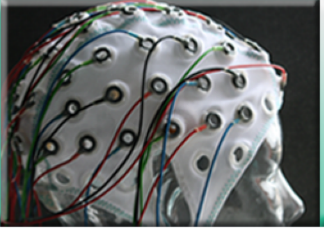
Kognitive Neuropsychologie



03.11. Geschichte der kognitiven Neurowissenschaft

10.11. Funktionelle Neuroanatomie

17.11. Methoden der kognitiven Neuropsychologie I

24.11. Methoden der kognitiven Neuropsychologie II

01.12. Visuelle Wahrnehmung

08.12. Objekterkennung

15.12. Auditive Wahrnehmung

05.01. Sprache

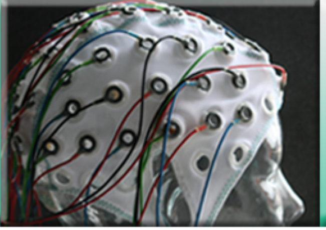
12.01. Aufmerksamkeit und Selektion

19.01. Kognitive Kontrolle

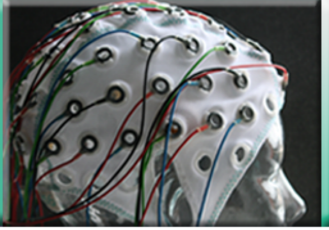
26.01. Gedächtnis & Lernen

02.02. Kognitives Altern

Das Auditive System



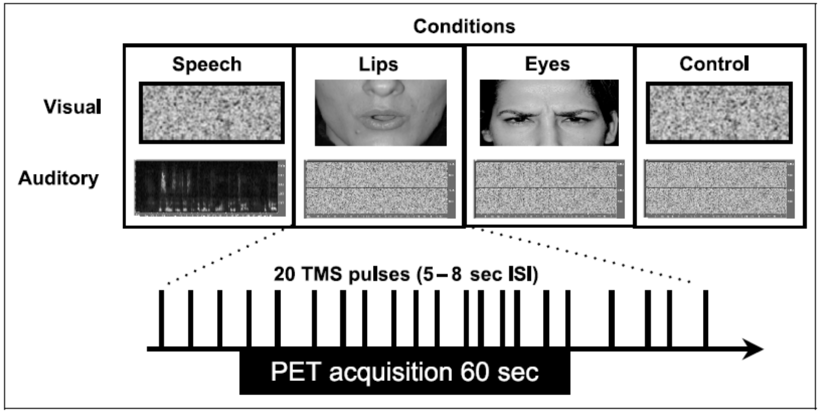
- Hören
- Vom Ohr zum Gehirn
- Der primäre auditorische Kortex
- Schalllokalisation
- Das „What“ und das „Where“ System
- Auditives Gedächtnis
- Musik
- Stimmen
- Sprache



Motor Theory of Speech Perception

Understanding acoustic signal = matching to stored inputs

Motor representations of how sound is articulated?



🟥 Speech
🟩 Lips
🟦 Eyes

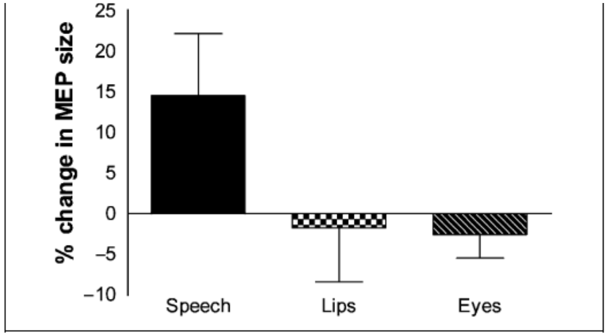
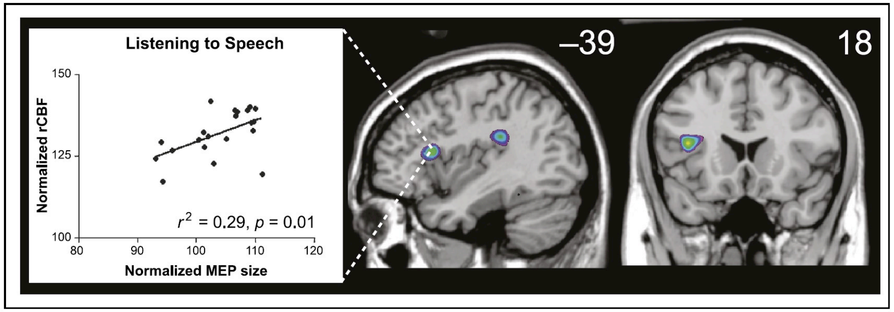
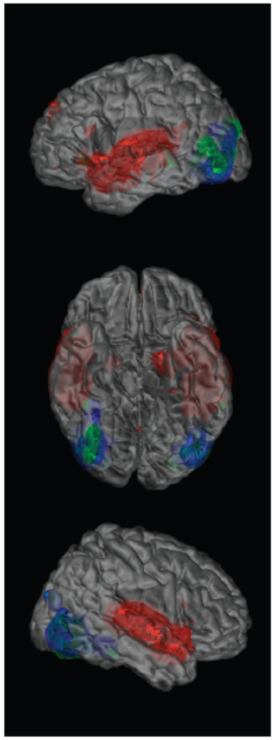


