

# Techniques in Cognitive Neuroscience

*Daniel Shaw, M.Sc.*

Shaw et al. (2011a) Development of the Action-Observation Network During Early Adolescence: A Longitudinal Study. *Social, Cognitive, and Affective Neuroscience [SCAN]*...

Shaw et al. (2011b). Development of Functional Connectivity During Adolescence: A Longitudinal Study Using an Action-Observation Paradigm. *Journal of Cognitive Neuroscience*....

Shaw et al. (*submitted*). Development of Functional Connectivity in the Face-Processing Network During Adolescence: A Longitudinal Study. *Journal of Neuroscience*....

# Introduction

## Lecture Series:

1. (a) Introduction; (b) **Neuropsychology**
2. **Magnetic Resonance Imaging (MRI)**
3. **Functional MRI (fMRI)**
4. **Transcranial Magnetic Stimulation (TMS)**
5. **Electroencephalography (EEG/ERP)**

# Introduction

...lectures

6. Combining Techniques (e.g. TMS-fMRI)
7. Revision/Discussion
8. Exam

# Introduction

## Essay (50%)

- 1500 word **research proposal**, applying a technique of choice to a research area of choice
  - a) Show understanding of the neurophysiologic underpinnings of the chosen technique(s)
  - b) Show awareness of the applications of the chosen technique in a particular domain of neuroscience research
  - c) Shown an appreciation for the inferences that can be drawn through applications of the chosen technique(s)
  - d) Shown understanding of the advantages and limitations of the chosen technique(s)

# Introduction

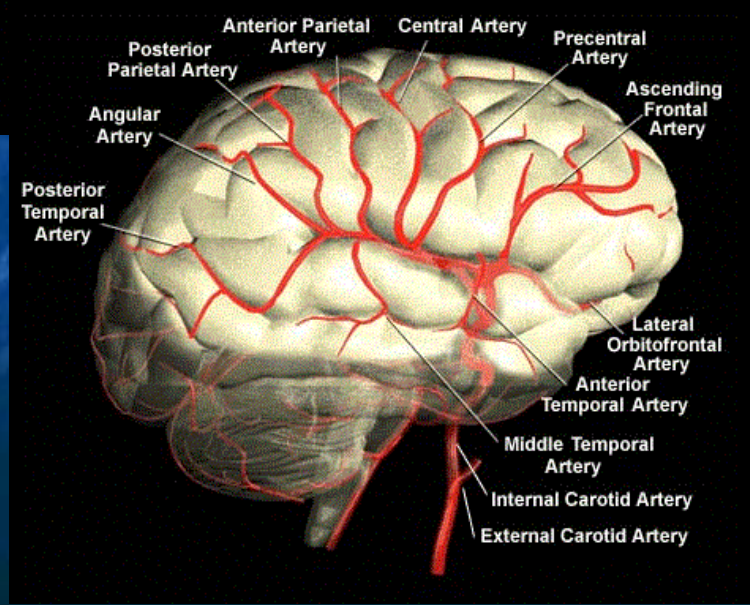
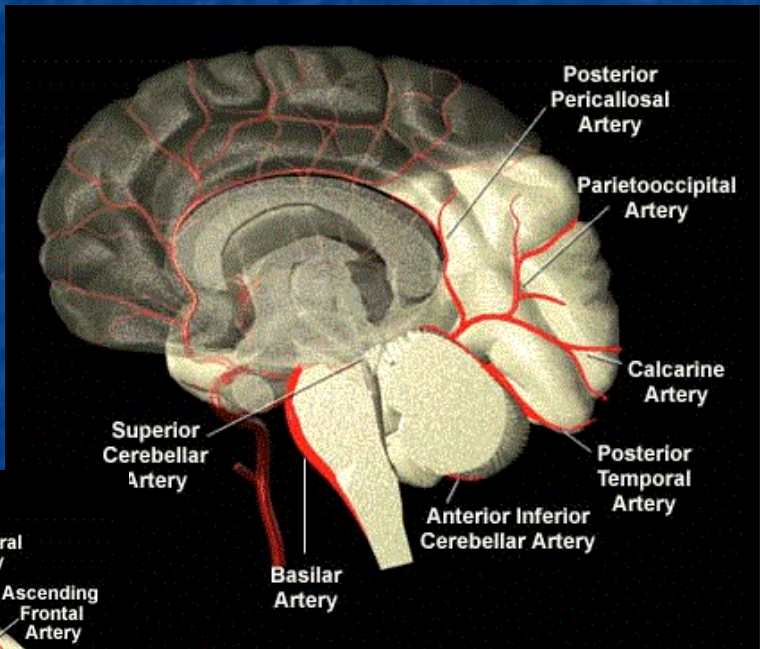
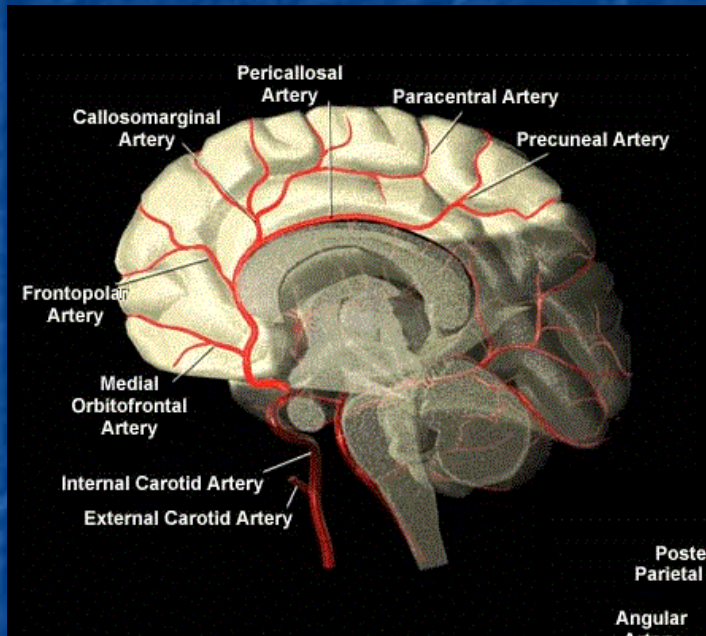
## Exam (50%)

- 1hr written exam answering 2 questions (related to techniques covered in the lectures)
  - a) Show understanding of the neurophysiologic underpinnings of the chosen technique(s)
  - b) Show a critical awareness of the applications of the chosen technique in neuroscience research
  - c) Shown understanding of the advantages and limitations of the chosen technique(s)

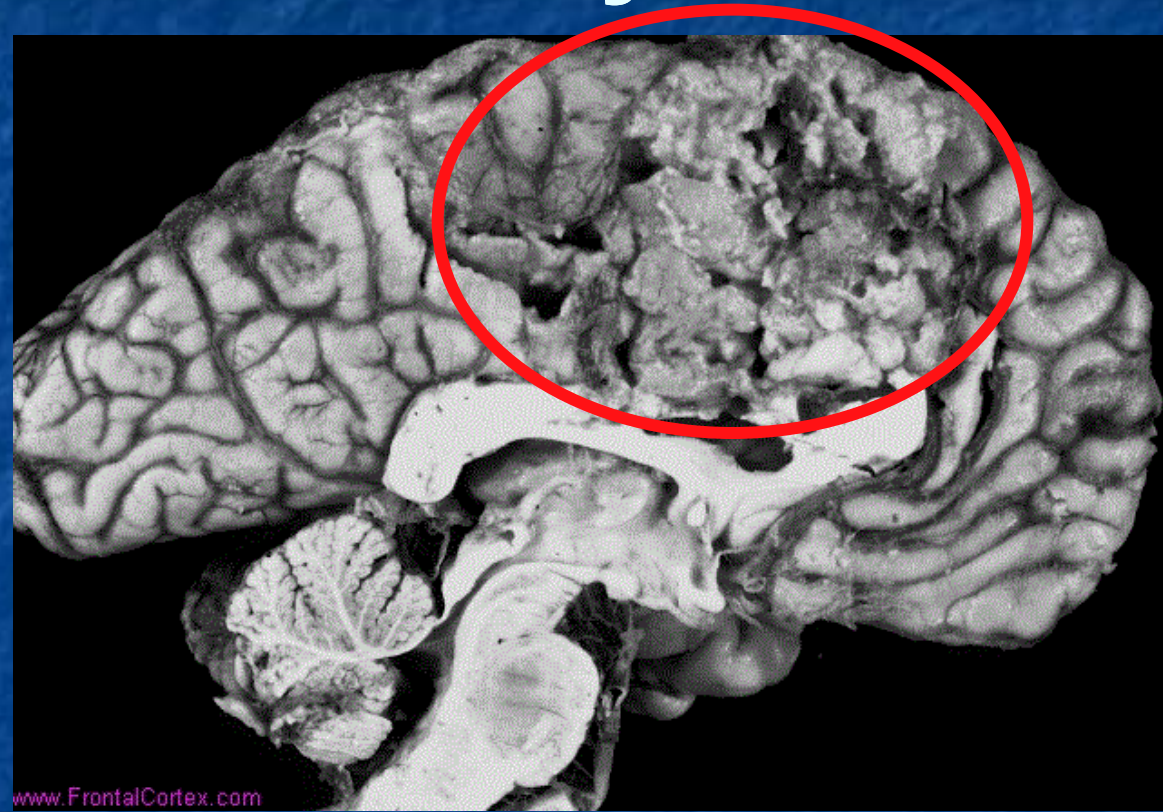
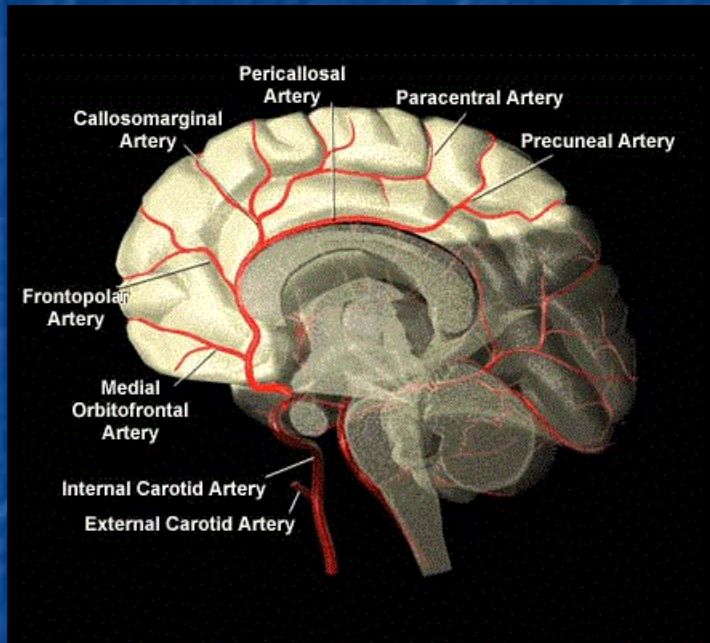
# Neuropsychology

