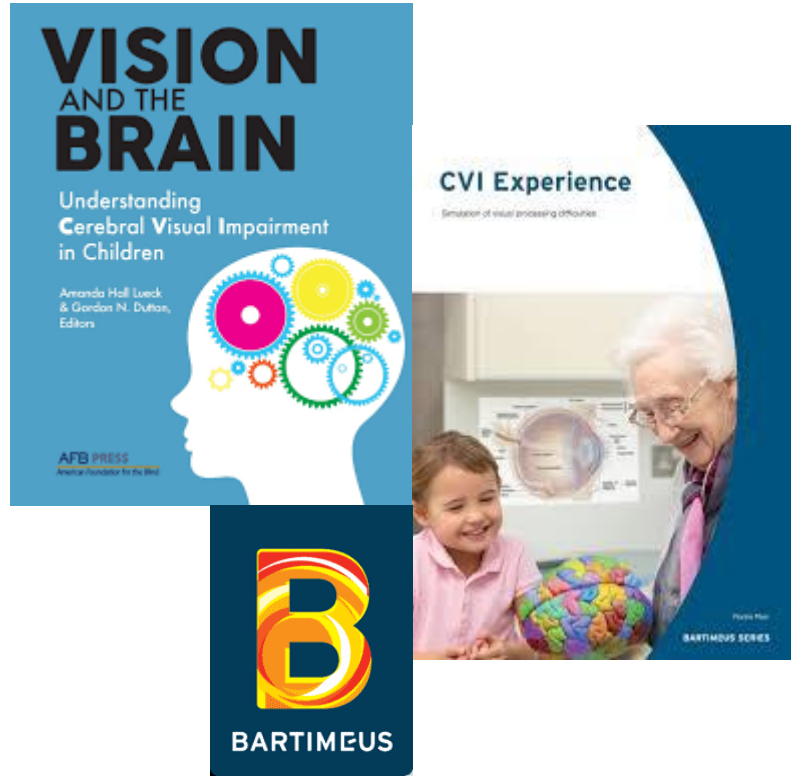
Cerebral visual impairment in the classroom

Cathy Williams
Reader in Paediatric Ophthalmology
University of Bristol
Consultant Paediatric Ophthalmologist, Bristol Eye Hospital, UK

Cerebral Visual Impairment (CVI)

- Children use vision to learn
- Abnormalities in brain-related visual functions can affect many aspects of learning
- Specific examples:
  - Reading
  - Mathematics
  - Social interactions (Autistic Spectrum Disorders)

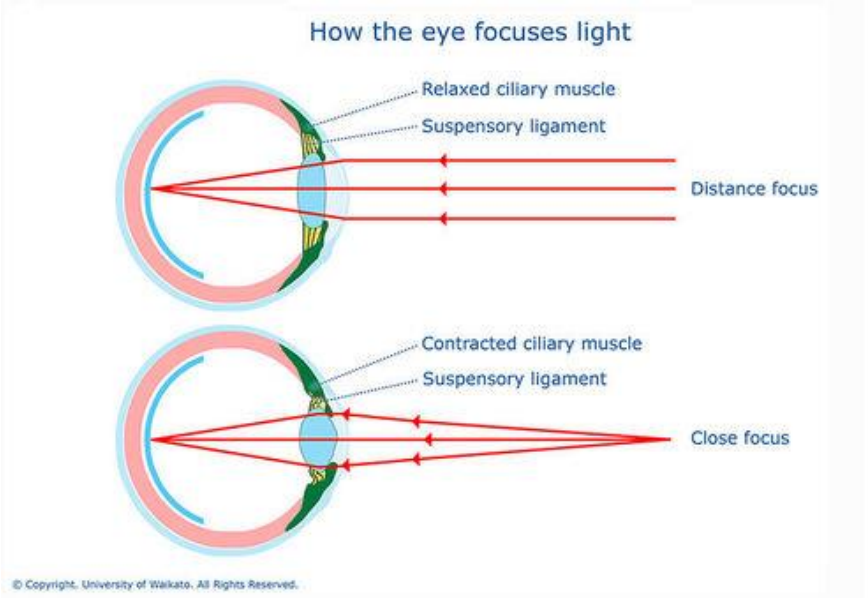


Reading

- Focussing (accommodation)
- Field loss
- Eye movements
- Visuocognitive
  - Simultanagnosia (clutter)
  - Recognition problems (agnosia)
  - Visual attention disorders

Reading and focussing problems

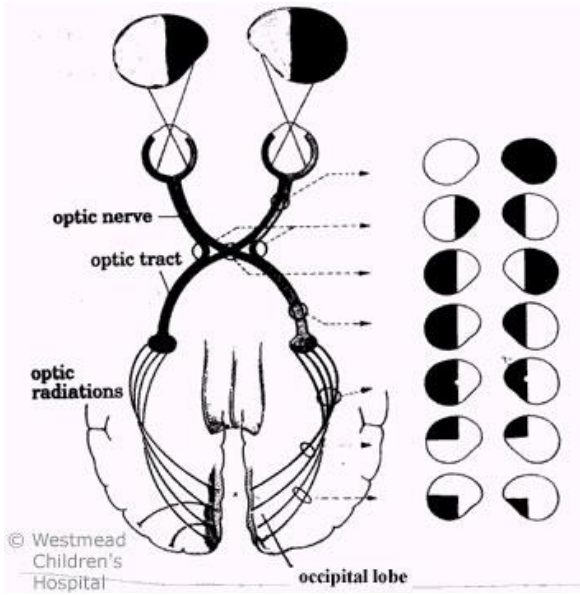
- Near vision depends on adjusting the power of own lens
- Some children unexpectedly poor
  - Premature
  - Cerebral Palsy
  - Down syndrome
- Some drugs inhibit focussing
  - Hyoscine or scopolamine patch
- Lenses may improve other aspects eg oculomotor (AMR research)