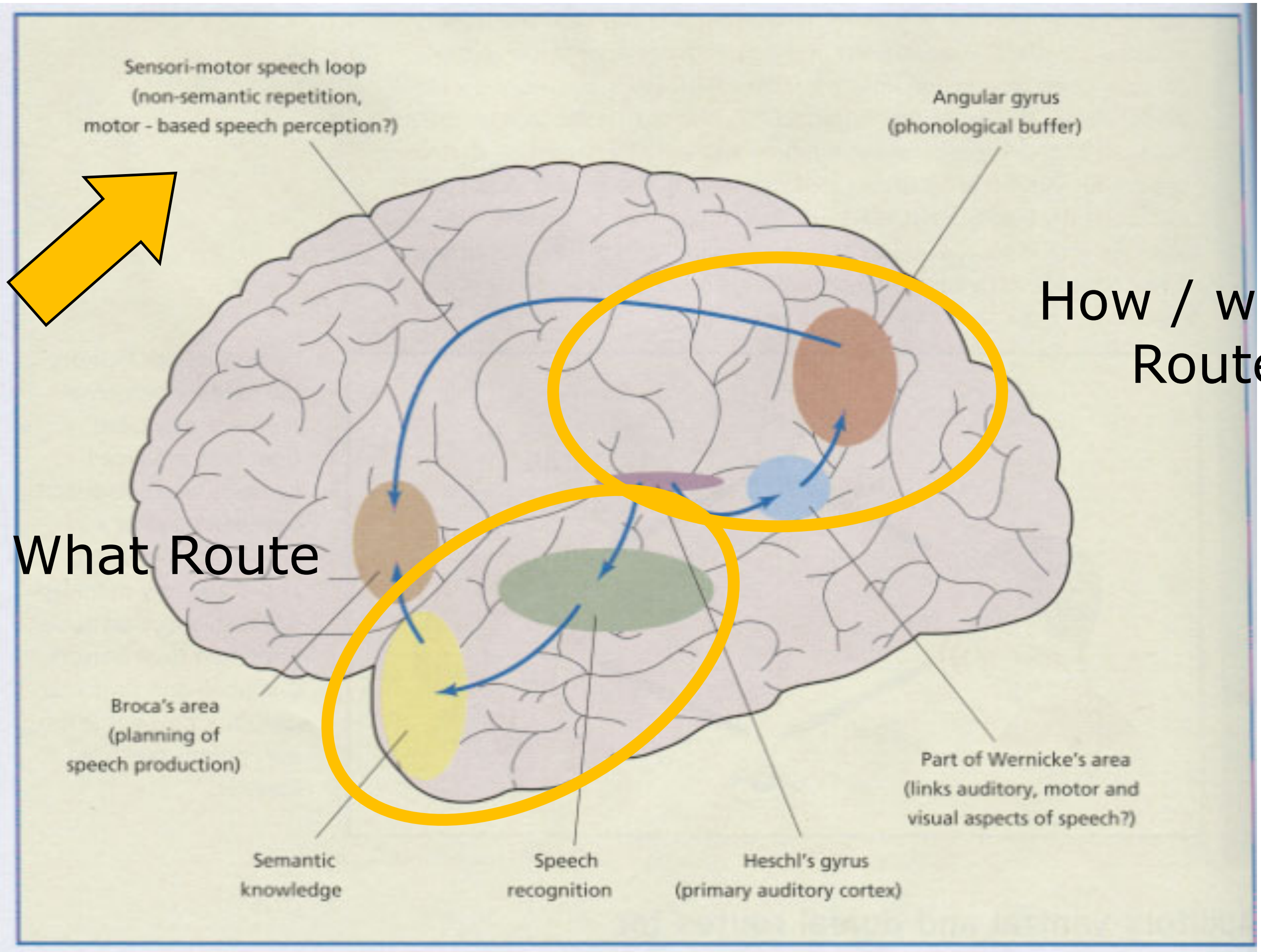
Figure 2. Motor excitability changes. The graph shows the mean of the change in size of the motor-evoked potential for the Speech, Lips, and Eyes conditions relative to the Control condition. Error bars represent standard errors of the mean.





