



# Mind/Brain and Language

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## Outline

- Linguistics and language
- Neurolinguistics/biolinguistics
- fMRI & ERP studies of language

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## Linguistics and language

- Linguistics is the scientific study of language.
- As a linguist, we get to ask cool questions about language.

What do you know when you know a language?

“zhefangjianhaoleng~”

這房間好冷~

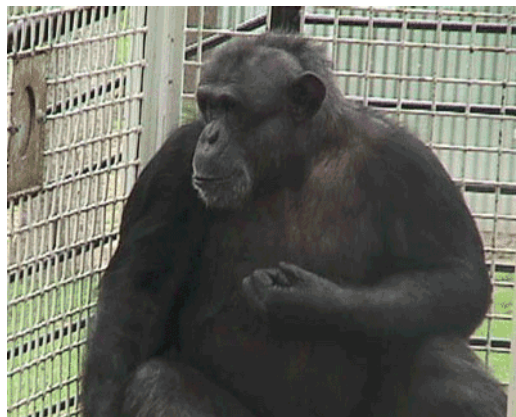
### Steps the brain takes

- phonetic string recognition
- lexical decoding
- Grouping of phrases
- Creating/imaging a grammatical sentence
- Grasping the levels of meaning

## Is language unique?

*Terrace, H. S., Petitto, L. A., Sanders, R. J., & Bever, T. G. (1979)*

“Give orange me give  
eat orange me eat  
orange give me eat  
orange give me you”



## Is language specific/modular?

- **The KE family** (Myrna Gopnik, 1990).
  - *It's a flying finches, they are.*
  - *Carol is cry in the church.*
  - *Yesterday I fall over*
  - *One wug. Two ? Wugness*
  - *One zoop. Two? Zoopes*
- **Williams Syndrome** (Bellugi, Marks, Bihrlé and Sabo, 1988)

Question: *"What if you were a bird?"*

  - *"You could fly, you could have babies, fly north or south, east or west"*
  - *"Good question. I'd fly through the air being free; and I would fly, and if I liked a boy, I would land on his head and start chirping"* (Bellugi et al 2000)