## *The “Lesion Method”*

# Basic Anatomy

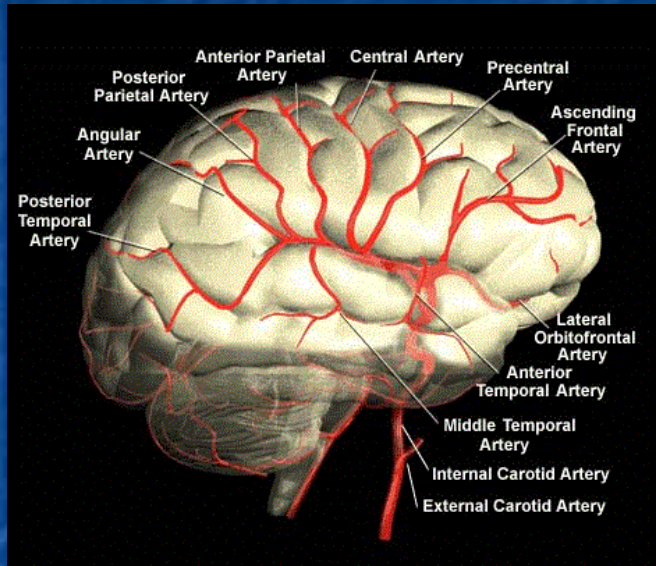


# Basic Anatomy

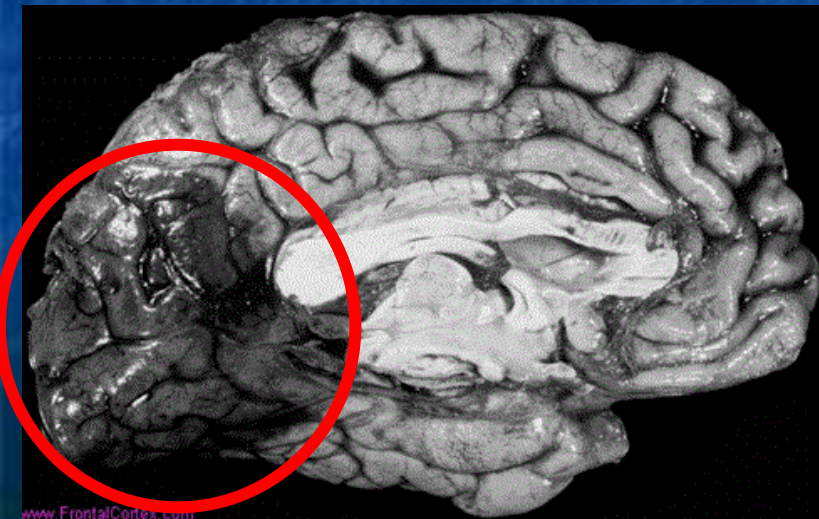
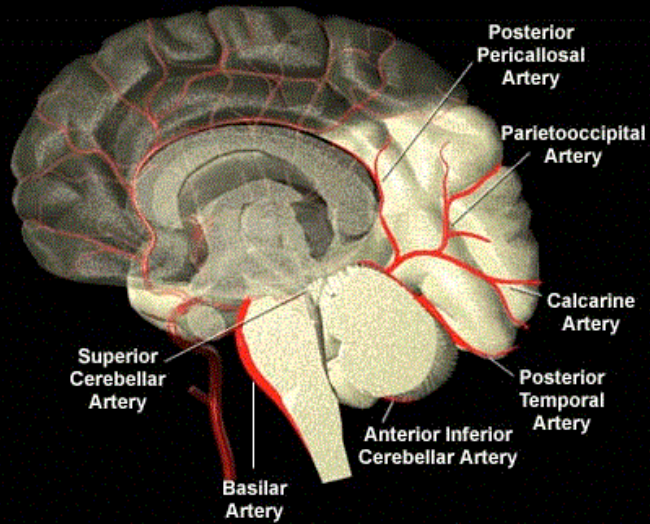




# Basic Anatomy

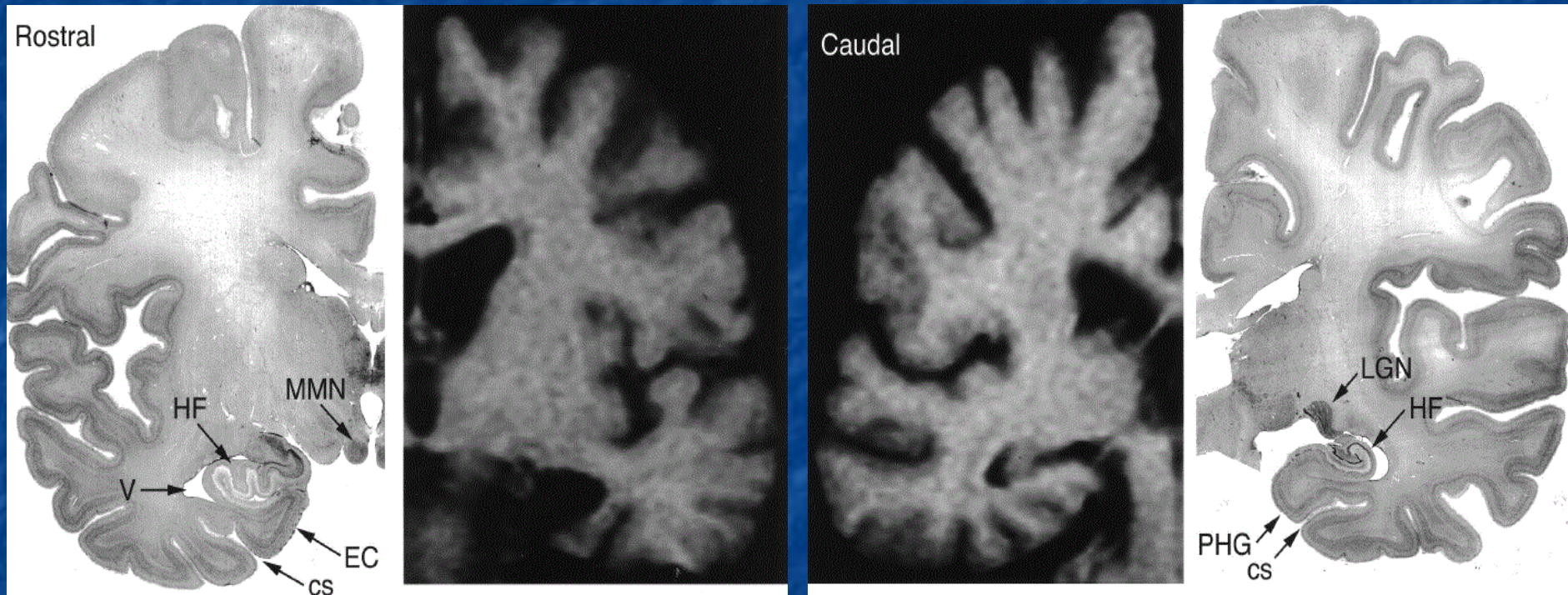


# Basic Anatomy



# Memory

## *Amnesic Patient H.M.*



(Scoville & Milner, 1957; Corkin et al., 1997)

# Memory

## *Amnesic Patient H.M.*

**Table 1. The Amnesic Patient H.M.: Wechsler Intelligence-Scale and Memory-Scale Results (1953–1983)**

Date	Age	Test	Verbal IQ	Performance IQ	Full Scale IQ	Memory Quotient	Delayed Recall	
							Verbal (Deficit ≤ 11)	Nonverbal (Deficit ≤ 7)
Preop 1953	27	W-B I	101	106	104	*	*	*
Postop 1955	29	W-B I	107	114	112	67	*	*
1962	36	W-B II	109	125	118	64	1	0
1977	51	W-B I	107	126	118	74	5	0
1978	52	W-B II	91	104	98	63	1	0
1980	54	W-B II	97	108	104	64	1	0
1983	57	W-B II	97	115	108	64	0	0

\*Not assessed

(Corkin, 1984)

# Memory

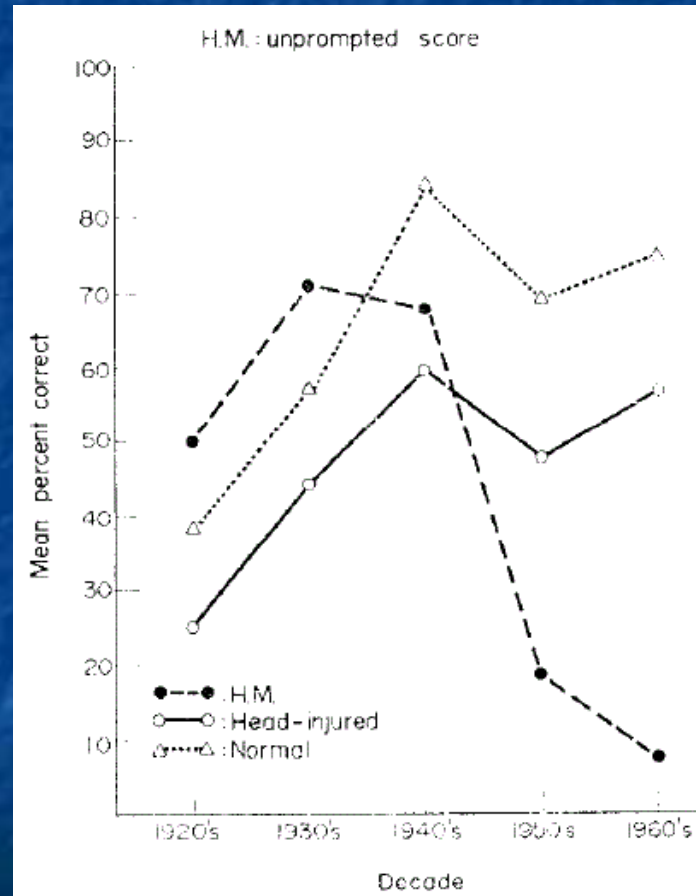
## *Amnesic Patient H.M.*

Exp. 1 (Single digits)		Exp. 2 (Digit triples)			
k	P(yes)	L5		L7	
		k	P(yes)	k	P(yes)
*	0.14	*	0.04	*	0.12
1	0.91	1	0.44	1	0.29
2	0.87	2	0.63	2	0.21
3	0.85	3	0.84	3	0.31
4	0.85	4	0.88	4	0.50
5	0.92	5	1.00	5	0.64
6	0.94			6	0.83
7	1.00			7	1.00
8	1.00				
*2+5	0.09				
2+5	1.00				

(Wickelgren, 1968)

# Memory

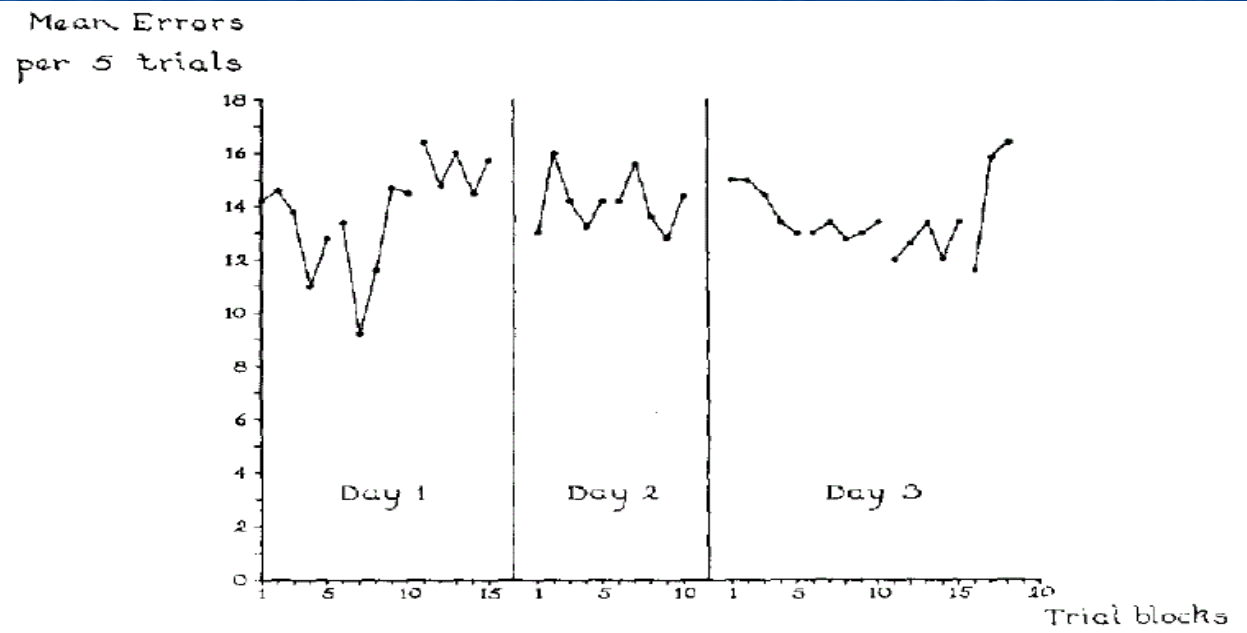
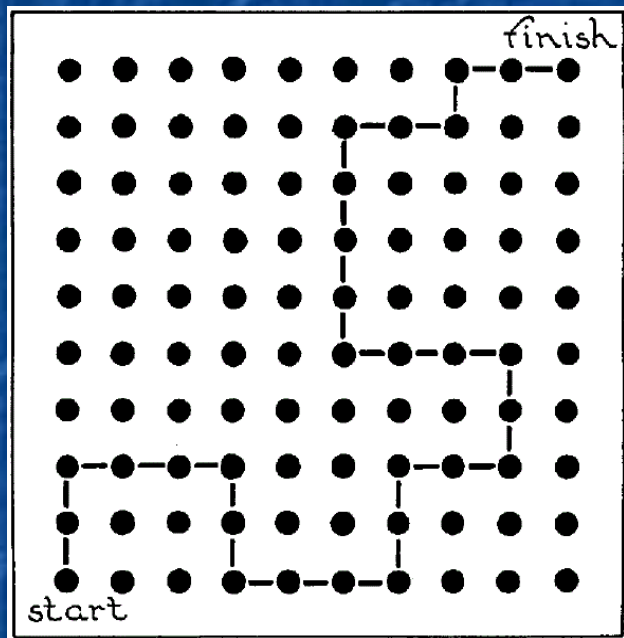
## *Amnesic Patient H.M.*



