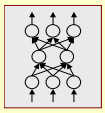
Connectionist Models of Language Deficits



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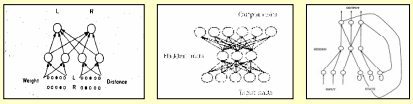
Overview

- **Part One:** Connectionism
  - Principles
  - Properties
  - What are connectionist models…really?!!
- **Part Two:** Models
  - Specific Language Impairment (SLI)
  - Deep Dyslexia
- Take home message

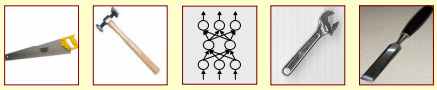
Part One: Connectionism



Models

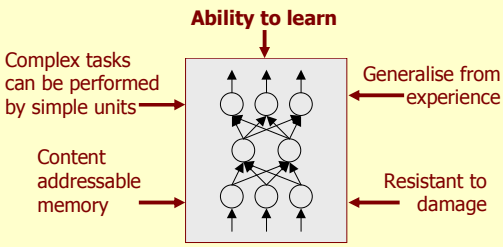
- Analogous simplified systems
- Many different types
- More manipulable than target system
- Improve our understanding

Models as Tools

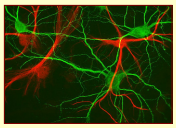


- Parameterise, develop, and test theories
- Try to explain *why*
- Controlled means of testing
- Compare with empirical data
- Generate predictions

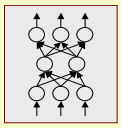
Properties of Connectionist Models



Where's the Knowledge?



Hippocampal neurons
(with glial cells shown in red)



Representation of a connectionist network

- neurons = *units*
- connections = *weights*

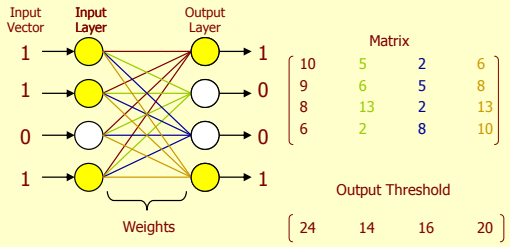
Knowledge is stored in the weights and is acquired through learning

What ARE connectionist models?

What do they look like?

How do they work?

A Simple Connectionist Model



Matrix

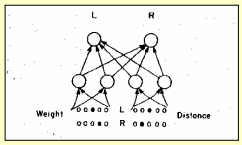
10	5	2	6
9	6	5	8
8	13	2	13
6	2	8	10

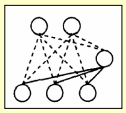
Output Threshold

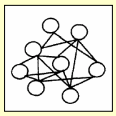
24	14	16	20

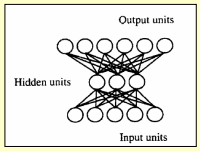
Models learn by updating their weights

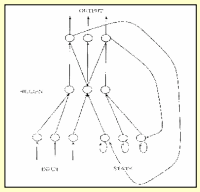
Connectionist models come in all sorts of shapes and sizes ...





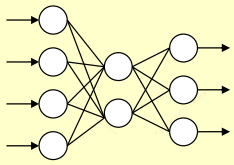


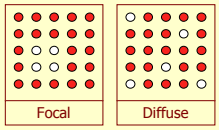




Creating Deficits

- "Lesioning"
- Degrading the signal
- Removal of **connections** or **units**

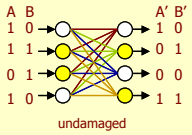




- You can also...
  - Add noise
  - Change processing unit discriminability

The Effect of Damage

Dissociations in a distributed memory (Wood, 1977)



undamaged

Output Threshold

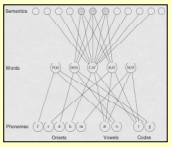
24	14	16	20

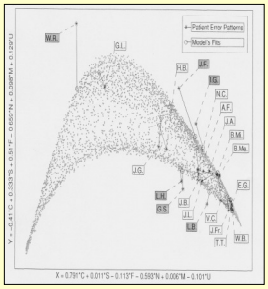
Matrix

1	5	2	6
9	6	5	4
8	13	2	6
6	2	8	10

Matching model performance to patient data

Dell et al. (1997)





"lesion" the model to match patient data

How should we model disorders?

- Remember connectionist models **learn**

Acquired disorders: end (or towards end) of learning

Developmental disorders: damage during learning

End of Part One
Questions?

