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School of Psychology

CENTRE FOR BRAIN RESEARCH
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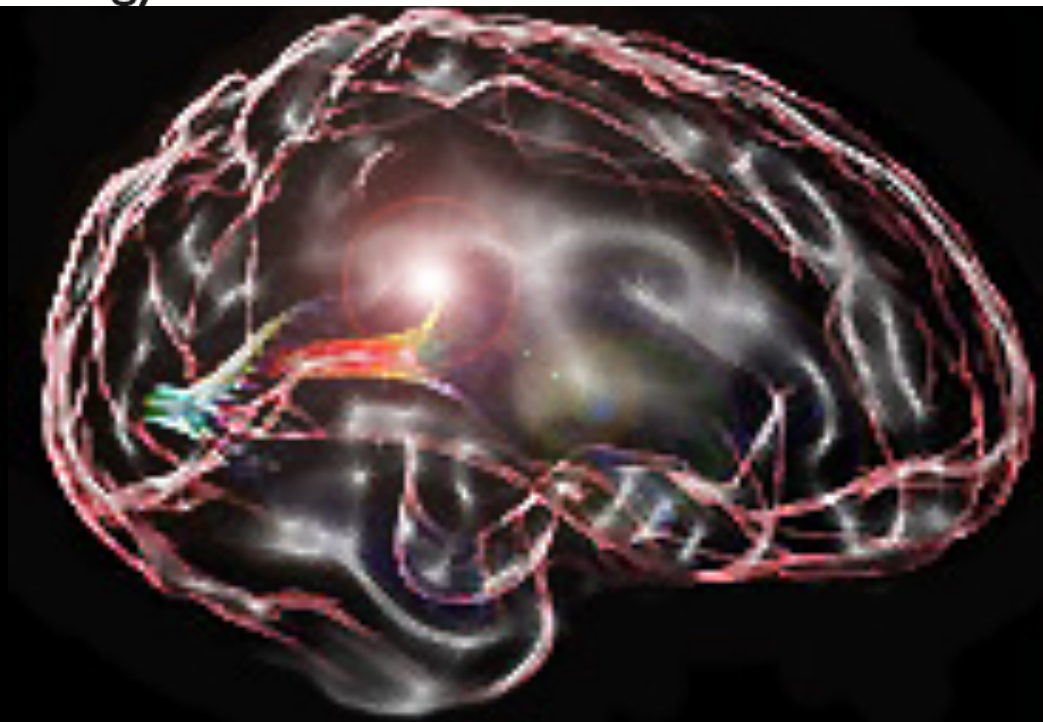


The brain and neuroplasticity in dyslexia and ADHD

A/Prof Karen E Waldie

CBR Learning Difficulties Workshop

Friday 9:10am 17 April 2015

Developmental disorders: A group of conditions identified in childhood that involve serious impairment in different areas

Dyslexia: phonological awareness

Dyscalculia: number sense

ADHD: executive functioning

ASD: social awareness

My research: Cognitive and neurological biomarkers; comorbidity

- Outline:
  1. My background; General introduction to neuroplasticity
  2. Frontal lobe development and ADHD
  3. Compensation, dyslexia and remediation

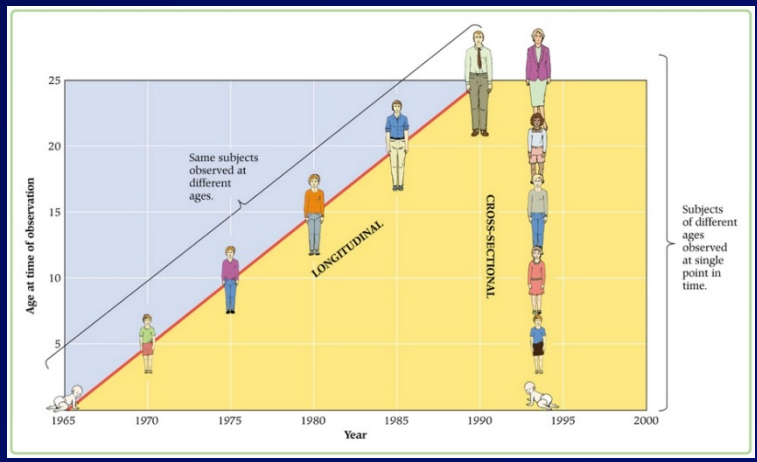
My background: longitudinal research

The Relationship Between Learning Disabilities and Persisting Delinquency

Karen Waldie and Otfried Spreen

Recidivism of delinquency in juveniles with learning disabilities (LD), the focus of the present study, has been virtually unexplored in previous research. Data from a longitudinal study initiated in 1978 are examined. Sixty-five subjects with LD (47 males and 18 females) who had been diagnosed and assessed between the ages of 8 and 12 years were located and, during a personal structured interview at the median age of 18 years, reported police contact. This population was subdivided into two groups on the basis of whether police contact had continued or discontinued, as reported in a second personal interview at the age of 25 years. Discriminant analysis on parent and subject variables correctly classified 75% of the subjects and revealed that certain personality characteristics, such as impulsivity and poor judgment, discriminate between persisting and nonpersisting delinquency in youth with learning disabilities.