(Marlsen-Wilson & Teuber, 1975)

# Memory

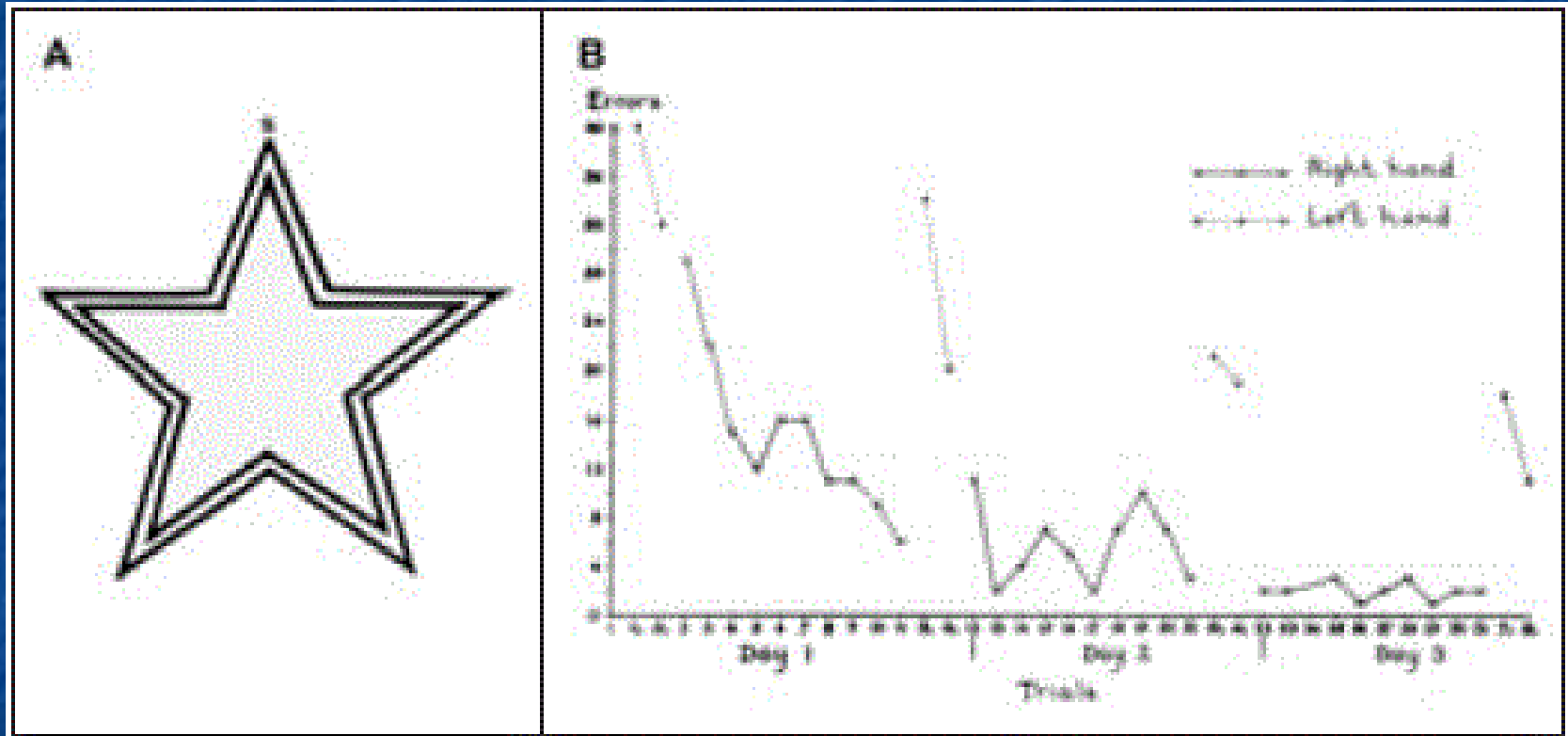
## *Amnesic Patient H.M.*



(Milner, 1965)

# Memory

## *Amnesic Patient H.M.*



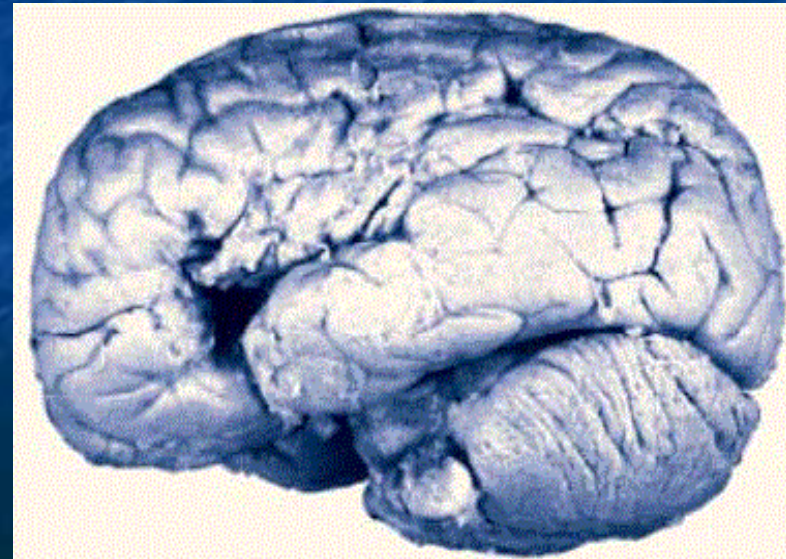
(Milner, 1962; [Corkin, 1968])



# Language

## *Expressive (Broca's) Aphasia*

- Impairment of verbal expression (spoken and written), with (relatively) unimpaired comprehension
  - Speech limited to agrammatical sentences with omissions of modifiers or propositions
    - e.g. *“Me go”* vs *“I am going”*



# Language

## *Receptive (Wernicke's) Aphasia*

- Impairment of verbal comprehension (spoken and written), with (relatively) unimpaired fluent expression
  - Spoken and written language is fluent and grammatically correct, but nonsensical
    - Paraphasias and *neologisms*



(Geschwind, 1970; Ogden, 2005)

# Double Dissociations

- **Single Dissociation**

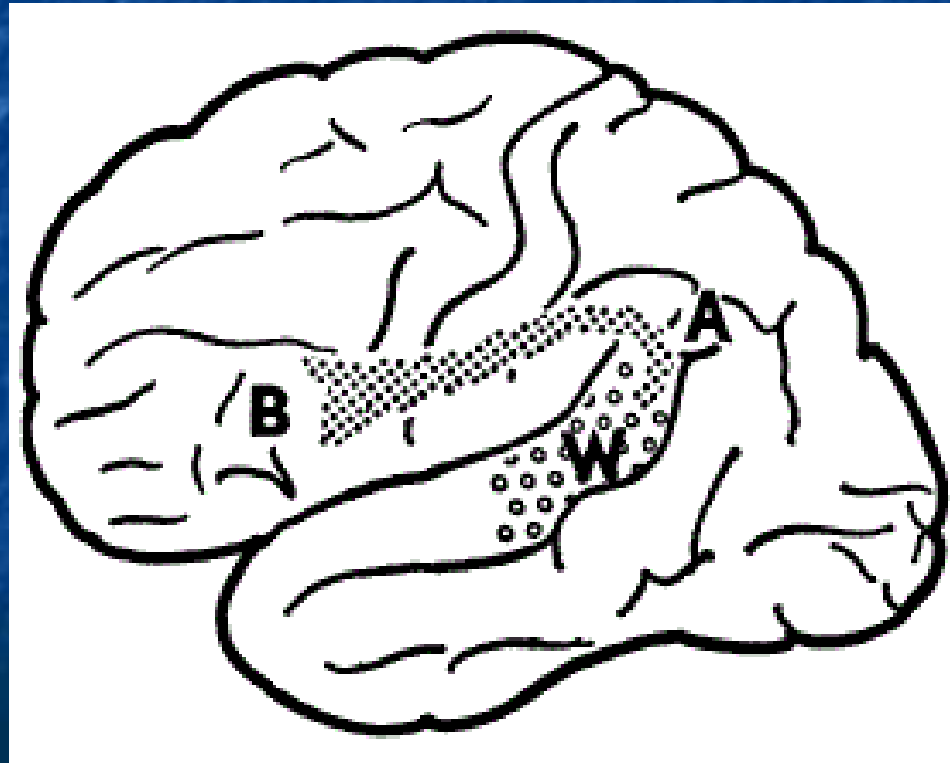
- Damage to brain structure A causes a deficit in behaviour A but not in behaviour B
  - Suggest that behaviours A and B are independent of one another and associated with the brain structure(s)
  - But *resource artefact*

- **Double Dissociation**

- Damage to brain structure A causes a deficit in behaviour A but not in behaviour B, and damage to brain structure B causes a deficit in behaviour B but not in behaviour A
  - Behaviours A and B are independent of one another and associated with independent brain structures

# Language

## *Wernicke's Theory*

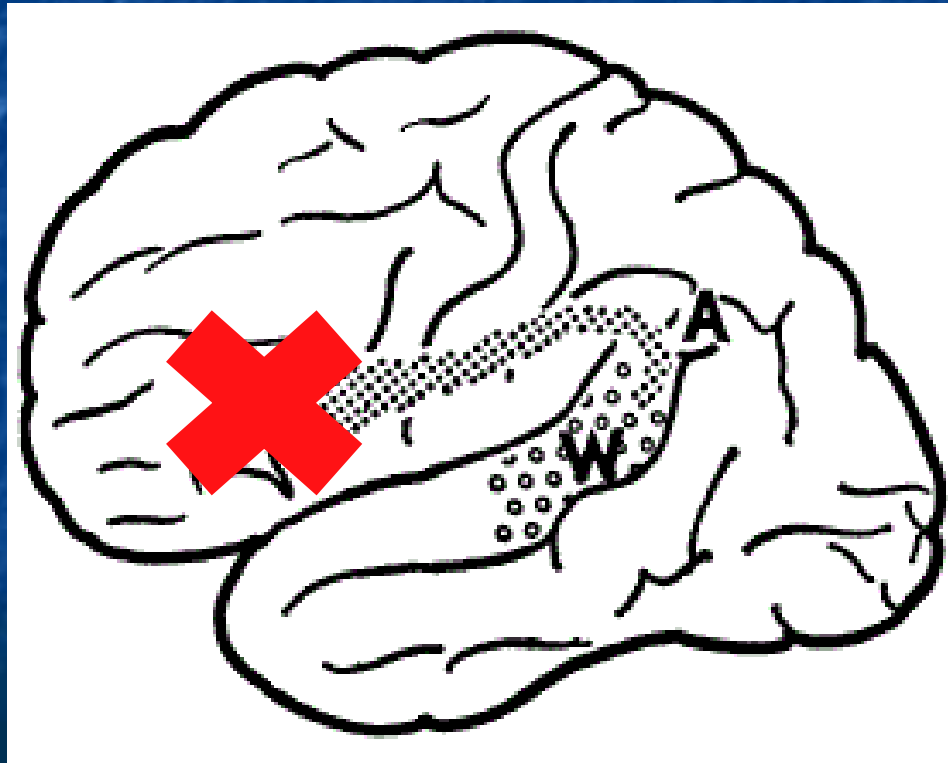


(Geschwind, 1965; 1970)

