Introduction to cognitive neuropsychology: From patient studies to cognitive models.

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La Sapienza – 26/4-2018
Cognitive neuroscience

UNIVERSITY OF COPENHAGEN

Thursday April 26th 14 – 17. Introduction to cognitive neuropsychology: From patient studies to cognitive models.

Task in class: Be prepared to talk for one minute about the cognitive function you find most interesting at the moment.

Suggested readings:

Caramazza, A., & Coltheart, M. (2006) Cognitive neuropsychology twenty years on. *Cognitive Neuropsychology, 23;* 3-12.

Laws, K.R. (2005). Illusions of normality: A methodological critique of category specific naming. *Cortex: 41,* 842-851.

Leff & Starrfelt (2014) *Alexia: Diagnosis, treatment, and theory.* Chap 5. Alexia theory and therapies: A heuristic.

Overview

- Presentation of the teacher and the course
- Presentation of you + your favourite cognitive function
- The foundations of cognitive neuropsychology
  - A bit of not so recent history
  - A bit of more recent history
- Cognitive neuropsychology: The first studies
- Basic principles of cognitive neuropsychology

The teacher

www.psychology.ku.dk/starrlab

StarrLab

StarrLab is a research group working on neuropsychological aspects of visual recognition, with a focus on reading and face recognition. We conduct studies of patients with brain injury (mostly stroke), developmental disorders, as well as experimental studies with normal subjects.

StarrLab is led by Professor Randi Starrfelt.

Research

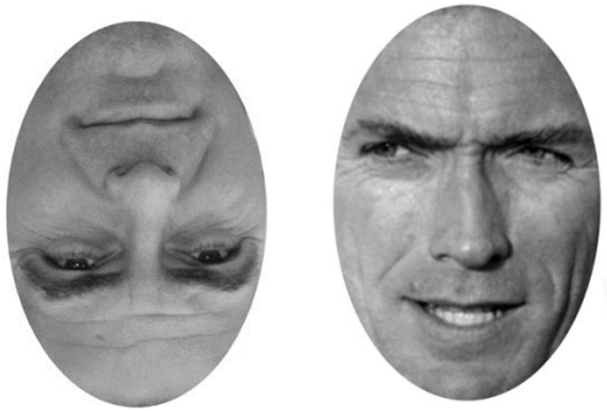
A description of current and previous research projects can be found on the following websites:

- The Back of the Brain Project (BoB)
- Developmental Prosopagnosia
- Previous projects

Our research:

1. Neuropsychological and experimental studies of reading and visual word recognition (problems).

2. Neuropsychological and experimental studies of face recognition (problems).



3. Is there a relation between reading and face recognition?

What does reading and face recognition have in common?

- Based on visual recognition.
- Fast and automatic procesess.
  - (Almost) impossible to study by introspection; We need sensitive experimental paradigms.
- Big difference:
  - Reading is learned by instruction.
  - Face recognition is innate / develops automatically through experience.

Disorders of word and face recogntion

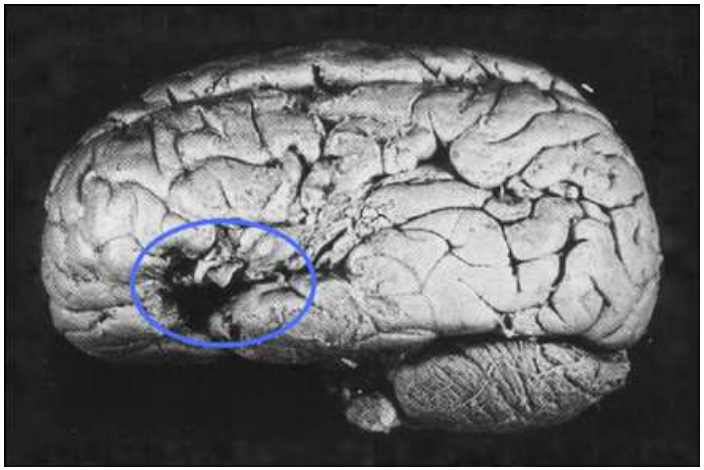
- Developmental dyslexia
- Developmental prosopagnsosia ("face blindness")

- Acquired dyslexia (alexia)
- Acquired propsopagnosia

The foundations of cognitive neuropsychology

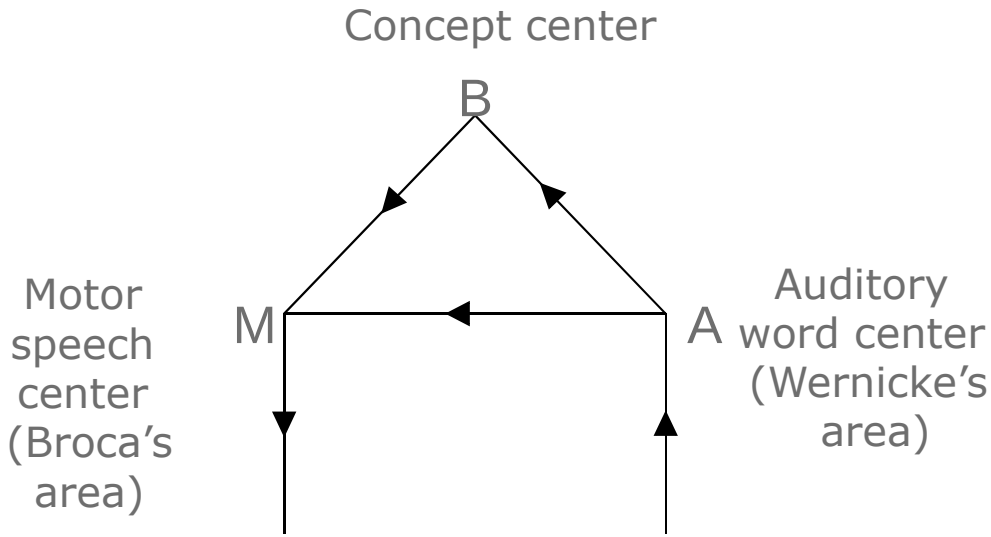
Broca (1861; 1865)

"We speak with the left hemisphere"



Wernicke (1874)

Reports patients with loss of speech comprehension



The Wernicke-Lichtheim model

Another early "cognitive neuropsychologist"

Dejerine (1892): Presented Monsieur C. A patient with reading deficits without writing or language deficits.

Joseph Jules Dejerine (1849-1917)

In Engish:

Bub, D. N., Arguin, M., & Lecours, A. R. (1993). Jules Dejerine and his interpretation of pure alexia. *Brain and Language,* 45, 531-559.

An early clinico-anatomical description

Dejerine (1892): Monsieur C. *Alexia without agraphia*

A later stroke left the patient unable to write as well: *Alexia with agraphia*

Second lesion

First lesion

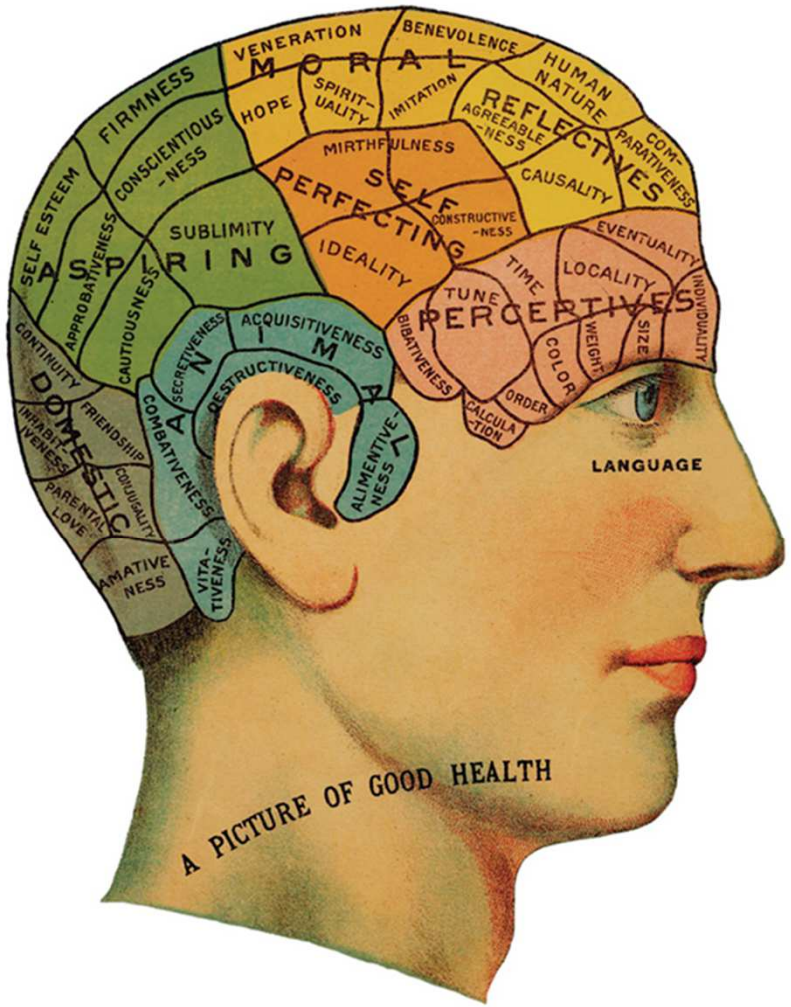
Definitions

- Alexia: Impairment in reading in *previously literate adults* following brain injury or disease.
- Agraphia: Impariment in writing in *previously literate adults* following brain injury or disease.
- Different from dyslexia and dysgraphia, that refer to developmental disorders in the absence of brain injury.