Journal of Learning Disabilities, 26(6), 1993, 417-23.

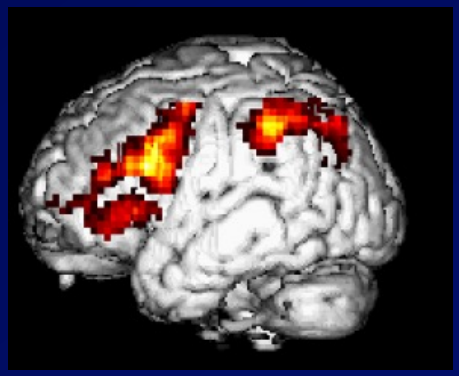


1. DMHDS
2. ABC Study
3. Growing Up in NZ (www.growingup.co.nz)

Modern brain imaging methods

In the last 20 years, the field of cognitive neuroscience has developed non-invasive methods for studying healthy human brains in action, in adults and now children.

Electro-encephalography (EEG)



Functional magnetic resonance imaging (fMRI)

My background: brain scanning

CENTRE FOR Advanced MRI

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

1. Neuroplasticity

General introduction

My 1st developmental psychology lectures:

1. Born with 100 billion brain cells
2. Following ~ the first 3 years of life the brain was relatively static

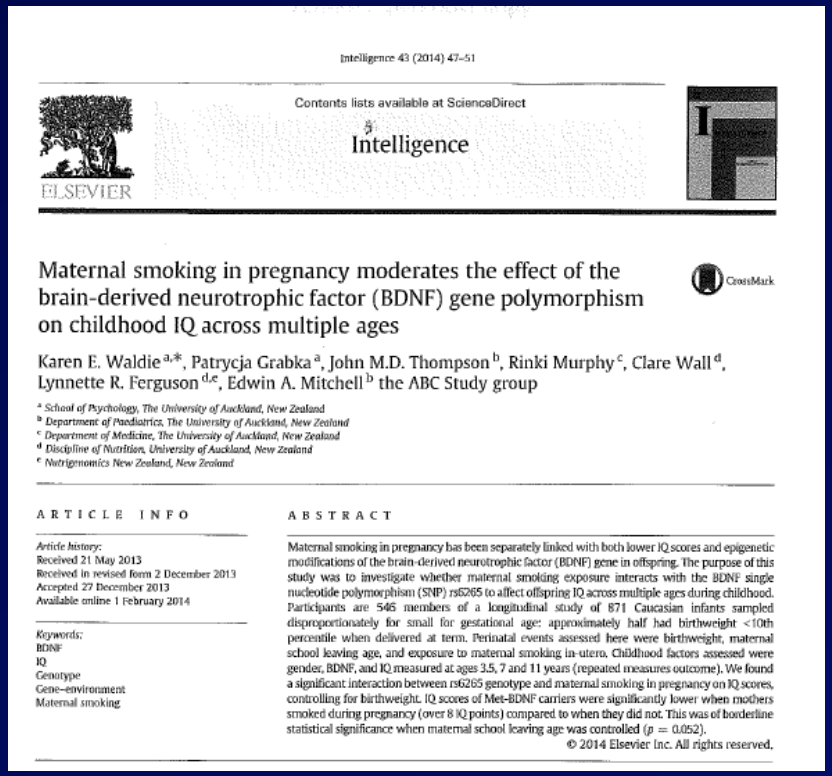
- neurogenesis occurs in humans up to 72 years of age
- stress inhibits neurogenesis
- environmental enrichment enhances neurogenesis

– The capacity of the brain to rewire through experience

1. Neuroplasticity

General introduction

- *Responsiveness* to experiences
  - Can be negative; vulnerable to damage
    - Early sensory deprivation
    - Antenatal maternal smoking, stress, drug use



Intelligence 43 (2014) 47–51

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Intelligence

ELSEVIER

Maternal smoking in pregnancy moderates the effect of the brain-derived neurotrophic factor (BDNF) gene polymorphism on childhood IQ across multiple ages

Karen E. Waldie [a,*], Patrycja Grabka [a], John M.D. Thompson [b], Rinki Murphy [c], Clare Wall [d], Lynnette R. Ferguson [d,e], Edwin A. Mitchell [b] the ABC Study group

