

**Dyslexia for the Paediatrician:  
Reading the wrong way with the right hemisphere  
RACP Congress 2007, 9 May 07**

**Karen E. Waldie, PhD**  
Research Centre for Cognitive Neuroscience,  
Department of Psychology, The University of Auckland



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Department of Psychology

## Research Centre for Cognitive Neuroscience

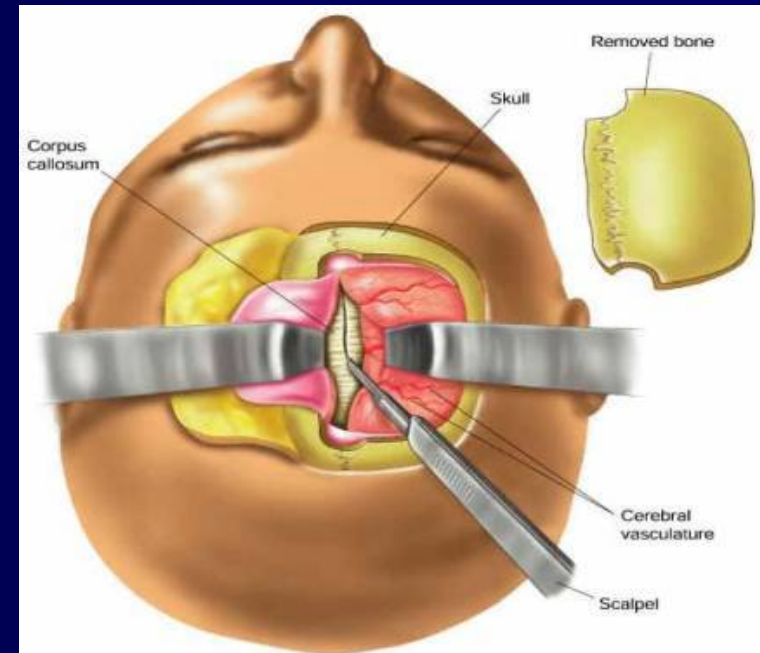
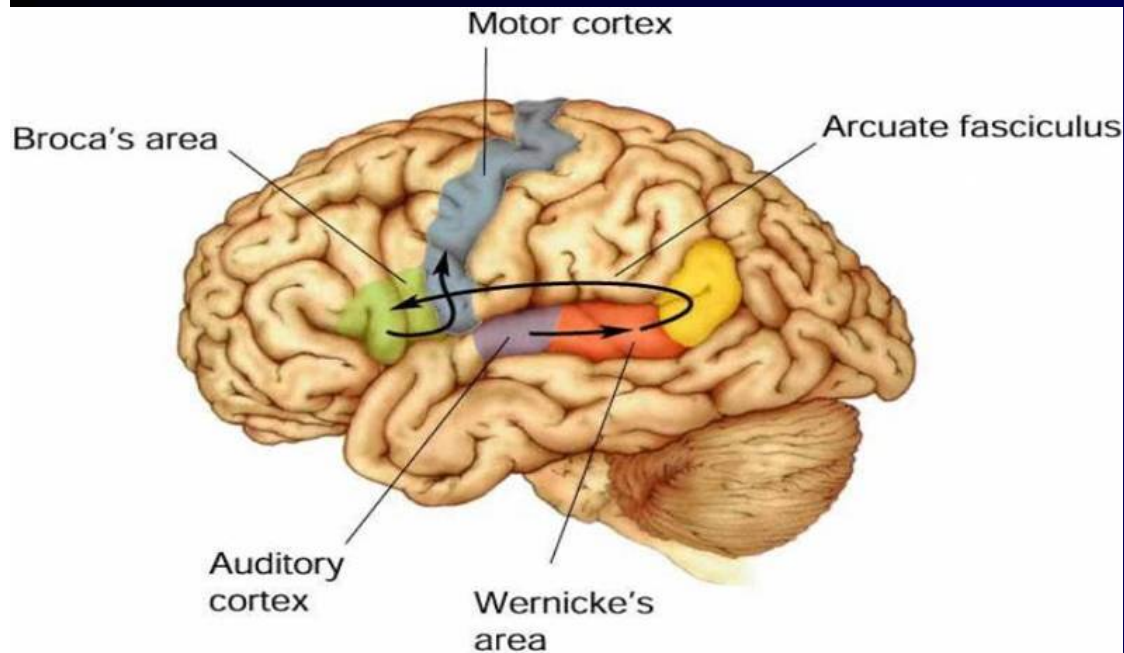
- **Language and the brain**
  - How the typical brain reads: fMRI results
- **Developmental dyslexia**
  - What is it? Why do we care?
  - How the *atypical* brain reads
    - main theories
    - fMRI results



- Oral language is innate
- Basic principal of cerebral laterality
- Studies with split-brain patients

## Is written language different from oral language?

- Written language is not innate - cultural invention



- What brain areas are important for written language?

# Brain Research Institute



fMRI allows us to map increases in oxygenated blood flow that accompany local synaptic activity during cognitive tasks

# Method

8 right-handed males

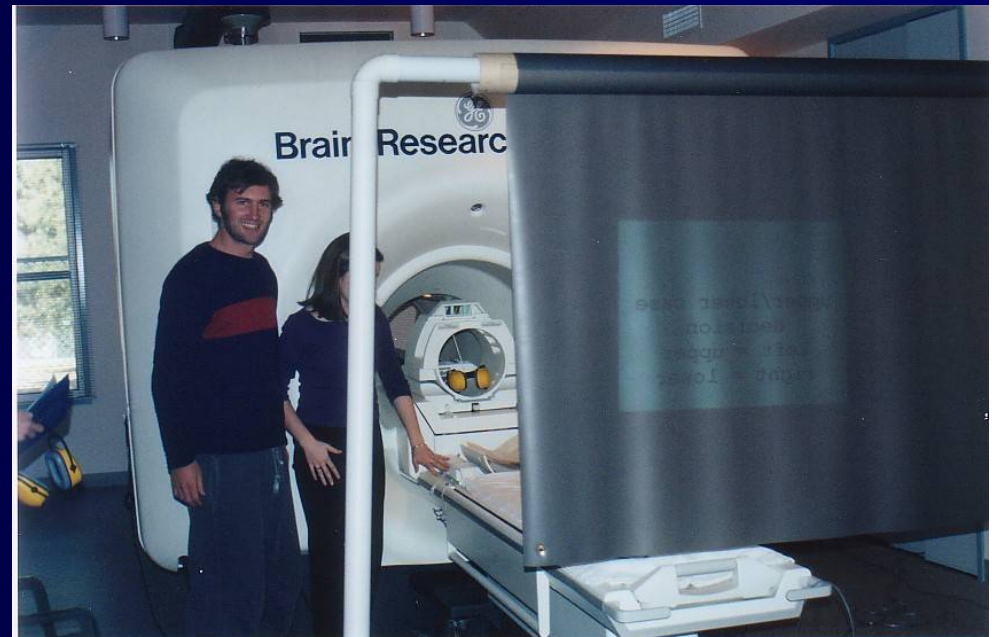
3-Tesla fMRI

3 tasks (EPrime) in block design

Statistical analysis: SPM99

## Activation Tasks (go/no-go)

1. Letter case decision
2. Lexical decision
3. Sublexical decision



Letter case  
decision

upper/lower?