The diagram makers in context

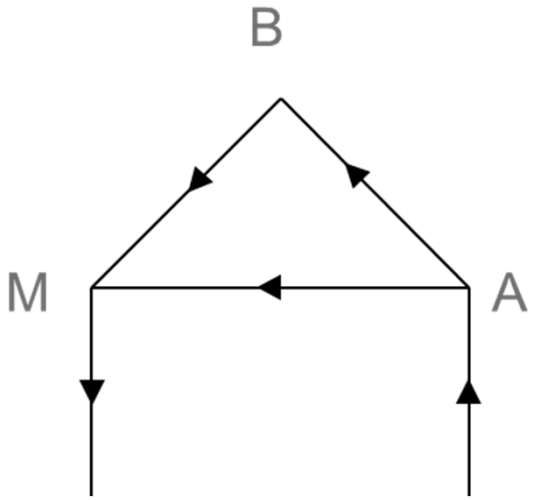
- The dominating theory before Broca's presentation was that the brain was an udifferentiated whole:
- Equipotentiality: "The apparent capacity of any intact part of a functional brain to carry out… the [memory] functions which are lost by the destruction of [other parts]". *Karl Lashley*
- In contrast, Broca suggested that *cerebral localisation* of function was possible.
- His findings were revolutionary (but many did not accept them at the time).

Many thought the diagram makers were just a new form of "phrenology"



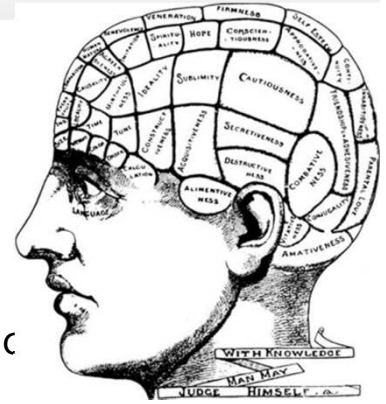
Mary Evans Picture Library/Image Works.

- And they weren't all wrong…
- But the key objective for the diagram makers was to make models of cognition, not to localise functions in the brain.



Phrenology – cerebral localisation

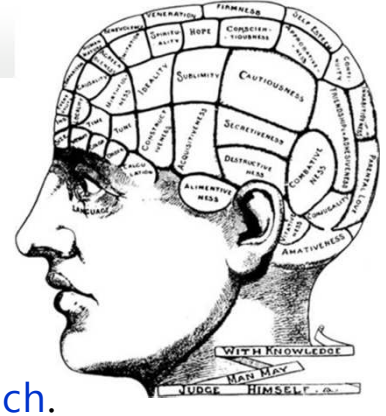
Gall, Spurzheim: ca. 1800-1840



27 abilities

1. The instinct of reproduction (located in the cerebellum).
2. The love of one's offspring.
3. Affection and friendship.
4. The instinct of self-defence and courage
5. The carnivorous instinct; the tendency to murder.
6. Guile; acuteness; cleverness.
7. The feeling of property; the tendency to steal.
8. Pride; arrogance; haughtiness; love of authority; loftiness.
9. Vanity; ambition; love of glory
10. Circumspection; forethought.
11. The memory of things; facts; educability; perfectibility.
12. The sense of places; of space proportions.
13. The memory of people; the sense of people.
14. The memory of words.
15. The sense of language; of speec
16. The sense of colours.
17. The sense of sounds; the gift of music.
18. The sense of connectedness between numbers.
19. The sense of mechanics, of construction;
20. Comparative sagacity.
21. The sense of metaphysics.
22. The sense of satire; the sense of witticism.
23. The poetical talent.
24. Kindness; compassion; sensitivity; moral sense.
25. The faculty to imitate; the mimic.
26. The organ of religion.
27. The firmness of purpose; perseverance; obstinacy.

Phrenology – cerebral localisation



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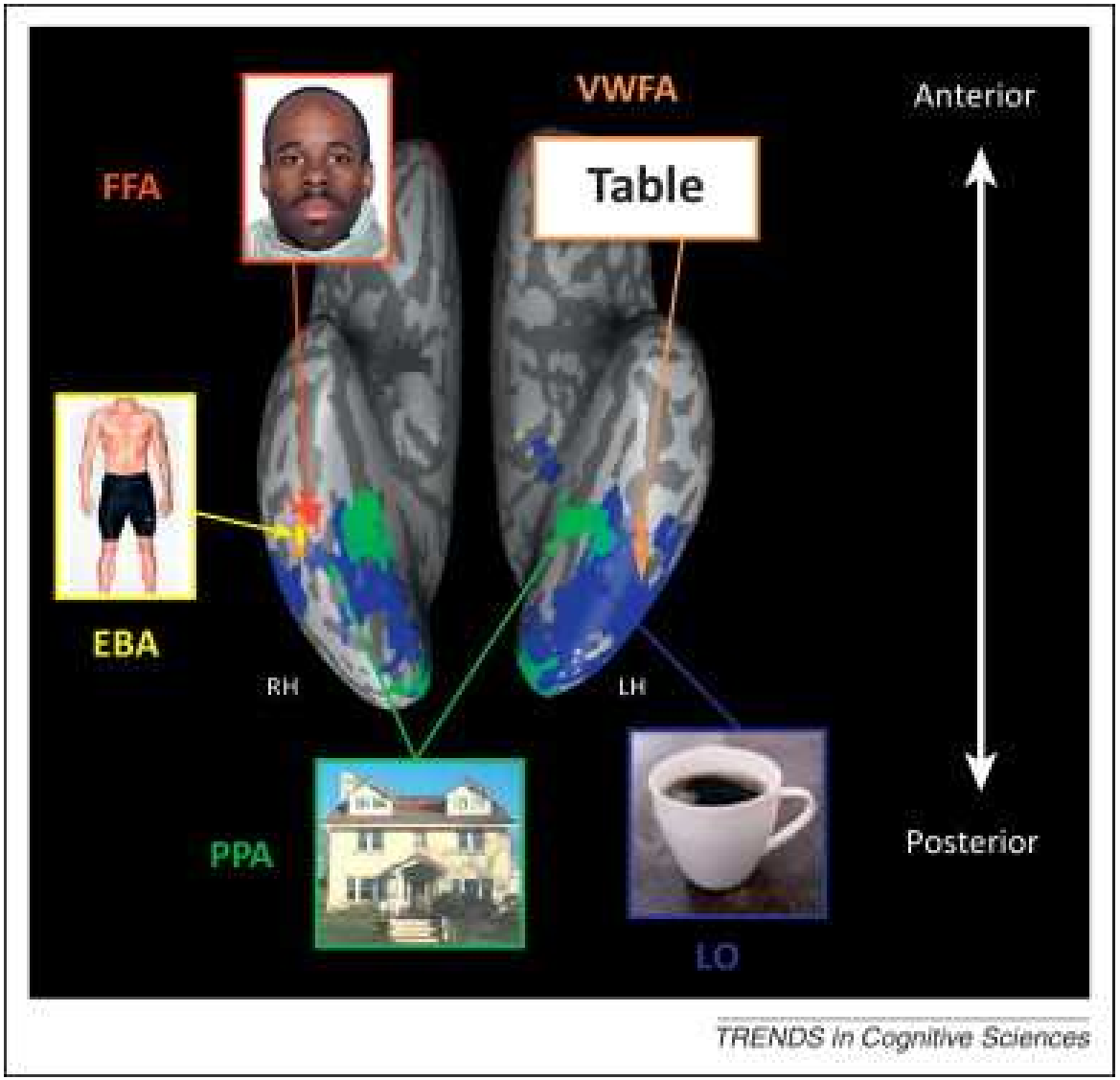
Is modern cognitive neuroscience much different?



Behrmann & Plaut, TICS 2013

The question of cerebral localisation

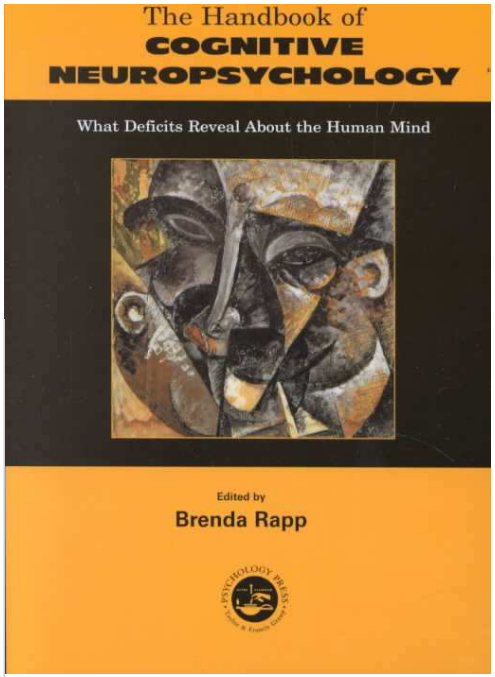
- Is still relevant
- Still highly debated (though framed differently)

- Is not (necessarily) relevant for cogntive neuropsychology…

Cognitive neuropsychology - A rough historical sketch

- Late 1800's: Broca, Wernicke, Lichtheim, Dejerine
- Early 1900's: critisism of the case method. Very few studies.
- [Behaviorism]
- 1945-1970 (and later): Group studies – averaging
- Late 1950's-1960's: "The Cognitive Revolution" (Broadbent, Chomsky, Miller)
- Late 1960's, early 1970's: Cognitive neuropsychology:
  - 1960's: Norman Geschwind reintroduces the diagram makers in a series of papers.
  - Warrington : Experimental / psychophysical measures in brain injured patients. (e.g., simultanagnosia, alexia)
  - Marshall & Newcombe (1966, 1973) The cognitive neuropsychology of reading.
  - Deep dyslexia meeting 1977

Recommended historical reading



2

A Historical Overview of Contributions From the Study of Deficits

Ola A. Selnes

INTRODUCTION

The history of our attempts to understand how the brain gives rise to mental activity can be divided into three major periods. During classical antiquity, the emphasis was not on specific cognitive functions but rather on the question of the localization of the soul (Cassano, 1996). The medieval period saw the development of a three-part model of cognition and was dominated by the ventricular localization theory (Schiller, 1997). The modern era of cortical localization is often considered to have begun with the work of Paul Broca (1861, 1863), but there were of course many antecedents to his discovery.[1]

Cognitive neuropsychology

- Is considered a branch of cognitive psychology (not neuropsychology or neuroscience).
- Key interest in understanding the normal cognitive system.
- Study of patients is "just a method" for doing this.