# Language

## *Wernicke's Theory*

- Expressive (Broca's) aphasia

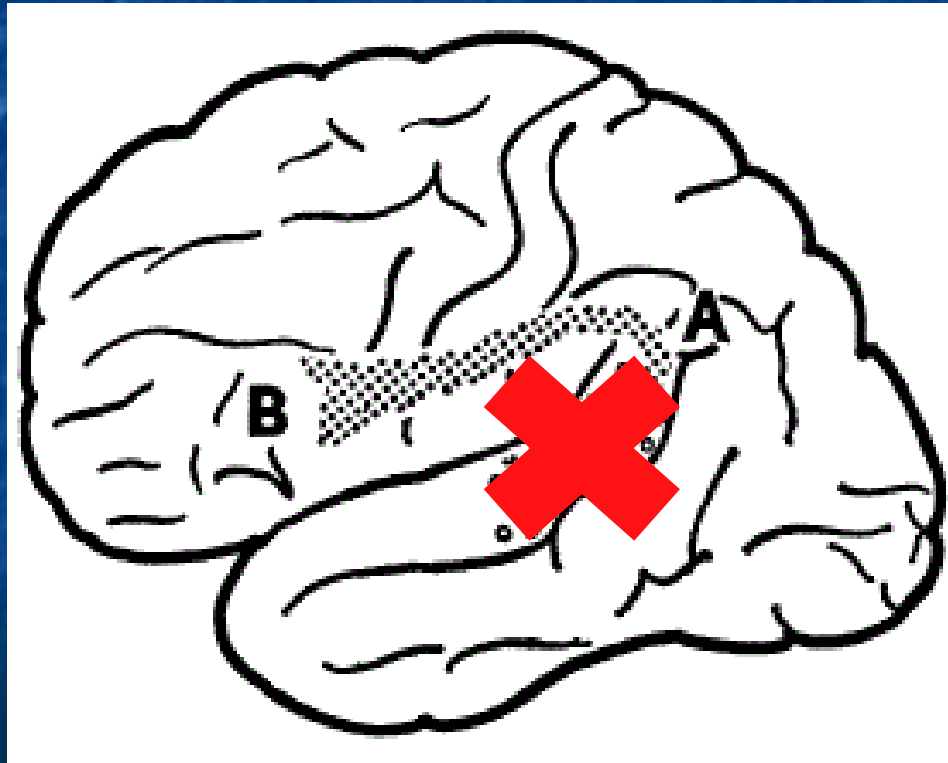


(Geschwind, 1965; 1970)

# Language

## *Wernicke's Theory*

- Receptive (Wernicke's) aphasia

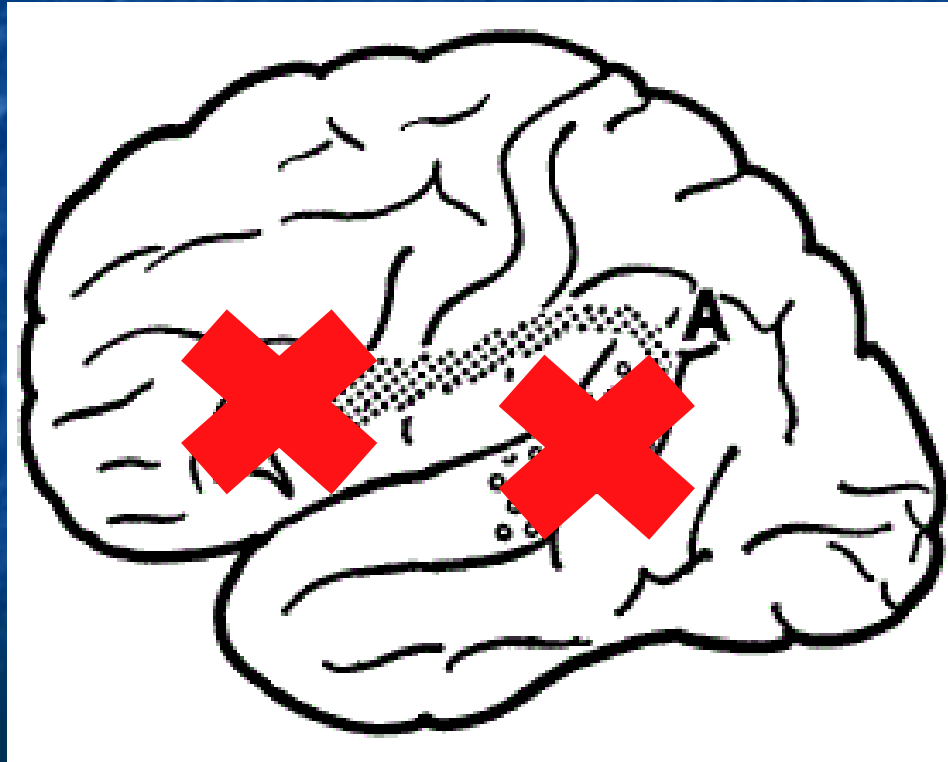


(Geschwind, 1965; 1970)

# Language

## *Wernicke's Theory*

- Global aphasia

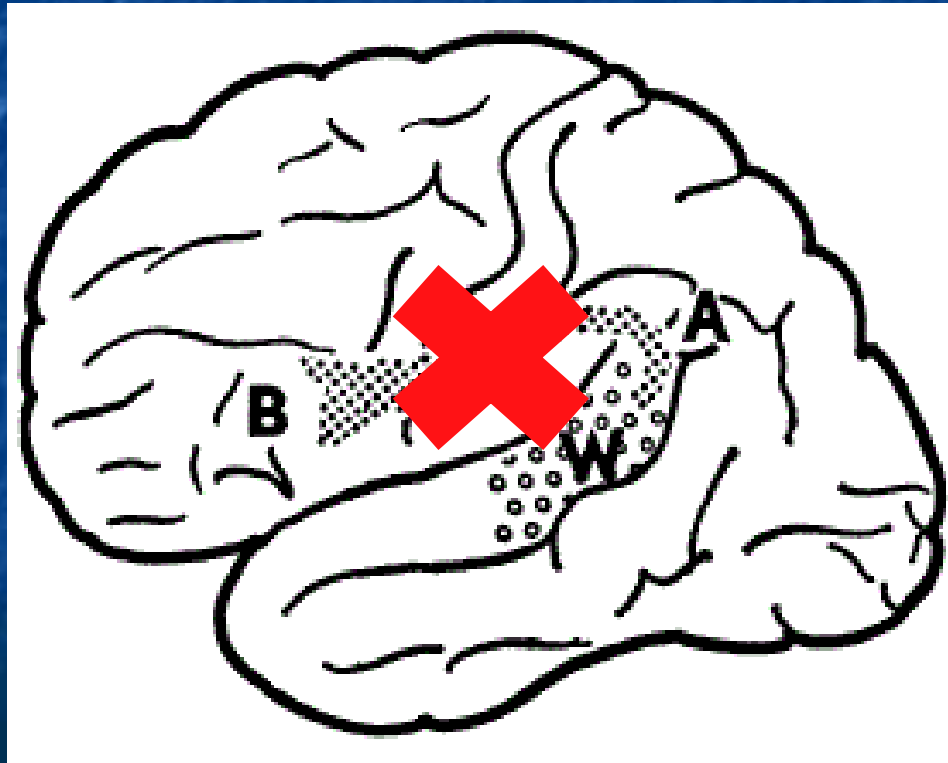


(Geschwind, 1965; 1970)

# Language

## *Wernicke's Theory*

- Disconnection Syndrome (“*Aphasia of the insula region*”; Wernicke, 1874)



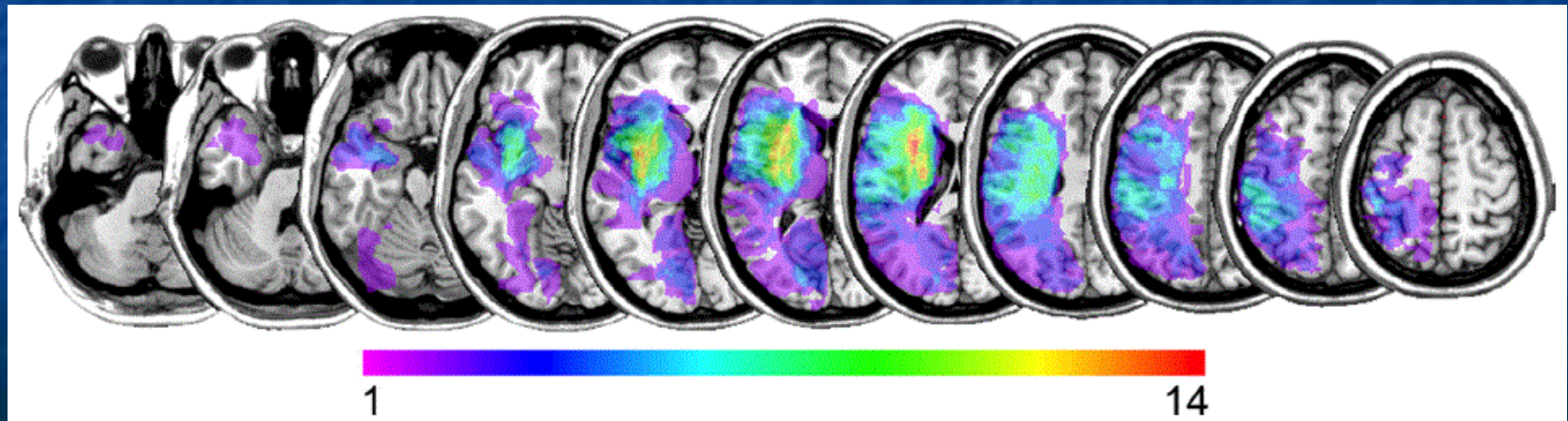
(Geschwind, 1965; 1970)



# Language

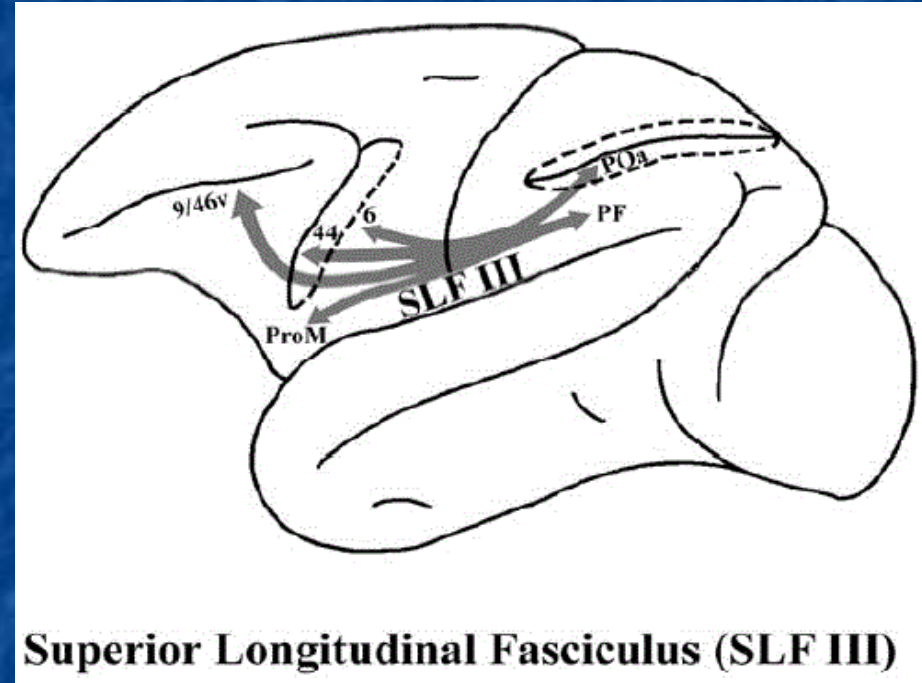
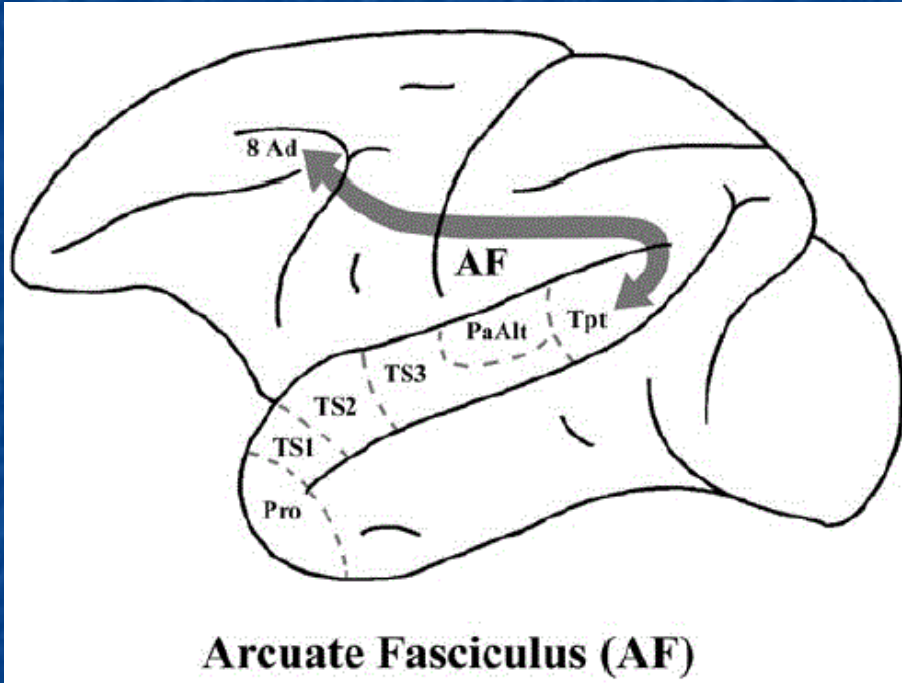
## *Conduction Aphasia*