## And many other interesting questions...

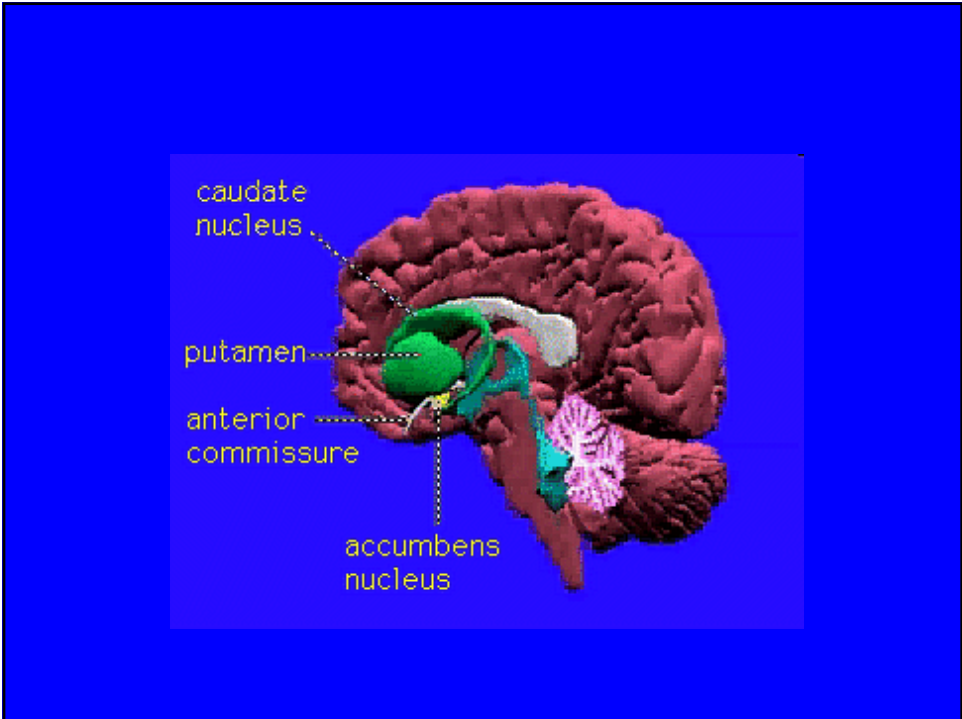
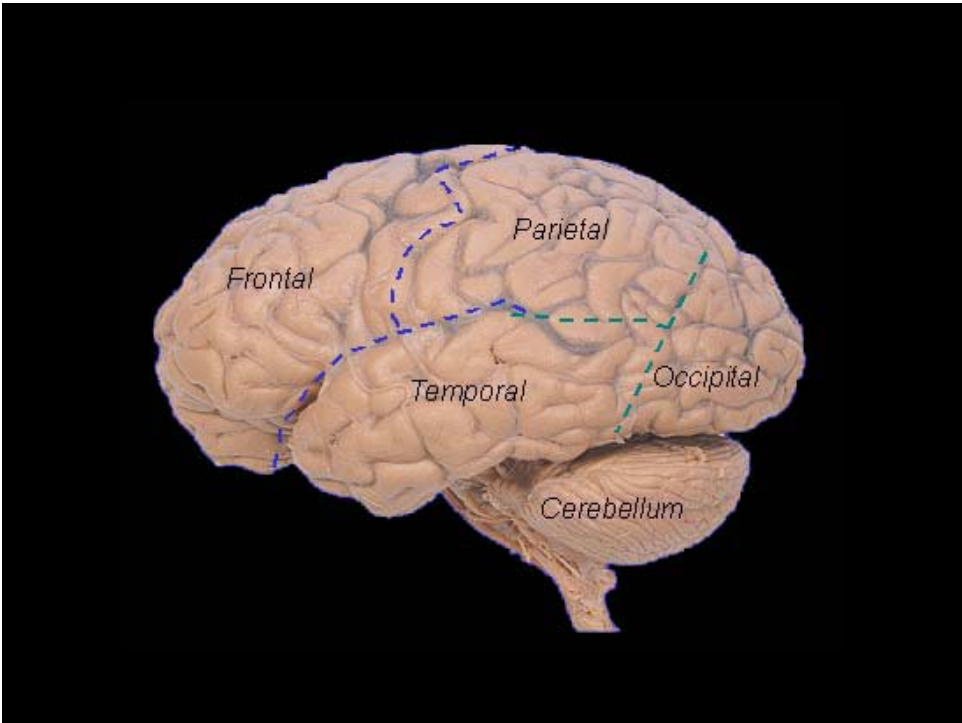
- **WHAT** we know
  - e.g., universal grammar
- **HOW** we learn it
  - e.g., nature vs. nurture
- **HOW** we know/use it
  - e.g., language comprehension/production
- **WHERE** the brain represents it
  - e.g., language evolution

## Outline

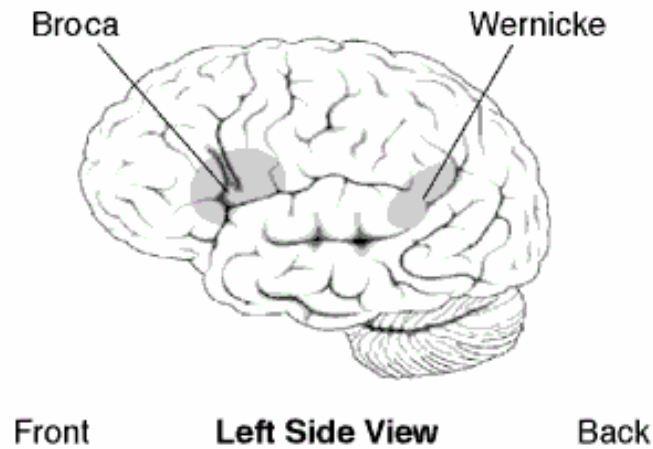
- Linguistics and language
- **Neurolinguistics/biolinguistics**
- fMRI & ERP studies of language

## Neurolinguistics/Biolinguistics

The branch of linguistics that studies the relation between language and the brain