" The functional analysis of patients with selective deficits provides a very clear window through which one can observe the organisation and procedures of normal cognition. ***No account of "how the brain works" would even approach completeness without this level of analysis****."*
(McCarthy & Warrington, Cognitive neuropsychology, a clinical approach, 1990)

- Not interested in localisation in the brain; when cognitive neuro-psychologists talk about localisation they typically refer to a module or part of the cognitive system.

Cognitive neuropsychology

- Some clinical applications described (e.g. PALPA) – but this is not the goal.
- Cognitive and clinical neuropsychology are quite separate diciplines.

Cognitive neuropsychology vs cognitive neuroscience

- Branch of cognitive psychology / cognitive science.
- Interest in behavior / performance, not underlying anatomy.
- Localisation within cognitive models not brains.

- Branch of neuroscience
- Interest in brain-behavior correlations; functional brain organisation, localisation of functions (focal or network)

The data used in cognitive neuropsychology are the patterns of performance produced by brain-damaged subjects. Because the basic data used in cognitive neuropsychology are the result of a biological manipulation - a brain lesion - these data will be directly relevant to claims about the functional organization of the brain.
Hence cognitive neuropsychology may also be considered to be a branch of cognitive neuroscience. However, (...) there is considerable variation in the specific weight given by any one investigator to the cognitive or the neural part of the brain/cognition equation

Caramazza, 1992

Cognitive neuropsychology assumptions

- Aim: To create models of normal cognition.
- Studies of brain injured patients cognitive deficits (and intact abilites) is the empirical foundation:
- The subtraction hypothesis: Behavior of brain injured patient(s) = normal cognitive system ÷ specific function(s)
- Universality assumption: All healthy cognitive systems are the same.

Discussion

The universality assumption (Caramazza & Coltheart, 2006):

"there is no qualitative variation across neurologically intact people in the architecture of the cognitive system that these people use to perform in a certain cognitive domain.

This allows us to infer that, although patient X and patient Y currently have very different systems as a consequence of their brain damage, they had the same system premorbidly, and it is about that system that we want to make inferences from studying patients X and Y."

How likely do you find this assumption?

Try to come up with one argument for and one against it.

Cognitive neuropsychology - the functional architecture

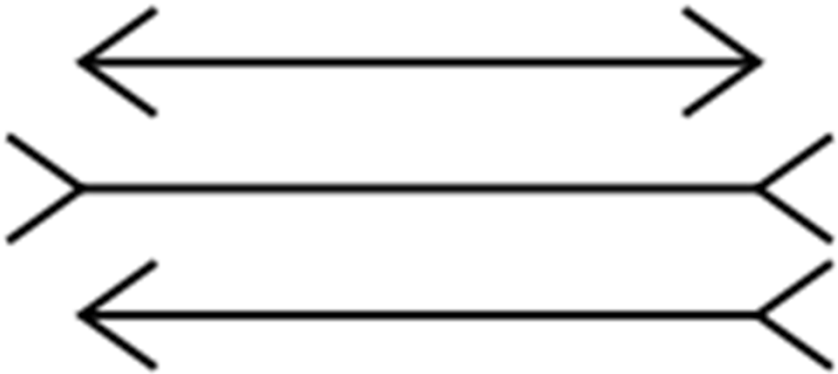
- Cognitive models describe the functional architecture of a given cognitive function: Schematic drawings of "box-and-arrow models", representing psychological components and processes.

- These components are **modules:** Specialised information processing components.

- Module = "storage of knowledge" or "processes working on this knowledge".

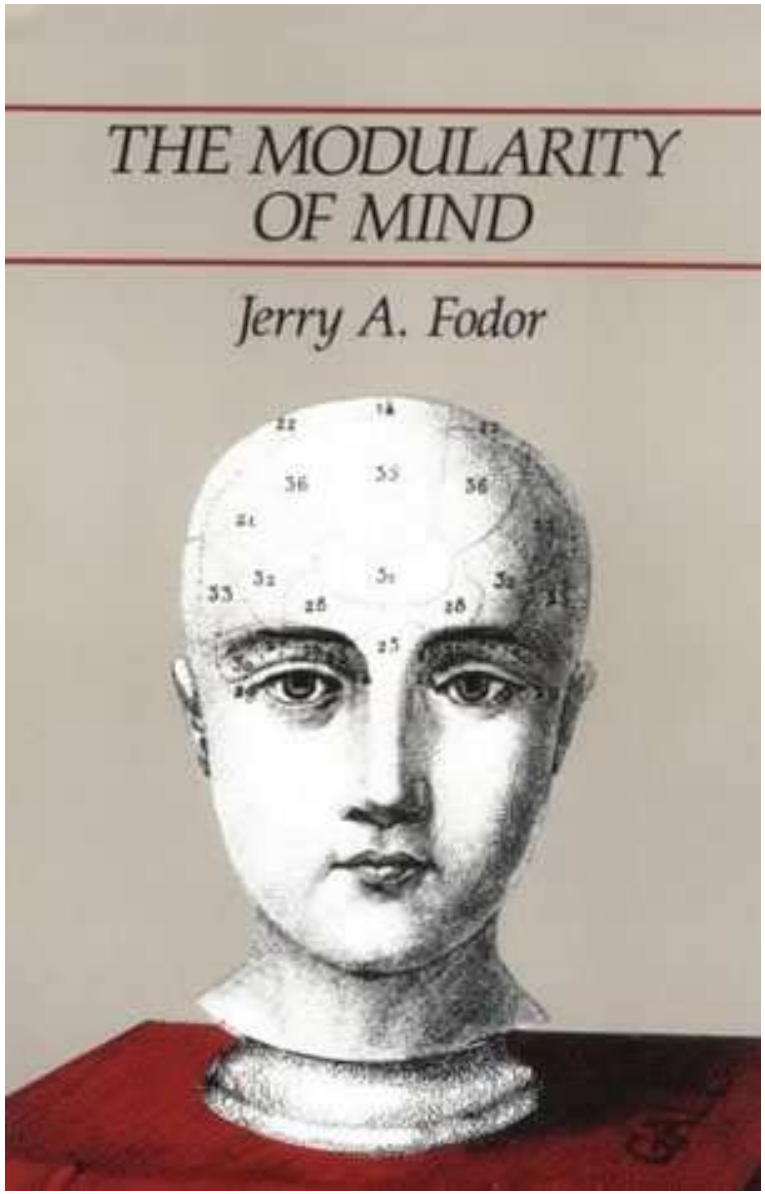
- Information may be exchanged between modules, but with modules processing is independent of other modules/other types of processing. This is why modules can be selectively impaired.

- Modular processing is unconcious, and thus relatively unaffected of higher order processing (free will, logical thought).



Modularity

- Fodor (1983)
- Provides criteria for what may consitute a module (e.g., domain specificity, information encapsulation, developmental trajectory)
- Only basic / lower cognitive processes considered modular (e.g. perception)
- Higher cognitive functions (e.g. problem solving, exectuive functions) not considered modular.



