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Language & Modularity

CCC workshop, April 7, 2006

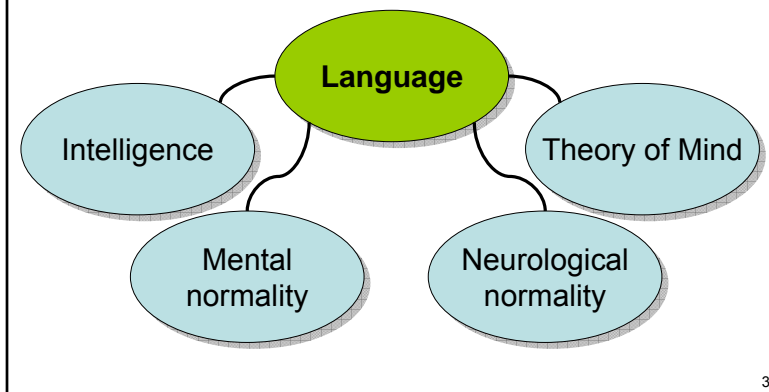
Outline

- External Modularity:
 - Language and Mind
- Internal Modularity
 - The Architecture of Language
- Implementation
 - Language and Brain

2

External Modularity

- Double dissociations:



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graph TD
    Language((Language)) --- Intelligence((Intelligence))
    Language --- TheoryOfMind((Theory of Mind))
    Language --- MentalNormality((Mental normality))
    Language --- NeurologicalNormality((Neurological normality))
  
```

3

External Modularity

	'Normal' Language	IQ	Mentally normal	Neurologically Normal	Theory of mind
Normal	✓	✓	✓	✓	✓
Blind, deaf, etc.	✓	✓	✓	-/✓	✓
Insanity, psychopathy	✓	✓	-	✓	-/✓
Down's syndrome	✓	-	-	-	✓
Williams syndrome	✓	-	-	-	✓
S.L.I.	-	✓	✓	(✓)	✓
Broca's Aphasia	-	✓	✓	-	✓
(Severe) Autism	(✓/)-	-	-	-	-

4

External Modularity

- Acquisition is independent of intelligence
 - Down's Syndrome, Williams Syndrome
- Acquisition is independent of formal teaching
 - Language acquisition seems to happen automatically / instinctively (cf. Pinker 1994)
 - Child-directed speech ("motherese") is helpful but not a prerequisite
 - The !Kung San drill their babies in sitting up
- Acquisition is independent of learning skills
 - Requires good learning: math, playing instruments, games, reading, writing...
 - No "bad" language users
 - Infants acquire language but are incapable of much else
 - Williams Syndrome: poor learners, very good language-users

5

External Modularity

- Acquisition seems to follow a specific **biological clock**

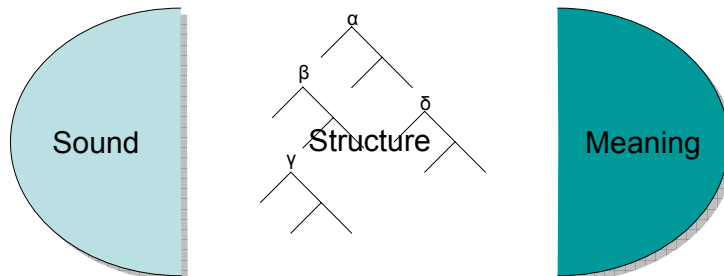
Age in months	Neural development	Linguistic development
Birth	Completed cell formation and migration	left hemisphere specialization
9	Adult distribution of metabolism, long-distance connections established	suppression of non-native sounds - fine-tuning the phonetic inventory
12		one word stage
18	Peak in number of connections within and between cortical regions	"vocabulary spurt", two word stage - primitive syntax
36		"grammar explosion" - rapid increase in number of syntactic constructions and complexity
48	peak in overall brain metabolism	"successful" language acquisition

- ...like sitting, walking, milk teeth, puberty, etc.
- Language is universal
- All children go through the same stages
- There is a 'sensitive period' for first language acquisition before puberty

6

Internal Modularity

- The linguistic sign



- Duality of patterning

- meaningless sounds → morphemes
- meaningful morphemes → words and phrases

7

Internal Modularity

- Structure dependency:

