

Where and how are syntax and semantics processed in the human brain?

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Overview

- Introduction
- Purpose
- Experimental design
- Method
- Hypothesis
- Theoretical models
- References

Introduction

- based on lesion studies a 'classical model' of language processing is located in the left hemisphere, consisting of:
 - Broca's area (the inferior frontal gyrus, pars triangularis and pars opercularis, Brodmann area, BA 44/45)
 - Wernicke's area (posterior region of the superior temporal gyrus BA, 42)
 - arcuate fasciculus (neural connection)

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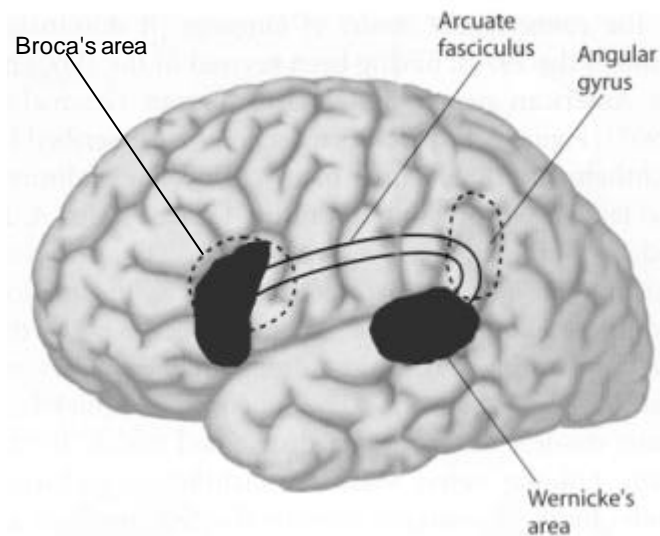


figure 1 adopted from Gazzaniga et al. (1998)

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Introduction

- with non-invasive functional imaging methods (fMRI, EEG etc.) possibility to examine healthy subjects
- based on studies realized with these methods extension of the 'classical' network of language processing

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Introduction

- Stromswold et al. (1996)
- Binder et al. (1997)
- Kang et al. (1999)
- Kuperberg et al. (2000)

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Introduction

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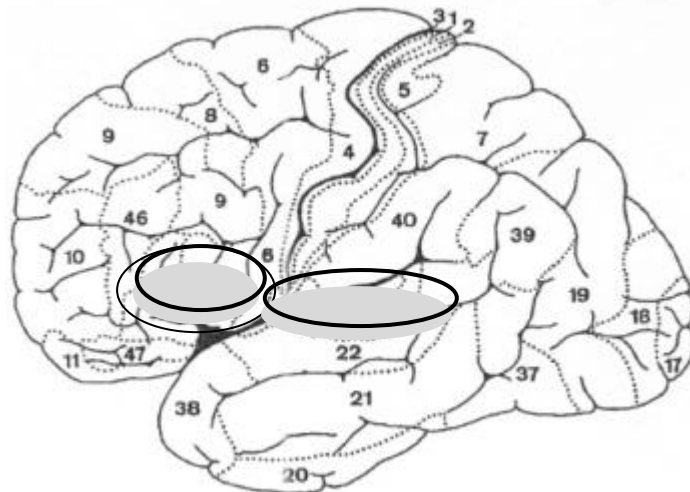


figure 2 Brodmann areas, adopted from Pulvermüller&Preissl (1991)

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Introduction

- Stromswold et al. (1996)
- Binder et al. (1997) Human Brain Language Areas identified by fMRI
- Kang et al. (1999)
- Kuperberg et al. (2000)

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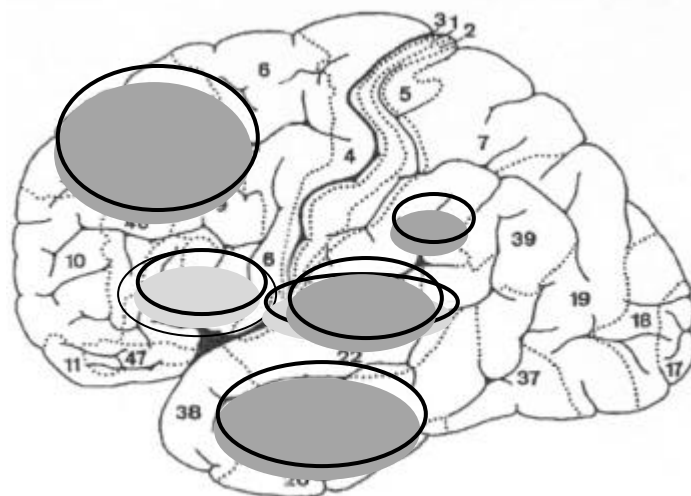