Watkins & Paus, (2004), Journal of Cognitive Neuroscience, 16-6, 978-987

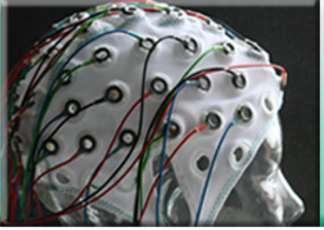
Motor-based speech perception in the „where“ route?



How / where
Route

What Route

There may be two routes for perceiving and repeating speech: one that is based on lexical-semantic processing and one that is based on auditory-motor correspondence. These have been termed the ventral "what" route and the dorsal "how" route, respectively.



Different levels of language

Syntactical level

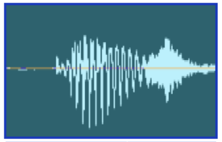
Syntactic structure building
Thematic role assignment
Syntactic integration

Semantic-conceptual level

Lexical level

-noun
-singular
-…

Phonological level



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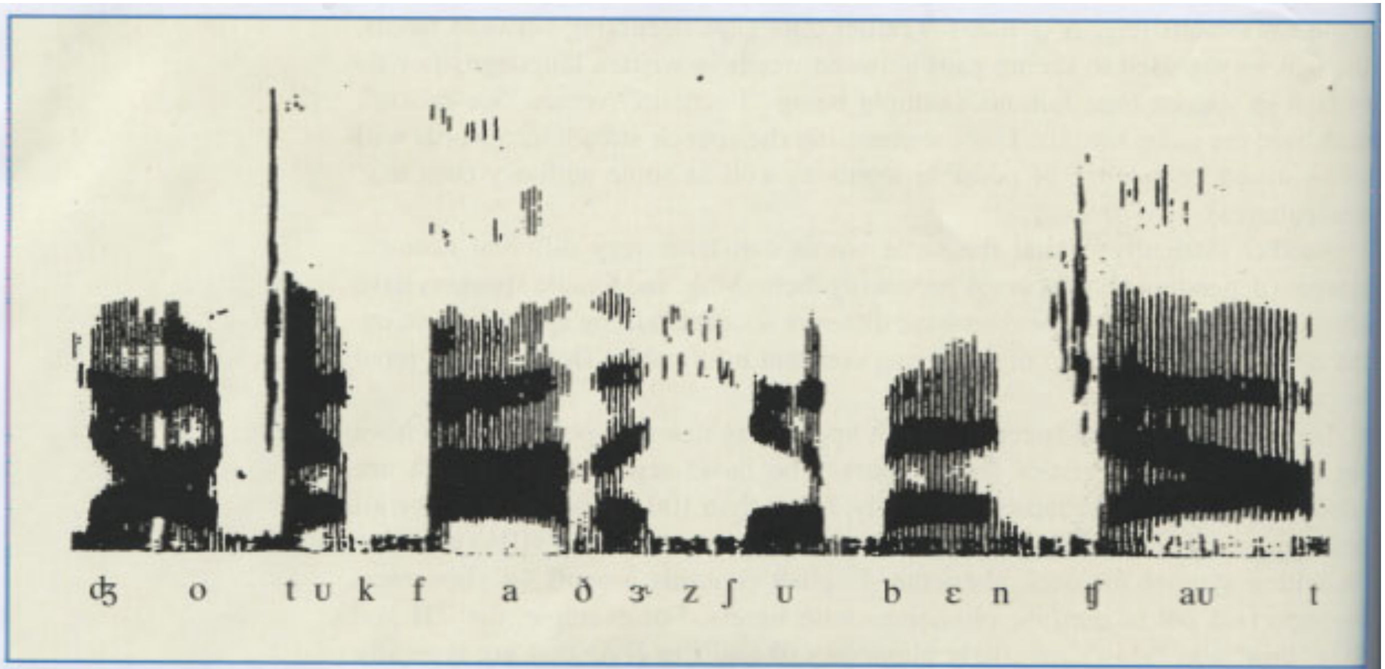
Das Sprachsignal