From neuropsychology to mental structure

Cognitive neuropsychology analyses relations between deficits, looking for:

- Single dissociations (Task A impaired, Task B preserved)
- Double dissociations (Two patients with opposite performance on Task A and Task B)

I.e.:

- Patient 1: Reading is impaired, writing spared = single dissociation
- Patient 2: Writing is impaired, reading spared = single dissociation

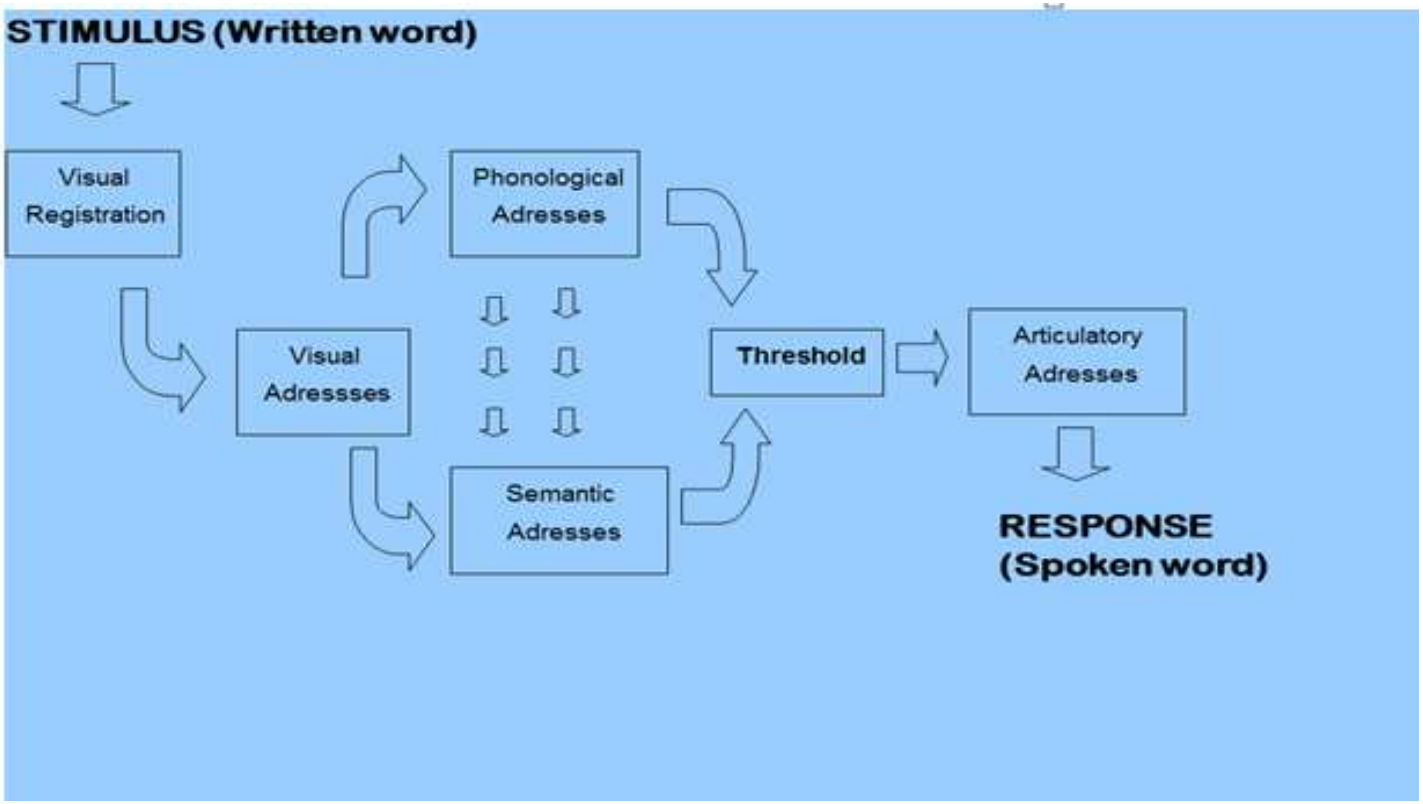
- Patient 1 + patient 2 = double dissociation: taken as evidence that the two processes are *functionally independen.*

Patterns of paralexia – the seminal study

- Marshall & Newcombe (1973):
  - One should study the *errors* patients with alexia commit, and classify the alexias according to patterns of error.
  - Create model of reading on this basis

  - = The cognitive neuropsychology of reading.

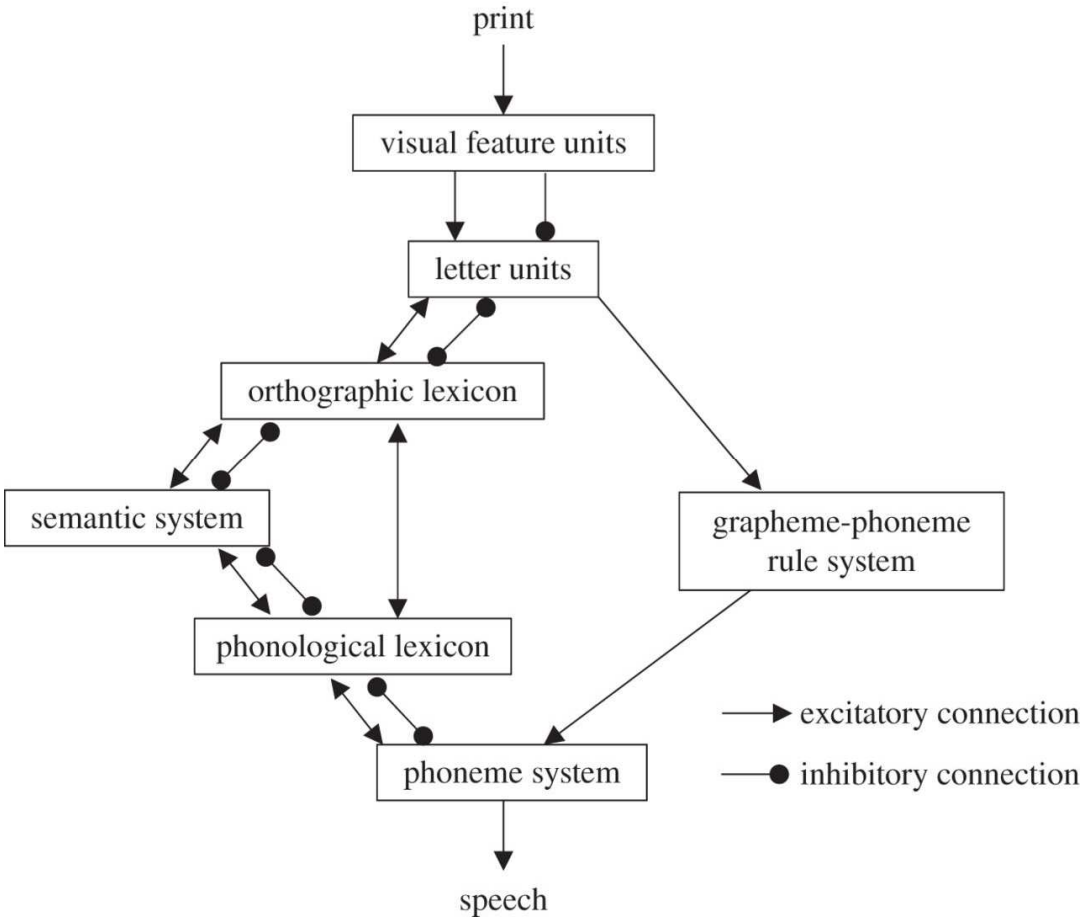
Marshall and Newcombe's model of reading

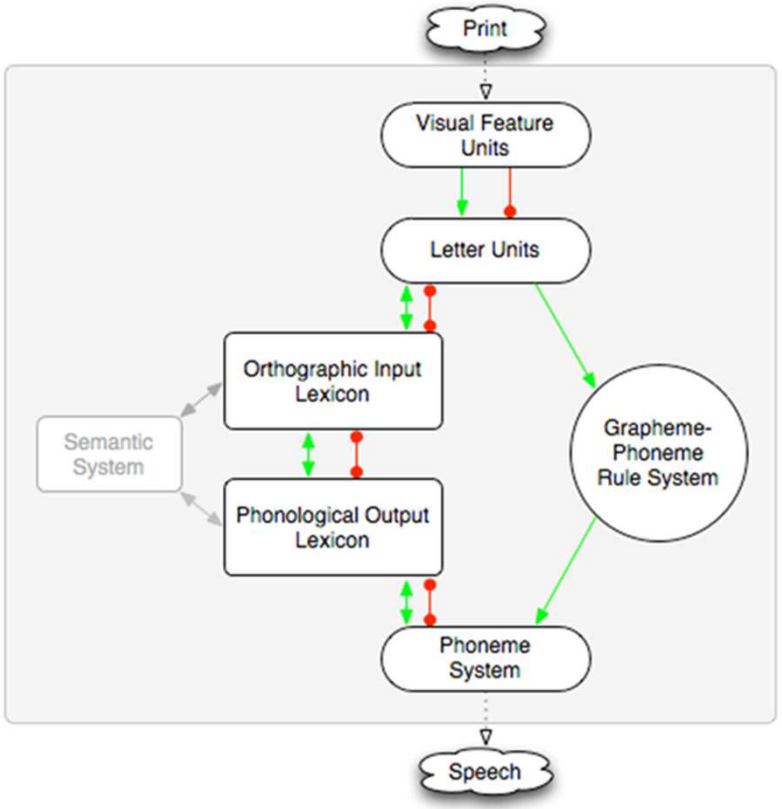


This model was based on 6 patients

- 2 with mainly visual errors (visual alexia)
- 2 with mainly regularisation errors (surface dyslexia)
- 2 with severe deficits and mixed errors (deep dyslexia)