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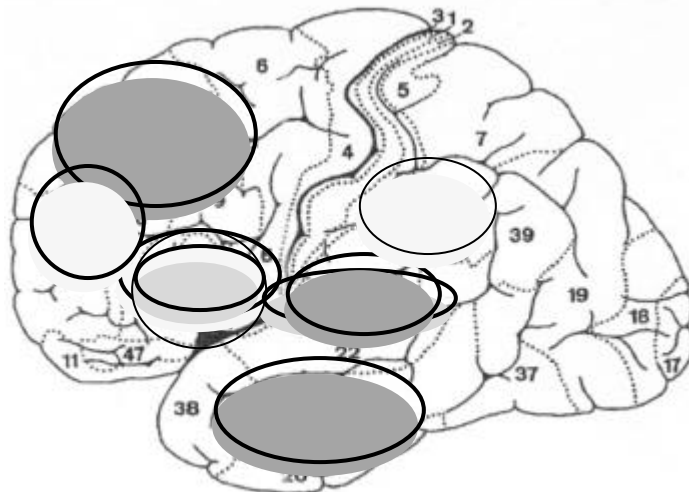


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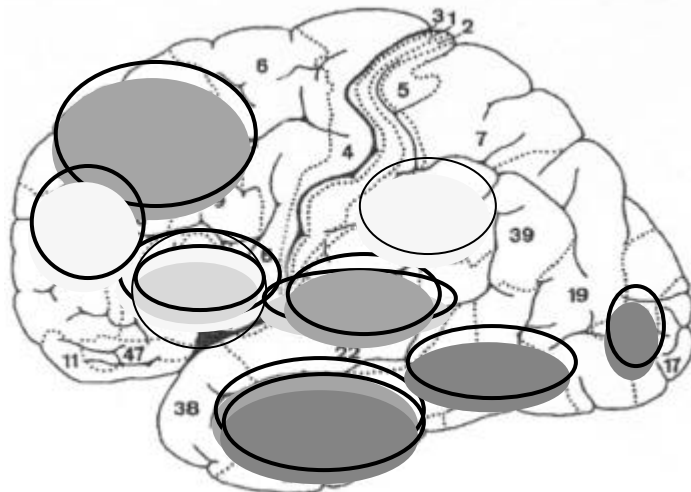


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Introduction

- Indefrey and Levelt (2000): The neural correlates of language production
- meta-study of 58 speech-production experiments

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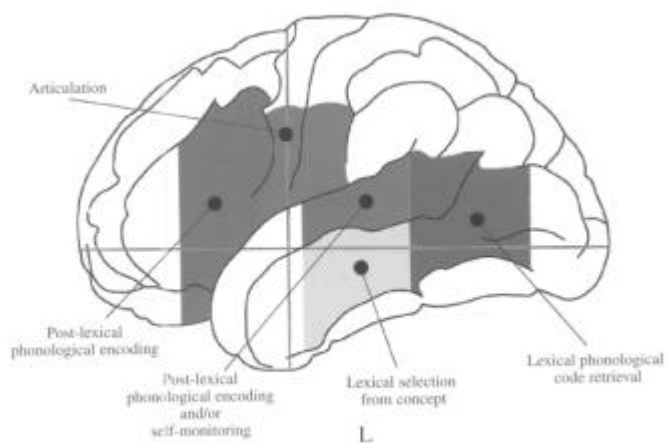


figure 3 adopted from Levelt/Indefrey (2000)

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Introduction

- Question: Is every activated brain region functionally related to the specific language tasks?

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Purpose

- isolation of syntactic and semantic processing in speech production
- experiment with two methods:
 - fMRI (functional Magnetic Resonance Imaging) and
 - EEG (ElectroEncephaloGraphy)
- locate the steps of language processing and find a unique electrical pattern associated with these steps

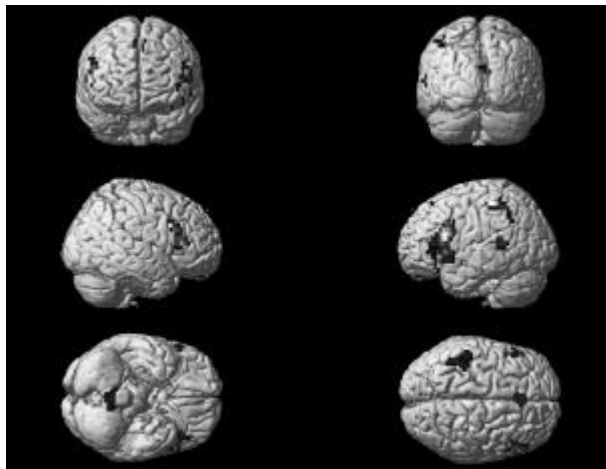
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Purpose

- fMRI-experiment on syntactic and semantic processing in speech production (see Dogil et al. (2002))
- brain images showed overlapping activated areas in the semantic and syntactic tasks

