Introduction to Linguistics

Modularity
Previously on Intro to Linguistics...

The rise of localization theories:

- We reviewed historical views on high functions in the brain (= language)
- We discussed Broca’s aphasia and Paul Broca’s contribution to the localization of language
- We highlighted Carl Wernicke’s contribution to the emergence of early connectionism
• The **connectionist** approach to language was further elaborated by Carl Lichtheim, who added a concept center – not anatomically localized

• On the basis of this diagram, he postulate disorders that had not yet been described, but which could be explained by disruption of information flow between the three centers

• The notion that *disconnection* leads to *dysfunction* has been coined the **Disconnection paradigm**
The debate continues

- The Wernicke- Lichtheim scheme generated a wave of criticisms.

- The existing models could not explain why injury to anatomically distinct language regions could give rise to apparently unpredictable and overlapping symptoms.

- Language models were categorised as either localisationistic (including associationistic models), or holistic, based on whether they focused on language processing as being locally specialised or less tightly allocated to distinct brain regions, respectively.

- **Freud** criticized the Wernicke- Lichtheim scheme, rejected the classification into cortical and conduction aphasia and the explanation that the variety of aphasias can be explained by different localisations of destructive lesions. Instead, he accepted the existence of a continuous, left hemispheric cortex area as a language zone.
The return of localism

- The holistic approach prevailed until connectionism was revived by the neurologist Norman Geschwind

- In the 1960s, Geschwind crystallized early anatomical findings by adding new insights into brain connectivity as derived from anatomical and physiological studies both in animals and humans

- He also extended the disconnection paradigm beyond white matter lesions to lesions of association cortex
Conduction aphasia (revisited)

Interpretation of conduction aphasia had evolved:
It is no longer considered a disconnection syndrome but rather a deficit caused by cortical dysfunction (often following damage to the Supramarginal gyrus).

The long segment fibres (red) connect Broca’s and Wernicke’s territories.

The anterior segment fibres (green) connect Broca’s and Geschwind’s territories.

The posterior segment fibres (yellow) connect Wernicke’s and Geschwind’s territories.

Catani and ffytche, 2005
Broca’s area (revisited)

A 2007 study in the journal *Brain* revealed the extent of the lesion using MRI imaging.
Broca’s area (revisited)

• Broca localized the center for articulate language at the foot of the third frontal convolution, even though the lesion in his two (most famous) patients extended well beyond this area.

• Both cases had lesions extending into the superior longitudinal fasciculus (SLF), a large intrahemispheric fibre tract that connects posterior and anterior cortex regions.

• It has been shown that a lesion restricted to Broca’s area gives rise to a transient impairment of language production and that the full complement of symptoms associated with Broca’s aphasia is the result of more extensive damage to cortical and sub-cortical regions in the frontal lobe.
Aphasiology (revisited)

Fluency

- YES
- NO

Comprehension

- YES
- NO

Repetition

- YES
- NO

(Anomia)

- Conduction
- Wernicke’s

Transcortical sensory

- Transcortical motor
- Transcortical mixed

Broca’s

Global

- Transcortical motor aphasia
- Transcortical sensory aphasia
- Conduction aphasia
- Global aphasia
- Chronic Broca’s aphasia
- Wernicke’s aphasia

Saffran, 2000
Fodor’s Modularity

• The idea of modularity was formulated in Jerry Fodor's ground-breaking book *The Modularity of Mind* (1983)

• Modularity of mind is the notion that a mind may, at least in part, be composed of innate neural structures or modules which have distinct established evolutionarily developed functions

• Fodor lists nine features that collectively characterize the type of system that “interests him”. In original order of presentation, they are:

1. Domain specific
2. Information encapsulation
3. Mandatory operation (automaticity)
4. Inaccessibility to consciousness (limited central access)
5. Fast acting
6. Shallow outputs
7. Fixed neural localization
8. Characteristic breakdown pattern
9. Follow maturational sequencing
Encapsulation example

- Although these items have since been taken to be a sort of diagnostic checklist for modularity, Fodor himself was careful to emphasize that these were neither necessary nor defining features of modules...

- Instead, he suggested that “the notion of modularity ought to admit of degrees” and that when he referred to a system as modular, this meant that it was modular “to some interesting extent” (Fodor, 1983, p. 37).

- **Information encapsulation**, for example, is more or less essential for modularity.

*The Müller-Lyer illusion*

Jerry Alan Fodor (1983)
The Implication of the modularity idea

- A lighting rod for subsequent two decades of psycholinguistics research
- Provides a neuropsychological framework for theories of language processing
- Stimulated specific experimental paradigms and methods of computational modeling (that challenged this view)
Checking modularity

• Assessing modularity of language with experimental paradigm
• CMLP – Cross-Modal Lexical Priming

Lexical priming

• Prime and target
• Lexical decision task:
  “IS IT A REAL WORD?”

  DOCTOR  BREAD  >  NURSE

• We measure reaction times to the target
• We witness facilitation in cases when the Prime and target are related

Cross Modal

• Prime and target appear in different modalities
Checking modularity

• Swinney, 1979

Is Lexical access an autonomous process or is it integrative, context-dependent process?