- Impairment of repetition, with (relatively) unimpaired fluent expression and verbal comprehension
  - Repetition severely impaired



# Language

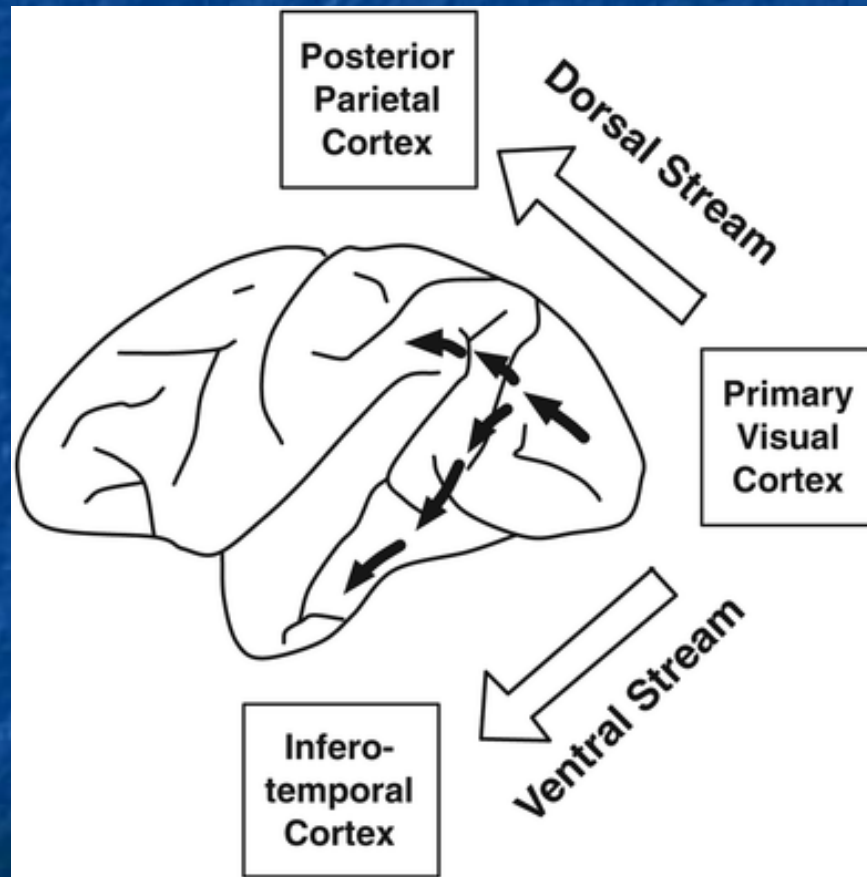
## *Arcuate Fasciculus*



(Petrides & Pandya, 1984; see Mariën & Abutalebi, 2008)

# Visual Perception

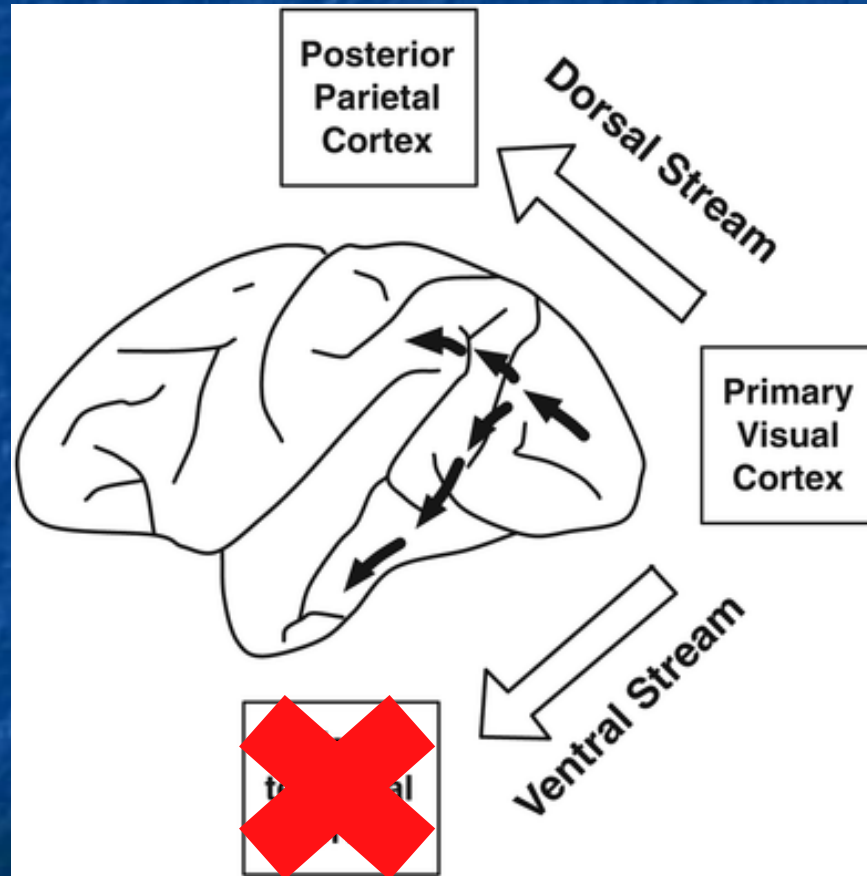
## *Two Visual Systems*



(Milner & Goodale, 1995; 2008; Ungerleider & Mishkin, 1982)

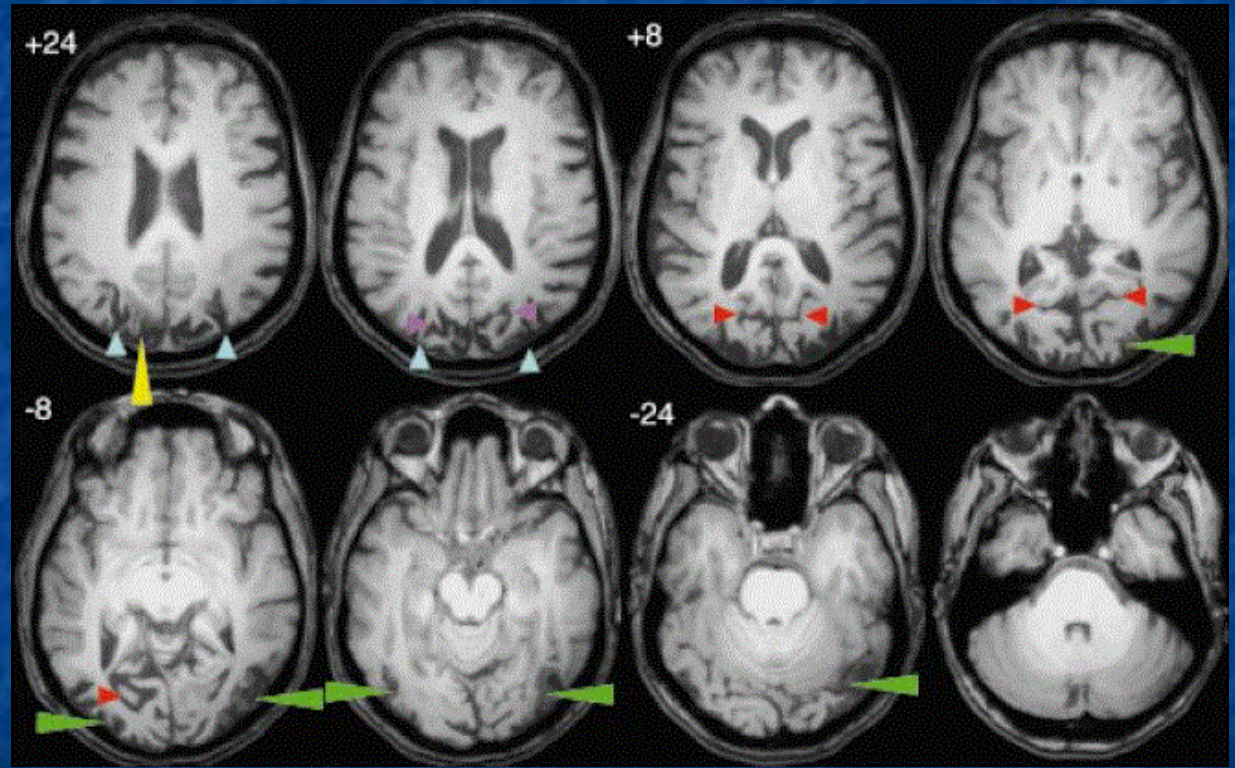
# Visual Perception

## *Two Visual Systems*



# Visual Perception

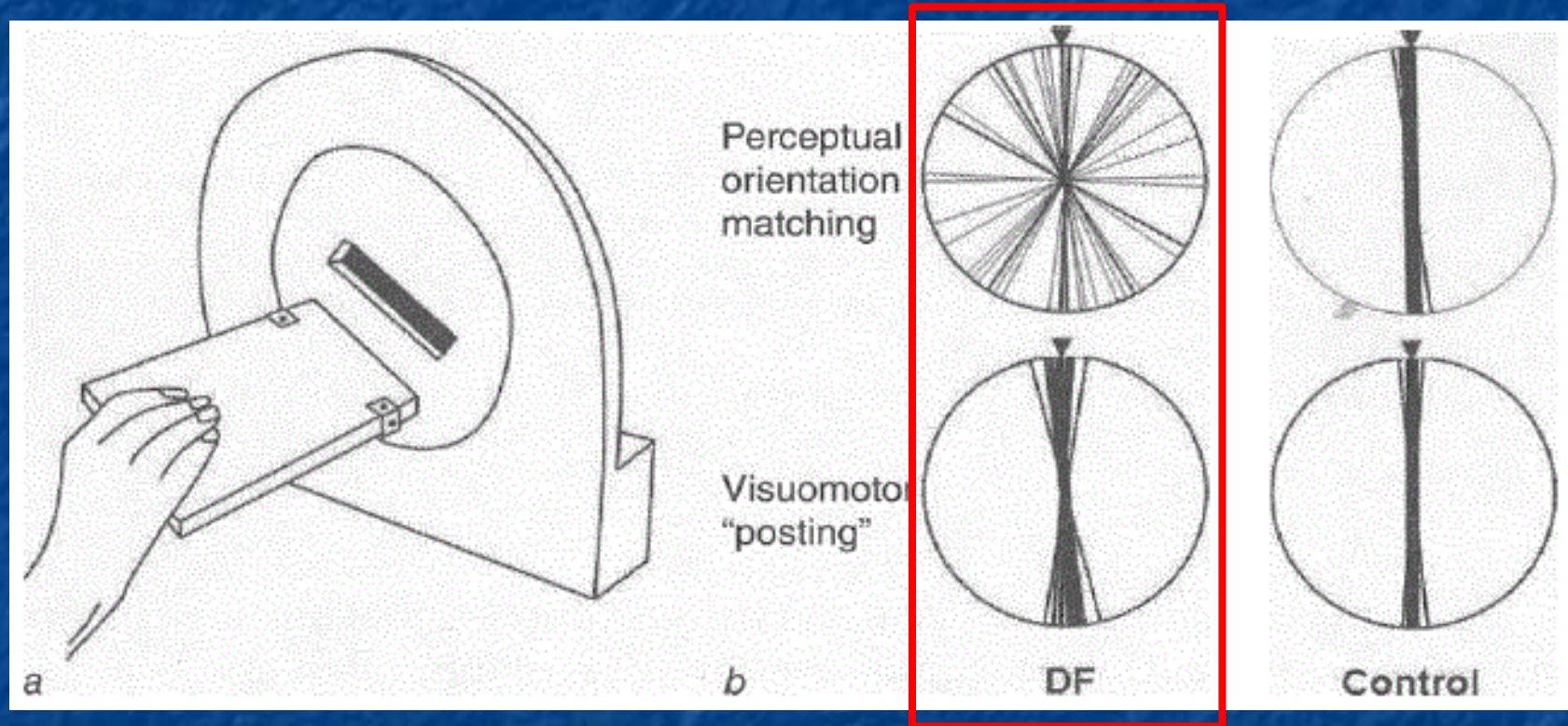
## *Visual Form Agnosia (D.F.)*



(Goodale et al., 1994; James et al., 2003)