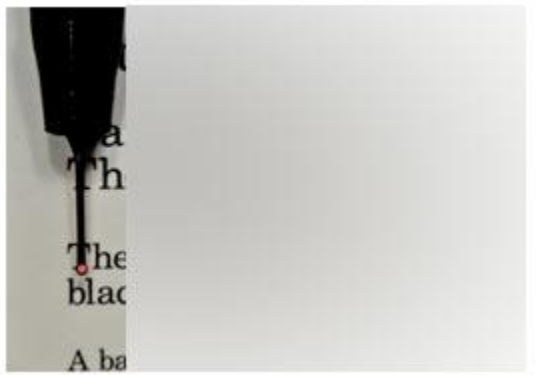


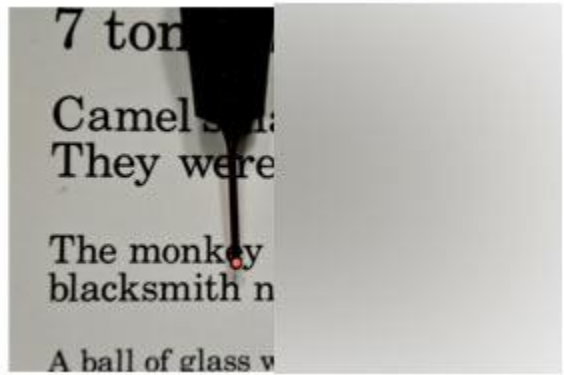
Action Medical Research- Dr Maggie Woodhouse

Reading and Field loss or inattention

- Field testing difficult in children
- Inattention vs Absolute loss
- Types of loss
  - Hemianopia –
    - miss end of word (Right HH)
    - miss start of line (left HH)
  - Inferior
  - Patchy
  - General constriction
- Head, body posture, position in class may help

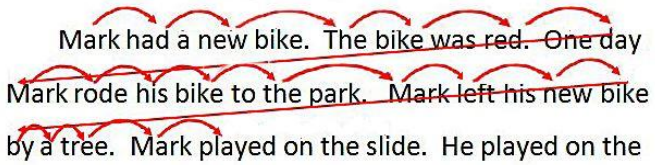




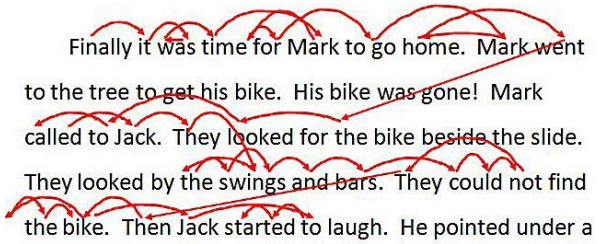


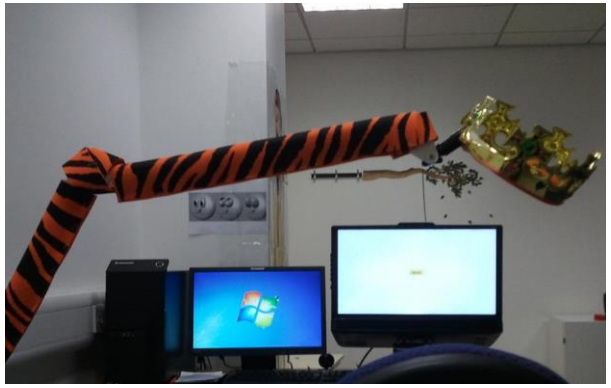
Reading and Eye movements

- Saccades to reposition eyes
- Microsaccades to move between words
- Affected by text
- May co-exist with reading problems, rather than cause
- Cardiff research:
  - Prof J Erichsen, Dr M Woodhouse and Dr Flors Navarro
  - eye tracking in non-reading tasks
  - children with vs without reading problems



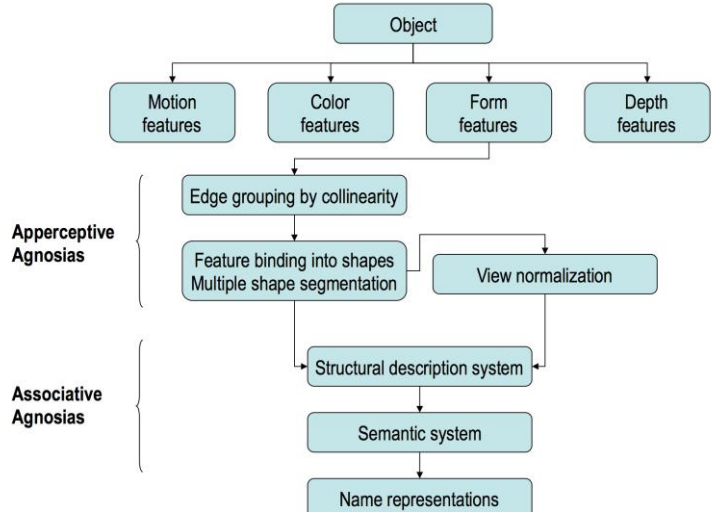
Eyecanlearn.com

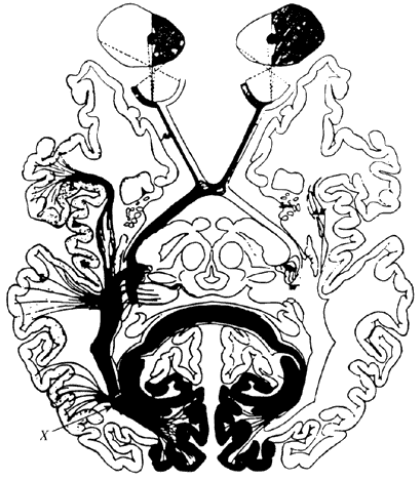


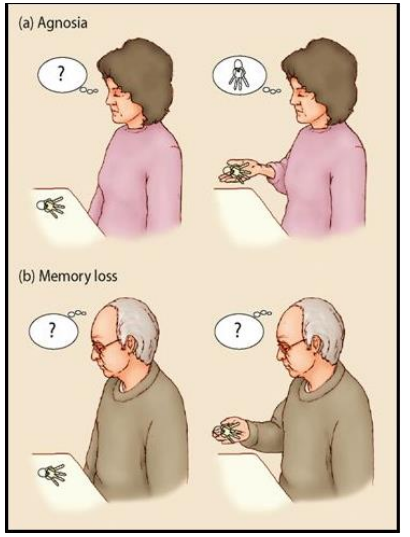


Reading and Visual Agnosias (i)

