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)

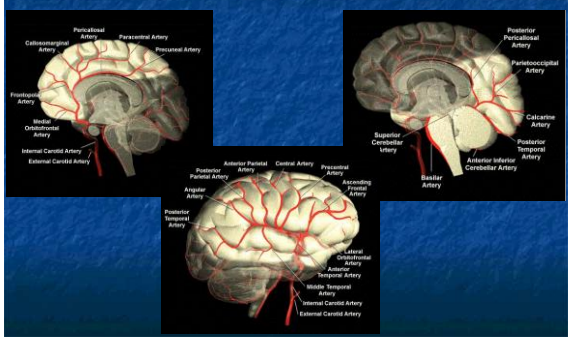
Introduction

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)

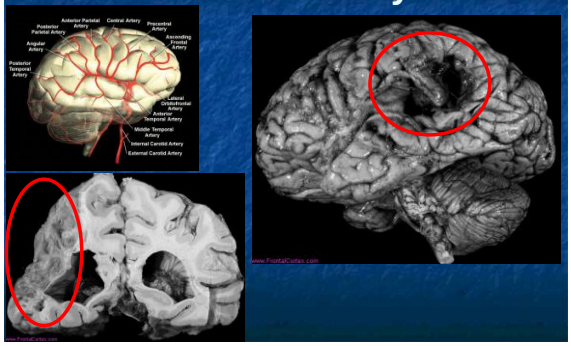
Neuropsychology
The "Lesion Method"

Basic Anatomy

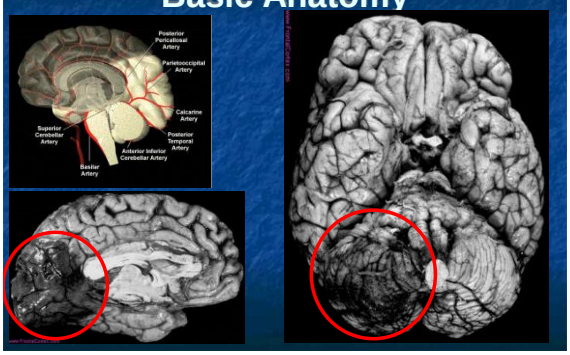


Basic Anatomy

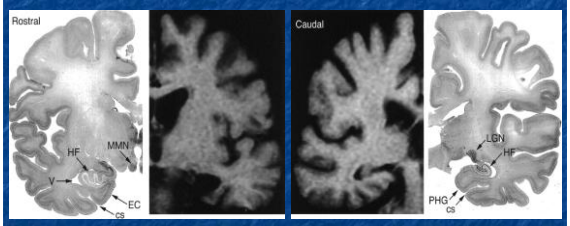
Basic Anatomy



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)	Delayed Recall: 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

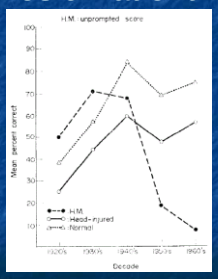
(Corkin, 1984)

Memory
Amnesic Patient H.M.

Exp. 1 (Single digits)		Exp. 2 (Digit triples)			
		L5		L7	
k	P(yes)	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				
*2-4-5	0.09				
2-4-5	1.00				

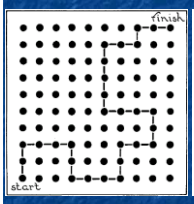
(Wickelgren, 1968)

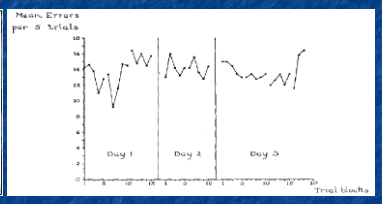
Memory
Amnesic Patient H.M.



(Marlsen-Wilson & Teuber, 1975)

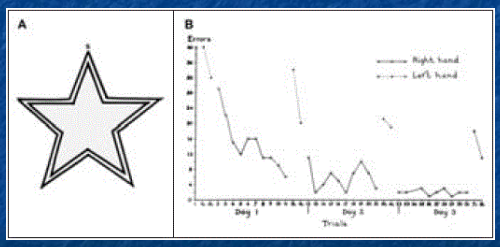
Memory
Amnesic Patient H.M.