- 'Garden paths' (problem: structure):
 - The horse raced past the barn fell.*
 - Fat people eat accumulates.*
 - The old man the boat.*

- Well-formed nonsense (problem: meaning)

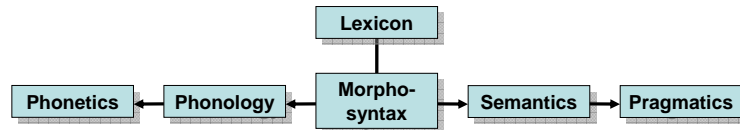
- Colourless green ideas sleep furiously.*
- More people have been to Paris than I have.*

- "The Autonomy of Syntax"

8

Internal Modularity

- The *Language Faculty* consists of at least:



- ...all of which in turn consist of sub-modules.

9

Implementation

- Modules may be found at all levels of description
 - (See also "Outline", slide 2)
- There need not be any simple correspondence between modularity at one level and modularity at another level. (Jenkins 2000, Friston et al. 1996, Chomsky 2004)
 - Module (level n) \neq Module (level $n \pm 1$)

Cognitive Modules:
(Chomsky 2000)

-Face recognition
-Language

Input systems:
(Fodor 1983)

-Perception

Cell Structure:

-Neurons

10

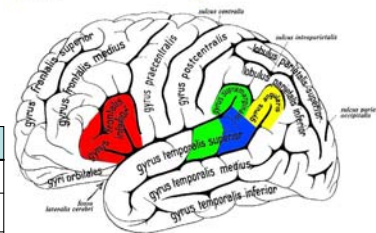
Implementation

- Focal Brain Damage and Language (Christensen 2001)

- Language per se is not impaired

- Aphasia type / breakdown pattern depends on lesion site

■ Broca's & transcortical motor aphasia
■ Wernickes aphasia
■ Conduction aphasia
■ Anomia
■ Transcortical sensory aphasia



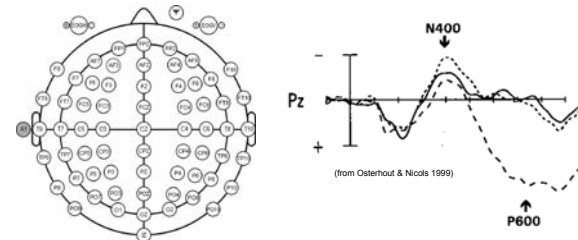
Left hemisphere	Right hemisphere
Phonology, phonetics	Prosody
Lexical semantics	Pragmatics
Morphosyntax	Thematics

11

Implementation

- Syntactic and semantic anomalies elicit qualitatively different changes in the electric fields around the brain
 - Different timing, distribution, and polarity

- Syntactic: *P600*, (*E*)*LAN*
 - Semantic: *N400*
- (Osterhout & Nicols 1999, Saddy et al. 2004)



12

Implementation

- Neuroimaging with *fMRI* (Christensen 2005)
 - The Language module does not correspond to a single module in the brain

Linguistic task:

Anomalous / OK?

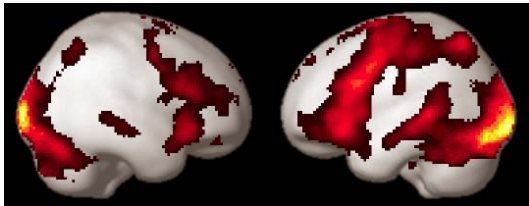
The doctor didn't hear any noises.

Which houses didn't the expert eat?

>

Non-linguistic task:

4...3...2...1...



13

Implementation

- Syntactic displacement
 - A sub-component of the syntax sub-module

Non-canonical word order:

Hvilke fejl har lægen ikke fundet ___?

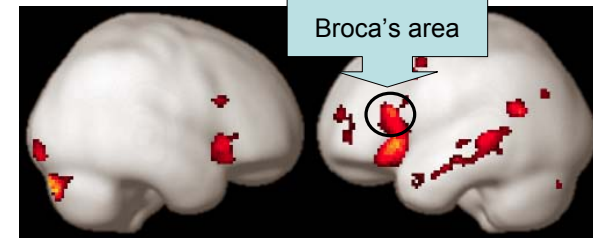
Which errors has the doctor not found?

>

Canonical word order:

Har lægen ikke fundet nogen fejl?

Has the doctor not found any errors?



14

In short

- Language is a cognitive module, a self-contained sub-component of the mind.
- The architecture of language consists of several distinct sub-modules.
- Language is implemented in the brain as a network of sub-modules distributed over several computational “centres”.

15

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