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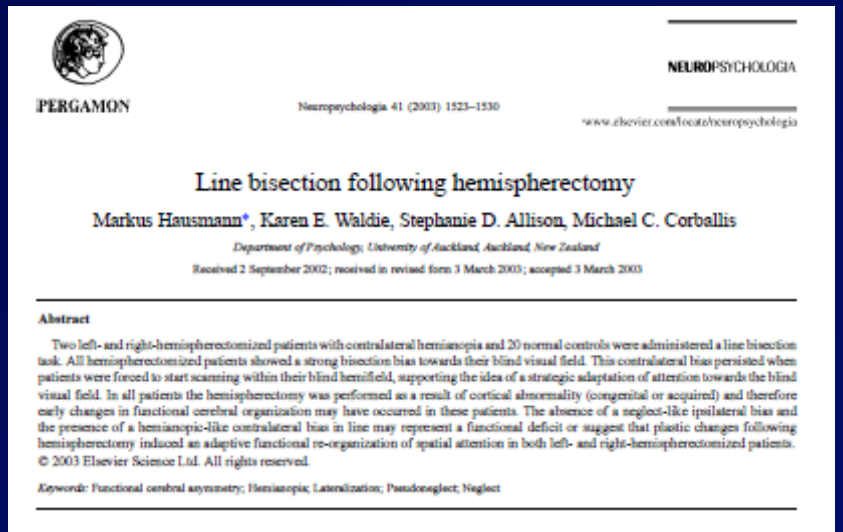
ABSTRACT

Maternal smoking in pregnancy has been separately linked with both lower IQ scores and epigenetic modifications of the brain-derived neurotrophic factor (BDNF) gene in offspring. The purpose of this study was to investigate whether maternal smoking exposure interacts with the BDNF single nucleotide polymorphism (SNP) rs6265 to affect offspring IQ across multiple ages during childhood. Participants are 546 members of a longitudinal study of 871 Caucasian infants sampled disproportionately for small for gestational age: approximately half had birthweight <10th percentile when delivered at term. Perinatal events assessed here were birthweight, maternal school leaving age, and exposure to maternal smoking in-utero. Childhood factors assessed were gender, BDNF, and IQ measured at ages 3.5, 7 and 11 years (repeated measures outcome). We found a significant interaction between rs6265 genotype and maternal smoking in pregnancy on IQ scores, controlling for birthweight. IQ scores of Met-BDNF carriers were significantly lower when mothers smoked during pregnancy (over 8 IQ points) compared to when they did not. This was of borderline statistical significance when maternal school leaving age was controlled ($p = 0.052$).

1. Neuroplasticity

General introduction

- *Responsiveness* to experiences
  - Can be negative; vulnerable to damage
    - Early sensory deprivation
    - Antenatal maternal smoking, stress, drug use
  - Can be positive
    - Aids in recovery from brain damage/injury (e.g., hemispherectomy)



PERGAMON

Neuropsychologia 41 (2003) 1523–1530

NEUROPSYCHOLOGIA

www.elsevier.com/locate/neuropsychologia

Line bisection following hemispherectomy

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Department of Psychology, University of Auckland, Auckland, New Zealand

Received 2 September 2002; received in revised form 3 March 2003; accepted 3 March 2003

Abstract

Two left- and right-hemispherectomized patients with contralateral hemianopia and 20 normal controls were administered a line bisection task. All hemispherectomized patients showed a strong bisection bias towards their blind visual field. This contralateral bias persisted when patients were forced to start scanning within their blind hemifield, supporting the idea of a strategic adaptation of attention towards the blind visual field. In all patients the hemispherectomy was performed as a result of cortical abnormality (congenital or acquired) and therefore early changes in functional cerebral organization may have occurred in these patients. The absence of a neglect-like ipsilateral bias and the presence of a hemianopic-like contralateral bias in line may represent a functional deficit or suggest that plastic changes following hemispherectomy induced an adaptive functional re-organization of spatial attention in both left- and right-hemispherectomized patients.