Further developments led to:
Dual route cascaded model of reading



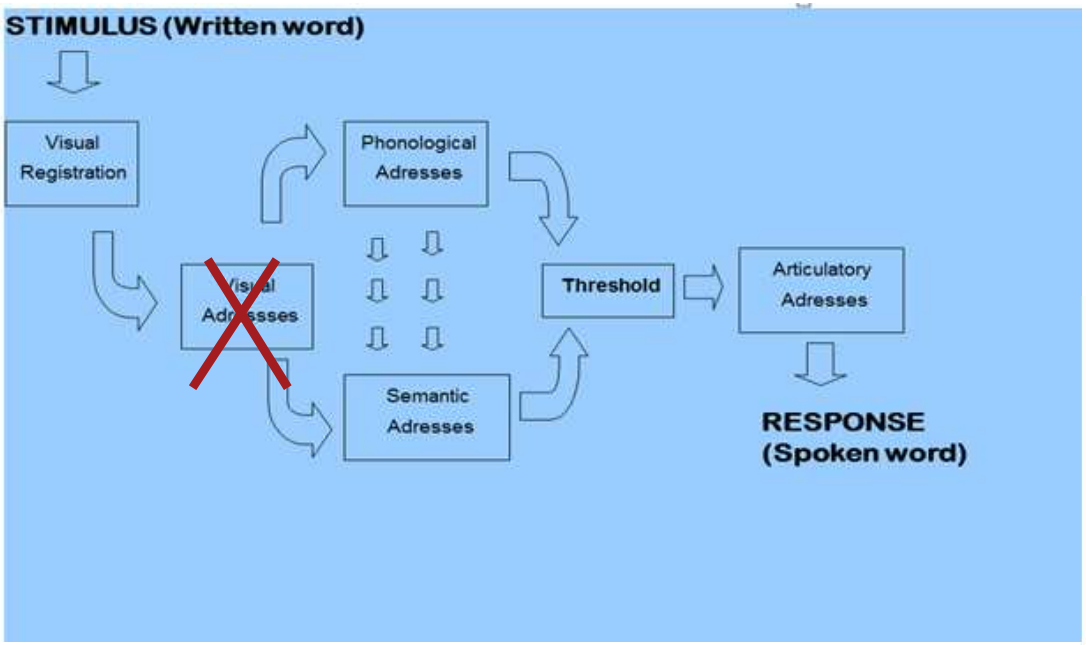


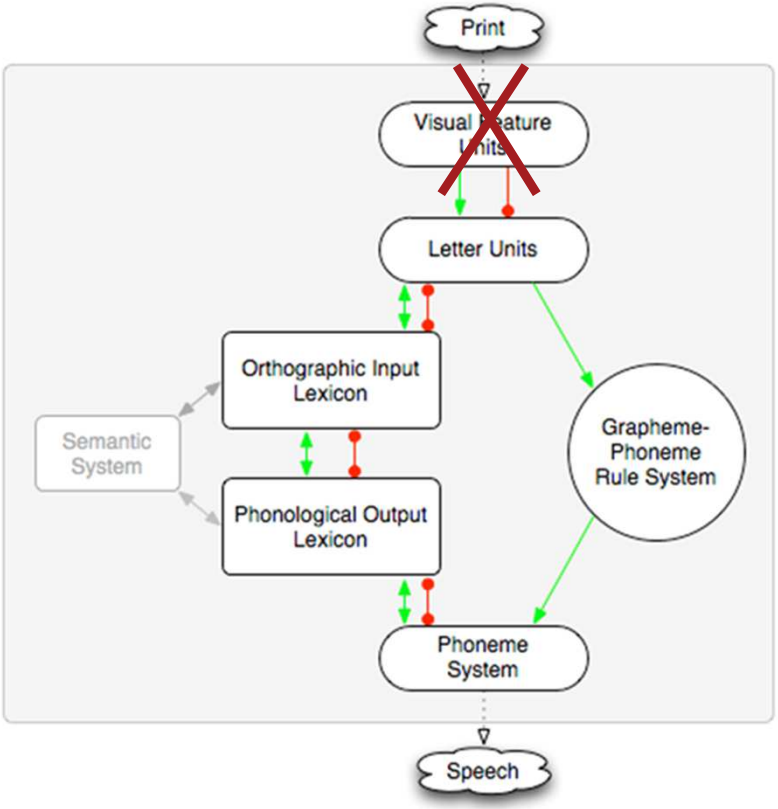
Coltheart et al., 1993; 2001

Visual alexia

- Patients made visual errors (e.g., misidentifications)
- Read correctly as long as they could see the letters correctly
- This indicates that there is a (separate) visual processing stage in reading.

Visual alexia - localisation

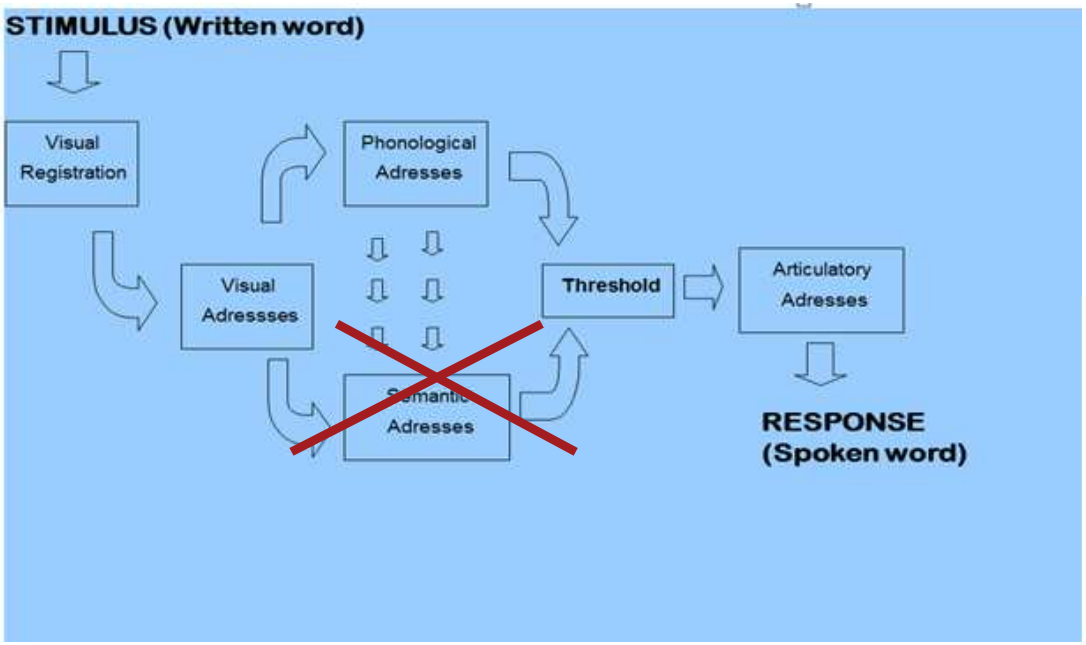


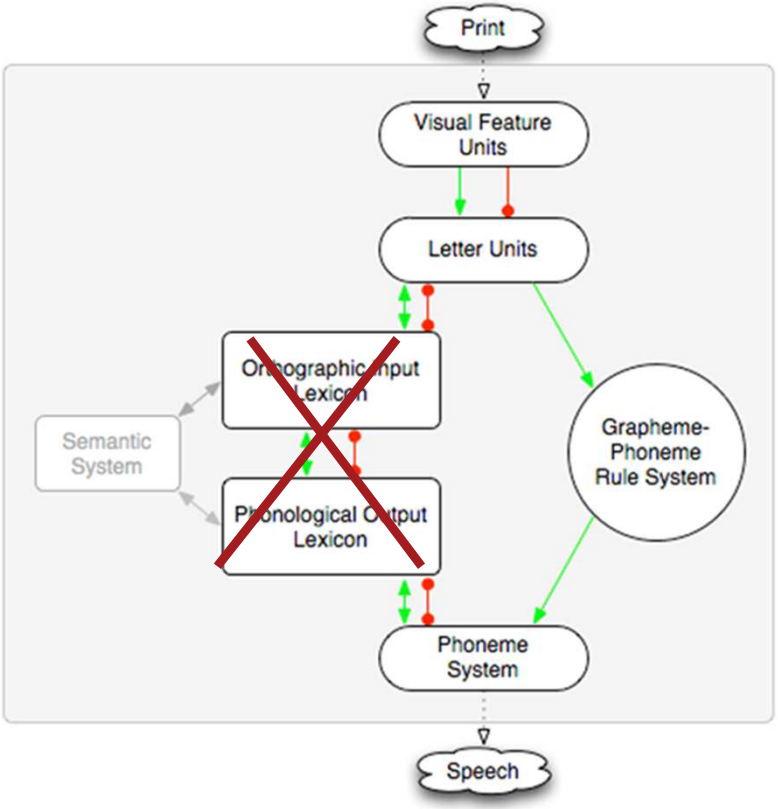


Surface alexia

- Evident when patients read *irregular words* (e.g., *PINT*); regularisation errors.
- Read familiar words as if they do not know them: rely on *grapheme-phoneme conversion*
- I.e. Cannot access semantics from written words (read via the semantic route)
- This suggests that there are separate routes for semantic and letter-sound conversion reading.

