How to study the brain?
If only mice could read...
How to study language in the human brain?

- In the 1800’s:
  - Study people who have language problems, and then, after they’re dead, study their brains.
Paul Broca & Broca’s aphasia

- First localization of language function.
- Patient could only produce a single syllable “tan”.
- Production problem.
  - Broca’s aphasia
- Lesion in the posterior part of the left third frontal convolution
  - Broca’s area
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Production problems of Broca’s aphasia

- Slow, laborious, non-fluent speech. Output limited to short utterances of less than four words.
- Speech understanding and reading may be relatively intact, but writing is limited.
Wernicke’s aphasia

- A language problem distinct from Broca’s aphasia first described by Carl Wernicke (in 1908).
- Damage to the boundary of the temporal and parietal lobes --> Wernicke’s area.
- Fluent but disordered speech.
  Similar writing.
- Impaired understanding of speech.
  Impaired reading.
Wernicke’s aphasic
Wernicke’s aphasic
The classic model

**Motor images of words**

**Acoustic images of words**

**Broca’s aphasia (non-fluent aphasia):**

Ah ... Monday ... ah Dad and Paul [patient’s name] ... and Dad ... hospital. Two ... ah doctors ..., and ah ... thirty minutes ... and yes ... ah ... hospital. And, er Wednesday ... nine o’clock. And er Thursday, ten o’clock ... doctors. Two doctors ... and ah ... teeth. Yeah, ..., fine. (Goodglass, 1976)

**Wernicke’s aphasia (fluent aphasia):**

Examiner: What kind of work did you do before you came into the hospital?

Patient: Never, now mista oyge I wanna tell you this happened when happened when he rent. His - his kell come down here and is - he got ren something. It happened. In these ropiers were with him for hi - is friend - like was. And it just happened so I don’t know, he did not bring around anything. And he did not pay it. And he roden all o these arranjen from the pedis on from iss pescid. (Kertesz, 1981)
Conduction aphasia

- Lesion to the arcuate fasciculus (= the bundle of nerves connecting Wernicke’s and Broca’s areas).
- Results in inability to repeat words, especially nonwords.
Problems with the classic model

- Broca’s aphasia not just a production problem.
- Early characterization (Goodglass & Kaplan, 1983): Broca's aphasics "may be confused by more complex spoken messages".
Syntactic constructions that Broca’s aphasics...

... have trouble understanding:
- Passives: 
  *The boy was chased _ by the girl...*
- Object relatives:
  *The boy who the girl chased _...*
- Object clefts:
  *It was the boy who the girl chased _*

... do OK on:
- Actives
  *The girl chased the boy.*
- Subject relatives:
  *The girl who _ chased the boy...*
- Subject clefts:
  *It was the girl who _ chased the boy.*
Trace Deletion Hypothesis (Grodzinsky):

- Broca’s area supports chain formation.

  \[ \text{The boy was chased } t \text{ by the girl} \]

- Traces are deleted from Broca's aphasics’ syntactic representations.

- Broca’s aphasics apply a strategy assigning the first NP the Actor role. If they encounter another Actor later on in the sentence, they guess.

  → result is \textit{chance} performance in cases where arguments roles are reversed
Problems for TDH:

Wh-questions:

- BAs can’t do:
  - Discourse-linked object questions: Which boy did the girl chase _?

- BAs can do:
  - Discourse-linked subject questions: Which boy chased the girl?

- BAs can do:
  - Non-discourse-linked object questions: Who did the girl chase _?
Problems for TDH:

- Above-chance on passives without by-phrases, e.g. The mouse was chased (Beretta, et al., 1999)
- Patients do not choose a scenario with two agents (Beretta & Munn, 1998).
Problems for TDH:

- Broca’s area is activated by lots of tasks and stimuli that nothing to do with chain formation.
  - Verb generation
  - Phonological processing
  - Imitation of various sorts
    - Broca’s are lights up if your watching someone drum their fingers *or* if you drum them yourself (Iacoboni et al. Science, vol 286, p 2526).
    - Broca’s area as part of the “mirror system” (Rizzolatti & Arbib).
Rizzolatti & Arbib on Broca’s area:

“... it is probably no coincidence that the area which links action recognition and action production in the monkey brain is exactly the same area that in humans has been linked to speech production ... the development of human speech was made possible by the fact that F5, the precursor of Broca's area, was endowed with this mirroring mechanism for recognising actions made by others. This ... was a prerequisite for the development of communication and ultimately of speech. It made us "language-ready"...”

http://www-inst.eecs.berkeley.edu/~cs182/readings/ns/article.html
Processing accounts of Broca’s aphasia

- Movement requires storage of the moved element in working memory and this is what BA’s fail on.
Broca’s and Wernicke’s aphasias as lexical access problems (Blumstein)

- Underactivation in BA.
  - Lexical access is general slow in BA. At a trace site it just fails because you can’t even hear the word!

- Overactivation in WA.
  - Relatively uncontroversial that Wernicke’s area is involved in processing of word meaning.
Consensus?

- No, nor should there (probably) be, since the patient group is extremely heterogeneous. Lesions are not precisely limited to Broca’s area.
Broca’s area and Broca’s aphasia

- Only 85 percent of patients with chronic Broca’s aphasia have lesions in Broca’s area.

- Only 50-60 percent of patients with lesions in Broca’s area have a persisting Broca’s aphasia. (N. Dronkers, Brain and Language, 2000)
Lots of non-lesion evidence that Broca’s area does not just perform syntax and (definitely) does just perform *specific* aspects of syntax.