## “Language areas”



## The classical theory of language disorders

- Broca's aphasia
  - *Yes ... ah ... Monday ... er Dad and Peter H ... (his own name), and Dad ... er hospital ... and ah ... Wednesday ... Wednesday nine o'clock ... and oh ... Thursday ... ten o'clock, ah doctors ... two ... an' doctors ... and er ... teeth ... yah.*
- Wernicke's aphasia
  - *Well this is .... mother is away here working her work out o'here to get her better, but when she's looking, the two boys looking in other part. One their small tile into her time here. She's working another time because she's getting, too.*

## Measurements

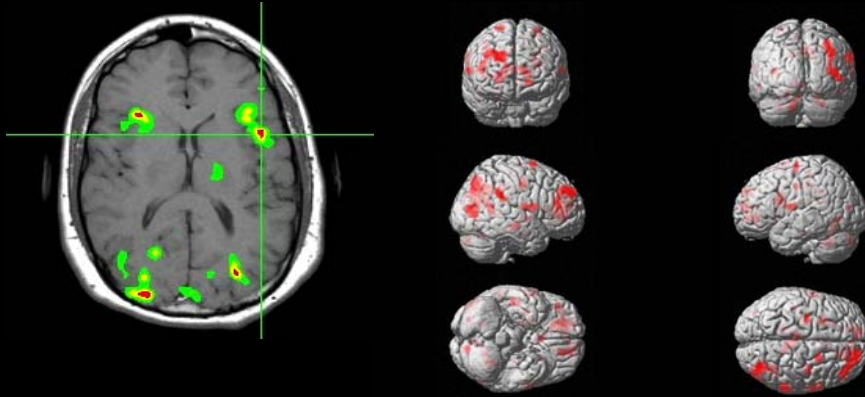
- **Spatial aspect of language processing**
  - Where is language located?
  - Etc.
    - **Functional magnetic resonance imaging (fMRI)**  
功能性核磁共振造影
    - **Positron emission tomography (PET)** 正子斷層
- **Temporal aspect of language processing**
  - What is the general time frame for language processing?
  - Etc.
    - **Event related brain potentials (ERP)** 腦波誘發電位
    - **Magnetoencephalography (MEG)** 腦磁圖

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- Neurolinguistics/biolinguistics
- **fMRI & ERP studies of language**