In the spectrogram, time is plotted along the *x*-axis and frequency along the *y*-axis, with intensity represented by darkness. There are no gaps between words but certain consonants (e.g. "b") block the flow of air and produce gaps. Vowels are represented by bands of horizontal stripes (called formants). The spectrogram represents "Joe took father's shoe bench out". From Tartter (1986). Copyright © Vivien Tartter. Reprinted with kind permission of the author.

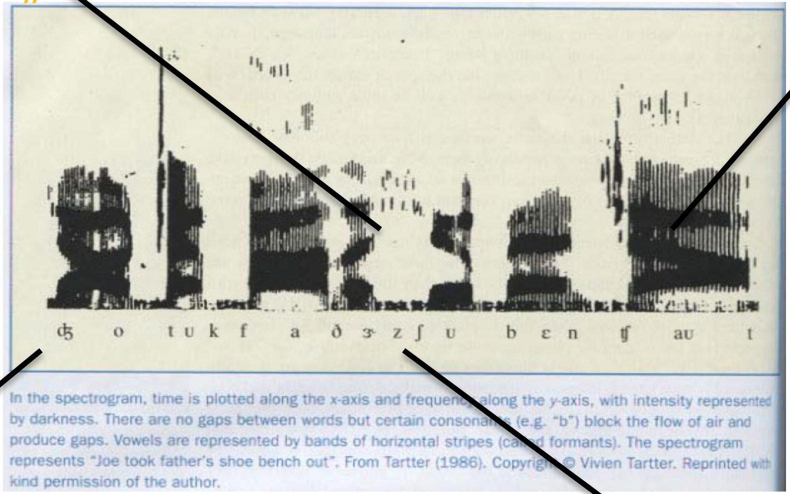
„Joe took father's shoe bench out"

Das Sprachsignal

Keine Unterbrechung zwischen Wörtern
(Ice cream / I scream)

Formanten

„Joe took father's shoe bench out“



In the spectrogram, time is plotted along the x-axis and frequency along the *y*-axis, with intensity represented by darkness. There are no gaps between words but certain consonants (e.g. "b") block the flow of air and produce gaps. Vowels are represented by bands of horizontal stripes (called formants). The spectrogram represents "Joe took father's shoe bench out". From Tartter (1986). Copyright © Vivien Tartter. Reprinted with kind permission of the author.

Phonemes (IPA)
Aspiration
Co-Artikulation

Voicing
“zzzz”
“ssss”