- Impairments of visual recognition – can be very specific
- NOT due to memory loss or lack of understanding
- Many subtypes
  - Lexical agnosia “word blindness”
  - Difficulties in recognition of letters (but not words or numbers)
  - Prosopagnosia (face)





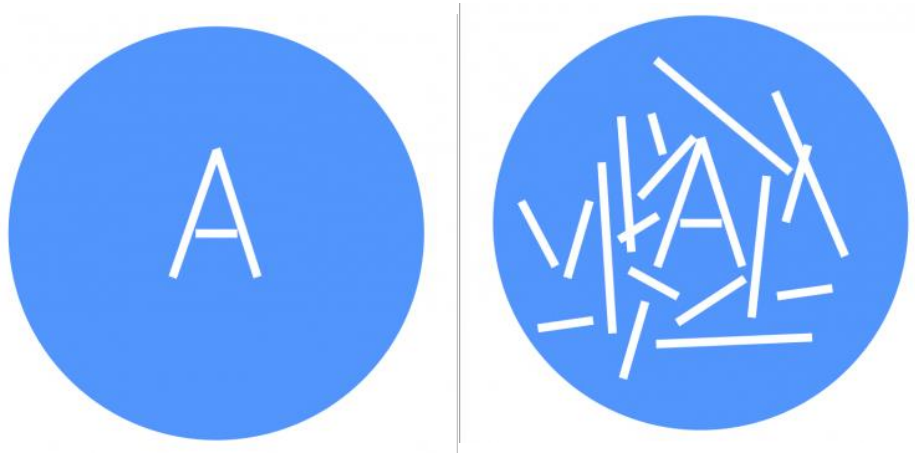


Dejerine J: Sur un cas de cecite verbale avec agraphie, suive d'autopsie. CR Societè du Biologie 43:197, 1891

Reading and Visual agnosias (ii)

- Simultanagnosia
  - Impaired ability to discriminate target surrounded by distractors

- "Crowding Ratio"
  - Single optotype acuity/crowded
  - > 2 (3 lines) abnormal after age 6
  - Dekker et al 2012. Strabismus, 20(2), 49–54, 2012