(WXGT, knwc)

Lexical decision

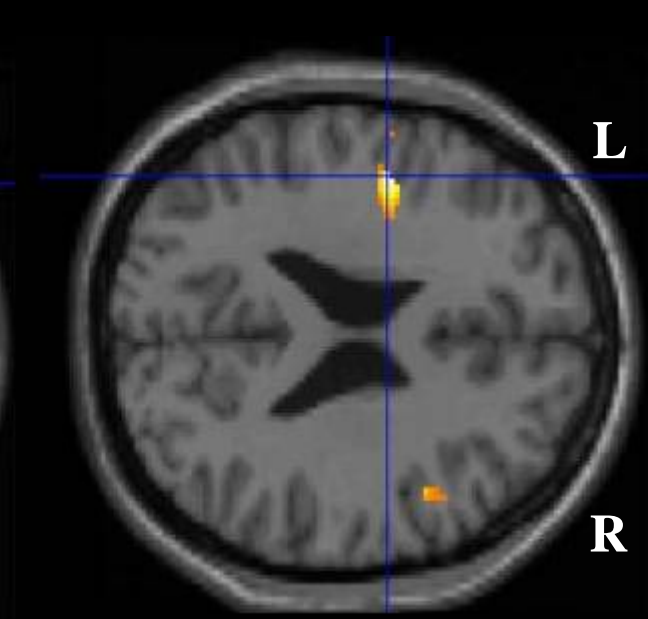
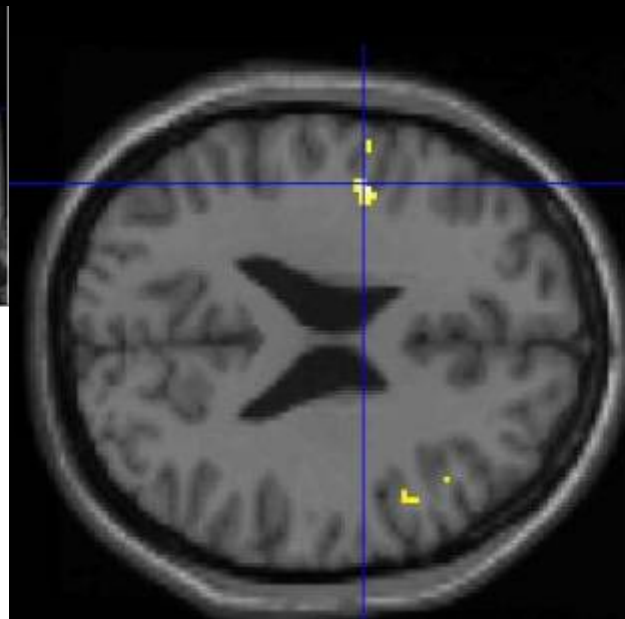
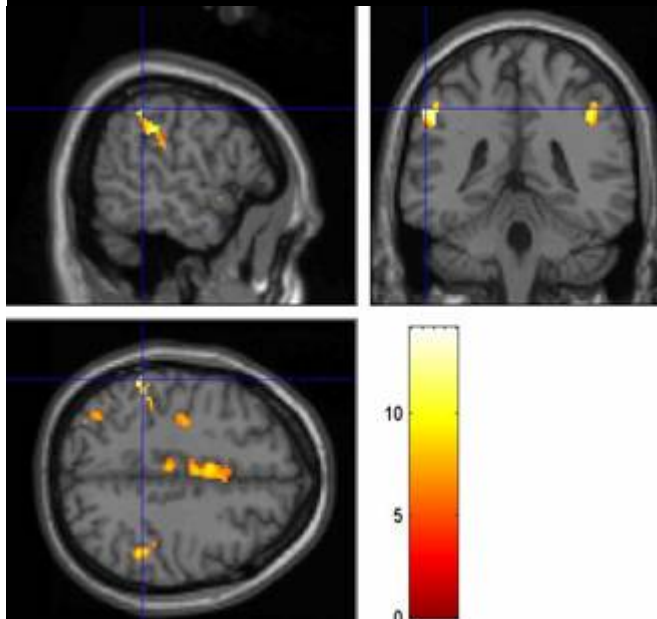
Word or nonword?

(bank, blint)

Sublexical decision

Sounds like word?

(pheat, trunt)