(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"*

(Broca, 1861; Geschwind, 1970; 1965)

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*

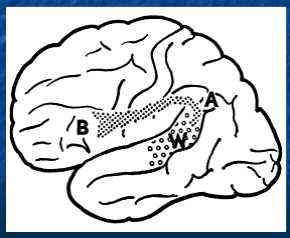
(Geschwind, 1970; Ogden, 2005)

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

(Chater & Ganis, 1991)

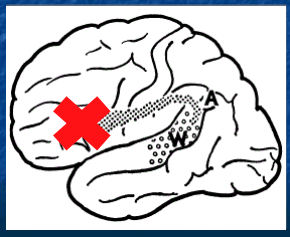
Language
Wernicke's Theory



(Geschwind, 1965; 1970)

Language
Wernicke's Theory

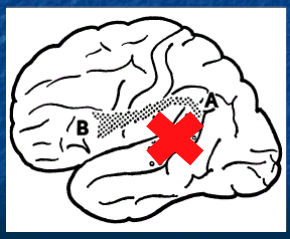
- Expressive (Broca's) aphasia



(Geschwind, 1965; 1970)

Language
Wernicke's Theory

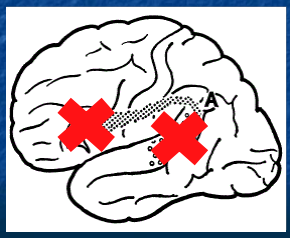
- Receptive (Wernicke's) aphasia



(Geschwind, 1965; 1970)

Language
Wernicke's Theory

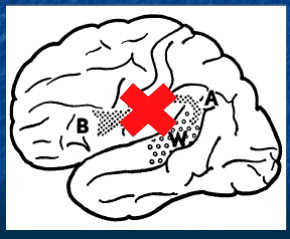
- Global aphasia



(Geschwind, 1965; 1970)

Language
Wernicke's Theory

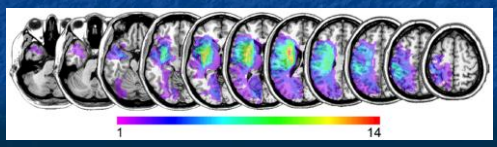
- Disconnection Syndrome (*"Aphasia of the insula region"*; Wernicke, 1874)



(Geschwind, 1965; 1970)

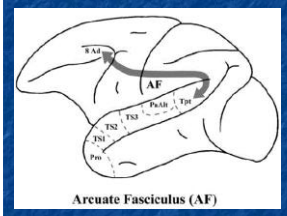
Language
Conduction Aphasia

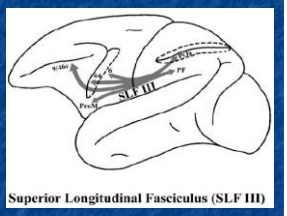
- Impairment of repetition, with (relatively) unimpaired fluent expression and verbal comprehension
  - Repetition severely impaired



(Fridriksson et al., 2010)

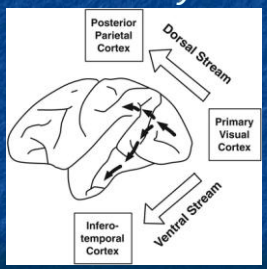
Language
Arcuate Fasciculus





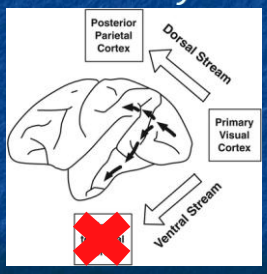
(Petrides & Pandya, 1984; see Mariën & Abutalebi, 2008)

Visual Perception
Two Visual Systems

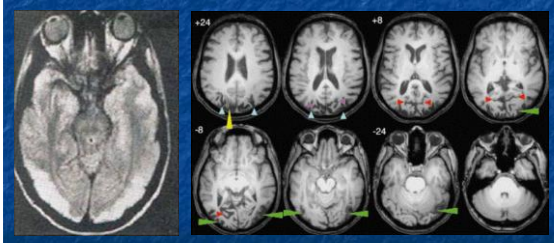


(Milner & Goodale, 1995; 2008; Ungerleider & Mishkin, 1982)

Visual Perception
Two Visual Systems

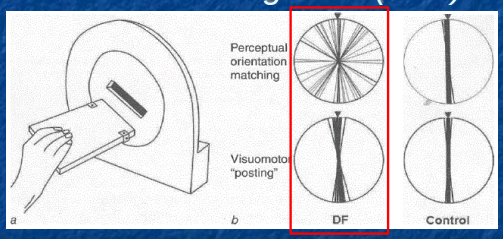


Visual Perception
Visual Form Agnosia (D.F.)