Part Two: Models of Language Deficits

Specific Language Impairment

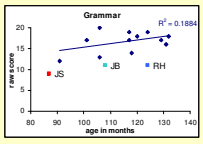
Deep dyslexia

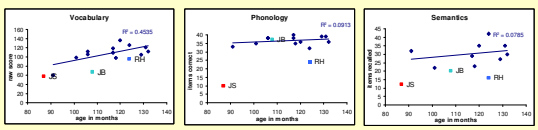
1. Models of Specific Language Impairment

About SLI

SLI is defined as a **developmental disorder of language** that occurs in the **absence** of any **cognitive impairment**

- **Expressive** and **receptive** language difficulties, particularly in the acquisition of **grammar**
- May also exhibit poor **semantic knowledge**, vocabulary and **phonological skills**





- Deficit in regular inflection in SLI and frequency effects for regular verbs

The English Past Tense

A "quasi-regular" domain

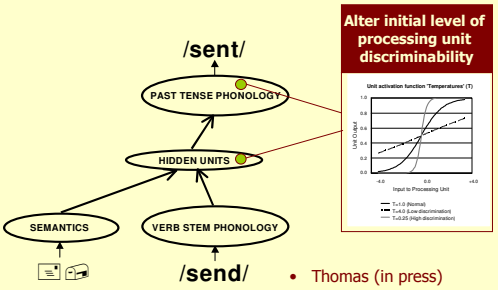
Regular: **TALK - TALKED**

Irregular: **THINK - THOUGHT, HIT - HIT**

Rule: **WUG - WUGGED**

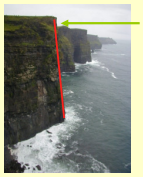
  - Ullman and Pierpoint (2006): developmental deficit to a system **specialised** for grammar (procedural memory system)
  - Thomas (in press): same data can arise from a deficit to a processing resource **common** to regulars and irregulars

The Model



- Thomas (in press)
- Thomas and Karmiloff-Smith (2003)

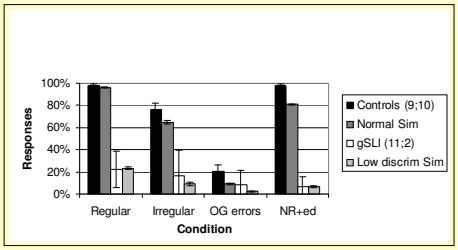
Transfer functions and category boundaries



Cliffs – sharp category boundary, good for rule-like distinctions

Slopes – broad category boundary, good for fine-grained distinctions

The Data

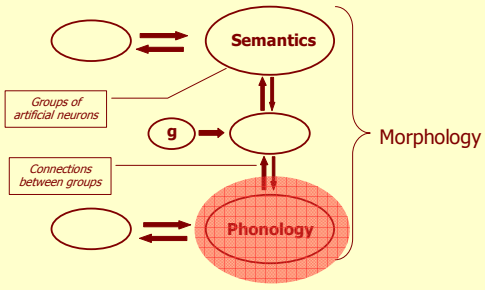


Thomas (in press)

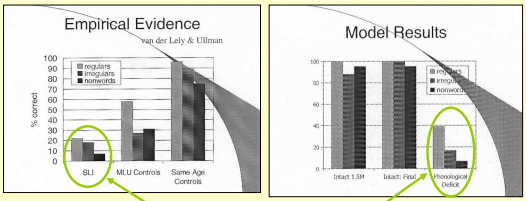
Multiple causality of developmental deficits

- Joanisse (2000): SLI pattern can be produced by another developmental manipulation
  - Poor speech perception affects the use of phonological information in working memory, which in turn leads to poor syntactic comprehension
- Domain-specific (phonological) deficit

The Model



The Data



matching pattern

Implications

- Developmental dissociations may emerge from alterations to domain-relevant properties of shared resources
- Similar deficits can be produced by both domain-general deficit and domain-specific deficit (though specific for phonology, not regulars)

2. A Model of Deep Dyslexia

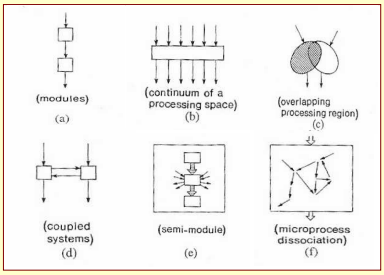
Dissociations and modularity

- Shallice (1988, p248):
- *"If modules exist then…double dissociations are a relatively reliable way of uncovering them. Double dissociations exist, therefore modules exist"*

but…

Delusions about dissociations…?

- Shallice describes a number of non-modular systems that could produce DDs.



Modules…?