Harrison et al. *Journal of Vision 14(1):21*, 1-16.2014

H

O

T

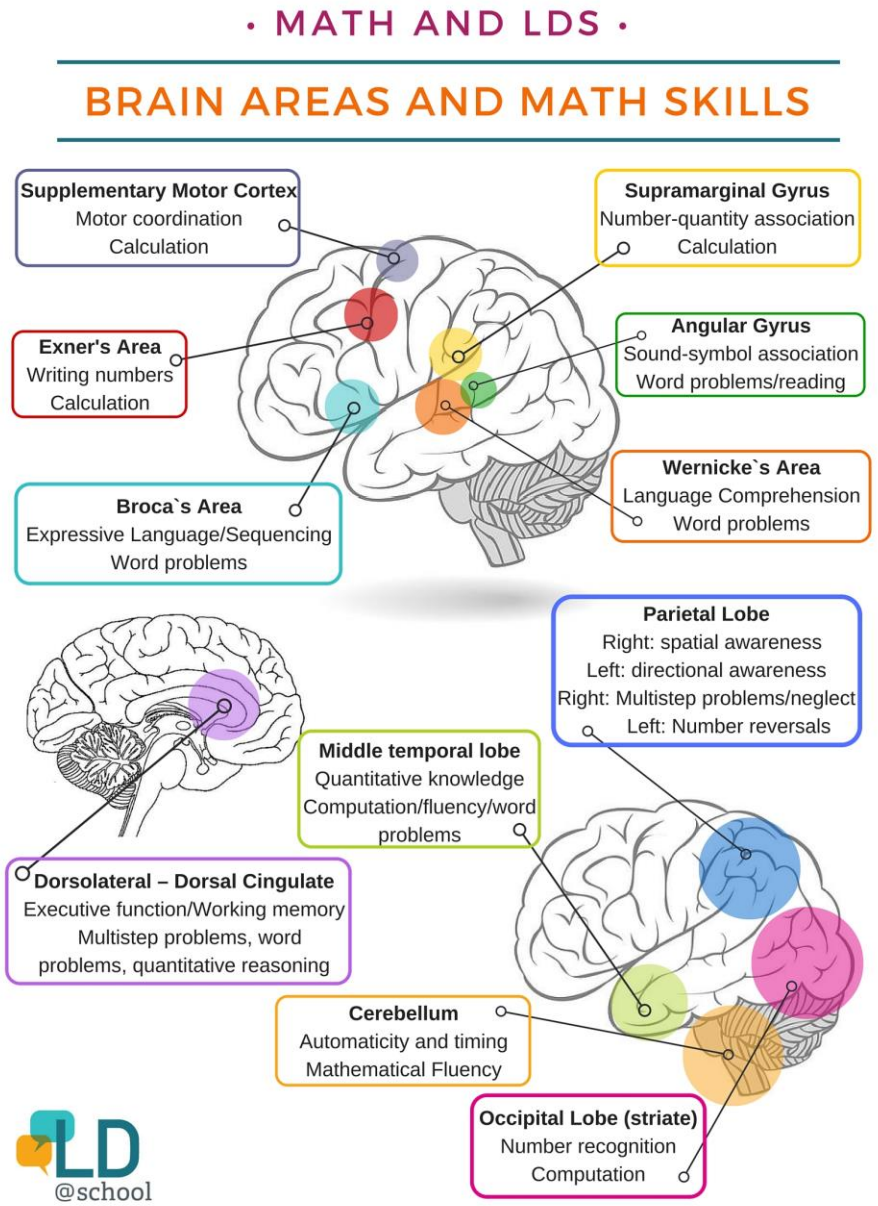
HOT

VOH

TVH

Mathematics

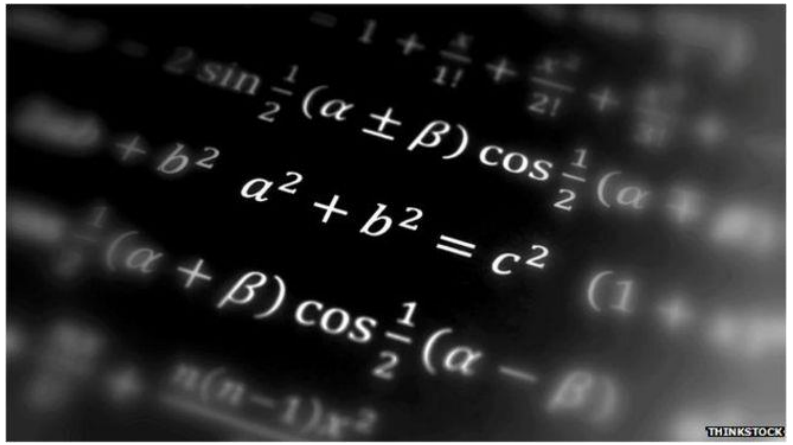
- Multiple brain areas
  - Frontoparietal
  - Temporal network
  - Motor, basal ganglia and CBM
- Dorsal visual stream
  - Visuospatial “Where”stream
  - Correlates with numerical judgement
  - Number line
- Ventral visual stream
  - Recognition
  - Computational skills

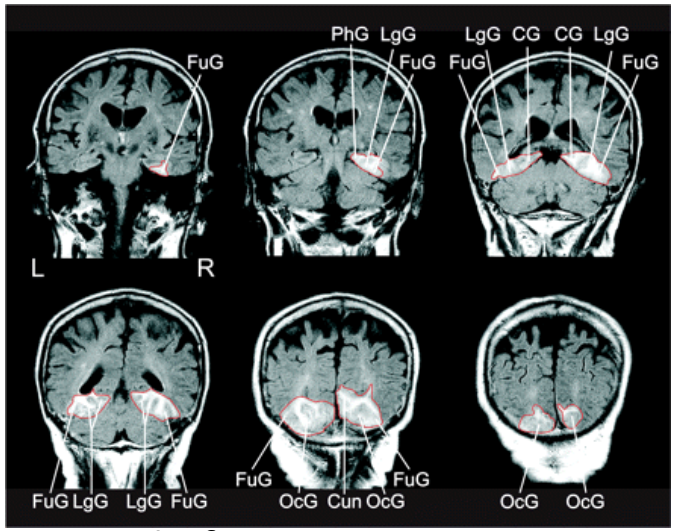


https://www.ldatschool.ca/about-us/

Mathematics and Visual agnosia

- Recognition “what”
- Occipital and temporal lobes involved in mathematics
- Occipital lesions can cause impaired number, shape or symbol recognition
- Other visual functions eg acuity, visuomotor may be unaffected as in PCA territory bilateral stroke

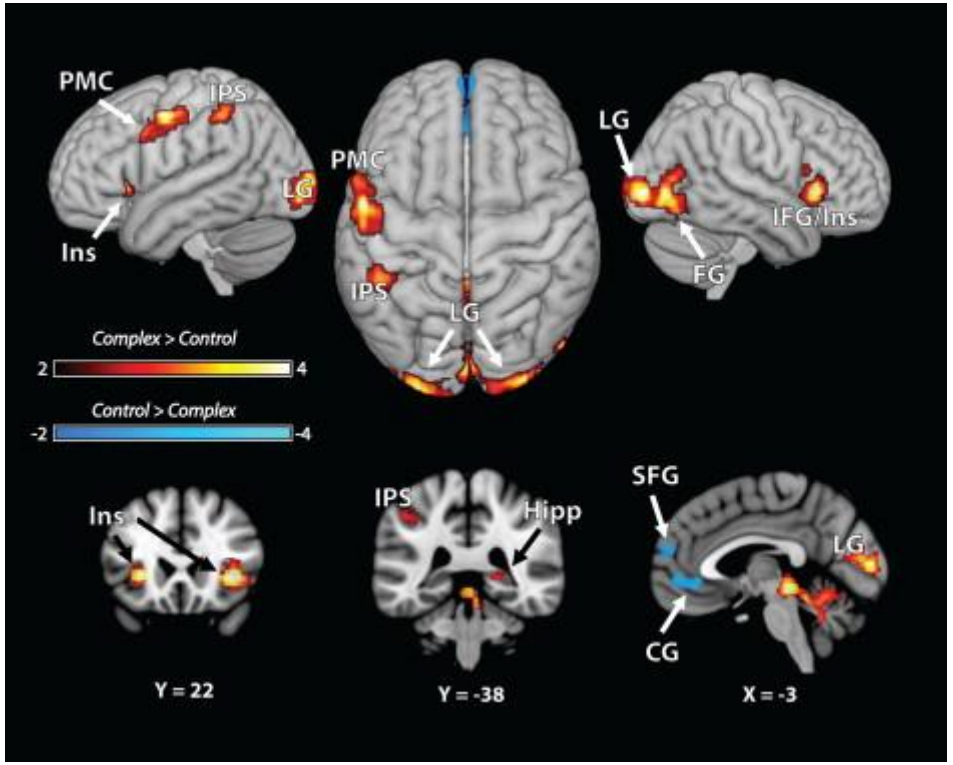




Karnath et al. Journal of Neuroscience 6 May 2009, 29

Mathematics skills

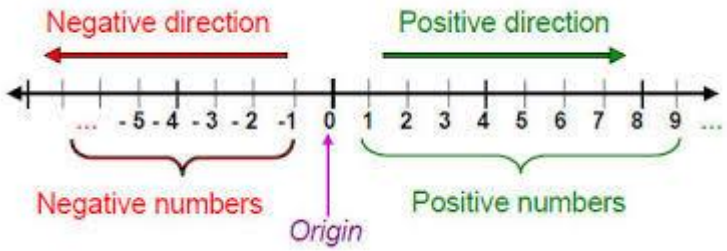
- Many maths related locations in brain - parietal and frontal lobes
- Overlap with dorsal visual stream and ventral
- Developmental changes as children use more specific areas