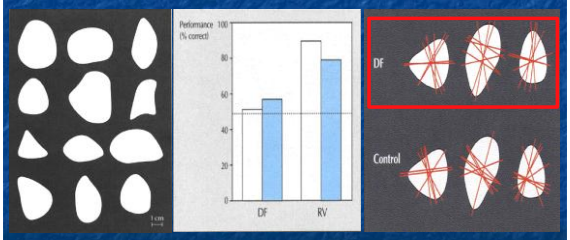
(Goodale et al., 1994; James et al., 2003)

Visual Perception
Visual Form Agnosia (D.F.)



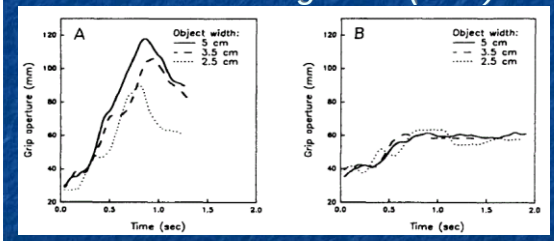
(Goodale, Milner, Jakobson & Carey, 1991)

Visual Perception
Visual Form Agnosia (D.F.)



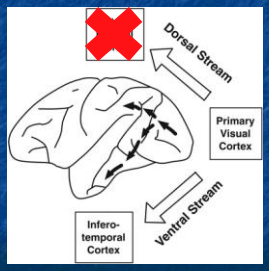
(Goodale et al., 1994)

Visual Perception
Visual Form Agnosia (D.F.)

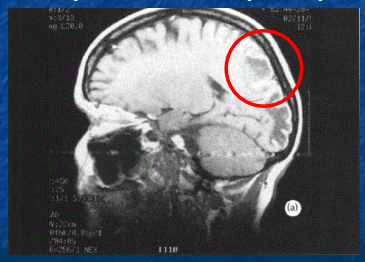


(Goodale, Jakobson & Keillor, 1994)

Visual Perception
Vision for Action

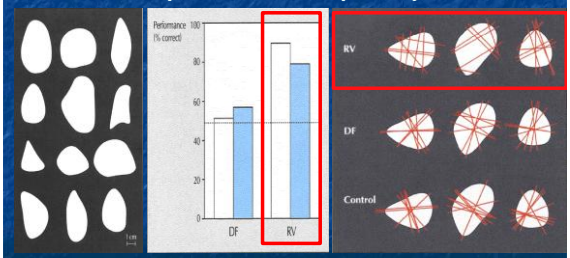


Visual Perception
Optic Ataxia (R.V.)



(Goodale et al., 1994)

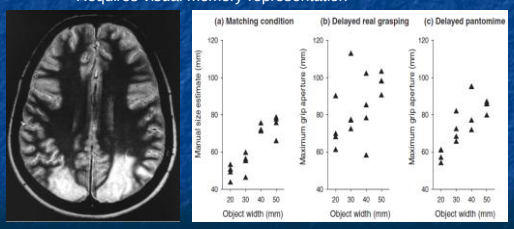
Visual Perception
Optic Ataxia (R.V.)



(Goodale et al., 1994)

Vision for Action
Optic Ataxia (I.G.)

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



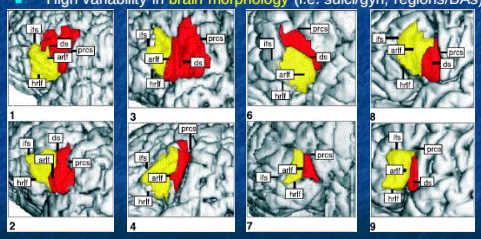
(Milner et al., 2003)

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

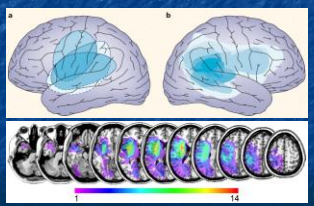
- High variability in brain morphology (i.e. sulci/gyri; regions/BAs)



(Amunts et al., 2004)

Limitations
2a. Lesion Variability

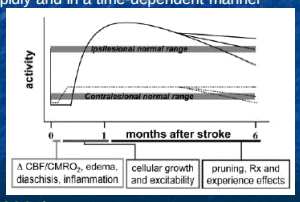
- High variability in *location* and *extent* of lesion
  - Overlay method permits group studies



(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)

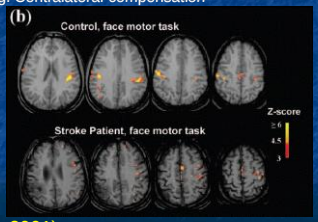
Limitations
4. Neural Plasticity...

- 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