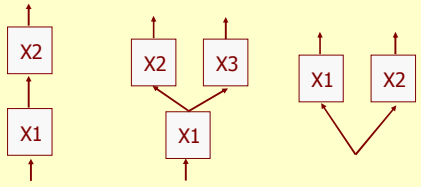
- Shallice (1988, p249):
- *"the idea that the existence of a double dissociation necessarily implies that the overall system has separate subcomponents can no longer be taken for granted"*

"functional specialisation"

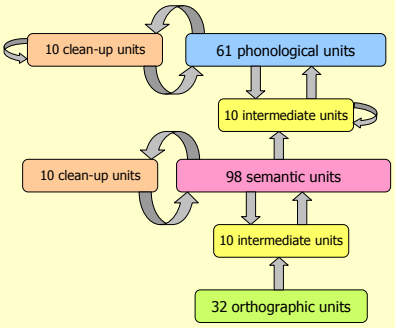
- Shallice (1988): "functional specialisation" is a more appropriate inference from dissociations in patients
- But the dimensions on which behavioural dissociations are based may not be a direct reflection of the function responsible for specialisation
- If so, the degree of specialisation may not be a useful guide to system architecture and functional organisation

Dissociations and Modules

- Sartori (1988): Components in a fully serial architecture can only produce single dissociations . Some contribution of parallel organisation is required for double dissociations.



A Model of Word Reading
Plaut & Shallice (1993)

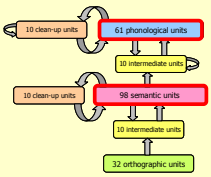


Deep Dyslexia

- The hallmark: semantic errors
  - i.e. reading CAT as "dog"
- Also…
  - Visual errors: CAT -> cot
  - Mixed errors: CAT -> rat
  - Morphological: GOES -> go

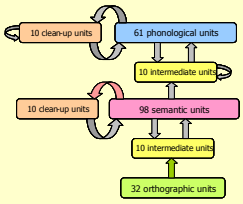
"Double dissociation without modularity"

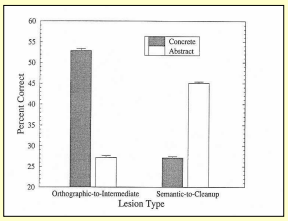
- There is a double dissociation between **concrete** and **abstract** word reading
  - Most researchers believe that skilled readers rely almost exclusively on the **phonological** route
  - Only in cases where this route is inoperative as as in deep and phonological dyslexia, are strong semantic effects such as concreteness observed
- Patient CAV exhibited better performance on abstract words *(partial reliance on semantic route)*



Lesion location and behaviour

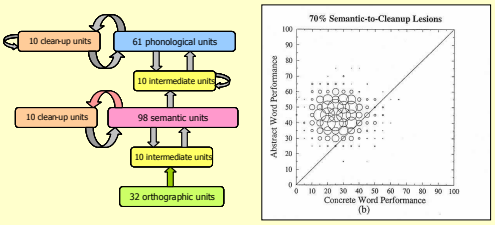
- Damage to connections between processing units





Lesion severity and behaviour

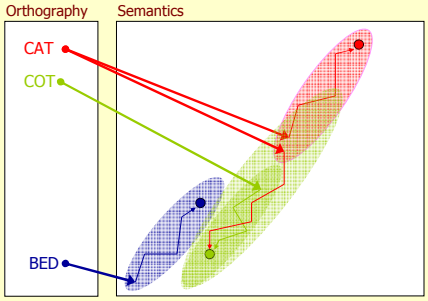
• percentage of damage inflicted upon connections



Functional specialisation

- Different parts of the network have a different function: pointers and valleys
- Abstract words are assumed to have fewer semantic features (sparser semantic neighbourhood)
- Concrete relies more on valleys, abstract more on pointers

Attractor space: pointers and valleys



Implications: Plaut (1995)

- "…Both pathways are involved in processing both types of words. However, they make different contributions the course of this processing…"
  - The direct pathway generates an initial approximation of the semantics
  - These are refined by the clean-up pathway
- Functional specialisation: this exists in the network "but does not directly correspond to the observed behavioural effects under damage (abstract vs. concrete words)"
- "[Regarding Averaged vs. Rare lesions]… the occasional lesion of each type may produce effects that are exactly opposite to those produced by most quantitatively equivalent lesions
  - The observation of a double dissociation does not even indicate functional specialisation, as Shallice (1988) suggests, for how can the same portion of a mechanism be "specialised" in two different ways?"

Conclusions

- Concrete-Abstract double dissociation appears to violate Sartori's (1988) argument that double dissociations cannot arise from serial stages
- Clean-up pathway appears to follow Direct pathway in a serial fashion
- Either parallel processing permits this, or the two parts of network do not conform to independent stages (see McClelland, 1979)

Summary

- Connectionist models are **tools** for theory development
- Connectionist models are **learning** models
- Models can be **damaged** to produce **deficits**
  - A controlled testing environment
  - Connectionist models have pushed the boundaries of traditional cognitive neuropsychology
  - Connectionist models themselves have become working theories

Take home message

Connectionist models provide a controlled environment for testing the effects of both acquired and developmental deficits. They are ideal for this practice because when damaged they do not collapse, and they are models that can learn. Connectionist models are tools for theory development that have pushed the boundaries of traditional neuropsychology

The End

Questions?