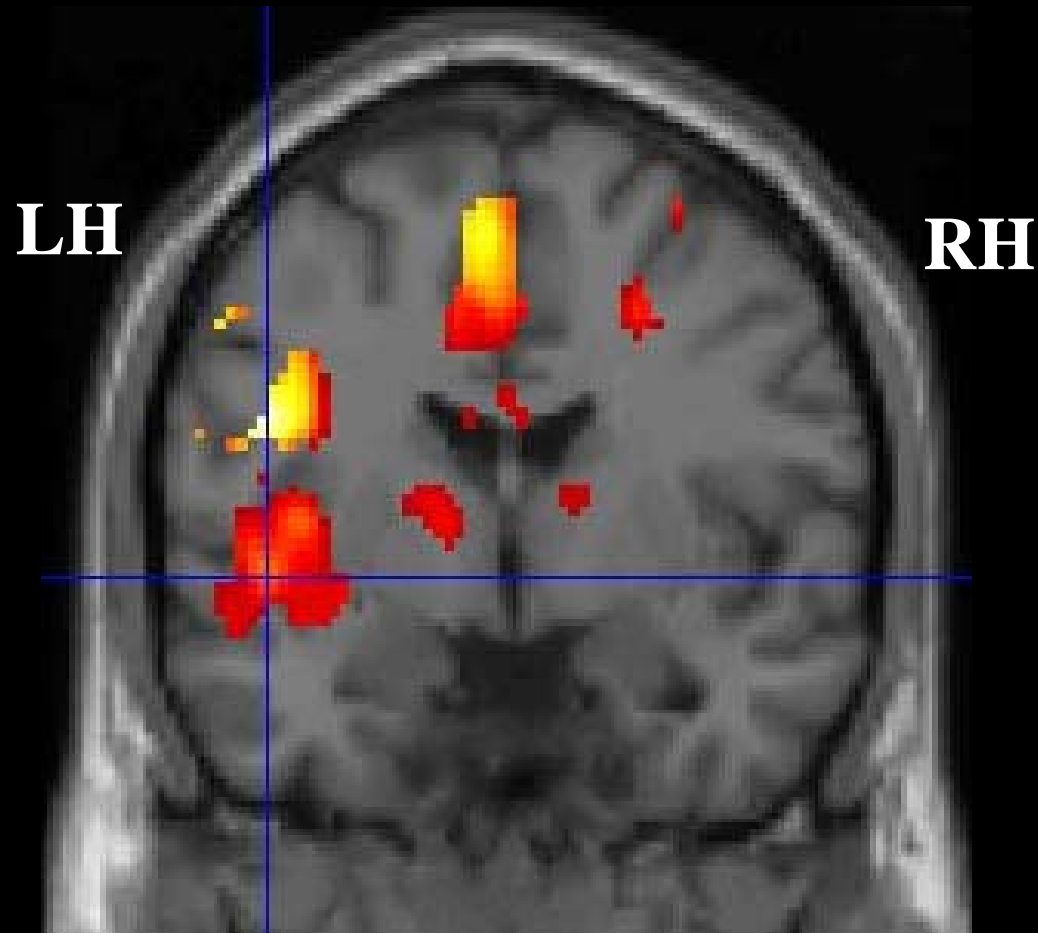


Note:

Activity from letter case decision is subsequently subtracted from the other tasks

## Lexical decision task: Coronal section view

Dyslexia: Are LH networks functionally disrupted?



# What is Developmental Dyslexia?

"An unexplained difference between adequate spoken language & severe reading/spelling difficulties despite normal intelligence and opportunities for schooling"

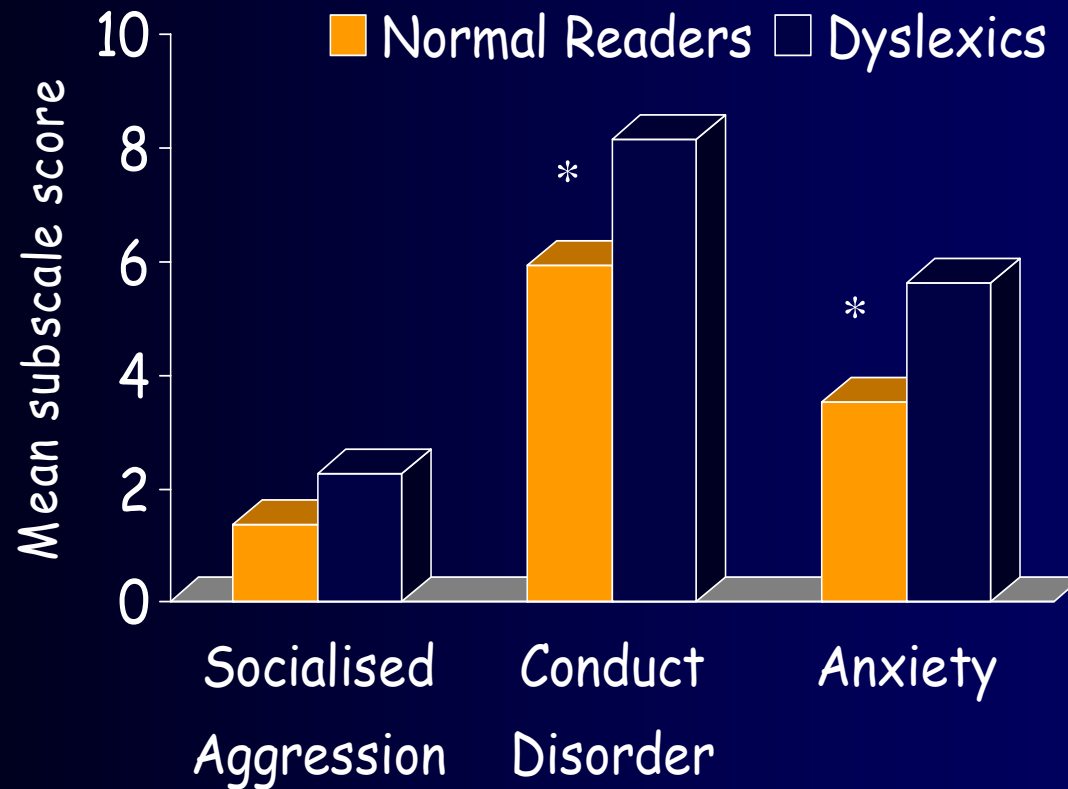
*World Health Organization*

**5-10%** (versus 30%) of the population

- Diagnosis by exclusion
- Hereditary disorder, males, left-handedness
- Why do we care? Long-term outcome studies
  - Dunedin Multidisciplinary Health and Development Study



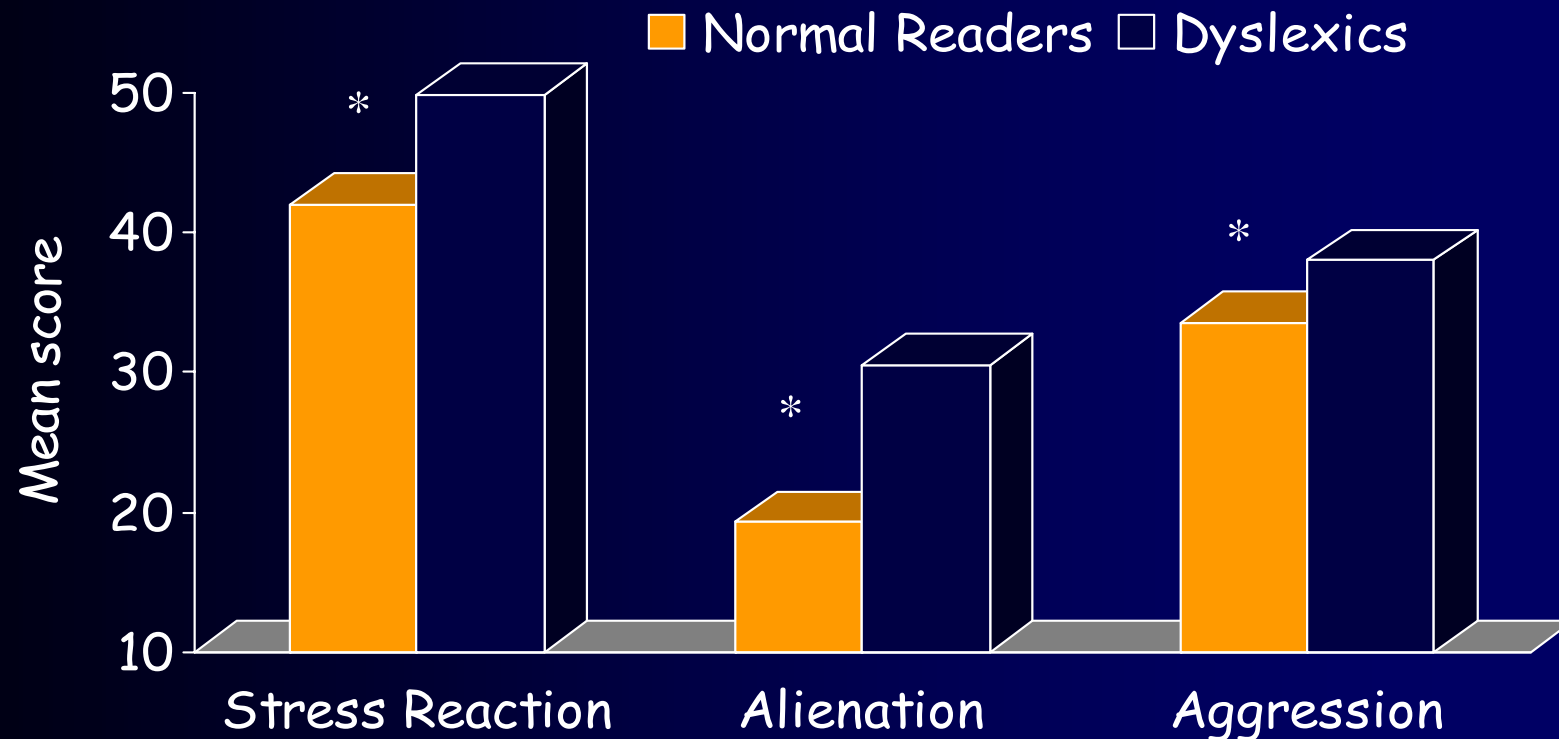
# Mid-adolescence: Psychological problems