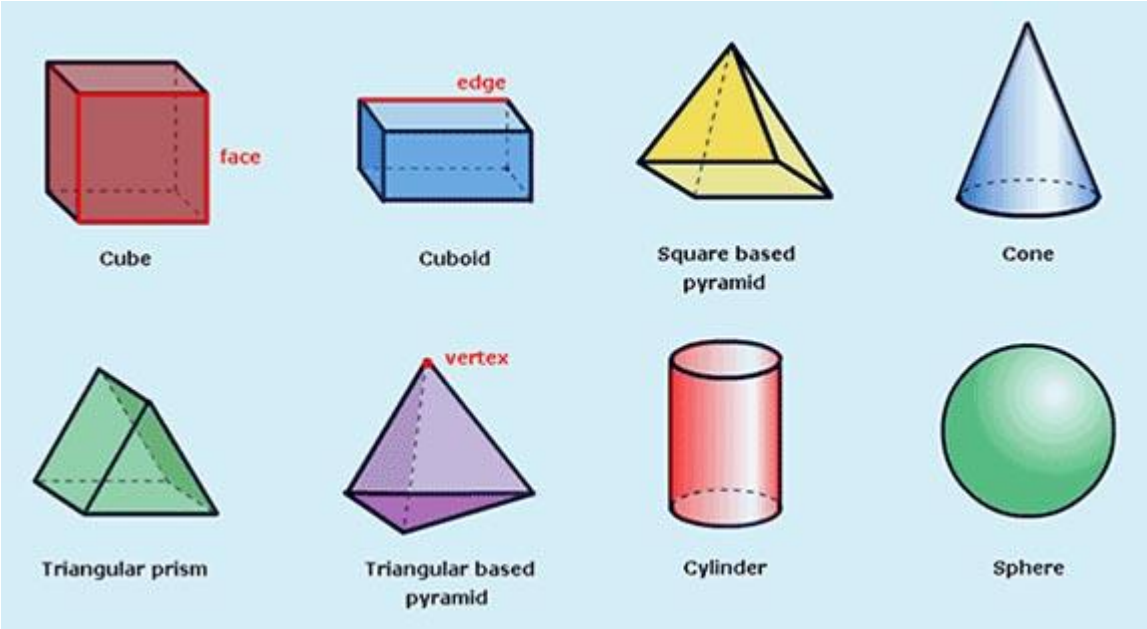


Metcalfe et al. Developmental Cognitive Neuroscience Volume 6, October 2013, Pages 162–175

Mathematics and Dorsal Stream

- Number line
- Bigger vs Smaller
- Visuospatial configurations





Social Communication and Autistic spectrum disorders

- Many aspects of altered cerebral visual function reported
  - Face recognition
  - Facial emotion recognition
  - Colour
  - Motion
  - Superior abilities in visual search, perceptual grouping
    “Weak central Coherence”

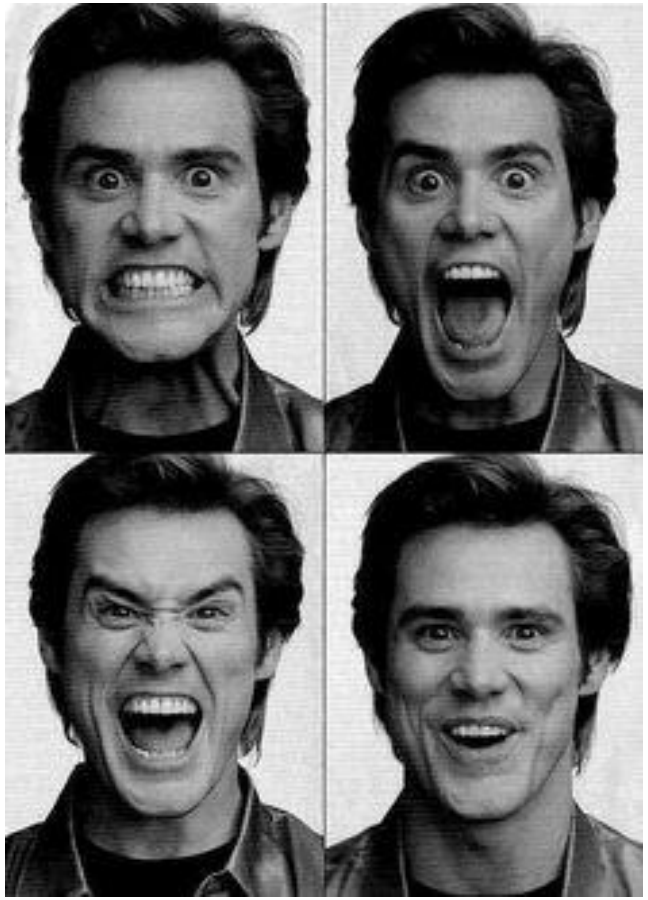
ASD and Facial identity recognition

- Often reported in ASD
- Specific neurones for prosopagnosis
- Other visual agnosias occur in ASD eg music
- Prosopagnosia may occur alone (autosomal dominant)
- *Central field, contrast, motion also all needed for face recognition*