# Visual Perception

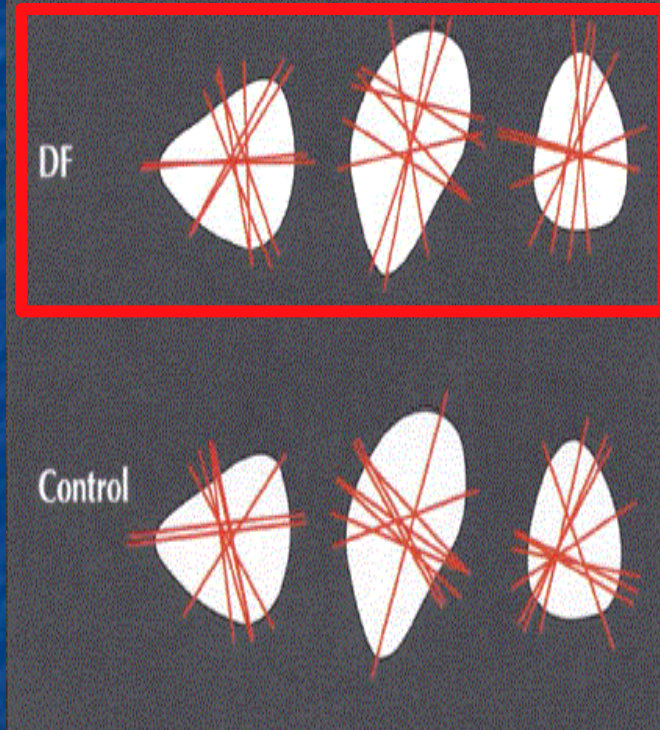
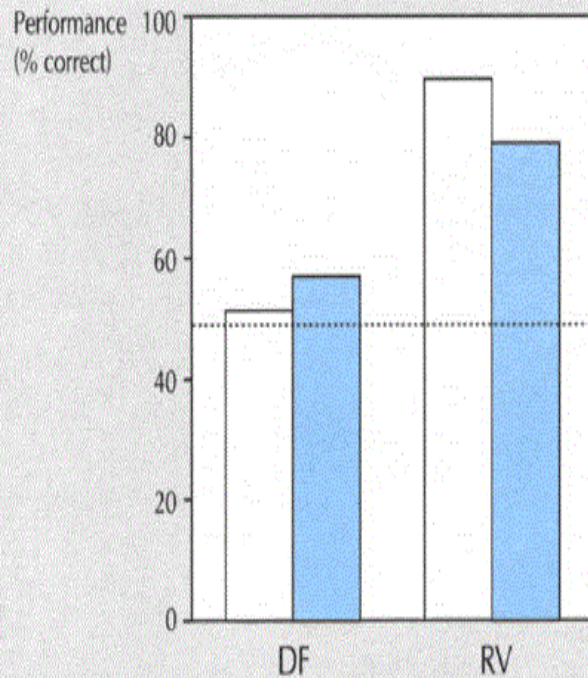
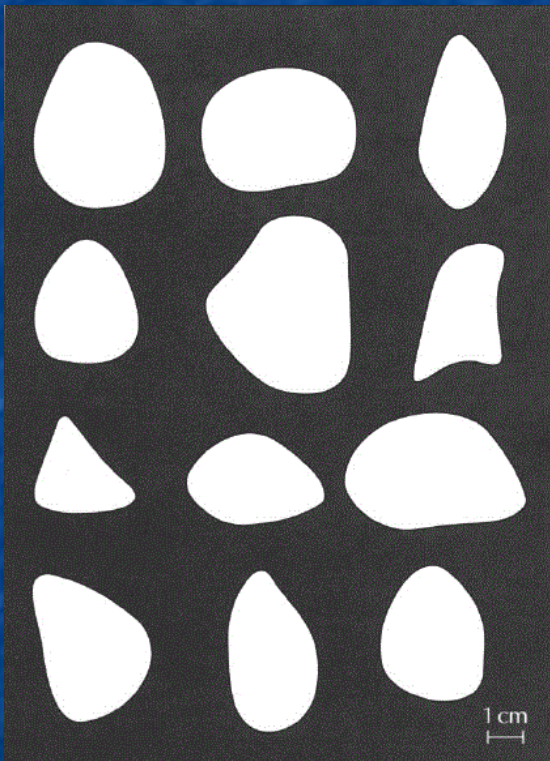
## *Visual Form Agnosia (D.F.)*



(Goodale, Milner, Jakobson & Carey, 1991)

# Visual Perception

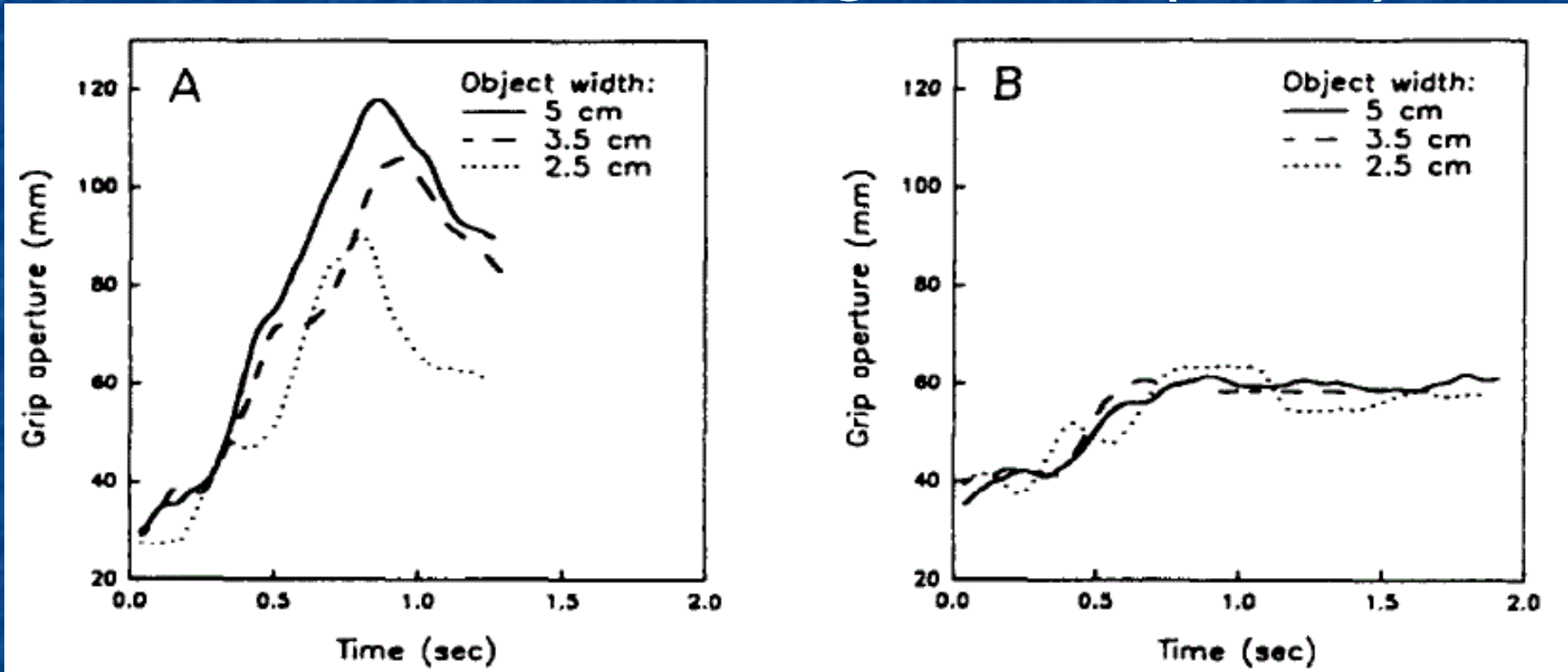
## *Visual Form Agnosia (D.F.)*



(Goodale et al., 1994)

# Visual Perception

## *Visual Form Agnosia (D.F.)*

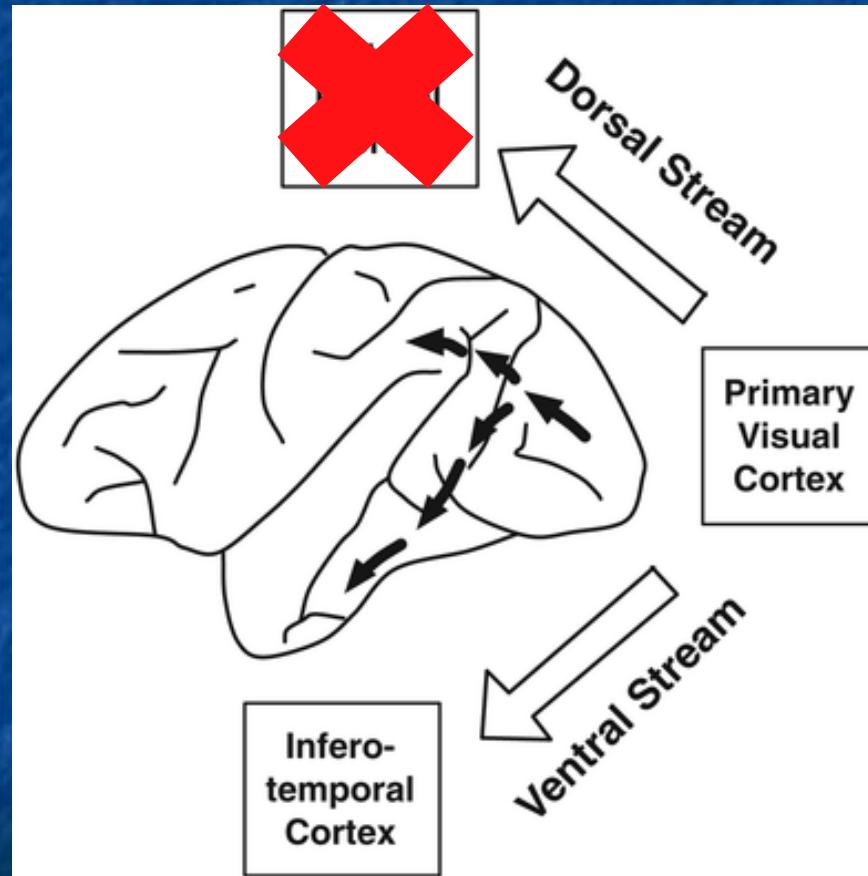


(Goodale, Jakobson & Keillor, 1994)