## Functional Magnetic Resonance Imaging (fMRI)

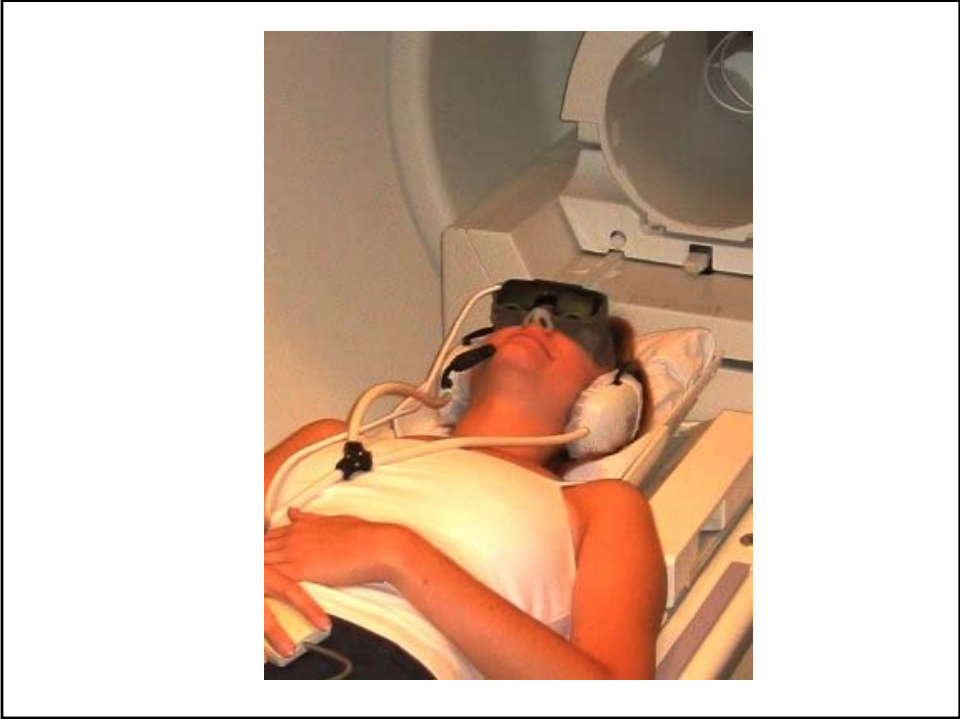


## A 3T Scanner

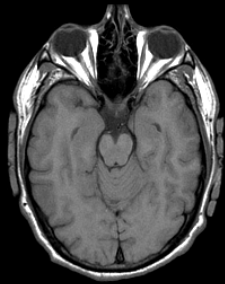
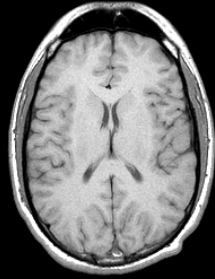


Approx. 60,000 times stronger than the magnetic field of the earth

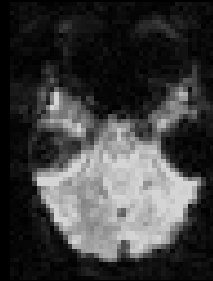
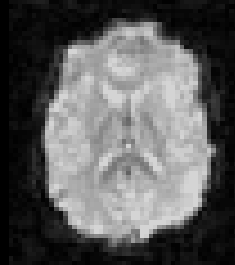




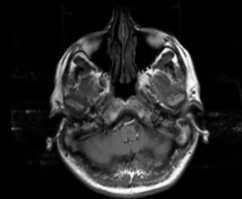
Anatomical



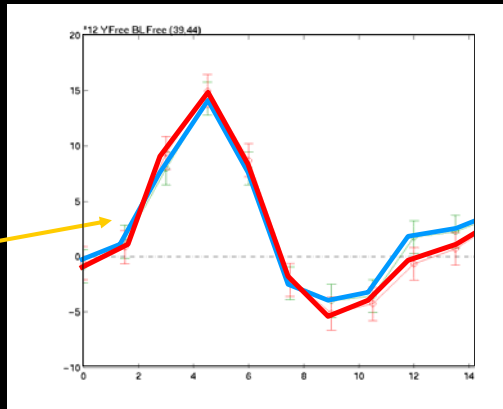
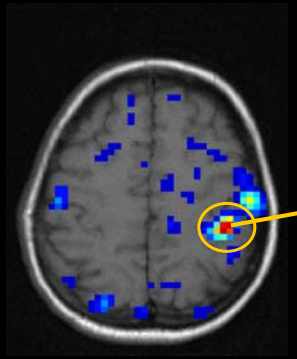
Functional