Dunedin Multidisciplinary Health and Development Study



# Early adulthood: Psychological problems



**Stress reaction:** nervous, sensitive, prone to worry

**Alienation:** Feels mistreated, victimized, betrayed

**Aggression:** Hurts others for own advantage

## Adulthood: Mental health disorders

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	Any Depressive Disorder	Any Substance Dependence	Any Anxiety Disorder
Normal Readers	9.3%	9.9%	9.7%
Dyslexics	8.3%	12%	22.9%*

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## Age 26: Degree qualifications, income

	Bachelors Degree	Masters Degree	PhD, Law, Med	Median income before tax
Normal	23.5%	2.2%	2.9%	\$30,001 - \$40,000
Dyslexic	2.7%*	0	0	\$20,001 - \$30,000*

## Age 32: Degree qualifications, income

	No school qualification	Bachelors Degree	Masters, PhD, Law, Med	Median income before tax
Normal	14.1%	20%	6.3%	\$38,216 (\$46,654)
Dyslexic	48%*	2.7%*	0*	\$27,500* (\$29,058)

Chi square (3) = 84.75, p<.001

## Age 32: SES (includes homemakers)

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	Low (1&2)	Medium (3&4)	High (5&6)
Normal	28.2%	54.2%	17.6%
Dyslexic	54.7%*	40%*	5.3%*

Chi square (2) = 29.4,  $p < .001$

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## Age 32: General Health

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	Poor/Fair	Good	Very good- Excellent
Normal	6.8%	32.5%	60.7%
Dyslexic	9.3%	48%	42.7%*

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Chi square (3) = 9.74, p=.04

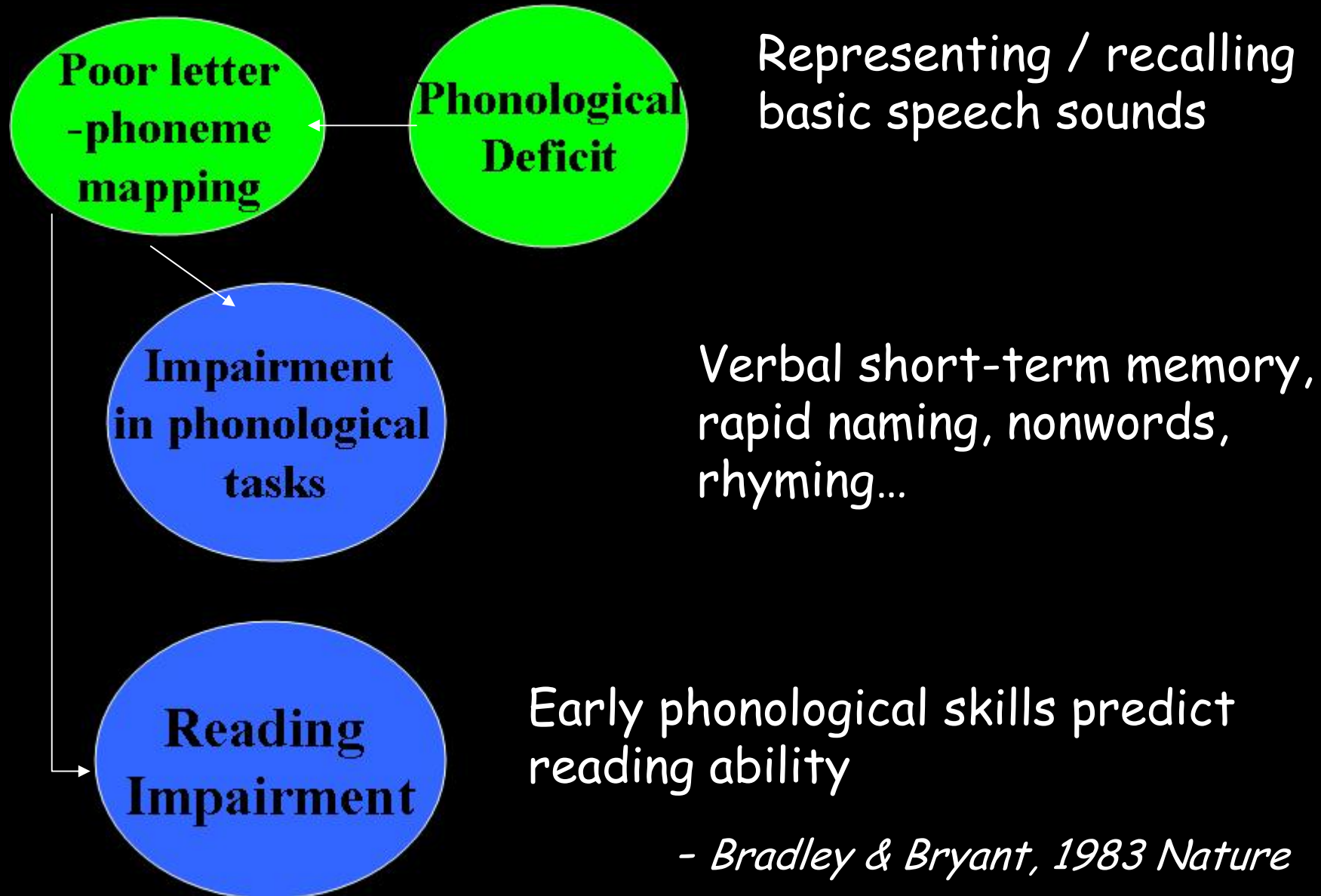
**Bottom Line:** Early identification & intervention is imperative  
**Overall aim:** Neurophysiological phenotype

