Introduction to Clinical and Experimental Neuropsychology

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“In any well-made machine one is ignorant of most of the parts – the better they work the less we are conscious of them... it is only fault that draws attention to the existence of a mechanism at all.”

Kenneth Craik, 1943
What is Clinical and Experimental Neuropsychology?

- The study of the relation between behaviour and brain function

- **Clinical Neuropsychology**: how specific patterns of disordered human behaviour may arise from disruption of brain processes with a view to refining patient diagnosis and rehabilitating behavioural problems

- **Experimental Neuropsychology** is concerned with elucidating the mechanisms underlying abnormal and *normal* behaviour. Data from matched controls as well as patients
What is Clinical and Experimental Neuropsychology?

- Complementary fields
  - Cognitive Neuroscience
  -- Cognitive Science

- Draws on many other fields including philosophy, pharmacology and physiology
Course Outline

- 13th January Introduction
- 20th January Neuropathology and Assessment
- 27th January Sensation and Perception
- 3rd February Parietal lobe function
- 10th February Temporal lobe function
- 17th February Language Function
- 24th February Reading Week
- 3rd March Frontal Lobe Function
- 10th March The Ageing Brain
- 17th March Public Holiday
- 24th March Brain Plasticity
- 31 March Rehabilitation
How did the field evolve?

- The brain hypothesis (Aristotle)
- Dualism vs Monism (Descartes, Darwin)
- Localisationist vs Globalist Debate – early 19th Century
  - Phrenology, Franz Gall
  - Flourens, Golz
How did the field evolve?

Johannes Borgstein,
Caroline Grootendorst

This 7-year-old girl had a hemispherectomy at the age of 3 for Rasmussen syndrome (chronic focal encephalitis). Intractable epilepsy had already led to right-sided hemiplegia and severe regression of language skills. Though the dominant hemisphere was removed, with its language centres and the motor control for the left side of her body, the child is fully bilingual in Turkish and Dutch, while even her hemiplegia has partially recovered and is only noticeable by a slight spasticity of her left arm and leg. She leads an otherwise normal life.
Late 19th C - A More Sophisticated Localisationist Model

- John Hughlings Jackson
  - Early evidence of topographical representation of the body from epileptic patients
  - Many regions contribute to particular behaviours

- Broca (1861), Wernicke (1876)
Examiner: All right, I'm going to ask you to... tell me some uh answers to these questions. What do you do with a hammer?
Patient: Found... flound... uh... sss... tuh found... oh... ssst...
Examiner: You know, don't you?
Patient: Yes... sss... sss
Examiner: Do you write with it?
Patient: No.
Examiner: Do you eat with it?
Patient: No.
Examiner: Do you pound with it?
Patient: Yes.
Examiner: Okay.
Wernicke’s Aphasia

Examiner: I’m going to ask you some questions, and I just want you to answer “yes” or “no.” Okay? “Yes” or “no.” Is your name Smith?
Patient: Where would I be, what they’re eating avarment I don’t know.
Examiner: Is your name Brown?
Patient: Oh mistress triangland while listen you walking well things things this for year for thee.
Examiner: Okay, just say “yes” or “no.” Okay, is your name Brown?
Patient: What it is here, then let me see, I just don’t know. No I’m not going to an eat any sigh no.
Examiner: No? . . . Are the lights on in this room?
Patient: No [laughs] not. I just don’t sorry what you’re doing and you just saving walking and walking around here.
Examiner: You’re doing fine. That’s okay, I know it’s kind of hard for you. You’re doing fine.
Patient: I kinnd my own my eat my only for my and everythin like that an cleanin my dead me by is always clean me breveret eating and I can watch and everything in the morning.
Examiner: I see.
The Nervous system is not a big blob!
Cajal and Golgi share Nobel Prize 1906
The Debate Continues in the 20th Century - Holistic Approach

- Lashley (1935) - lesions made throughout the brain do not necessarily create problems when learning a new task

- A lesioned brain is like a new system, not an old system with one part missing?
1930s Philip Bard and Wilder Penfield demonstrate topographical representation, further elucidated by modern neuroimaging.
“The key to resolving the debate is to realise that complex functions... are accomplished by a host of underlying processes that are carried out in a single region of the brain” Kosslyn and Anderson (1992)

Modern Neuropsychology rests on the following assumptions

1. Monistic Hypothesis
2. Modularity of cognitive processing – consistent for the localisation view
3. Different combinations of these fundamental processes are recruited for different requirements – consistent for the holistic view.
A modular system is one in which several components interact to perform a function but where each of these components, or modules, is functionally autonomous. Thus, when the brain is damaged modules may dissociate from each other that reveal something about the underlying organisation of the system.