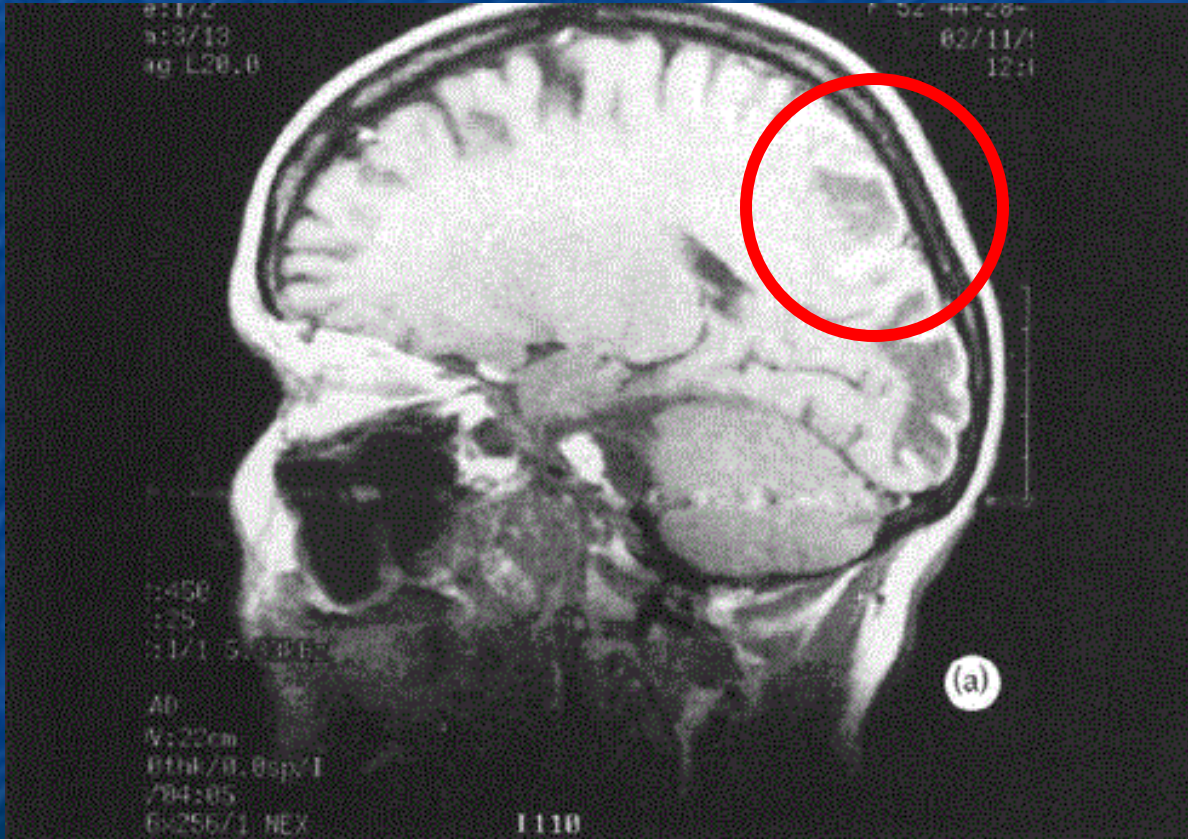
# Visual Perception

## *Vision for Action*



# Visual Perception

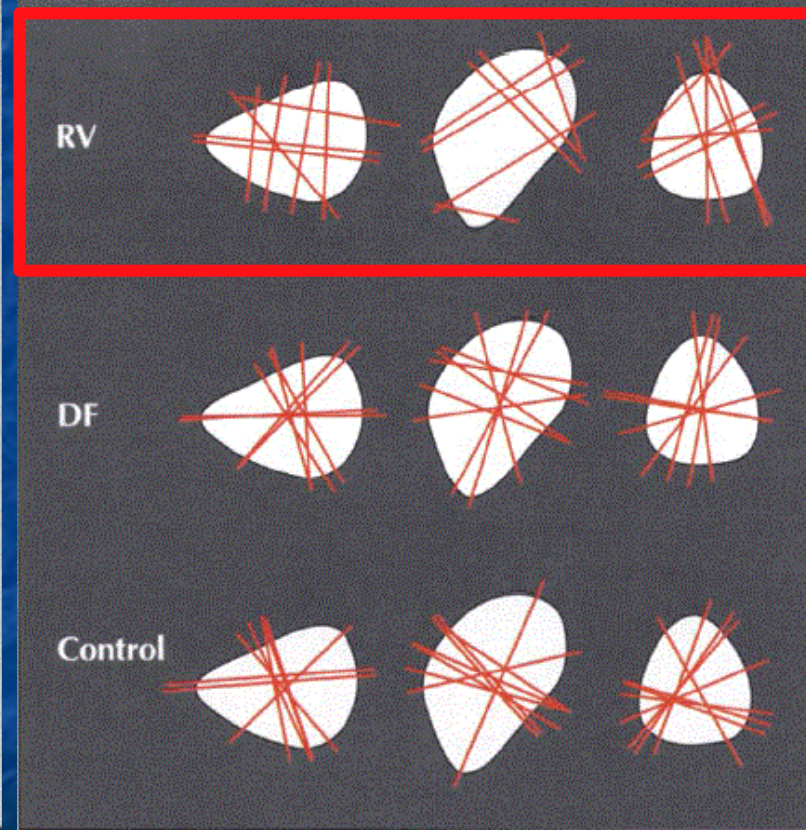
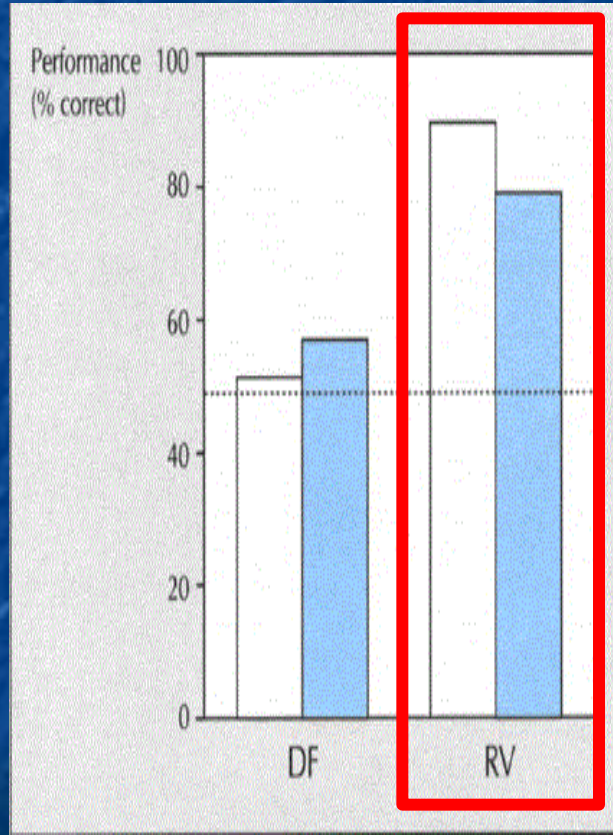
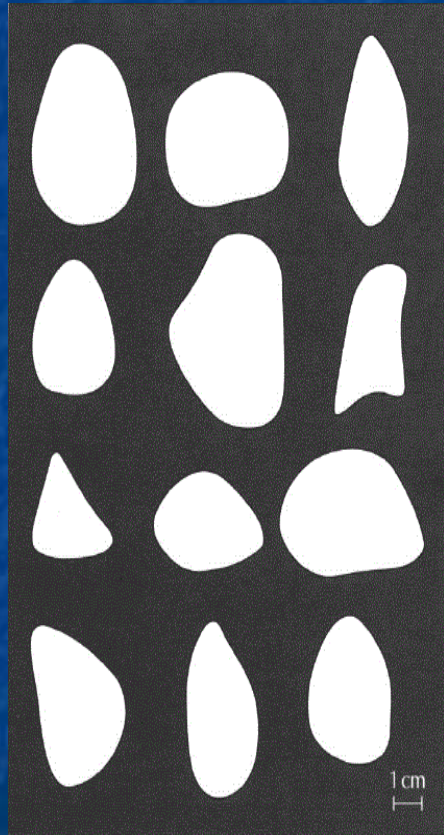
## *Optic Ataxia (R.V.)*



(Goodale et al., 1994)

# Visual Perception

## *Optic Ataxia (R.V.)*

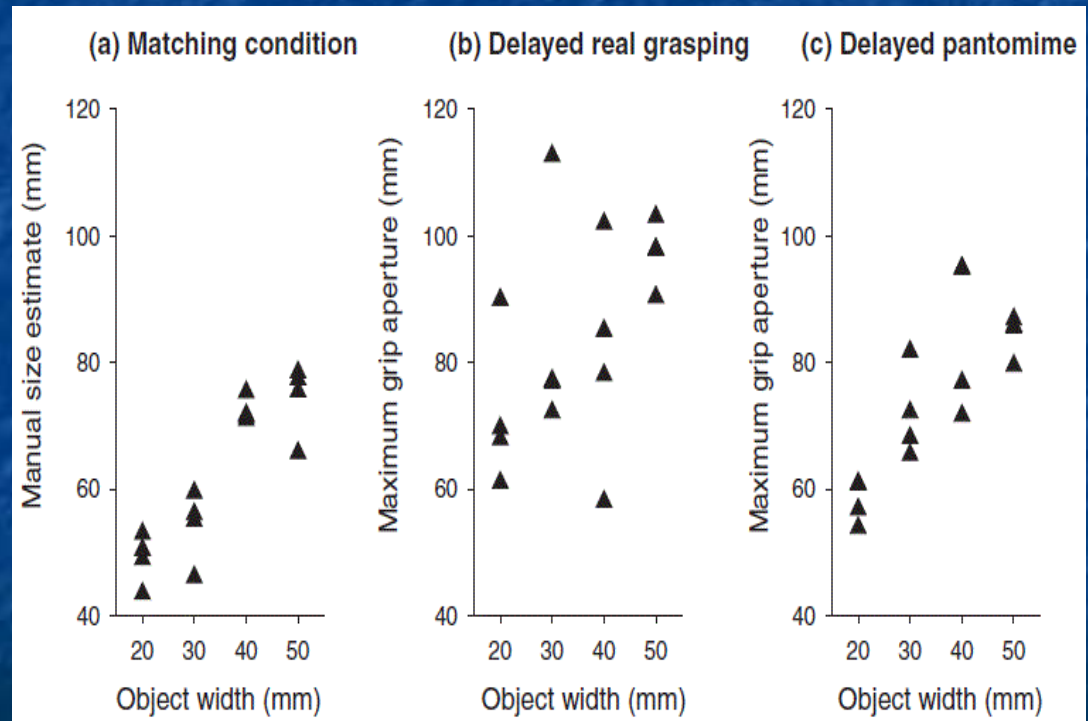
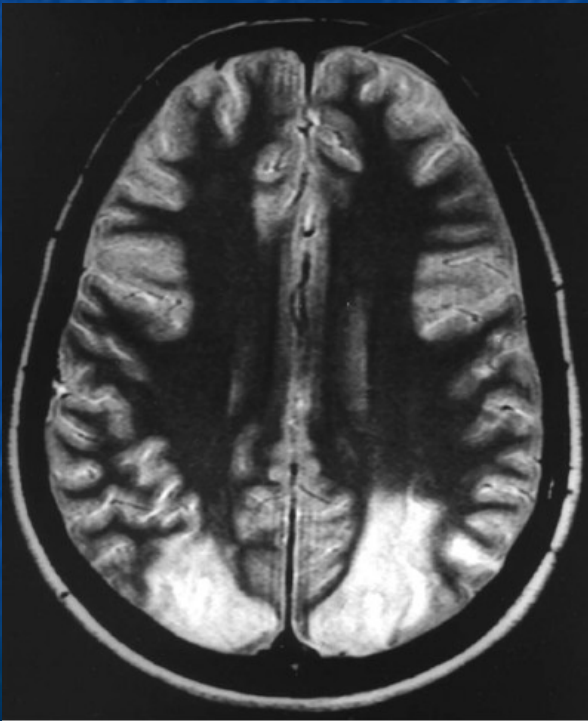


(Goodale et al., 1994)

# Vision for Action

## *Optic Ataxia (I.G.)*

- A = object present; B = pantomimed actions to removed objects
  - Requires visual memory representation



(Milner et al., 2003)

# Discussion

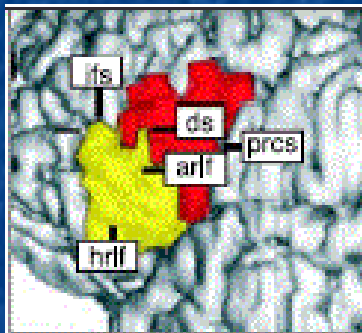
## ■ Advantages

1. Early neuropsychological investigations led to animals models that advanced dramatically our understanding of brain-behaviour relationships
2. Animals models can't be used to investigate language
3. Neuropsychological investigations inform cognitive models (e.g. identify cognitive sub-systems)
4. Neuropsychological investigations permit formal testing of cognitive models
5. Case studies can lead to tailored rehabilitation programs

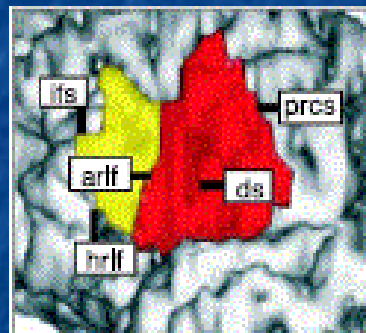
# Limitations

## 1. Morphological Variability

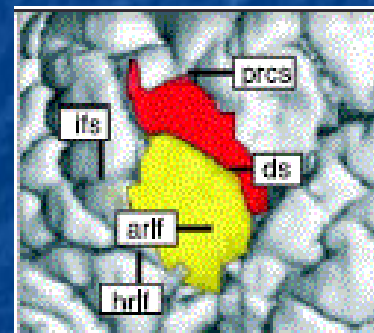
- High variability in **brain morphology** (i.e. sulci/gyri; regions/BAs)