“Jeff was concerned about Savings and Loan Institutions, so he went to the BANK *1 which his family *2 always used *3”

<table>
<thead>
<tr>
<th>Monetary content (בעד)</th>
<th>Geographical content (גדה)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Related: MONEY</td>
<td>Related: RIVER</td>
</tr>
<tr>
<td>Unrelated: CANON</td>
<td>Unrelated: TRUNK</td>
</tr>
</tbody>
</table>

*1 priming for both meanings!
*2 No priming for both meanings!
*3 priming only for MONEY
Checking modularity

1. Domain specific
2. Information encapsulation
3. Mandatory operation (automaticity)
4. Inaccessibility to consciousness
5. Fast acting

7. Fixed neural localization (???)
Exploring modularity

How can we establish what modules make up the cognitive architecture?

Coltheart (2002): *Cognitive Neuropsychology* provides a way to do it, if we only look

- a subfield of cognitive psychology, distinguished by the feature that it studies people with *brain lesion or disorders*

- Method is the same: behavioral studies of brain damaged patients

- The goal is more specific: to isolate the *neural substrate* that supports a brain module

- the assumption of *subtractivity*: brain damage can subtract modules, or pathways of communication between modules, from the normal system, but cannot add new modules or new pathways
Case studies

One reason that cognitive neuropsychological research is so exciting is that it continually reveals disorders of remarkable selectivity.

Patient KT
(McCarthy and Warrington, 1986)

normal at reading aloud pronounceable nonwords

(NIN, DOLD, SUST)

very impaired at reading aloud real irregular words

(PINT, FLOOD)

Patient MH
(Humphreys & Rumiati, 1998)

normal at recognizing visually presented faces and printed words

normal at recognizing objects

Patient AC
(Coltheart et al., 1998)

could provide on request any information about objects whose names were spoken to him - except visual information
Dissociations

- functions that are impaired due to a disorder (lesion or other) can be dissociated from other skills or functions that remain intact

- Patient MH: impaired object recognition with intact face and word recognition

- Is such evidence enough to show that the functional architecture of the visual recognition system includes a module specialized just for object recognition and not used for recognizing faces or printed words?
Double Dissociations

• We need to look for double dissociations

• A simple dissociation is found if a patient can perform process X but not process Y

• A double dissociation is found if there is also a patient who can perform Y but not X

• Back to our example: to complement patient MH, we need to find a patient who can not recognize faces, but could recognize objects and printed words.

A double dissociation is considered evidence that these two processes rely on separate brain mechanisms.

This is the main tool of cognitive neuropsychology in its search of modular cognitive processes.
## Another example

<table>
<thead>
<tr>
<th>Recognize words</th>
<th>Recognize faces</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impaired</td>
<td>Impaired</td>
</tr>
<tr>
<td>(agnosia)</td>
<td>alexia</td>
</tr>
<tr>
<td>Intact</td>
<td>Prosopagnosia</td>
</tr>
<tr>
<td>You</td>
<td>You</td>
</tr>
</tbody>
</table>

The diagram illustrates different patterns of brain function and their corresponding outcomes. The left hemisphere is shown as seen from underneath, with different areas labeled for written words and visual recognition.
Another (linguistic) example

- Caramazza et al. (2000) report the performance of two Italian-speaking aphasics who show contrasting, selective difficulties in producing vowels and consonants.

- Both had brain damage to left parietal \ temporal areas.

- Their spontaneous speech was fluent but paraphasic.

- Patients AS and IFA were asked to repeat large numbers of words.

- Substitution errors were distributed unequally for consonants and vowels for the two patients, but in opposite directions.

- Is this evidence of consonant / vowel modules within the language production system?
Back to Broca and Wernicke

- Is there double dissociation between Broca’s and Wernicke’s Aphasia?

<table>
<thead>
<tr>
<th>Aphasia type</th>
<th>Production</th>
<th>Comprehension</th>
<th>Repetition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broca’s</td>
<td>Non fluent</td>
<td>Good</td>
<td>Poor</td>
</tr>
<tr>
<td>Wernicke’s</td>
<td>Fluent, paraphasic</td>
<td>Poor</td>
<td>Poor</td>
</tr>
</tbody>
</table>

Specific deficits in morphology and syntax (grammar) have been observed in language production and comprehension.

<table>
<thead>
<tr>
<th>Aphasia type</th>
<th>Lexical-semantics</th>
<th>Syntax</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broca’s</td>
<td>Intact</td>
<td>Impaired</td>
</tr>
<tr>
<td>Wernicke’s</td>
<td>Impaired</td>
<td>Intact</td>
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</table>
Beyond modularity

What is the effect of focal lesions in different parts of the peri-sylvian language cortex in a model of overlapping functional webs distributed over these cortical areas?

Again, the idea is that acoustic, articulatory, and semantic information about words are bound together in functional units exhibiting specific cortical topographies. This means that these aspects of information processing are not separate functionally, although, originally, they may primarily have been housed in separate brain areas.

Pulvermüller, 2002