Jiang et al.NeuroImage: Clinical 2 (2013) 320–331

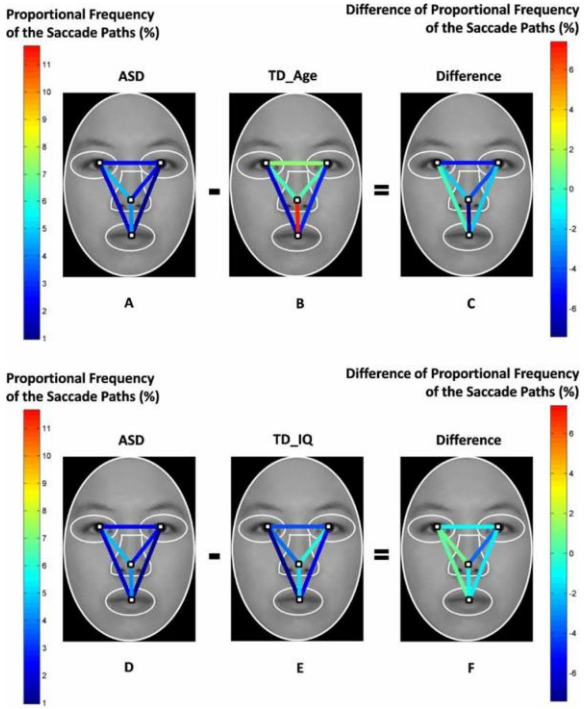
ASD and Facial expressions

- Key feature of many individuals with ASD
- Impaired ability to recognize emotion in facial expression
- May be more severe if associated with language impairment
- ASD ability very reduced if poor contrast so low spatial frequency
- *Biological motion, contrast and stereoacuity also associated with ability*



Ocular motility in ASD

- Abnormal gaze behaviour
  - Different features of faces
  - Reduced fixation time
- Strabismus
- Pursuit eye movements
- Seen in relatives
- Shared feature with other neurodevelopmental disorders eg schizophrenia



Yi et al. Journal of Vision August 2013, Vol.13, 5. doi:10.1167/13.10.5

urnal List › Genome Med › v.1(10); 2009 › PMC2784305

Genome Med. 2009; 1(10): 102.
Published online 2009 Oct 30. doi: 10.1186/gm102
PMCID: PMC2784305

Genetic overlap between autism, schizophrenia and bipolar disorder

Liam S Carroll[1] and Michael J Owen[✉1]

Author information ► Copyright and License information ►

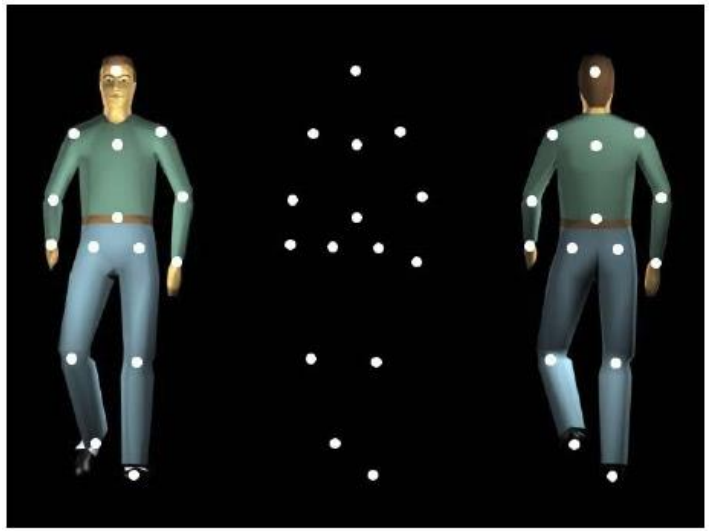
ASD and Colour

- Reduced sensitivity to colour, eg in visual search
- Sometimes strong colour preferences

ASD and seeing movement

- Impaired motion coherence (“rain”) thresholds

- Impaired biological motion
- ASD individuals not better at people motion vs object motion
- Difficulties in playground, road, watching films

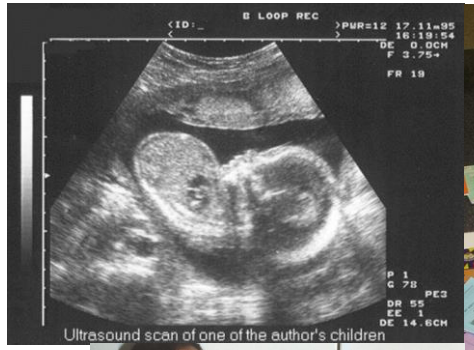


Weak central coherence: details focussed

- "Can't see the wood for the trees"
  - Deficit in "global" processing?
  - Bias towards local processing?
  - Co-existing with, not cause of social/communication disorder?
- Superior performance on some visual perceptual tests
  - Visual search
  - Embedded figures