## Two Common Myths of Dyslexia

1. **Letter reversals:** "a unique characteristic of dyslexia with etiological implications"
  - characterizes low reading levels (normal development)
  - imperfect knowledge of, or memory for, linguistic associations - not from *perceptual* confusion
2. **Erratic eye movements cause dyslexia:**  
"good readers make smooth, regular eye movements over the text"

- "If deficiencies in motor and visual-motor development or defects in eye movements caused perceptual impairment and reading problems, one would be at a loss to explain how so many children with cerebral palsy and various visual-tracking defects become literate"

## Main cognitive problem (phenotype)



## But....

- Not every child has a phonological impairment:  
Two main subtypes

### 1. Phonological (also called dysphonetic; ~70%)

- primary deficit in symbol-sound integration and in the ability to develop skills in phonetic word synthesis

### 2. Surface (dyseidetic; ~15%)

- primary deficit in the ability to perceive letters and words as a whole (i.e., configurations)
  - strategy of "sounding out" in order to read the word

NEXT: Two examples of phonological dyslexia - child, adult

ELENA BODER, M.D.  
SYLVIA JARRICO, M.A.

The  
Boder Test of  
Reading-Spelling  
Patterns

047

Idiosyncratic

CA: 12.3  
RA: 7.0  
PIQ: 110

Spelling Test Form

Name \_\_\_\_\_ Date 12/06/2002

Known Words		Unknown Words	
1. <u>not</u> ✓		1. <u>Big</u> ✓	
2. <u>ed</u> go R		2. <u>Red</u> ✓	
3. <u>up</u> up R		3. <u>Post</u> ✓	
4. <u>ish</u> ✓		4. <u>no</u> ✓	
5. <u>out</u> but ✓		5. <u>soff</u> <u>Salp</u> strip	
6. <u>comi</u> come		6. <u>maiva</u> mother	
7. <u>all</u> ball		7. <u>hid</u> GFE ride *	
8. <u>to</u> ✓		8. <u>blow</u> blue	
9. <u>the</u> ✓		9. <u>has</u> house	
10. <u>your</u> ✓		10. <u>what</u> GFE what	

ELENA BODER, M.D.  
SYLVIA JARRICO, M.A.

# The Boder Test of Reading–Spelling Patterns

CA 25.2  
RA 11.6

## Spelling Test Form

Name DYS 04

### Known Words

1. crocodile CROCODILE
2. human ✓
3. Program ✓
4. badge ✓
5. industry INDUSTRY
6. beauty BEAUTY
7. chalk CHALK
8. pleasure PLEASURE
9. sources ✓
10. writers ✓

### Unknown Words

1. Astronomy ASTRONOMY
2. democrat DEMOCRAT
3. quotation QUOTATION
4. represent REPRESENTATION
5. varnish VARNISH
6. crises GFE CRISIS
7. poultry POULTRY
8. orator HONORABLE
9. thorough THOROUGH
10. hasten GFE HASTEN

Total correct 50 %  
No. phonetic words 3  
No. nonphonetic words 2

Total GFEs (GFE misspellings and phonetic words correct) 20 %  
No. GFE misspellings 2  
No. phonetic words correct 2

Main problem with the cognitive model?

\* Note. Cognitive model is describing only the *symptom*

## Neural Basis of Developmental Dyslexia

“defective development occurring in the early stages of embryonic growth”

- Hinshelwood, 1917

Postmortem studies

*ctopias*: neurons clustered abnormally in patchy clumps

*Dysplasia*: alteration of the number of neurons and neuronal architecture

-Disruption of neuronal migration: 5-6 month of gestation

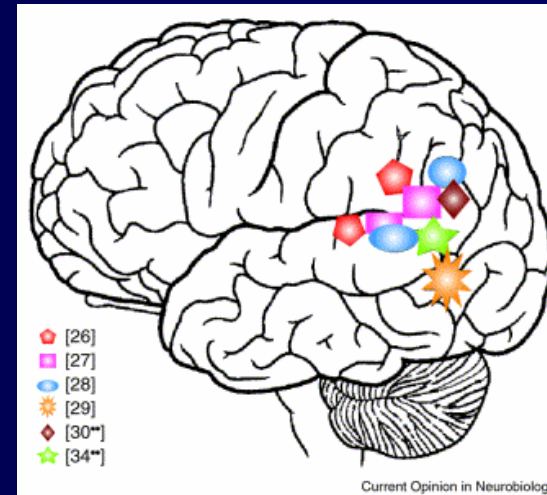
# Recent discovery of four "susceptibility genes"

1. DYX1C1
  2. KIAA0319
  3. DCDC2
  4. ROBO1
- All involved in neural migration
  - Anomalies lead to abnormal brain circuits (wiring) in experimental mice
  - Helps to explain why dyslexia co-exists with other LDs:
    - Specific Language Impairment (dysphasia)
    - Developmental coordination disorder (dyspraxia)
    - Mathematics disability (dyscalculia)

## Atypical neural development may affect:

### Left hemisphere language networks:

- "Atypical laterality"



**Corpus callosum:** "Interhemispheric communication"

**Cerebellum:** "Automatic Processing"

**Thalamus (Magno Pathways):** "Temporal processing"

Atypical brain wiring in *multiple* brain areas may also explain the other behavioural symptoms that are associated with dyslexia:

auditory, visual, motor deficits

# Dyslexia: LH networks functionally disrupted?

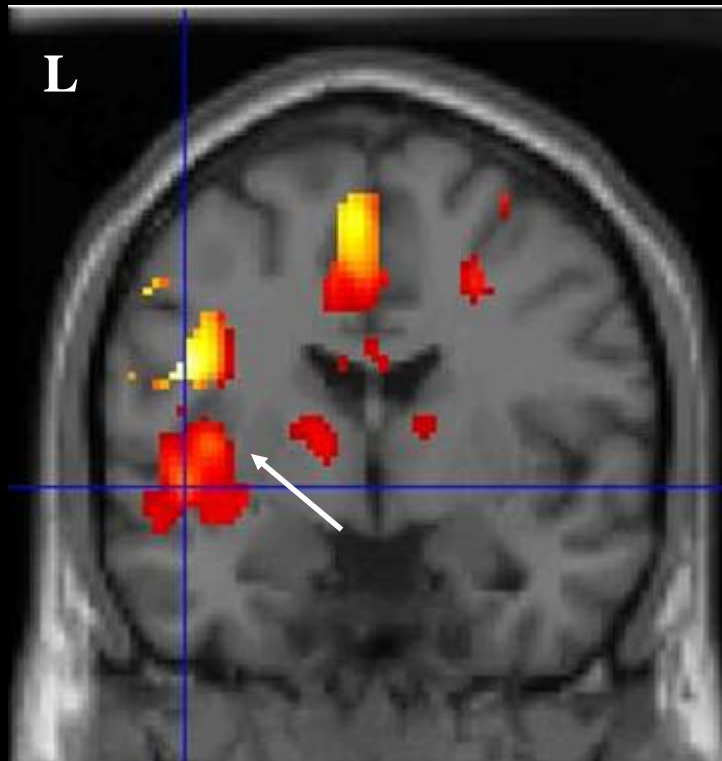
Do ~~As in RHD~~ ~~deficit in~~ ~~maximal~~ ~~in~~ ~~right~~ ~~inferior~~ ~~frontal~~ ~~types~~?