In the second half of the 20th century, increased focus on the problem of measuring individual processes that underlie complex abilities.

No longer trying to identify the locus of nebulous cognitive concepts.
Modularity and the Cognitive Revolution

- Improved understanding of the building blocks of cognition made it possible to identify selective processing in specific brain regions.

Lesion Logic

- The \textit{Lesion analysis}: selection of animals or humans with discrete brain damage to areas thought to be essential in a particular processing chain

- “The best-established paradigm of cognitive neuroscience” Gazzaniga
Classes of lesion

- **Accidental lesions**: result from brain insults such as cerebrovascular accidents (CVA; stroke); penetrating head injuries, focal contusions; neuronal sclerosis and neurodegeneration

- **Intentional Lesions**: tissue excision, destruction, deactivation and disconnection

- **Neurosurgery**
The Logic of Lesion Analyses - Dissociation

- Appropriate control conditions essential to correctly determine the function of a region (e.g., language)
- Is the problem primary or secondary?
- Experimental and control task
- Goal is to show selective impairment

<table>
<thead>
<tr>
<th>Group</th>
<th>Comprehension</th>
<th>Speech Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broca’s</td>
<td>99%</td>
<td>20%</td>
</tr>
<tr>
<td>Wernicke’s</td>
<td>20%</td>
<td>99%</td>
</tr>
<tr>
<td>Control</td>
<td>99%</td>
<td>99%</td>
</tr>
<tr>
<td>Type of Dissociation</td>
<td>Experimental Desirability</td>
<td>Theoretical and Experimental Rigour</td>
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<td>----------------------</td>
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<tr>
<td><strong>No dissociation</strong></td>
<td>Least desirable</td>
<td>'Fishing expedition' - asks what will happen if area A is damaged</td>
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<tr>
<td><strong>Single dissociation</strong></td>
<td>Moderately desirable</td>
<td>Reasonable control - lesion may be hypothesis or theory driven</td>
</tr>
<tr>
<td><strong>Double dissociation</strong></td>
<td>Most desirable</td>
<td>Best of all, as lesion must be driven by directly opposed experimental questions.</td>
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Lesion analysis compared to functional imaging

- Advantages of lesions: permanent removal of components of the processing chain; persistence over time (allows many systematic studies of the effects of the lesion on the processing chain)

- **Functional imaging complements lesion analysis by identifying necessary and contributing components of the processing chain; functional imaging also allows the identification of specific components of the processing chain.**

- Overall one strategy complements and underlines the other.

- **Note:** All of the above techniques require that you get the psychology right - if you do not have a good functional theory, applying technology will not get you a meaningful answer.
Levels of Analysis in Mind/Brain Disorders

- Quantum/atomic
- Molecular
- Cellular
- Systems
- Cognitive/Psychological/Behavioural
- Social
Multiple levels of analysis in action

2. Brain Imaging
   Inhibition and right prefrontal cortex

3. Neuropsychopharmacology
   Monoamines: Dopamine, noradrenaline

4. Genetics
   DRD2 and NET alleles
The only major region that does not receive input from the LC is the area that contains the basal ganglia’
(Sara et al Nature Reviews Neuroscience 2009)
Sustained Attention Performance and Noradrenaline in ADHD

Greene, Bellgrove, Gill and Robertson, 2009 Neuropsychologia

Right inferior frontal gyrus role in SART (random) commission errors) Mohlenberg and Vandenberghe, 2009
Human noradrenergic Markers?

Rajkowski et al 1993

Bellgrove and Robertson 2008
Results

EDUCATION AND AMYLOID PET IMAGING (Roe et al 2008)

A

- CDR-SB Score
- PiB negative
- PiB positive
- P values:
  - P = .02
  - P > .99
  - P < .01
  - P = .06
  - P = .94
  - P = .17

B

- MMSE Score
- P values:
  - P = .90
  - P < .01
  - P = .26
  - P = .27

C

- SBT Score
- P values:
  - P = .65
  - P < .01
  - P = .003
  - P = .93
  - P = .93
  - P = .21

D

- WAIS-III Similarities Subtest Score
- P values:
  - P = .02
  - P = .03
  - P = .03
  - P = .05
  - P = .04
  - P = .44
Social Networks May Weaken the Link between Pathology and Cognitive Function

Bennet et al, Lancet Neurology
Summary

- Tracing the evolution of neuropsychology reveals the fundamental assumptions upon which the field rests
- Localisationist versus globalist perspective
- Neuron hypothesis
- Modularity
- Hierarchical organisation, Distributed function, Parallel Processing
- The lesion method
- Neuropsychology does not operate in a vacuum
Recommended Reading