Examples from Avon Longitudinal Study of Parents and Children

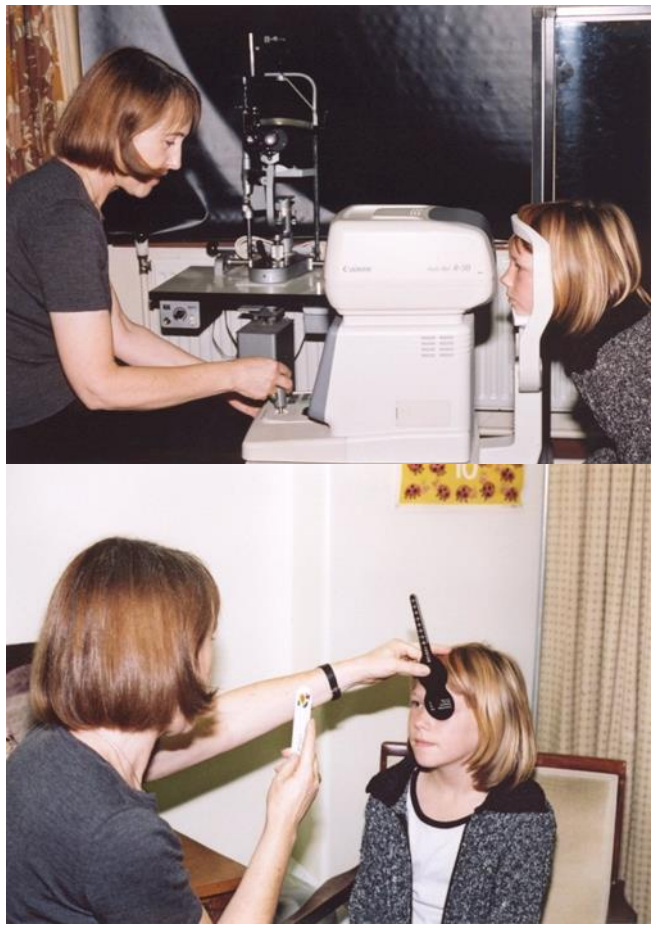
- All children born in Avon 1991-1992
- Approx 14,000 children
- Most detailed cohort study in the world
- Data collection by questionnaire, interview, direct tests, genetic samples, linkage to health and education
- Diagnoses, traits and outcomes available



Ultrasound scan of one of the author's children

Vision data in ALSPAC

- Orthoptic assessments
  - 6 monthly to 3.5yr (n=1000)
  - At age 7 (n=7500)
- Autorefraction
  - 7, 10, 11, 12, 15y
- Central visual functions
  - Stereoacuity 7-15y
  - Contour integration 11 -12
- Prof Dutton Qs at age 13-parent report of behaviour suggesting CVI

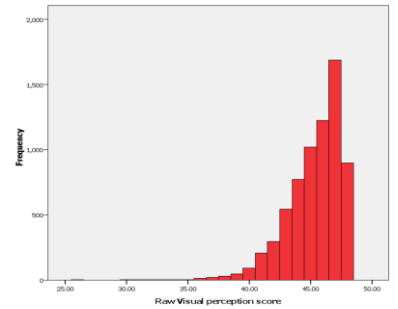


Questions on CVI in population sample 13 yr olds in ALSPAC study

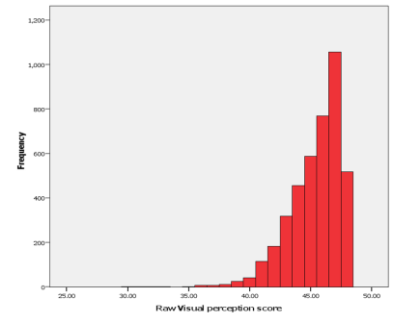
- Williams etc al PLoS ONE 6(3): e14772. doi:10.1371
- 12 questions to elicit responses indication CVI
- Parent reported
- All scored 1-5
- Unimodal distribution
- N=7000

- Range of responses in children with ICD10 diagnoses

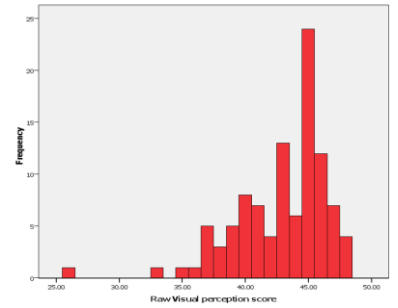
(a)



(b)



(c)



Distilling responses into factors

Question	Factor 1 (20.8%)	Factor 2 (11.5%)	Factor 3 (10.4%)	Factor 4 (8.5%)
Recognises close family			√√	
Recognises friends			√√	
Recognises people from photo	√		√	
Loses objects around house	√	√		
Difficulty grasping objects		√√		
Difficulty with step vs. line		√√		
Find objects on patterned carpet	√√			
Find objects in complex pictures	√√			
Misjudges doorways/corridors		√		
Finds way around house				√√
Difficulty seeing things in distance	√			
Find way in new surroundings	√√			

Associations with educational attainment

- Factor Analysis: 3 factors
  - Seeing-things-in-clutter
  - Visual-guidance-of-movement
  - Facial recognition
- Compared with standardised school results (SATS) age 14
- Adjusted for social class, IQ, parental education, sex

Mean Factor scores vs School results at 14

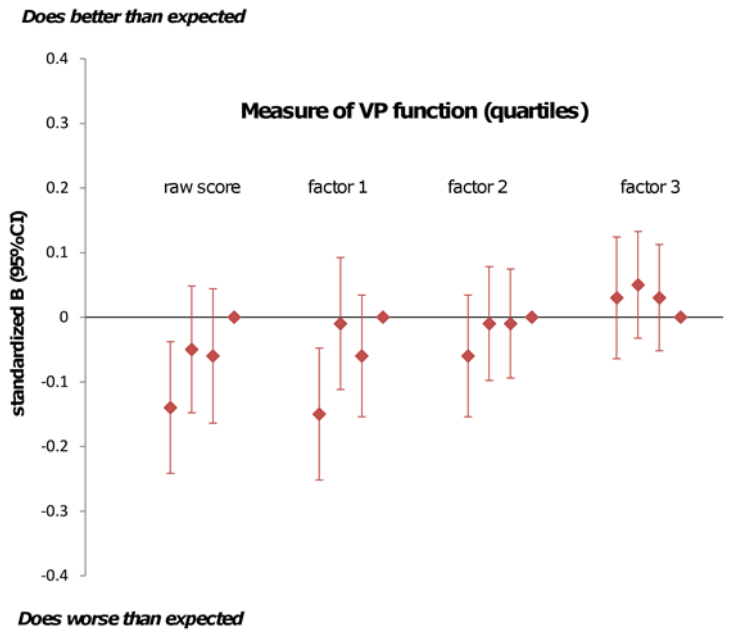
- Whole score and Factors 1 (clutter) and Factor 2 (visuospatial) related to reading achievement
- Whole score and Factor 2 (visuospatial) related to mathematics achievement
- Similar to earlier SATS results
- Same in imputed dataset