English Language is complex

- Regular (BELT) and Irregular (SHOE) words

**A.** Normal readers

**B.** Dyslexic adult



# Dual route model of reading

1. Indirect phonological (grapheme - phoneme)
  - reading nonwords (blint), non-English
2. Direct lexical ("whole-word", ideographic)
  - reading irregular words: foreign, yacht

# Experiment Two

## Centre for Advanced MRI: 1.5-Tesla fMRI

- **Subjects:** 15 normal readers, 15 dyslexic readers
- **Activation Tasks:** 40 stimuli each, 2.4s presentation time, 3s interscan interval

1. Letter-case judgment

2. **Shape decision**

3. **Lexical decision for regular words** 

4. **Lexical decision for irregular words**

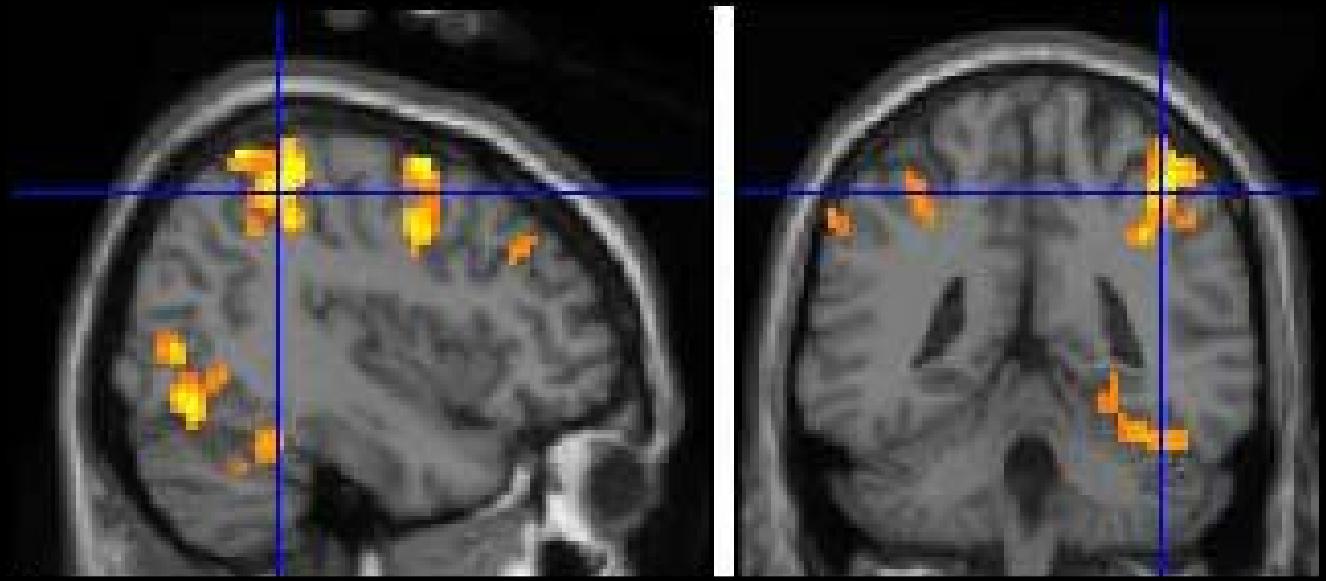
5. Sublexical Decision 