Keywords: Functional cerebral asymmetry; Hemianopia; Lateralization; Pseudoneglect; Neglect

1. Neuroplasticity

General introduction

- *Responsiveness* to experiences
  - Can be negative; vulnerable to damage
    - Early sensory deprivation
    - Antenatal maternal smoking, stress, drug use
  - Can be positive
    - Aids in recovery from brain damage/injury (e.g., hemispherectomy)
    - Can benefit from stimulation (e.g., playing a musical instrument; learning a new language; cognitive training / intervention)

Allows for *adaptability*

2. Neuroplasticity

ADHD and the frontal lobe:

Frontal lobe under-activity

- Reduced size / density (MRI)
- Decreased blood flow (activation) during executive tasks (PET, fMRI)

2. Neuroplasticity

ADHD and the frontal lobe:

Executive tasks/functions:

- Planning
- Inhibition
- Response selection
- Top-down allocation of attention
- Regulation of emotion
- Working memory

2. Neuroplasticity

ADHD and the frontal lobe:

Frontal lobe under-activity

- Frontal cortex has the most connections
- Fronto-striatal pathway inadequate in ADHD

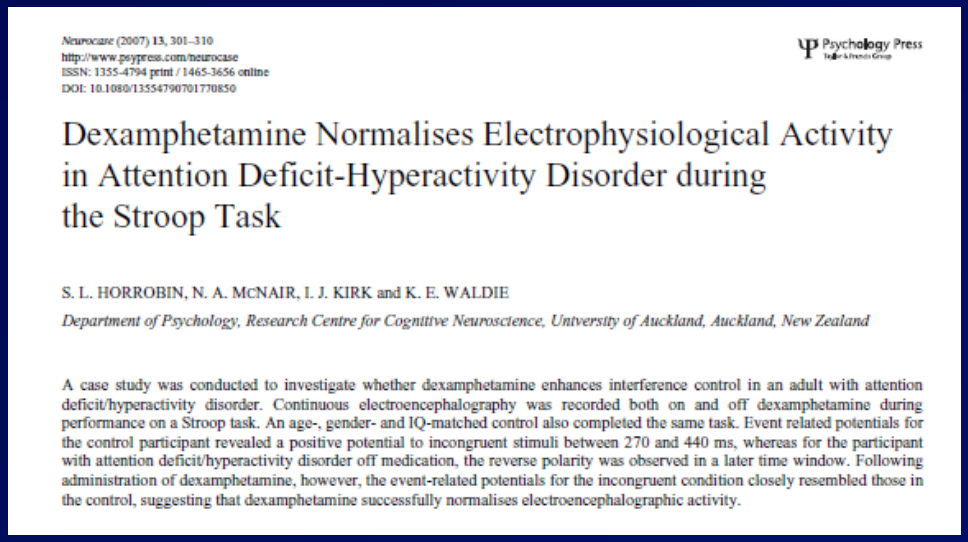
= Inattention and failure
to inhibit motor responses

2. Neuroplasticity

ADHD and the frontal lobe:

- These areas under-active because of neurotransmitter depletion (faulty metabolism of dopamine and/or norephinephrine at the synapse)

  = poor transmission of neural impulses in fronto-striatal pathway



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http://www.psypress.com/neurocase
ISSN: 1355-4794 print / 1465-3656 online
DOI: 10.1080/13554790701770850

Psychology Press

Dexamphetamine Normalises Electrophysiological Activity in Attention Deficit-Hyperactivity Disorder during the Stroop Task

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Department of Psychology, Research Centre for Cognitive Neuroscience, University of Auckland, Auckland, New Zealand

A case study was conducted to investigate whether dexamphetamine enhances interference control in an adult with attention deficit/hyperactivity disorder. Continuous electroencephalography was recorded both on and off dexamphetamine during performance on a Stroop task. An age-, gender- and IQ-matched control also completed the same task. Event related potentials for the control participant revealed a positive potential to incongruent stimuli between 270 and 440 ms, whereas for the participant with attention deficit/hyperactivity disorder off medication, the reverse polarity was observed in a later time window. Following administration of dexamphetamine, however, the event-related potentials for the incongruent condition closely resembled those in the control, suggesting that dexamphetamine successfully normalises electroencephalographic activity.

Challenge: non-pharmaceutical intervention to normalize the frontal lobe (see: http://movincog.org/public.html)

