individuals who are delayed in language or cognition generally.



# Reading Comprehension is Worse than Listening Comprehension

- Functionally significant criterion:
  - If listening comprehension is better than reading comprehension, assistive technology (e.g., text to speech) will be useful.
  - If listening comprehension is as bad as reading comprehension, assistive technology won't help.

# More Common in Boys?

## Controversial: Two Views

- 1. Male vulnerability is a myth. Equal numbers of girls affected.

## Controversial: Two Views

- It is a fact that more boys than girls are identified as having dyslexia.
- Given this fact, how could girls have a similar incidence of dyslexia?

## Controversial: Two Views

- If you are a teacher and have a limited number of referrals, why might you be more likely to refer a boy than a girl?
- Behavior problems. Referral bias could explain the fact of more boys being identified than girls.

# Key Study: Shaywitz et al. (1990)

- Obtained both school-identified ratio and objective ratio for same sample.
  - Statistically significant ratio of 2.2:1 found for school identified ratio.
  - Non-significant ratio of 1.4:1 found for objective criteria.
- Small sample (18 boys versus 13 girls with RD). A 2:1 ratio would not be significant.

# Gender Differences in Dyslexia: Reasons to Care

- 1. Gender bias in identification and provision of services may be pervasive.
- 2. Implications for theories of etiology.
- 3. New approaches to identification being considered potentially could mitigate referral bias if it exists.
  - Ex. Universal screening as front end of RTI.

# Current Controversy: Two Views

- 2. Male vulnerability is real.
  - Males are more vulnerable to nearly everything bad.
  - Life expectancy is years shorter than that for females.

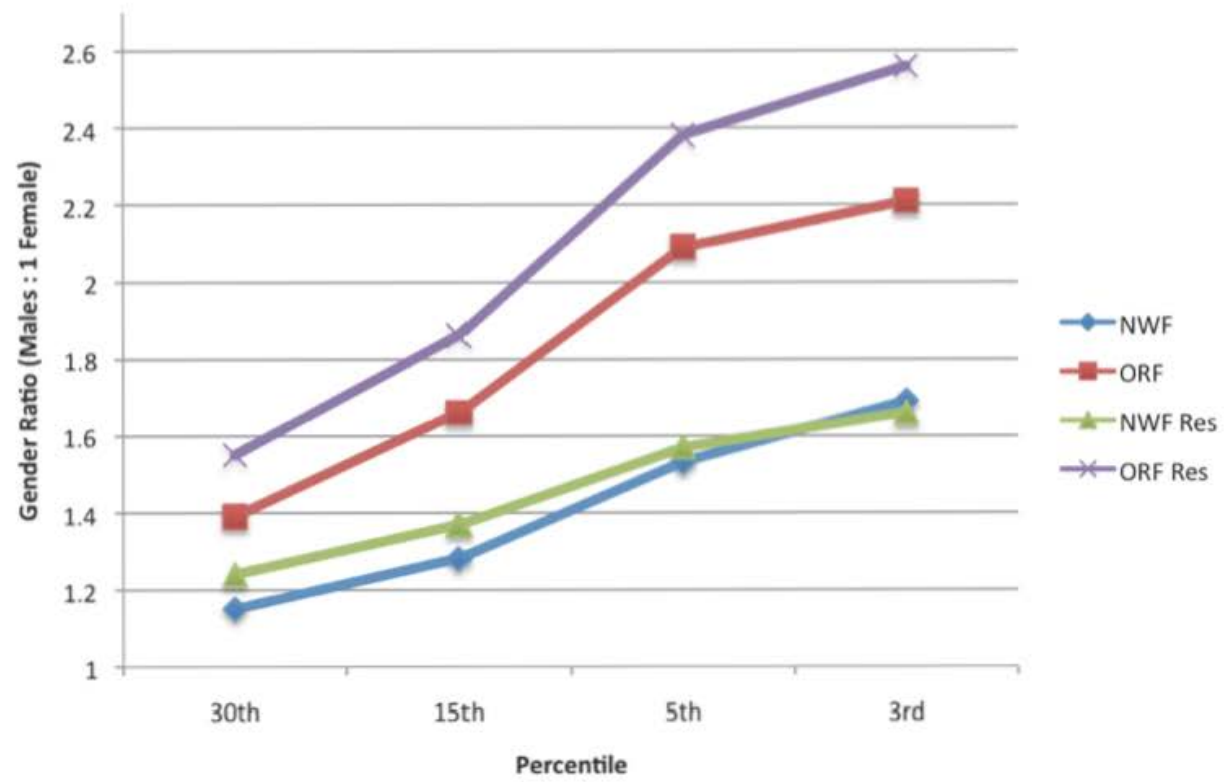


# Key Supporting Studies

- Liederman et al., 2005, review of the literature.
  - Ratios ranged from 1.2:1 to 6.8:1.
  - Concluded that true ratio was between 1.7:1 and 2:1.

## Quinn and Wagner (JLD, 2015)

- What if everyone is tested? No referral happens, so referral bias can't occur.
- Tested 5 cohorts of 2<sup>nd</sup> grade students (N = 491,000).



# Dyslexia Runs in Families

- If you have an affected first-degree relative (i.e., biological parent or sibling), your chances of having dyslexia are 4 times higher.

# A Dyslexia Gene?

- The search for the dyslexia gene has come up empty so far.
  - About 10 candidate genes have been identified.
  - Replication has been problematic.
  - Variance accounted for by individual candidate genes is small.

# Comorbid with Problems in Attention

- Comorbidity with ADHD is 35 to 40%.

# Conclusions

- 1. Reversal errors are not a cause or hallmark characteristic of dyslexia.

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- 2. Faulty eye-movements are not a common cause of dyslexia.



# Conclusions

- 1. Reversal errors are not a cause or hallmark characteristic of dyslexia.
- 2. Faulty eye-movements are not a common cause of dyslexia.
- 3. Dyslexia is a language problem not a visual problem. Language problem resides in the phonological system.

# Conclusions

- 4. Dyslexia runs in families.

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- 5. Children and adults with dyslexia may have other problems (e.g., ADHD).

# Conclusions

- 4. Dyslexia runs in families.
- 5. Children and adults with dyslexia may have other problems (e.g., ADHD).
- 6. Dyslexia occurs in boys and girls, but is about twice as common in boys.
- 7. Dyslexia is universal.

# Questions or Comments?