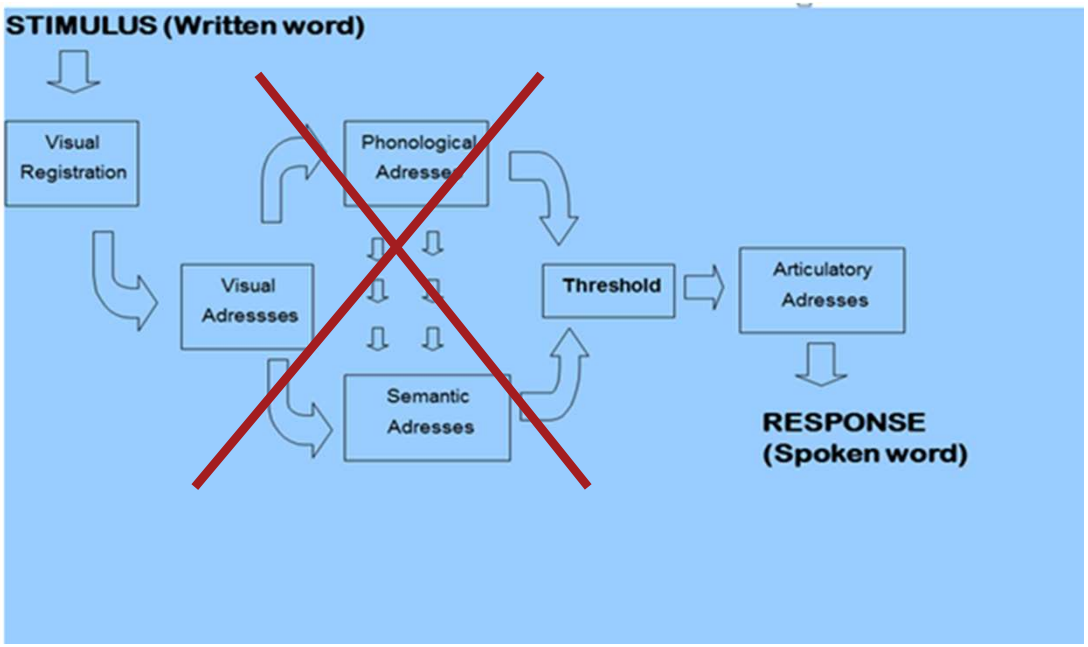
Surface alexia - localisation

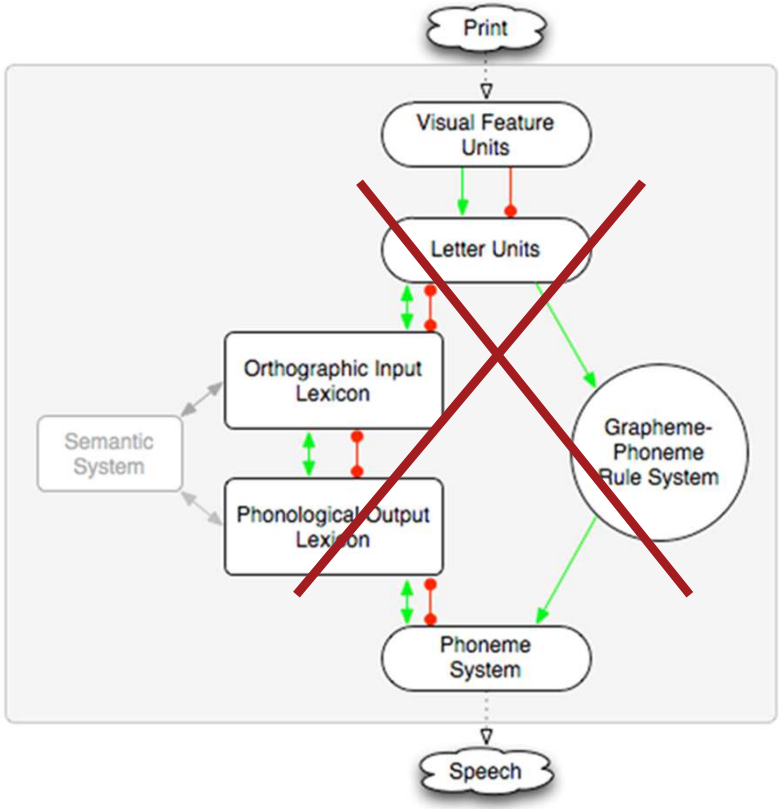




Deep dyslexia

- Key feature: semantic errors, also many other types.
- Patients typically have severe aphasia.





'Twas brillig, and the slithy toves

Did gyre and gimble in the wabe:

All mimsy were the borogroves,

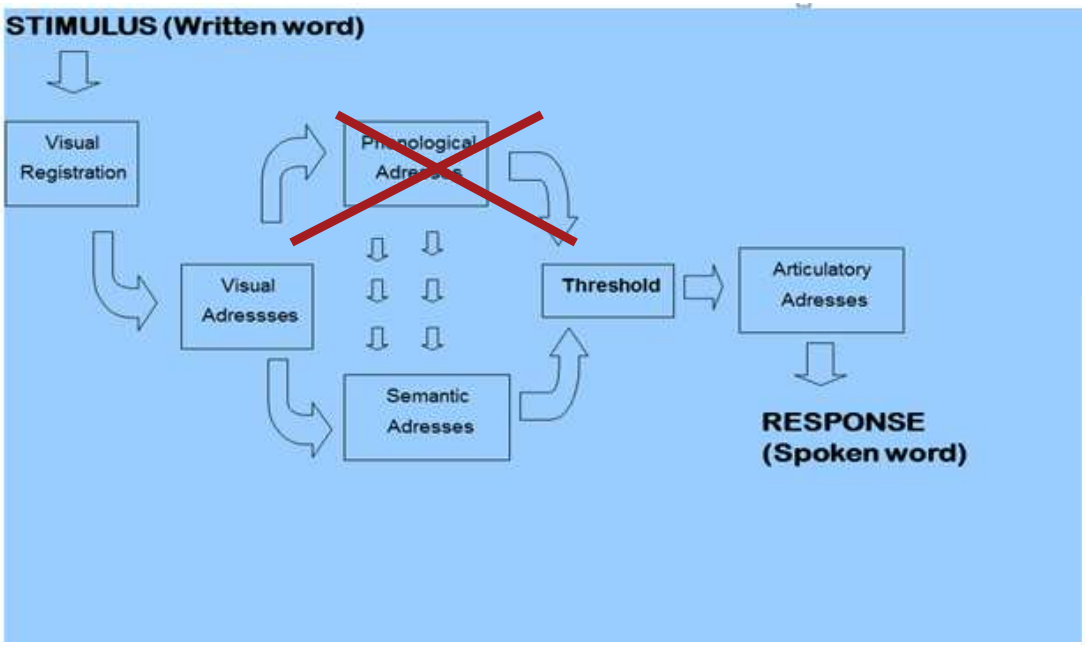
And the mome raths outgrabe.

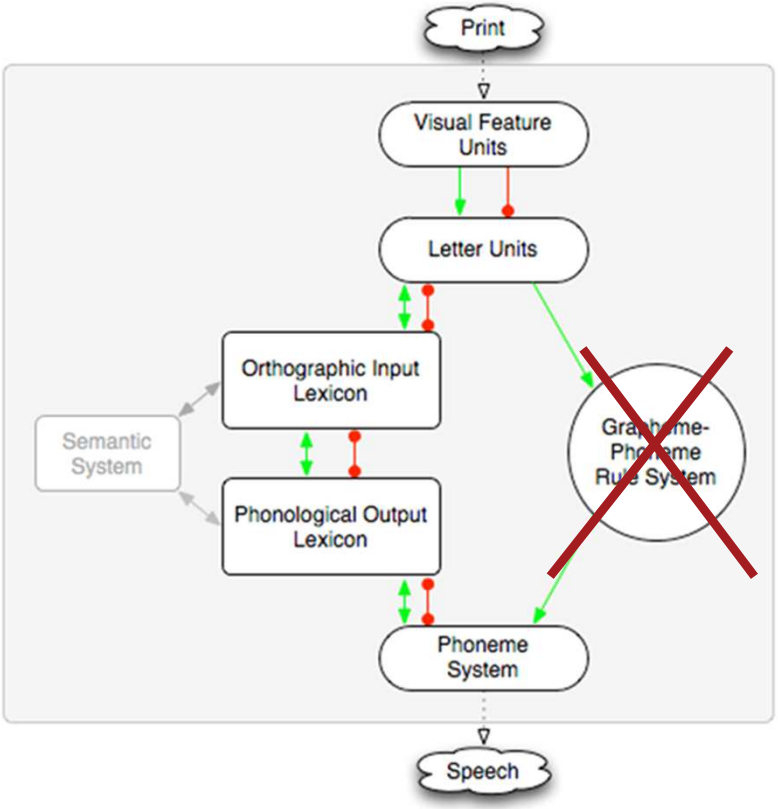
Lewis Carrol, *Through the Looking Glass* , 1872.

