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Cognition and Emotion

Lecture 3: Cognitive Neuropsychology

DR KATE WILLIAMS

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Lecture Overview

- ▶ What is Cognitive Neuropsychology
- ▶ Historical background
- ▶ Theoretical assumptions
- ▶ Methods of research
- ▶ Famous case studies
- ▶ Strengths
- ▶ Limitations

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What is Cognitive Neuropsychology?

- ▶ Examines cognitive performance of brain-damaged patients.
 - ▶ Both intact & impaired performance.
- ▶ Damage caused to brain by lesions (either from birth defect, injury or disease).
- ▶ Aim: can studying brain-damaged patients tell us anything about normal cognition?

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What is Cognitive Neuropsychology?

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- ▶ Although brain-damaged patients are studied, some neuropsychologists focus their research on the mind....
- ▶ Coltheart (2010, p.3): "The principle aim of cognitive neuropsychology is not to learn about the brain....instead to learn about the mind....to elucidate the functional architecture of cognition".
- ▶ Not all agree: instead focus only on the brain

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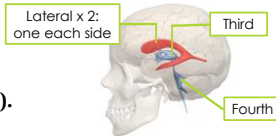
Background

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- ▶ Edwin Smith Surgical Papyrus: Egyptian medical text detailing effects of brain damage on functioning (circa 1600 BCE).



- ▶ 4th - 14th century: types of behaviour mediated by activity of the ventricles (hollow fluid-filled cavities).



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Background

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- ▶ 18th & 19th century, ventricle hypotheses no longer valid due to discoveries in anatomy and neurophysiology.
- E.g., discovery of various types of cells (neurons) in the brain that played different functions.
- Physician Camillo Golgi: discovered a way of tracing the structure of cells through a technique called staining.



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Background

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- ▶ Pathologist Santiago Ramon y Cajal: discovered the brain comprises a network of communication neurons.
- ▶ Physician Luigi Galvani: discovered that nerve cells produced electricity, this led to Helmholtz finding nerve cells communicated with each other using electrical signals.
- ▶ Discovery in psychopharmacology that the surface of neurons, known as their receptor sites, were responsive to various chemicals called neurotransmitters.

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Background

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- ▶ Key figures in understanding brain damage in the 19th C: Pierre Paul Brocca and Carl Wernicke.

- ▶ Anthropological society meeting (1861) on [equipotentiality](#)
 - ▶ Any part of an intact piece of the brain can still carry out the functions from a part that has been damaged.
 - ▶ Versus the [localisation theory](#): only that part of the brain can deal with a certain function.

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Background

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- ▶ Broca gave account of epileptic patient paralysed on 1 side of body who had not spoken for 20 years.
 - ▶ Post mortem found damage to left frontal convolution
- Basically a hole on the front left side of the brain had filled up with fluid.
- The patients speech production deficit became known as Broca's aphasia.
- Aphasia = communication disorder.



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Background

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- ▶ As only one hemisphere was damaged, it suggested the brain did not work in an equipotential way.
- ▶ Otherwise the patient would be able to produce words due to other parts of the brain taking on the functions of the damaged area.
- ▶ So, localisation was deemed more appropriate of how the brain functions.

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Background

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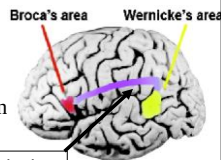
- ▶ Other important discovery:
 - ▶ Some aphasics are unable to comprehend speech - sensory aphasia (now known as Wernicke's aphasia).
- ▶ Associated with left hemisphere of the brain and would lead to inappropriate word use in the middle of a sentence or inability to name objects.
- ▶ Writing was also very impaired.

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Background

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- ▶ Wernicke: not only were specific regions responsible for specific functions but connections between regions also responsible for function



- Broca's area responsible for motor representations of speech, while Wernicke's area was responsible for storing 'sound images' - phonological representations of speech.

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Theoretical Assumptions 13 Coltheart (2001)

1. Modularity of the mind:

- Cognitive system has numerous modules operating independently and exhibit domain specificity.
 - E.g., face module that only responds when a face appears.
- Fritsch & Hitzig (1870) discovered the neocortex is **selectively** excitable by electrical stimulation.
- ❖ Electric current to anterior part of dogs brain certain parts of its body would move!!
- ❖ Four years later this was done on a human!!



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Theoretical Assumptions 14 Coltheart (2001)

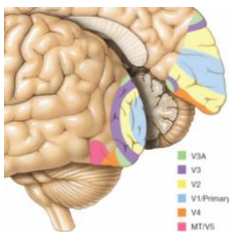
2. Anatomical Modularity:

- Each module is located in a particular/specific brain area.
- ▶ With evidence of localisation growing, researchers attempted to map out functions of the brain.
- ▶ By end of 19th C neuropsychology was truly established.
- ▶ Ribot reported a distinction between types of memory loss depending on whether an injury occurred before or after an event – retrograde and anterograde amnesia.
- ▶ He was the first to show that despite someone suffering from amnesia, they could still learn new material.