Anatomical slices

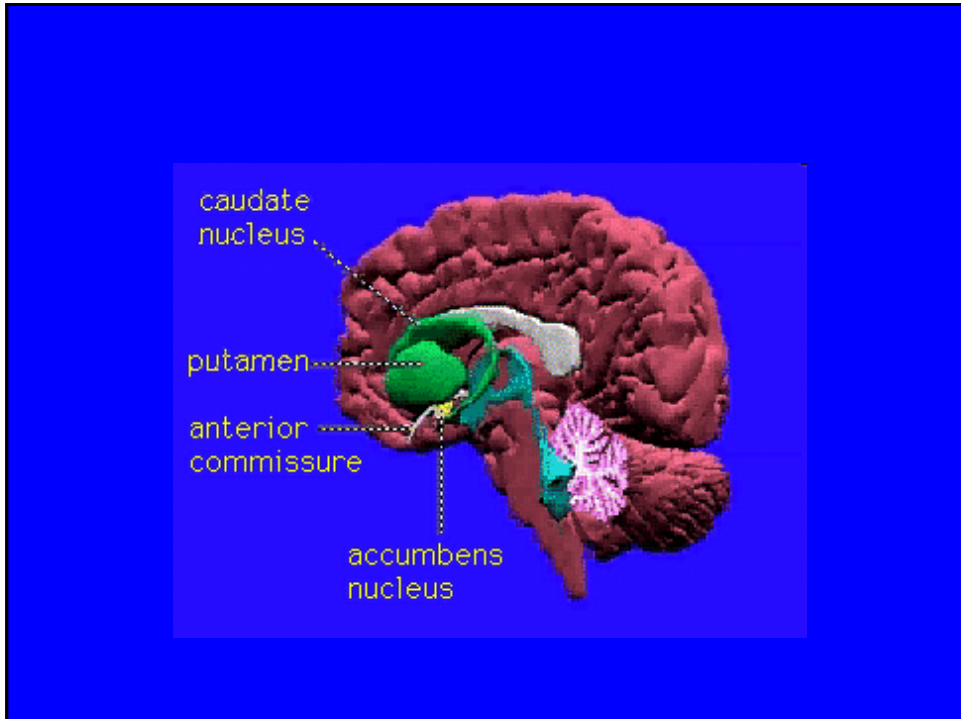


**fMRI measurement is relatively slow because the hemodynamic response takes time, even for a single, fast behavioral response**



## fMRI study

Linguistic sequencing in the cortex  
and basal ganglia



## Why not the BG?

- The classical theory: Most of the previous studies have been focusing on Broca's area, Wernicke's area and other cortical areas
- Technology problem: the BG are buried deep into the cerebrum.
- The basal ganglia (BG) have been associated with motor functions, whereas the cortex has been associated with higher cognitive functions.

## Non-linguistic functions of the basal ganglia: Sequence learning

- Animal studies
  - “Grooming syntax” in rodents (Cromwell and Berridge, 1996)



## Language in patients with BG lesions

- **Subcortical cerebrovascular disease** (腦血管疾病)
  - reduced voice volume, perseveration, foreign accent syndrome, agrammatism, first language more seriously damaged than 2<sup>nd</sup> language in bilingual
- **Neurodegenerative disease** (退化性神經疾病)
  - Parkinson's disease**
    - phonetic problems (VOT), sentence comprehension deficit, deficit greater in first language than second, problem with suffixation in regular verbs and novel forms
  - Huntington's disease**
    - the opposite suffixation pattern to that with PD: **walkeded**, sentence comprehension deficits
- **Genetic disease—the KE family** (遺傳疾病)

## Sequencing in language

- Phonology—adjoining phonemes together to form a syllable/word following the phonotactic order
- Morphology—adding inflectional and derivation suffixes to a stem following an order
- Syntax—putting words into a sentence
- Etc.

## fMRI methodology—Subtractions

Cognitive processes are additive

e.g.

Word recognition = letter recognition + lexical access  
(HAPPY)

String recognition = letter recognition  
(PPHAY)