OUTCOME	VP ABILITIES	CASES WITH COMPLETE DATA					
		Unadjusted (n = 4512)		Model 1 (n = 2968)		Model 2 (n = 2724)	
		β (95% CI)	p	β (95% CI)	p	β (95% CI)	p
Reading	All Questions	0.04 (0.03, 0.06)	*<0.0001*	0.03 (0.01, 0.04)	*<0.0001*	0.01 (0.00, 0.02)	*0.025*
	Factor 1	0.10 (0.07, 0.13)	*<0.0001*	0.05 (0.02, 0.08)	*0.001*	0.02 (−0.01, 0.05)	*0074*
	Factor 2	0.03 (−0.01, 0.06)	*0.063*	0.03 (0.00, 0.05)	*0.061*	0.02 (−0.01, 0.04)	*0.178*
	Factor 3	0.01 (0.01,0.05)	*0.204*	0.01 (−0.03, 0.04)	*0.725*	−0.01 (−0.04, 0.01)	*0.286*
Mathematics	All Questions	0.07 (0.05, 0.09)	*<0.0001*	0.02 (0.00, 0.03)	*0.016*	0.00 (−0.02, 0.01)	*0.395*
	Factor 1	0.14 (0.11, 0.18)	*<0.0001*	0.02 (−0.01, 0.06)	*0.150*	−0.01 (−0.03, 0.01)	*0.435*
	Factor 2	0.06 (0.03, 0.10)	*<0.0001*	0.03 (0.00, 0.06)	*0.026*	0.00 (−0.02, 0.02)	*0.974*
	Factor 3	0.01 (−0.03, 0.04)	*0.759*	−0.001 (−0.04, 0.03)	*0.644*	−0.01 (−0.03, 0.01)	*0.491*
				ALL CASES – IMPUTED DATA (n = 4512)			
				β (95% CI)	p	β (95% CI)	p
Reading	All Questions			0.02 (0.01, 0.03)	*<0.0001*	0.01 (−0.01, 0.02)	*0.218*
	Factor 1			0.04 (0.02, 0.07)	*0.002*	0.01 (−0.01, 0.03)	*0.523*
	Factor 2			0.03 (0.01, 0.05)	*0.042*	0.01 (−0.01, 0.04)	*0.197*
	Factor 3			−0.05 (0.03, 0.02)	*0.918*	0.00 (−0.02, 0.02)	*0.812*
Mathematics	All Questions			0.02 (0.01, 0.03)	*0.001*	0.00 (−0.01, 0.01)	*0.348*
	Factor 1			0.03 (0.01, 0.06)	*0.012*	−0.01 (−0.03, 0.01)	*0.356*
	Factor 2			0.03 (0.01, 0.06)	*0.015*	0.00 (−0.02, 0.02)	*0.985*
	Factor 3			0.01 (−0.04, 0.01)	*0.354*	−0.01 (−0.03, 0.01)	*0.125*

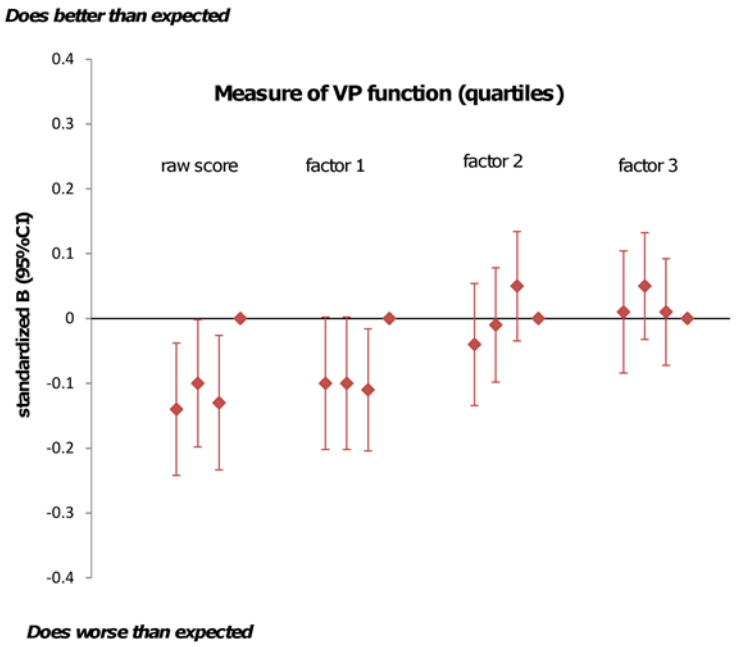
Legend for Table 3.
"All questions" refers to the score obtained by summing for each child all responses to questions about visual perceptual (VP) abilities.
*Model 1 is adjusted for Age at KS3 testing; Gender; Maternal education; Highest maternal/paternal social class; ICD10 diagnosis; visual problems, born at less than 37 weeks gestation; admitted to a Special Care Baby Unit in first month; low birthweight; total IQ.
**Model 2 is model 1 and additional adjustment for KS2 results.
doi:10.1371/journal.pone.0014772.t003

Results at 14 by quartile of CVI skill

Reading



Maths



Summary

- In general population, responses suggesting brain-related vision skills predict school attainment

- Brain related vision problems may co-exist with and/or contribute to academic difficulties including in reading, mathematics and social interaction
- Children with ASD may have impaired or superior vision processing

Thank you!

- Bristol Special Needs Vision Team (Sue Fraser, Helen McCarthy, Julie Parker, Penny Warnes)
- Child Health Community Partnership
- Bristol Sensory Support Service (Sue Rogers)
- The ALSPAC Study Team
  - Families
  - Staff
  - Funders: MRC, Wellcome, University of Bristol
- Prof Jean Golding
- Prof Gordon Dutton
- Dr M Woodhouse