## **Why lexical decision? (vs. silent reading words)**

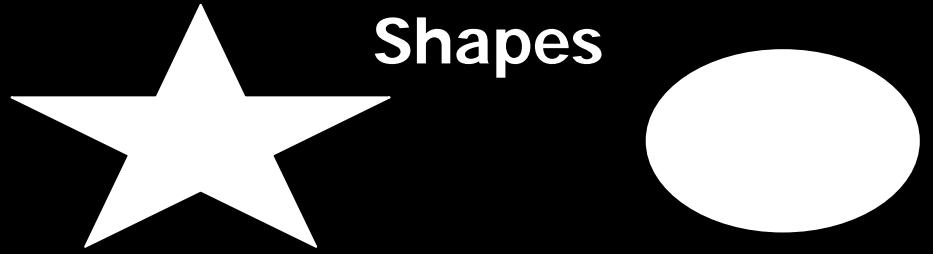
-Must *read* for correct response

-Can monitor task engagement

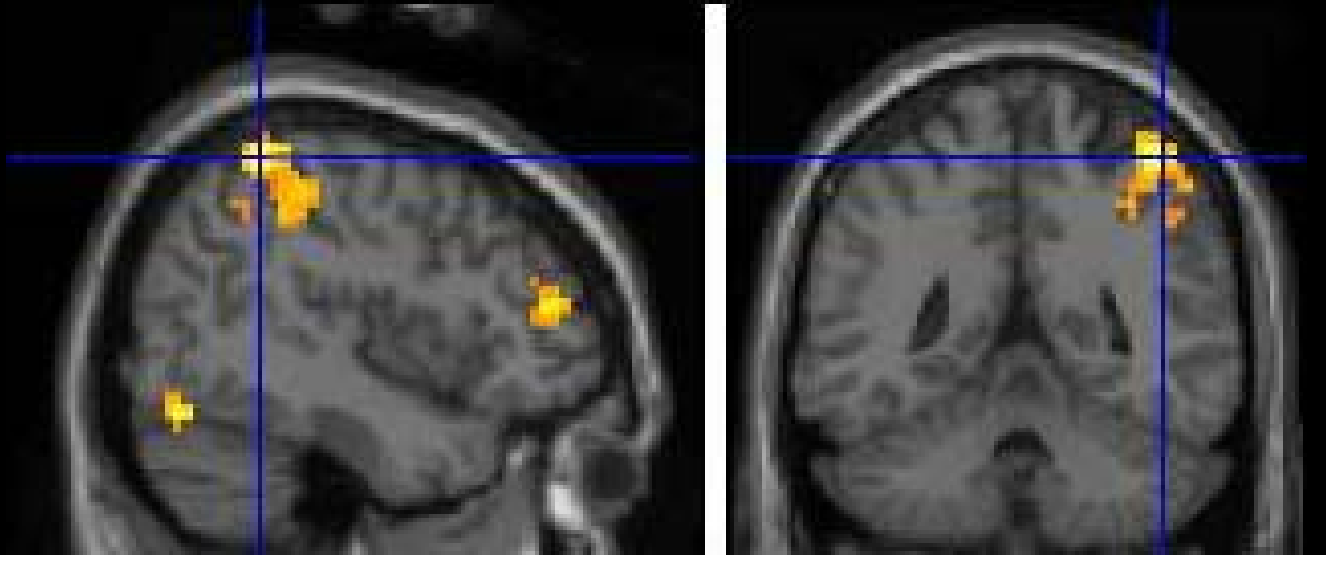
**Controls**



**Shapes**



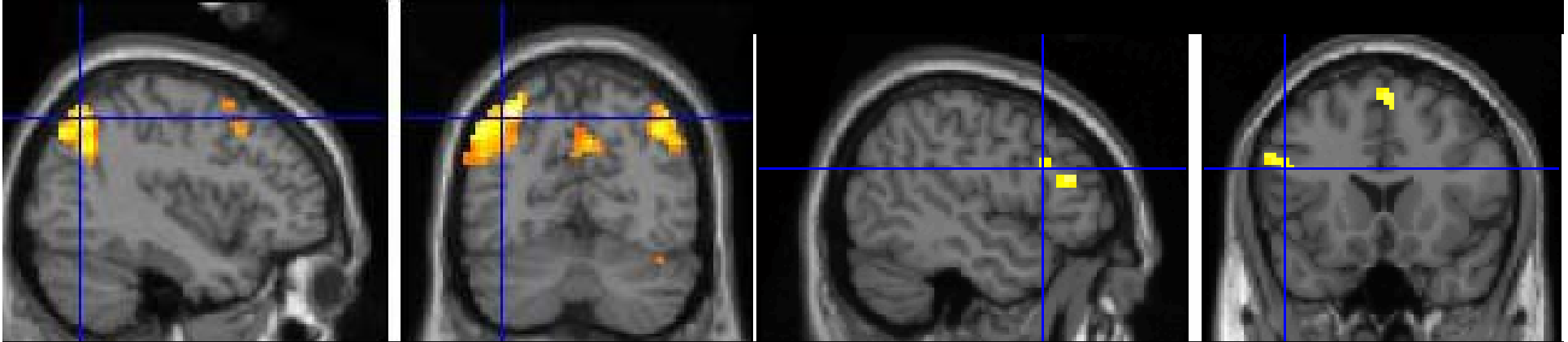
**Dyslexics**



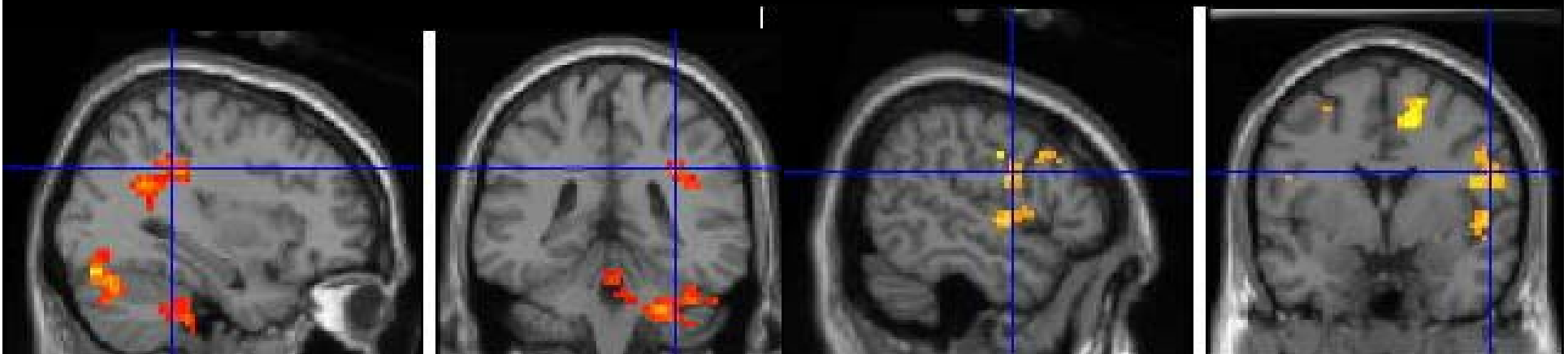
Regular words

Irregular words

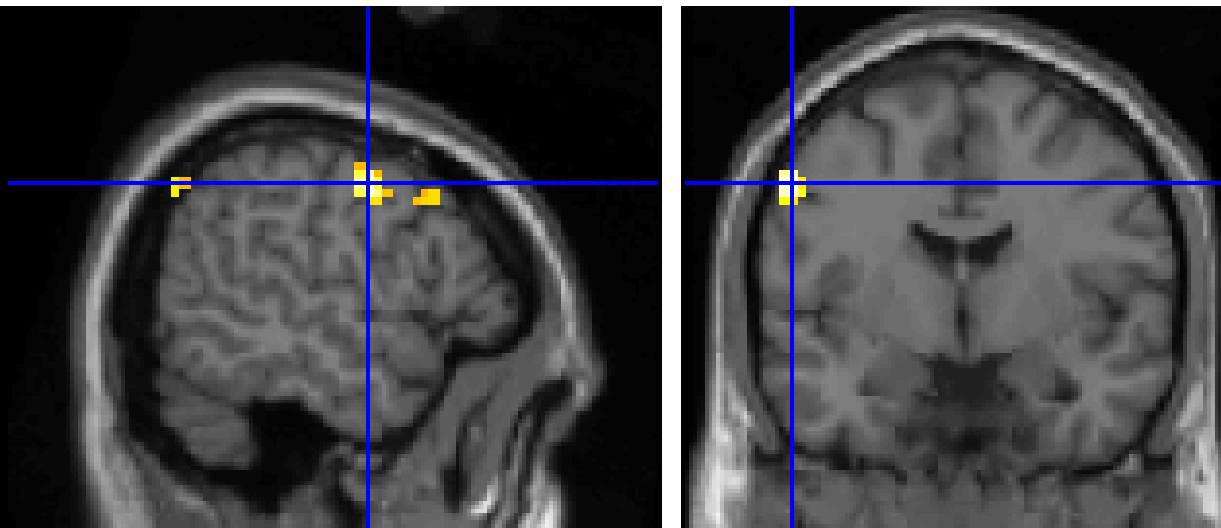
Controls



Dyslexics

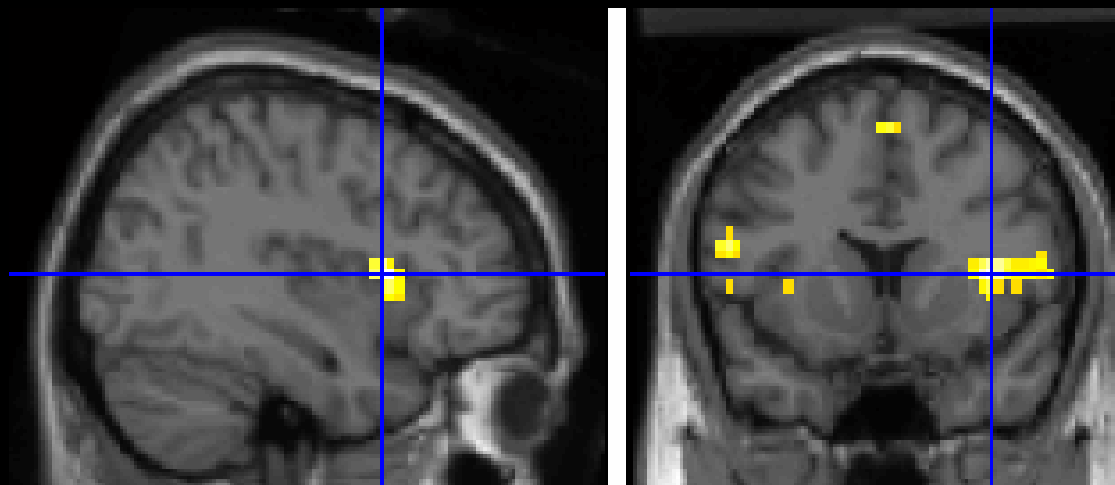


**Controls**



**Sublexical Task**

**Dyslexics**



## Summary: Group differences?

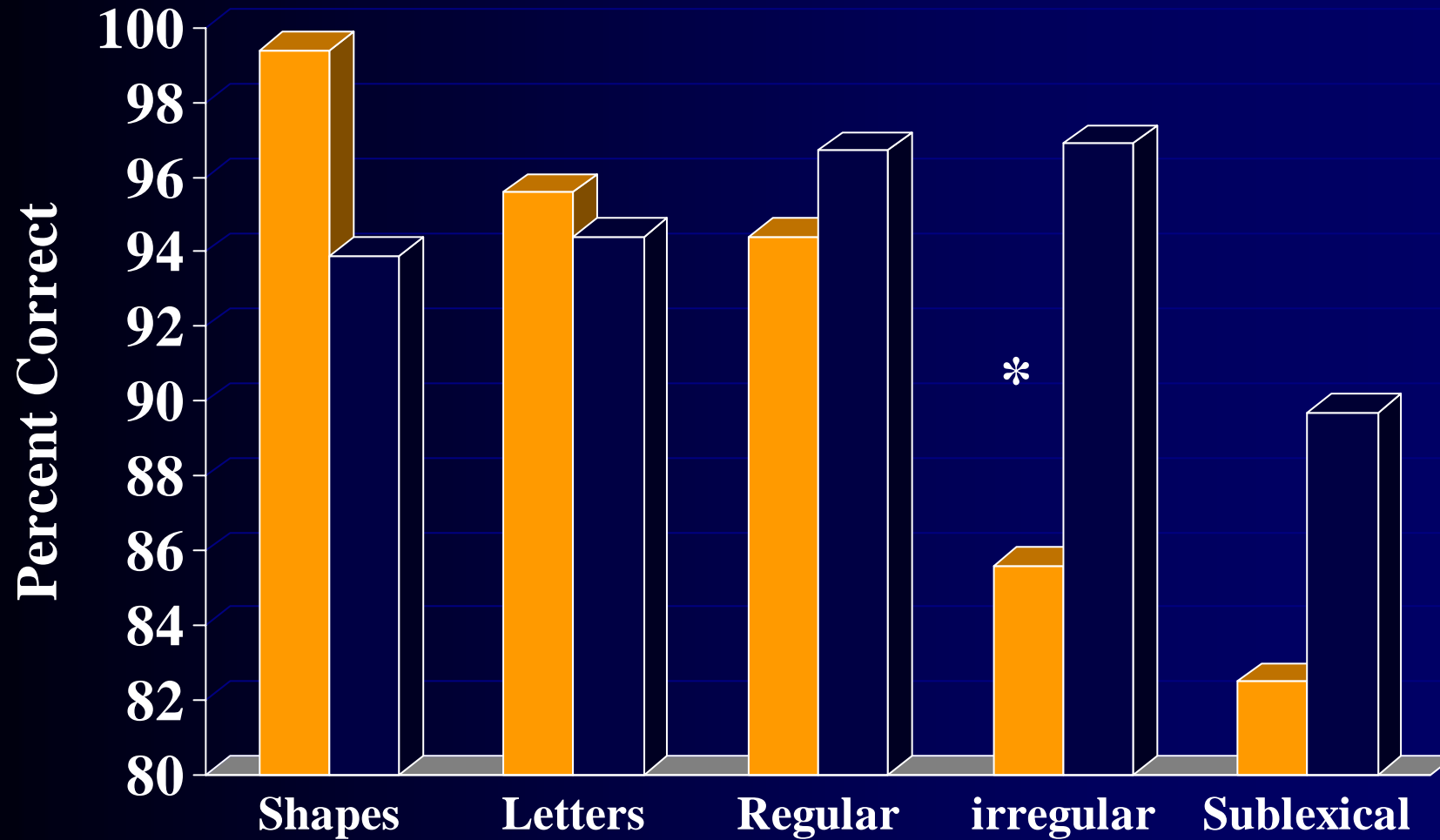
1. Nonverbal stimuli - similar (right parietal) activity
2. Verbal stimuli - differences: Regular & Irregular words, nonwords

### Left hemisphere networks functionally disrupted?

- All tasks: left posterior hypoactivation
- All tasks: **Right hemisphere over-activation**
  - Behavioural results

■ Dyslexics □ Controls

Dyslexics: 91.5% + .028  
Controls: 94.3% + .019



Task, Group X Task

# Conclusions

- Right hemisphere reading as a compensatory system
- Irregular words associated with the *most* RH activation and the poorest performance

**Bottom Line:** The right hemisphere is not specialised for Language and therefore compensates poorly

- fMRI as a diagnostic tool?
- Implications for brain plasticity/ remediation?

Future directions...

children, longitudinal, pre-post training, subtypes, comorbid groups



THE UNIVERSITY OF AUCKLAND  
NEW ZEALAND  
Department of Psychology

## Research Centre for Cognitive Neuroscience

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