Phonological alexia

- Discovered because the model predicts its existence.
- Patients have problems in reading novel words and non-words.
- Cannot read via grapheme-phoneme conversion, must rely on semantic route (that has no entry for unfamiliar words)

Phonological alexia - localisation





Double dissociation

- Surface and phonological alexia make up a double dissociation:

	Semantic reading	**Grapheme - phoneme**
Surface alexia	impaired	preserved
Phonological alexia	preserved	impaired

Exercise

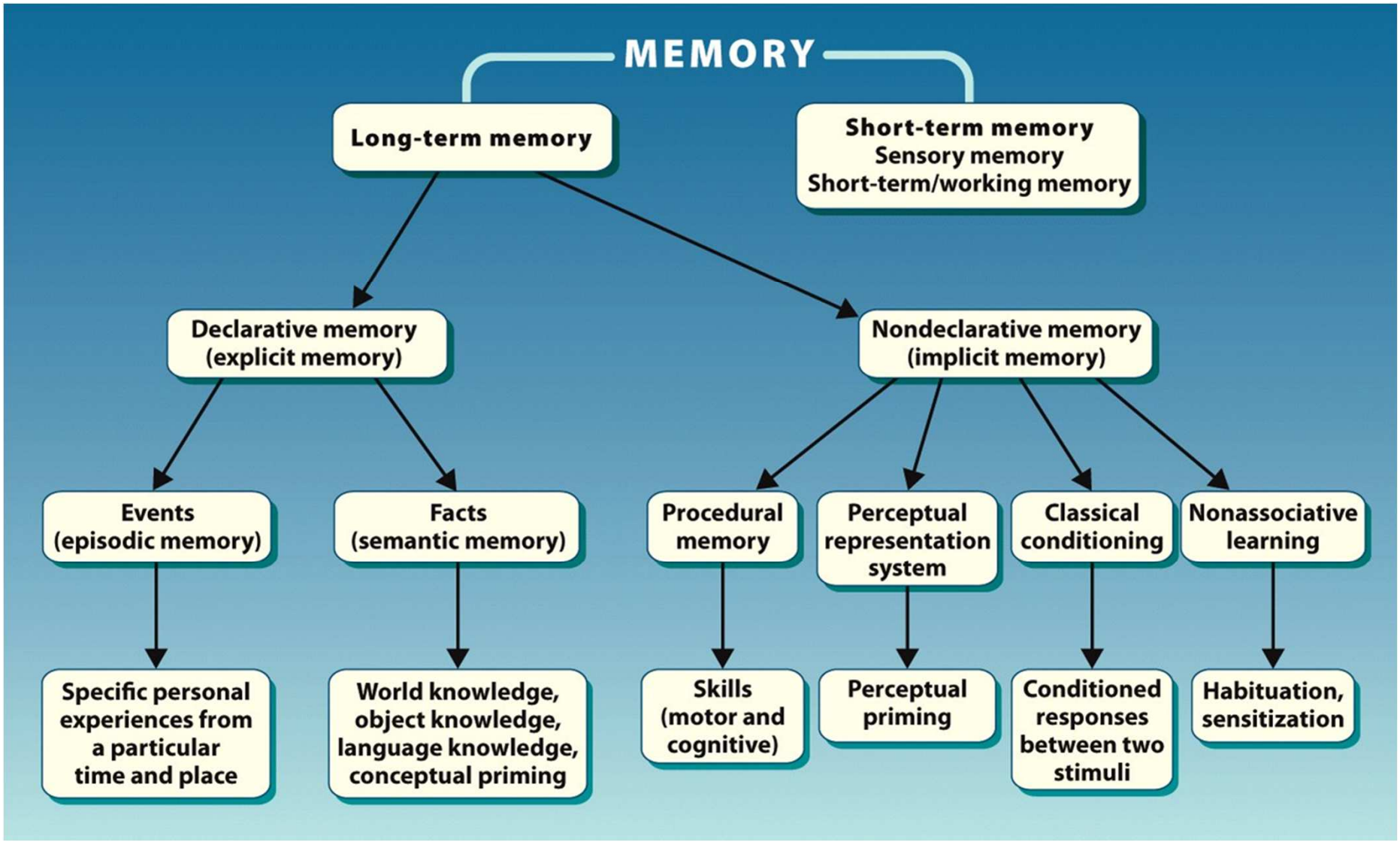
- Discuss with the person next to you:
- Can you come up with one or more examples of dissociations between cognitive functions?
- Can you come up with a classical /textbook example of dissociation

- These can be either within your favourite cognitive domain or within another system (e.g., within the language, vision, or memory domain?)

Examples of commonly accepted dissociations

- The memory systems
- Dorsal and ventral stream in vision

Memory systems – all based on dissocations / selective deficits



Eksplicit / Declarative

Word list learning

Car

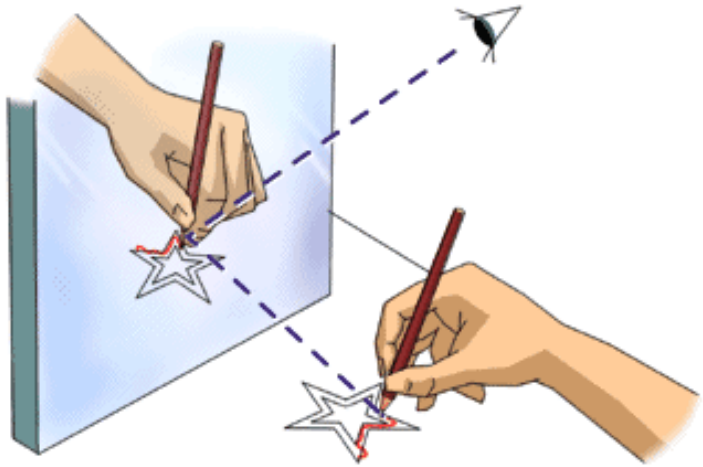
House

Dog

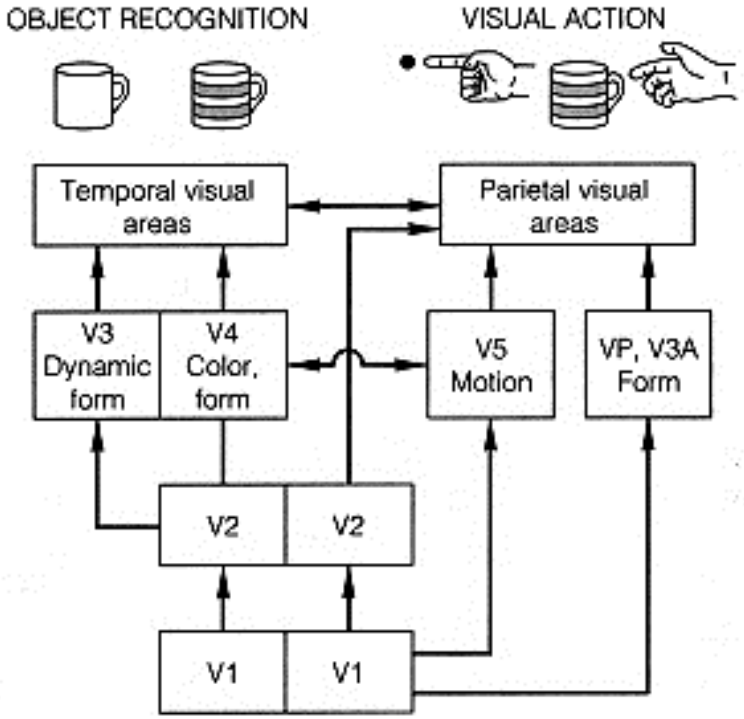
Lamp

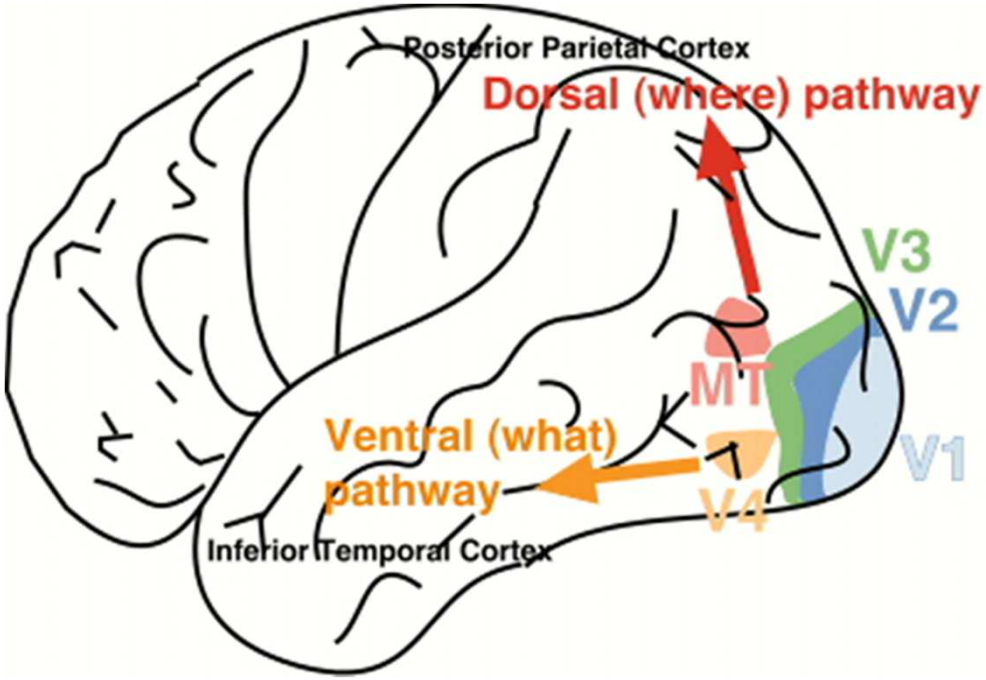
Implicit / Procedural

Mirror drawing



Visual perception – ventral and dorsal stream





More on dissociations

Some established dissociations are supported by double dissociations (e.g., implicit / explicit memory; semantic / episodic memory).

In many cases, however, the dissociation only goes one way.

- Because one task is harder than another?
- Because of normal processing differences?
- Because one function is localized / modular and the other is not?

Important: The aim is to support the claim that the same pattern of performance ("dissociation") observed in the patient can not be observed in the normal population.