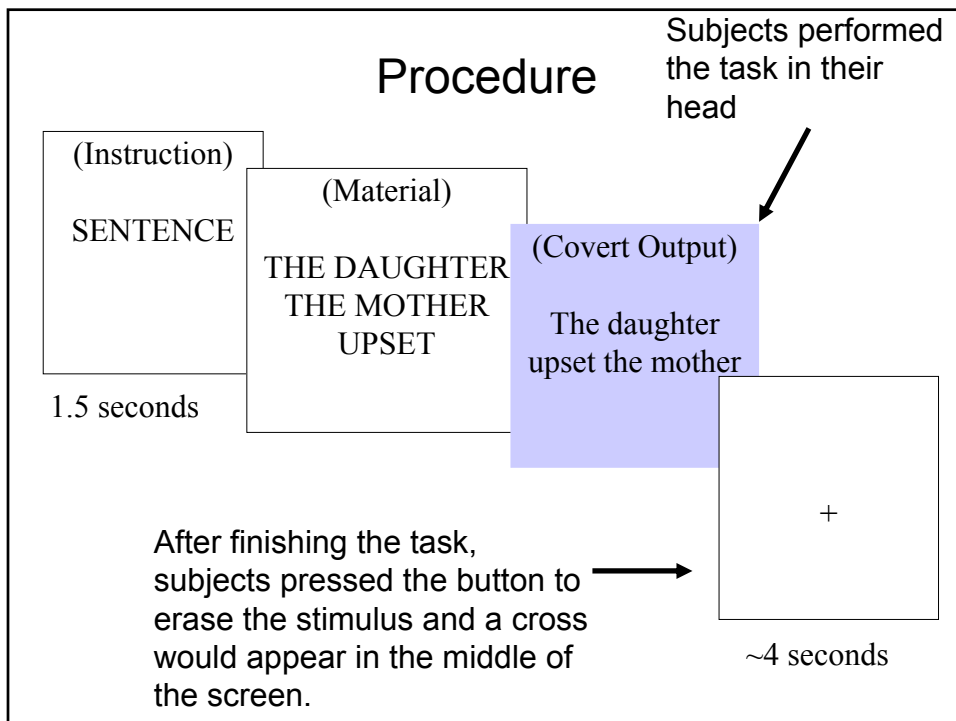
Rest =  $\emptyset$

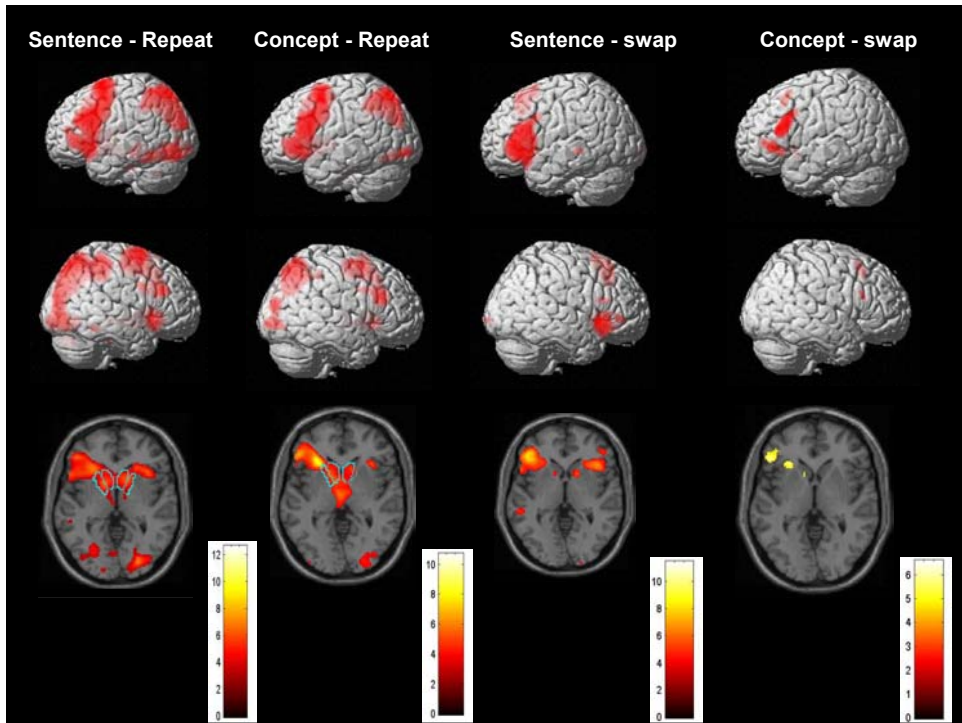
Lexical access = Word recognition – String recognition

Letter recognition = String recognition - Rest



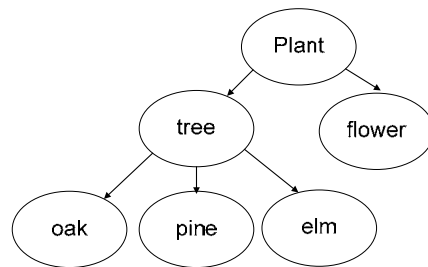
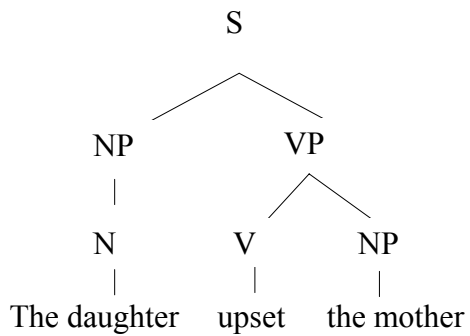
Experimental design		
<i>(This is where the linguistic expertise comes in)</i>		
Task	Sentences	Conceptual triplets
Reorder (linguistic sequencing)	THE DAUGHTER THE MOTHER UPSET	TREE PLANT PINE
Swap (non-linguistic sequencing)	THE DAUGHTER *THE MOTHER *UPSET	*TREE *PLANT PINE
Repeat	THE DAUGHTER UPSET THE MOTHER	PLANT TREE PINE
Expected response	The daughter upset the mother	Plant, tree, pine