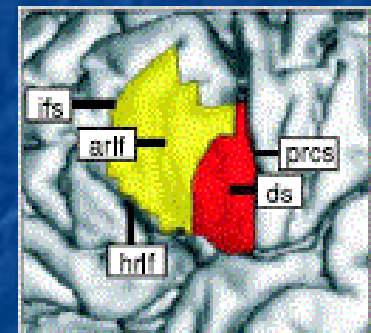
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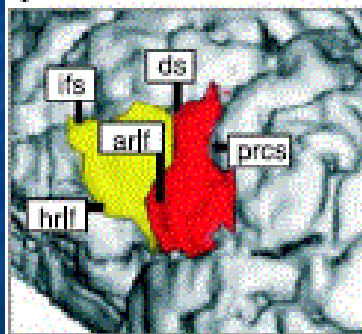
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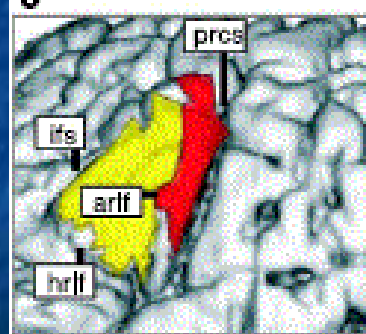
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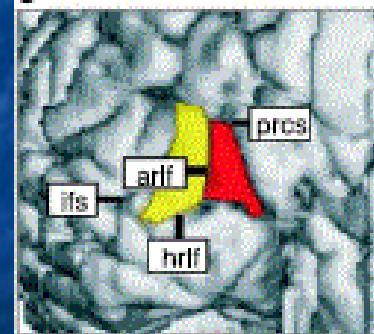
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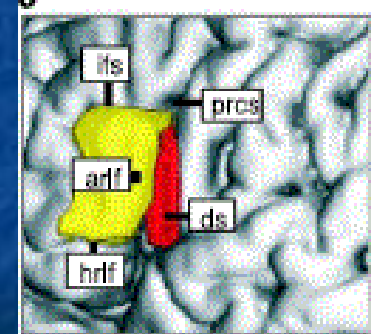
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4



7



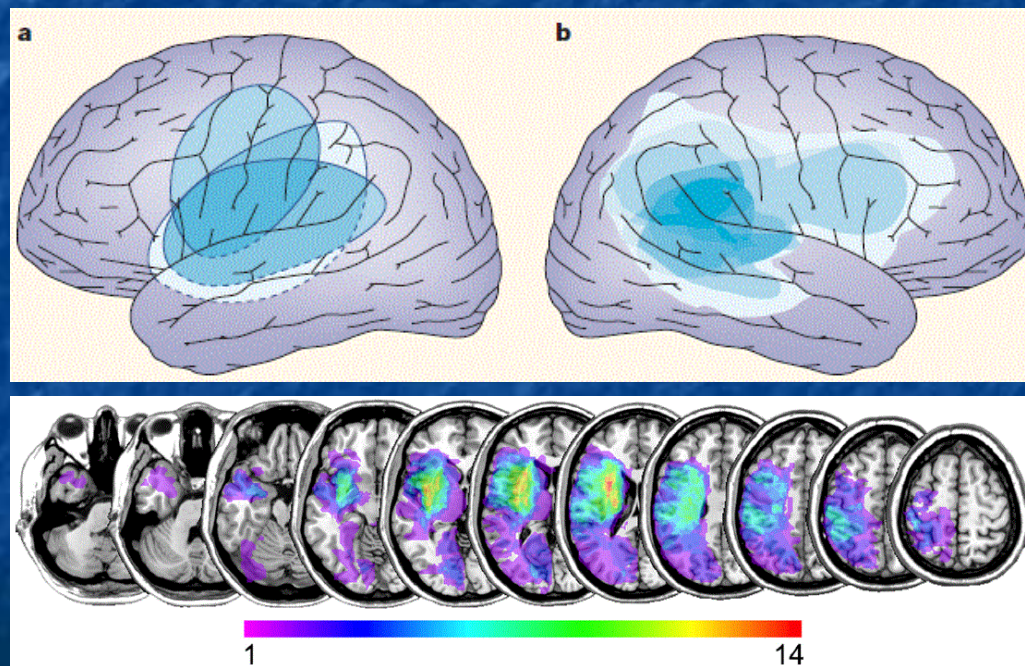
9

(Amunts et al., 2004)

# Limitations

## 2a. Lesion Variability

- High variability in *location* and *extent* of lesion
- Overlay method permits group studies

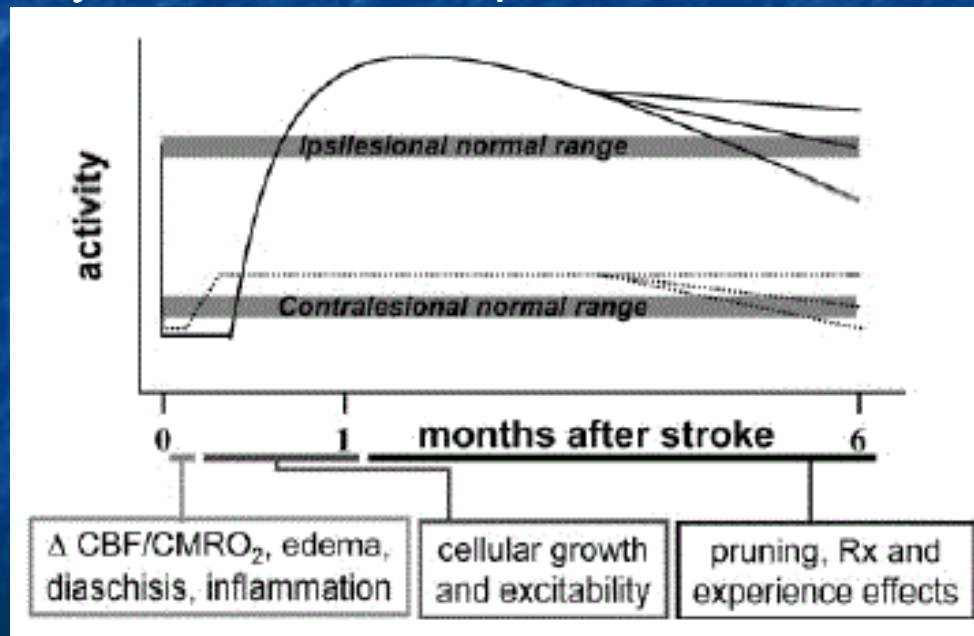


(Rorden & Karnath, 2004; Frederickson et al., 2010)

# Limitations

## 2b. Lesion Variability

- High variability in *time* lapsed since lesion
  - Post-stroke anatomical/functional re-organisation occurs rapidly and in a time-dependent manner



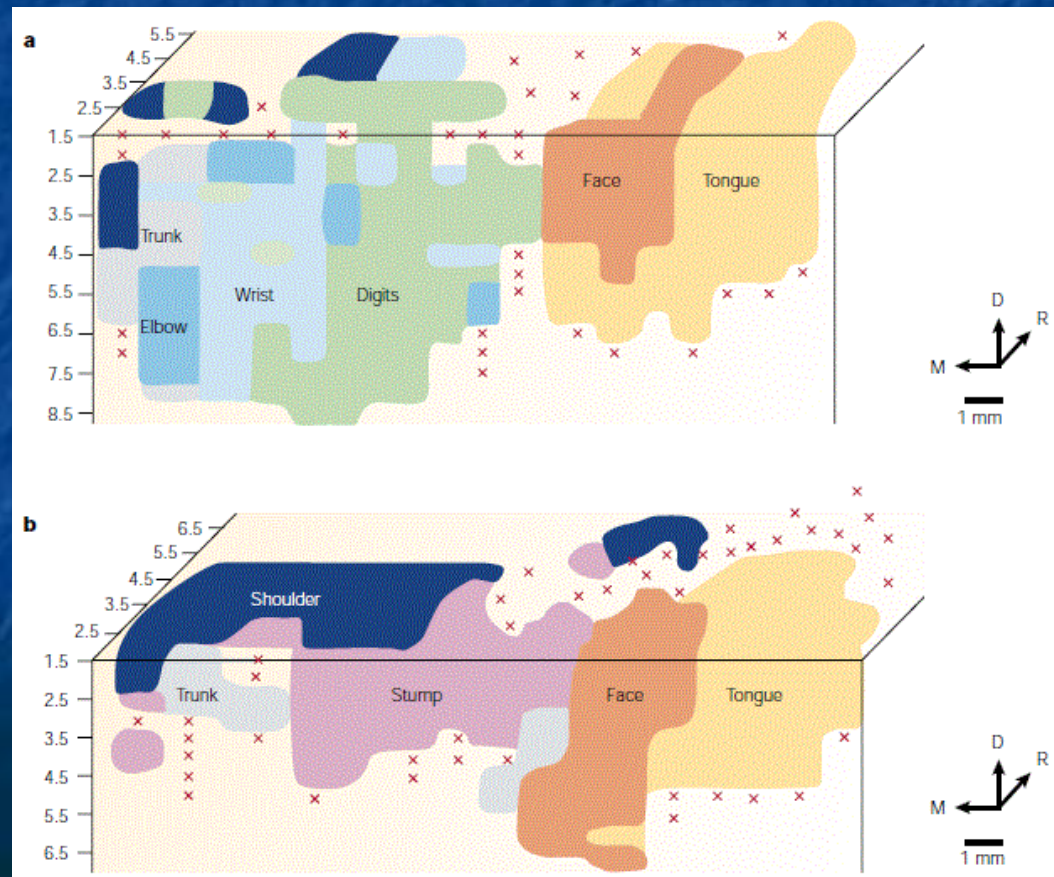
(Crammer, 2004)



# Limitations

## 4. Neural Plasticity...

- Re-organisation of neural systems following perturbation
  - Synaptic plasticity
    - LTP/LTD
  - Anatomic plasticity
    - Cortico-cortical
  - Re-myelination

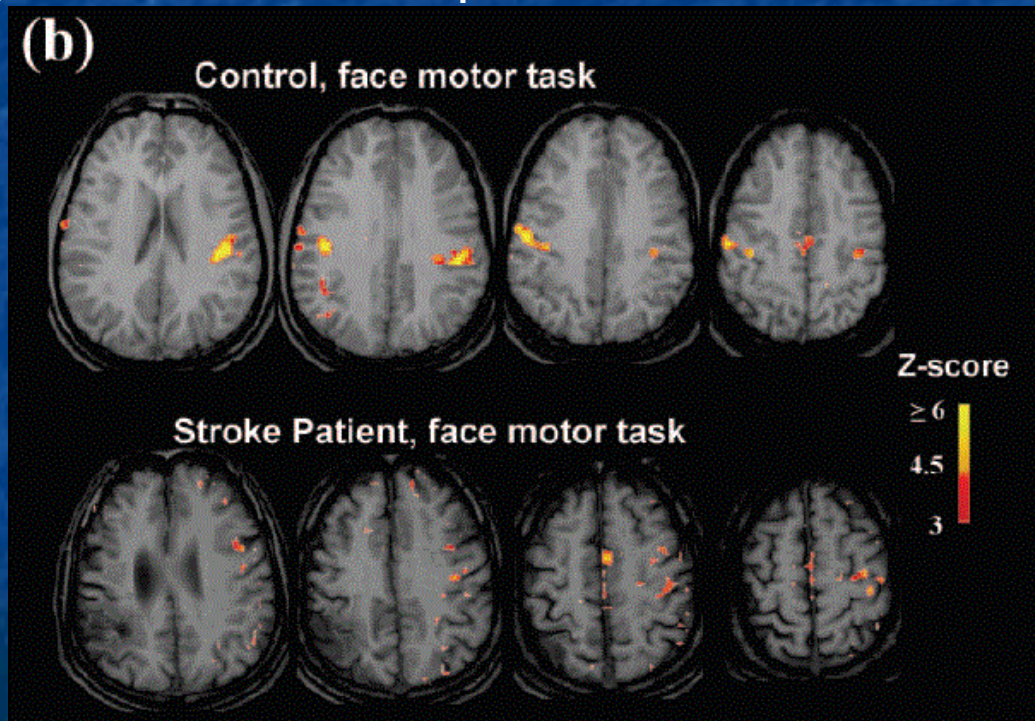


(Raineteau et al., 2001)

# Limitations

## 4. *Neural Plasticity...*

- Re-organisation of neural systems following perturbation
  - e.g. Contralateral compensation



(Crammer, 2001)

**The End**