Risk Factors

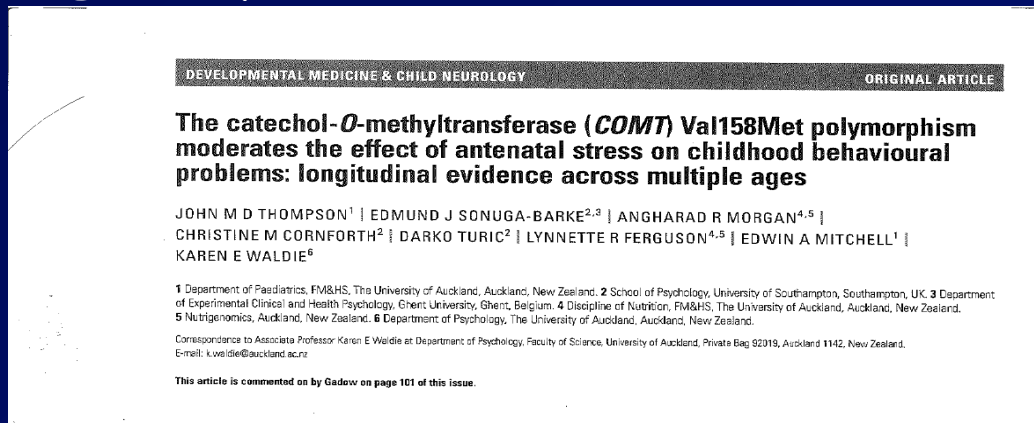
Genetic Defects

Concordance rates: if one identical twin has it, the other will too: Ranges from 70-90%

- ADHD genes are common in the general population. When genes from both parents combine – additive effect to cause condition

If genetic susceptibility:

- Low birth weight, Adverse environment,
- Smoking/alcohol during pregnancy
- Stress during pregnancy



DEVELOPMENTAL MEDICINE & CHILD NEUROLOGY ORIGINAL ARTICLE

The catechol-*O*-methyltransferase (*COMT*) Val158Met polymorphism moderates the effect of antenatal stress on childhood behavioural problems: longitudinal evidence across multiple ages

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This article is commented on by Gadow on page 101 of this issue.

3. Neuroplasticity

Dyslexia and compensation

DYS (Abnormal or impaired); LEXIS (words or language)

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

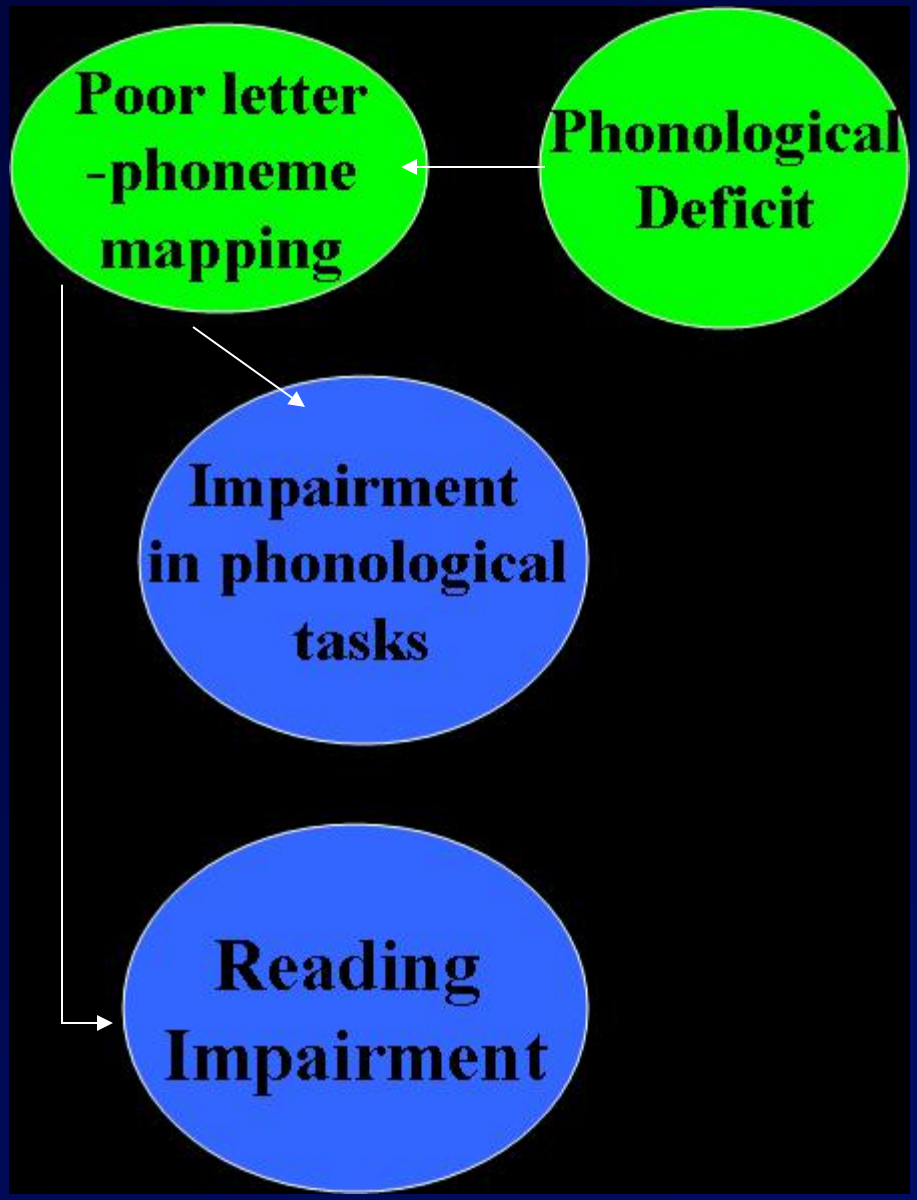
Affects 5% of the population (versus 30%)

- Hereditary disorder, males, left-handedness

"defective development occurring in the early stages of embryonic growth" Hinshelwood (1917) versus NZ…Ministry of Ed 2007

Brain anomalies cause dyslexia – areas of the brain involved in phonological processing (letter to sound).