## Data interpretation

Again, this is where linguistic knowledge can help you BIG TIME!



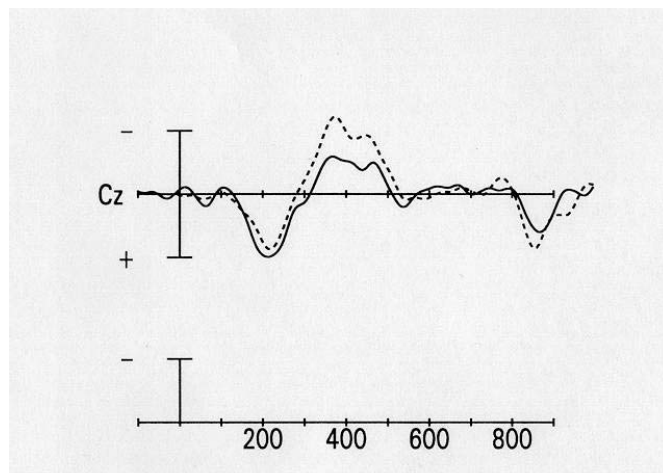
**Syntactic structure**

**Semantic structure**

## Conclusions for the fMRI study

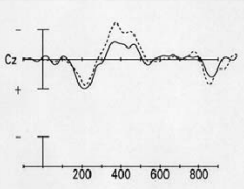
The basal ganglia (the caudate head in particular) are important structures in language processing.

## Event-related brain potentials (ERPs)



**ERPs can be measured using electroencephalography (EEG), a procedure that measures electrical activity of the brain through the skull and scalp.**





## ERP methodology—Violation

The man found Don's sketch of the hill

我上個禮拜一剛回到台灣

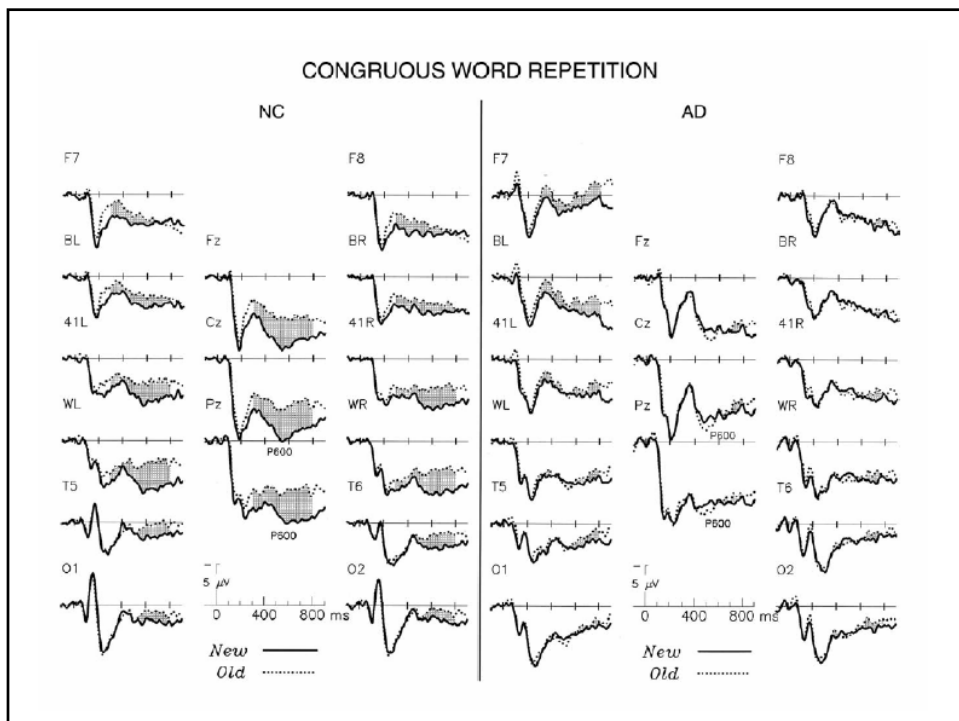
- Phrase structure error - negative 125 msec  
 The man found **of** Don's sketch the hill  
 我上個禮拜一剛回**了**到台灣
- Odd semantics -negative 400 msec  
 The man found Don's **headache** of the hill  
 我上個禮拜一剛回到**滑鼠**
- Syntactic error-positivity 600 msec  
 The man found in Don's sketch **left**  
 我上個禮拜一剛回到台灣**好**