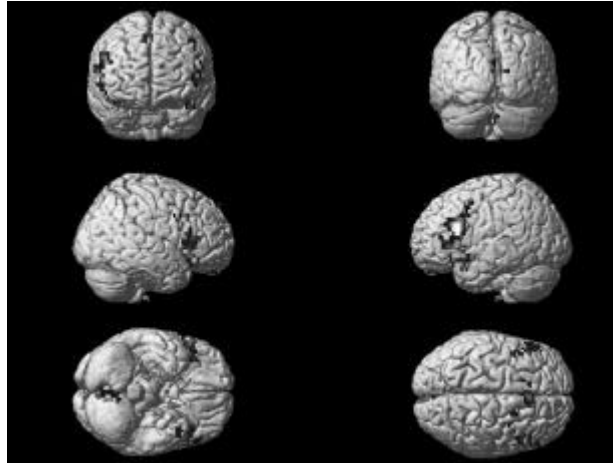
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semantics vs. reading



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syntax vs. reading



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Experimental Design

- stimuli: sentences and word lists
 - reading task
 - reading the presented sentence or word list
 - reserialisation task
 - moving the second NP or PP of the sentence/ the third or first element of the list in front
 - substitution task
 - replacing the second NP or PP by a generic term, the third element of the word list by "Monatsname"
 - task on judgment of coherence
 - judging if a presented picture is contained in the sentence or word list

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Experimental Design

- Reserialisation

- Wolken haben sich über dem Atlantik gebildet.
 - Über dem Atlantik haben sich Wolken gebildet.
- September Oktober November Dezember
 - November September Oktober Dezember
- März Januar Februar April
 - Januar Februar März April

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Experimental Design

- Substitution

- Wolken haben sich über dem Atlantik gebildet.
 - Wolken haben sich über dem Meer gebildet.
- September Oktober November Dezember
 - September Oktober Monatsname Dezember
- Januar Februar März April
 - Januar Februar Monatsname April

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Method

- subtraction design
- event-related, randomized trial presentation
- 20 right-handed subjects
- BOLD-effect will be measured
- fMRI data will be obtained across the whole brain volume (28 slices, 4 mm thickness, 1 mm gap)
- 1.5 T, TR 3s, matrix 64x64
- statistical analysis with SPM99
- 50 min: 2 sec stimuli presentation, 2 sec for the task, 12 sec intertrial break

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Method

- with EEG brain oscillations will be measured and transferred into frequencies
- different frequency bands:
 - alpha 8-13 Hz
 - theta 3.5-7 Hz
 - delta 0.5-3.5 Hz
 - gamma 30-70 Hz

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Method

- assumption that frequency-specific activation patterns correlate with specific steps of processing
 - Klimesch et al. (1997) found alpha-rhythms in a task on semantic judgement

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Hypothesis

- difference between semantic and syntactic processing not in the location of different functional areas, but in different frequencies
- these findings would support the idea of a central processor for syntactic and semantic processing

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Theoretical models

- Levelt (1989, 1999), model of speech production
- Friederici (in press), model of sentence comprehension
- Townsend and Bever (2001), model of sentence comprehension

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Theoretical models: Townsend/Bever

- comprehension sequence in LAST (Late Assignment of Syntax Theory)
 - Assign initial segmentation into words of local **phrases** using function words
 - Perform obligatory movements of **wh-phrases** in situ
 - Assign initial hypothesized meaning, using sentence templates (e.g. **NVN**)
 - Access syntactically defined predicate **subcategorization** information
 - Regenerate syntactic derivation and **check** against input
 - **Reanalyze** if necessary

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Theoretical models: Townsend/Bever

- LAST (Late Assignment of Syntax Theory)
- first three stages of syntactic processing (pseudosyntax):
 - Local phrase building based on function-word templates
 - Recognition of basic meaning
 - Access of auxiliary-verb frames related to verb meaning
- the pseudosyntax could form an initial hypothesis about the relation between meaning and form

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Theoretical models: Townsend/Bever

LAST-model	ERP-evidence of different studies
1. Phrase structure	ELAN: N125
2. Wh-placement	LAN: 300-500 ms
3. NVN	LAN: 300-500 ms
4. Verb subcategories	LAN: 300-500 ms
5. Grammar check	LAN/N400: 300-600 ms
6. Reanalysis	P600: 500-1000 ms

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Theoretical models: Townsend/Bever

- two critical implications:
 - it is "completely compatible with current syntactic theory"
 - "we understand sentences twice"

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Theoretical models: Townsend/Bever

- it is "completely compatible with current syntactic theory":
 - > the output of pseudosyntax consists of
 - overt lexical items
 - basic phrase grouping
 - an associated meaning that specifies basic grammatical values and semantic functions

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Theoretical models: Townsend/Bever

- "we understand sentences twice"
 - initial meaning-form pair is based on associative connections and templates in the *pseudosyntax*
 - based on meaning-form pair derived by the *grammar* successful comparison of the derived form and the stored input confirms the final interpretation

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References

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