Main cognitive problem



Representing / recalling basic speech sounds

Verbal short-term memory, rapid naming, nonwords, rhyming…

Early phonological skills predict reading ability

- Bradley & Bryant, 1983 Nature

Myths of Dyslexia

1. Letter reversals: "unique characteristic of dyslexia with etiological implications"
   - imperfect 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"

Breakthrough dyslexia study a first for New Zealand

By Sarah Moyes

It's one of those things that everyone's heard of, but no one really understands.

Dyslexia affects 7.7 percent of New Zealanders, however only a small number of people can define the reading disability.

Auckland University department of psychology senior lecturer Dr Karen Waldie is conducting a study about dyslexia and the maths learning disability dyscalculia.

"A lot of people with dyslexia also have dyscalculia. If you have one disability you're more than likely to have another," she says.

Dyslexia has been defined as the selective impairment of reading and spelling that is not caused by other reasons such as hearing or vision problems.

It affects people's ability to read even though they've had a good education.

"I'm trying to let people know that when you are talking about people with dyslexia and dyscalculia they are bright and educated people," Dr Waldie says.

She is originally from Canada, where dyslexia is recognised throughout the school system.

She says the New Zealand education system was slower to accept the worldwide evidence about dyslexia.

"The Education Ministry finally formally acknowledged the existence of dyslexia at the end of 2006.

"Teachers in New Zealand aren't trained properly about dyslexia," Dr Waldie says.

When she first came to New Zealand she says people had no conception of what a learning disability was.

"Kids who struggled were seen as lazy and stupid. There are a lot of misconceptions and rumours about dyslexia."

A study in Dunedin that Dr Waldie was involved in showed 48 percent of 32-year-old dyslexic adults had no school qualifications, compared to 14 percent of non-dyslexics.

Dr Waldie's current study hopes to raise awareness of dyslexia.

There are a few stages to the study, the most important being the final brain-imaging scan.

Using a new non-invasive brain-imaging technology – functional magnetic resonance imaging – Dr Waldie can see clearer images of the brain, allowing such a study to be done for the first time in New Zealand.

With the technology, Dr Waldie can map increases in oxygenated blood flow that accompany brain activity during reading.

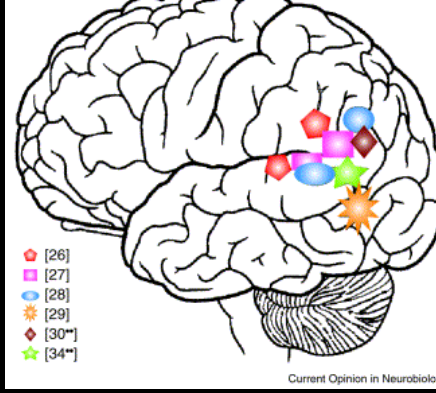
"In the scanner we can see the structure of the brain.

"The person performs different tasks – the machine can see what happens.

"We need to understand what causes it and why so many people have the two learning disabilities."