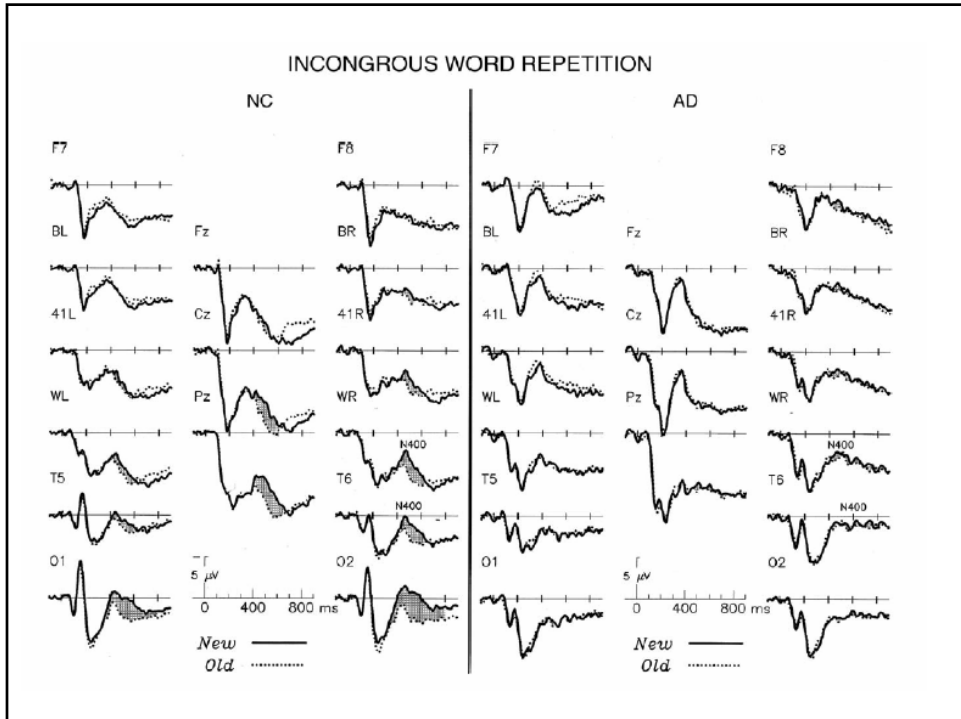
## ERP studies on mental lexicon: Searching for biological markers

- Schizophrenia
- FXTAS (fragile x-associated tremor/ataxia) syndrome
- Normal aging
- Alzheimer's disease patients

## Stimuli (word repetition paradigm)

- Congruous trials (memory):
  - A country in Asia—Korea
  - A breakfast food—pancake
- Incongruous trials (language):
  - An animal—clock
  - A body part—rodent





## Conclusions for the ERP study

Significant abnormalities of the N400 and P600 in mild AD were found, with both potentials showing markedly reduced sensitivity to word repetition.

## General conclusions

- Neurolinguistics/biolinguistics is a fascinating subfield of linguistics.
- With linguistic knowledge, we can design and interpret language experiments better.
- With neurolinguistic studies, linguistic knowledge can be applied to clinical use.