A step back: Types of single dissociations (Shallice, 1988)

1) Trend dissociation: Task I is performed ***markedly*** better than Task II.
   - No control group reference.

2) Strong dissociation: Neither task is performed at a normal level, but task I is performed ***very much better*** than task II.
   - Control group reference, or normals "expected to perform at ceiling level".

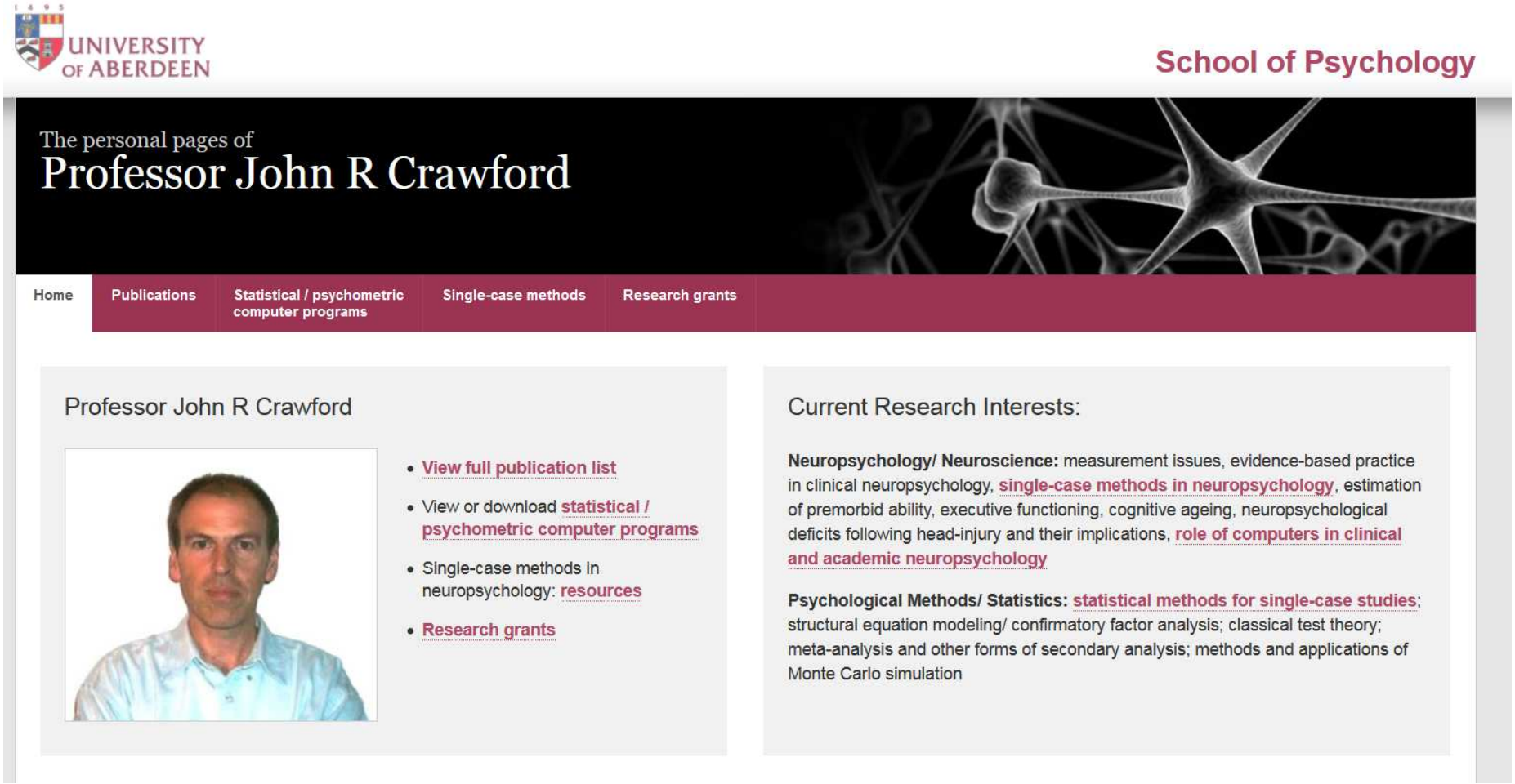
3) Classical dissociation: Task I is performed ***normally*** (compared to controls), performance on task II is impaired.

Quantitative / statistical criteria for 2) and 3) established by Crawford et al., e.g.,:

Crawford, J. R., Garthwaite, P. H. & Gray, C. D. (2003). Wanted: Fully operational definitions of dissociations in single-case studies. *Cortex, 39,* 357-370.

Resources

http://homepages.abdn.ac.uk/j.crawford/pages/dept/index.html



Why are control groups so important?

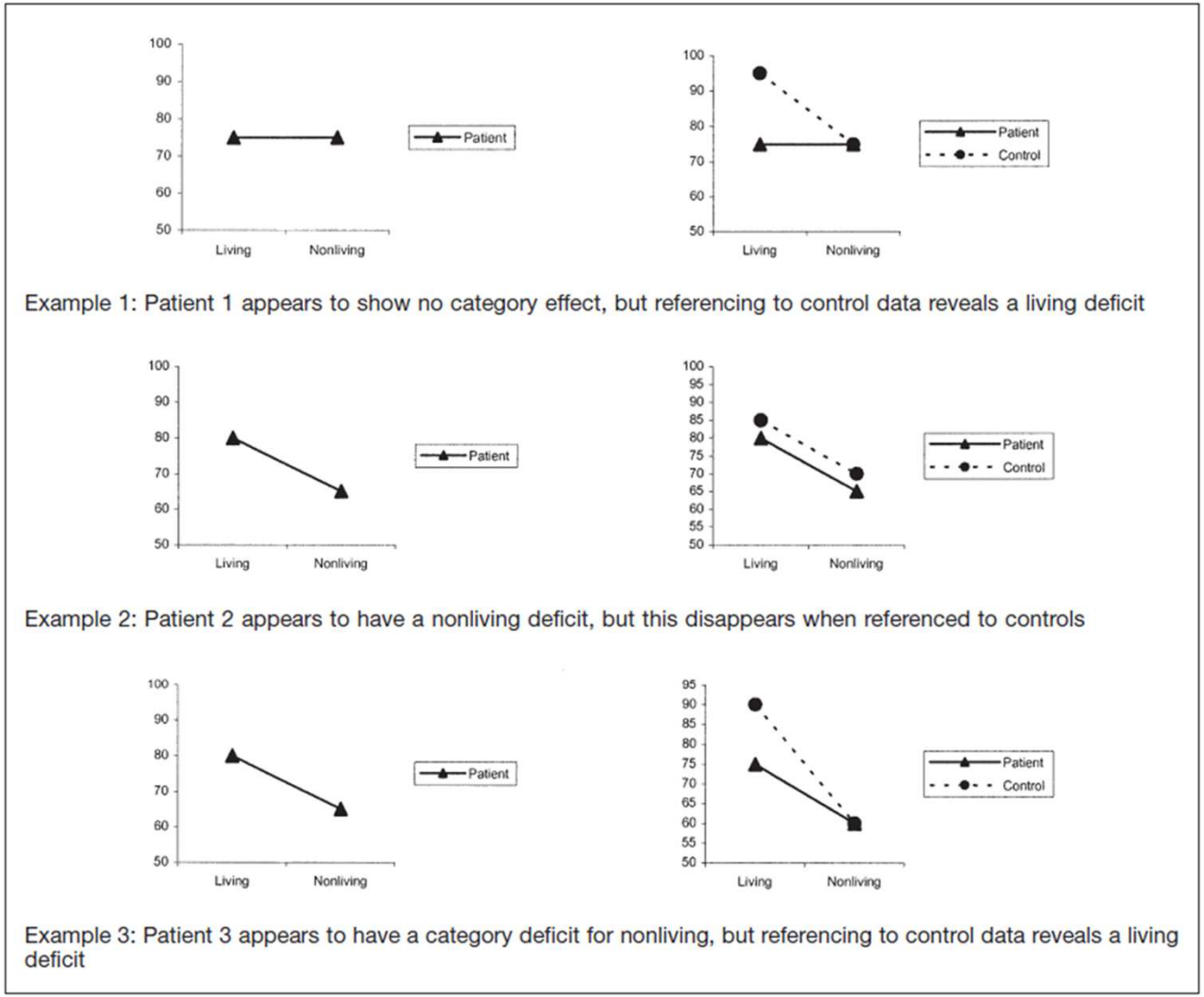


Fig. 1 – *Hypothetical examples showing how a lack of control data could distort the interpretation of category effects.*

Laws (2005)
Cortex

Next up:

Thursday May 3rd 12 – 15: The evolution of cognitive neuropsychology. Examples from patient studies of reading disorders.

Suggested readings:

Starrfelt, R. (2007). Selective alexia and agraphia sparing numbers-a case study. *Brain and Language, 102*, 52-63.

Starrfelt, R., Habekost, T., & Gerlach, C. (2010). Visual processing in pure alexia: A case study. *Cortex, 46*, 242-255.

Starrfelt, R., Habekost, T., & Leff, A. P. (2009). Too little, too late: reduced visual span and speed characterize pure alexia. *Cerebral Cortex, 19*, 2880-2890.

Starrfelt, R., & Behrmann, M. (2011). Number reading in pure alexia—A review. *Neuropsychologia, 49*(9), 2283-2298.

+ the reading for today if you didn't read them already:

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