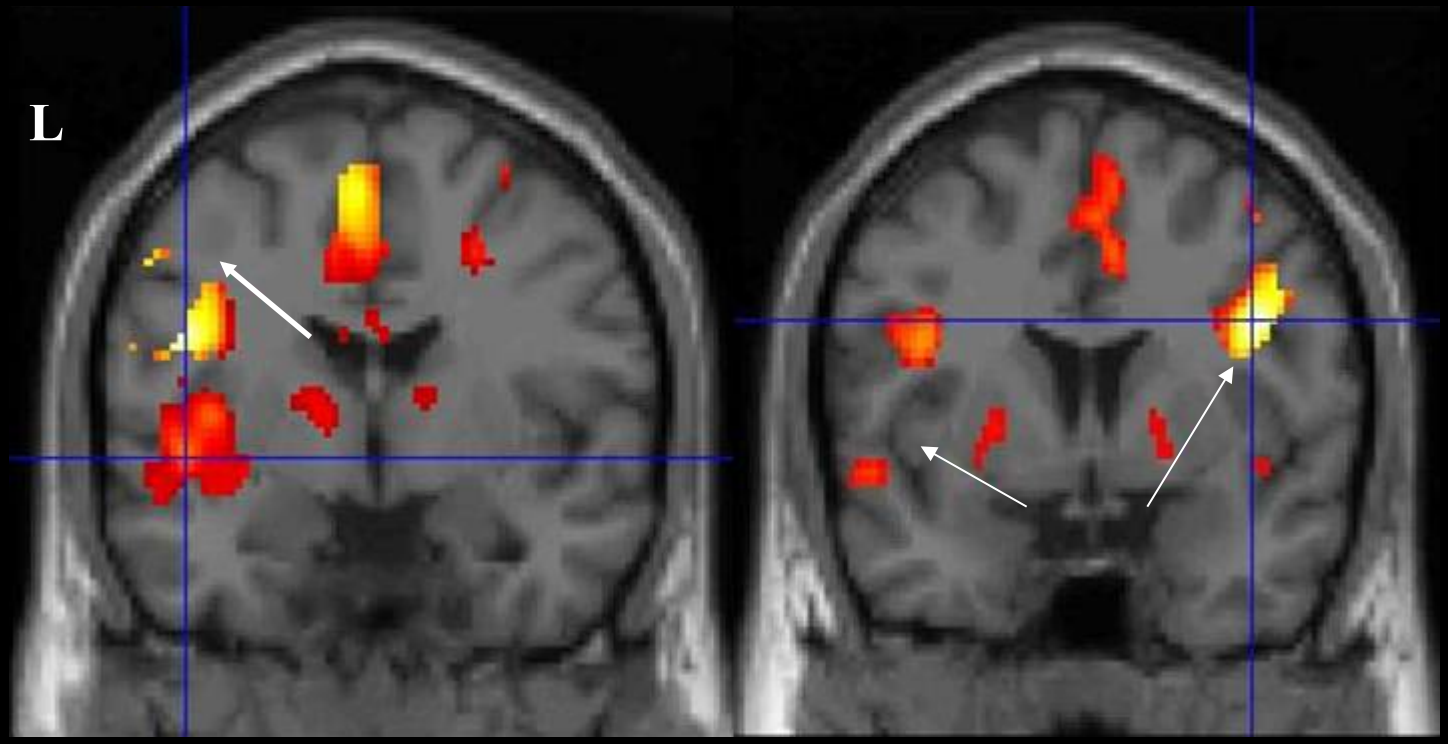
Dr Waldie is looking for people who have dyslexia and no other disability. Participants will be given an in-depth clinical report explaining their strengths and weaknesses.

For more information email Dr Waldie on k.waldie@auckland.ac.nz or LDstudy.auckland@gmail.com.

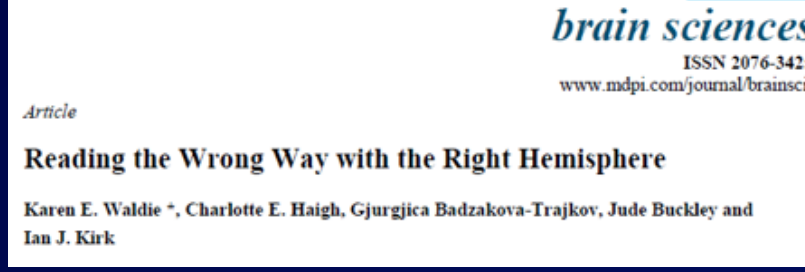


A. Typical readers

B. Dyslexic readers



WALDIE KE. Introduction to developmental neuroscience: Neurological development and the mechanisms underlying reading. In Jason Low and Paul Jose (Eds., pp.20-30), *Lifespan Development: The New Zealand Context*. Auckland, Pearson, 2005



- Right hemisphere reading is a compensatory system
  - But isn't specialised for reading, particularly phonological processing

	Left Hemisphere	Right Hemisphere
Thinking	Symbolic, analysis	Holistic, imagination
Focus on	Foreground, specific	Background, general
Aware of	Details	Overall picture
Better at	Structured tasks	Open-ended tasks
Language	Decoding, literal surface meaning	Context meaning, humor, metaphor

  - Remediation in Fast ForWord / phonics the best way to re-train the brain ?