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Anatomical modularity 15

- There is evidence within the visual processing system



Functional Specialisation: Zeki (1993, 2001)

V1 & V2 = Initial processing
V3 & V3A = Form processing
V4 = Colour processing
V5/MT = Motion processing

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Anatomical modularity

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- However: there is less support with more complex tasks...
- Despite Ps being required to complete very different complex tasks, the same areas of the brain became active.
 - E.g., Duncan & Owen (2000): Link to research paper: https://librarysearch.uwtsd.ac.uk/permalink/44WHELF_UWTSD/1ir6fgh/cdi-proquest_miscellaneous_72295828
 - Yarkoni et al. (2011): Link to research paper: https://librarysearch.uwtsd.ac.uk/permalink/44WHELF_UWTSD/1ir6fgh/cdi-pubmedcentral_primary_oai_pubmedcentral_nih_gov_3146590

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Theoretical Assumptions Coltheart (2001)

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3. Uniformity of functional architecture:

- Manner in which the mind is structured is the same for all.
- If the architecture of cognitive functioning was different from person to person then findings and implications from neuropsychology would not hold.

E.g., we are all thought to have an area in the brain, known as the fusiform face area, that deals with processing faces (Weiner & Grill-Spector, 2012)



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Theoretical Assumptions Coltheart (2001)

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4. Subtractivity:

- Brain damage can impair module(s) but cannot change or add anything.
 - This is just stuff of comic books and Marvel films!!
- However: there can sometimes be recovery of function..
 - Either in the area of brain damage or through recruitment of different brain regions (Cus et al., 2011).

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Research

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- ▶ Neuropsychological tests are used to measure cognitive ability: e.g., verbal ability, visuospatial awareness, and memory.
- ▶ These aspects of cognition may be sensitive to brain damage
 - ▶ If a person with brain damage performs badly on one of these types of tests.....
 - ▶ then depending where the injury occurred could tell us if that part of the brain is involved in that particular type of cognitive functioning.

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Research

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- ▶ Understanding cognitive functioning through dissociation:
 - ▶ when a patient performs normally on one type of task but is impaired on another –
 - ▶ E.g., amnesiacs perform normally on STM task but are impaired on LTM tasks.
- ▶ However, it doesn't necessarily mean the tasks involve different processing modules.

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Research

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- ▶ Comparing different tasks is an issue –
 - ▶ Maybe one is more difficult than the other and even normal control patients would perform differently on the two types of tasks.
- ▶ Instead look for a **double dissociation**:
 - ▶ When one patient performs normally on task X but is impaired on task Y, while another patient performs normally on task Y, but is impaired on task X.

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Famous case studies: 22

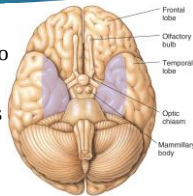
- ▶ **Phineas Gage:** Iron rod went through his face, skull & brain when laying down train tracks.
- ▶ After the accident his personality changed, he lost sense of responsibility & disregarded acceptable social conventions.
- ❖ Damasio (1994) examined his skull and estimated that the iron rod must have produced lesions to the left frontal lobe.
- ❖ Many other studies of frontal cortex damage suggest it produces personality disturbances



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Famous case studies: 23

- ▶ **H.M.:** Had surgery to remove medial temporal lobe on both sides of brain to stop his seizures.
- ▶ This area includes the hippocampus
- ▶ Part of the brain we now know is involved in memory.
- After surgery, seizures were alleviated but he suffered severe anterograde amnesia –
- He was able to converse but could not remember anything that had happened after 1953.



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Strengths of Cognitive Neuropsychology 24

- ▶ Has informed theory of language and reading
 - ▶ Patients show differences in ability to read regular vs. non-regular words
- ▶ Has had a substantial impact on theories of memory
 - ▶ HM's case in particular paved the way for understanding sub-divisions in long-term memory.
- ▶ Can show causal links between brain damage and cognitive performance

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Limitations of Cognitive Neuropsychology

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- ▶ The assumption that the cognitive system is modular might be too strong
 - ▶ Modular systems tend to be inflexible and based on serial processing.
 - ▶ However, we know cognition can be flexible and involve parallel processing.
- ▶ Neuroimaging only provides some support for anatomical modularity
- ▶ Sometimes patients develop compensatory strategies following brain damage, which may not enable full extent of cognitive deficit to be understood.
- ▶ There can be neural plasticity of the brain.
- ▶ Places too much emphasis on single case studies
- ▶ Shows limited interest in details of brain functioning

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Lecture Summary

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- ▶ **Cognitive Neuropsychology capitalises on opportunities to understand normal cognitive functioning through brain-damage patients.**
- ▶ **Assessments of various cognitive abilities are then mapped onto specific regions of the brain.**
- ▶ **It uses the case study approach but is confounded by having no control over the precise area of the brain that is damaged.**

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