3. Neuroplasticity

Dyslexia and compensation

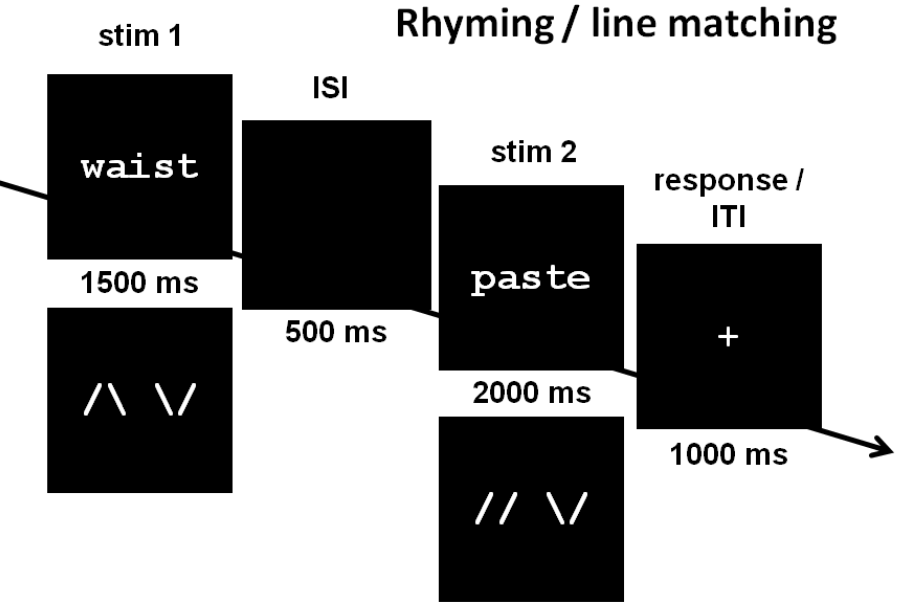
Typically reading children **Children with dyslexia before remediation** **Children with dyslexia after remediation**

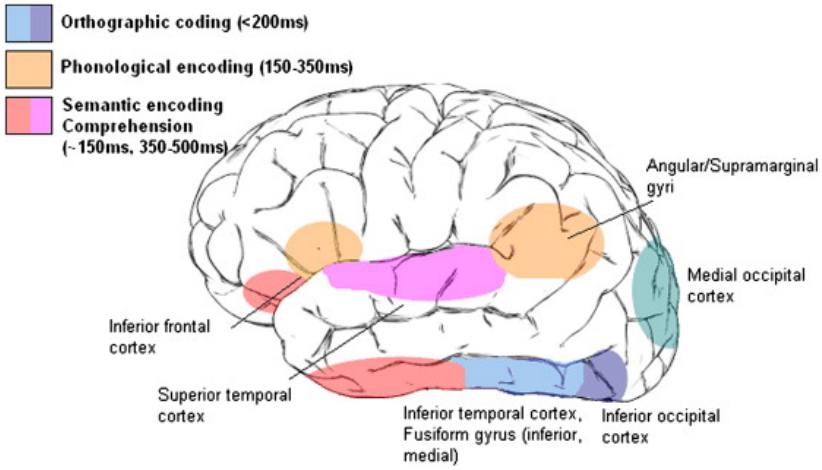
Functional activations shown on the left hemisphere for phonological processing in typically developing readers (left), age matched dyslexic readers (middle), and the difference before and after remediation in the same dyslexic readers (right). Red circles identify the frontal region, and blue circles identify the temporo-parietal region of the brain. Both regions are hypoactivated in dyslexia and become more activated after remediation.

Adapted from Temple E. *et al*., (2003) Proc Natl. Acad. Sci. U.S.A. 100, 2860.

Auckland Comorbidity Study: Untangling the 'dys' from dyslexia and dyscalculia

AIMS: (i) to determine the extent to which the neural networks implicated in dyslexia and dyscalculia overlap; (ii) to determine the relationship between activation and reading performance





Task design after Shaywitz et al. (1998).

3. Conclusions I

- reading performance is mediated by a different network in dyslexics than in typical readers.

- Can their brains be normalised?
- Does normalisation result in better reading performance?
- Does it last?

Campus Link / Centre for Brain Research intervention:

– A new cognitive programme for 5-7 year olds that takes advantage of what we know about neuroplasticity

- Why should we care?

Age 32: Degree qualifications, income

	No school qualification	Bachelors Degree	Masters, PhD, Law, Med	Median income before tax
Typical reader	14.1%	20%	6.3%	$38,216
Dyslexic reader	48%*	2.7%*	0*	$27,500*

Age 32: Mental health disorders

	Any Depressive Disorder	Any Substance Dependence	Any Anxiety Disorder
Typical reader	9.3%	9.9%	9.7%
Dyslexic reader	8.3%	12%	22.9%*

Bottom Line: Early identification & intervention is imperative

3. Conclusions II

Next steps:

Developing critical consumers

- Community outreach from Centre for Brain Research
- More neuroscience / psychology in teacher training
- Debunking neuromyths

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