Kategoriale Wahrnehmung

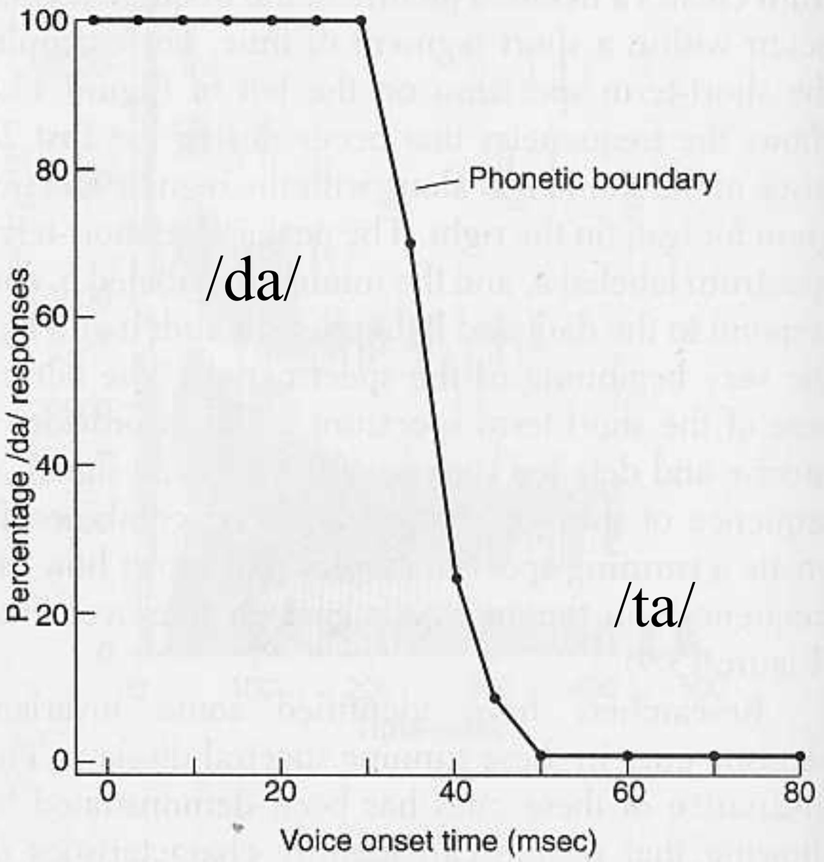


Figure 13.11
The results of a categorical perception experiment indicate that /da/ is perceived for VOTs to the left of the phonetic boundary, and that /ta/ is perceived at VOTs to the right of the phonetic boundary. (From Eimas & Corbit, 1973.)

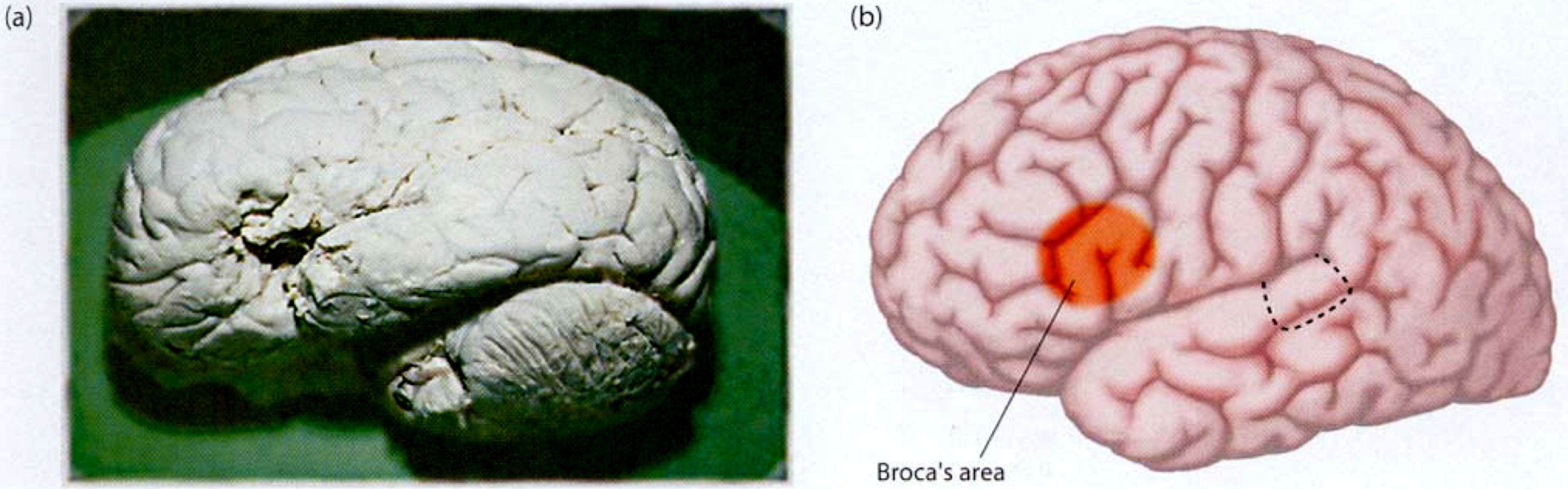
Paul Broca und die Beobachtung von Sprachstörungen

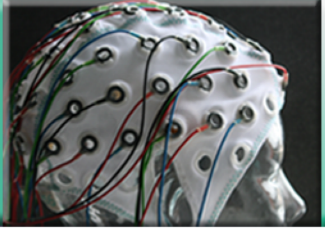
Paul Broca
(1824 – 1880)

Bericht über klinische Fälle, bei denen Sprachausfälle mit Schädigungen der 3. linken Stirnhirnwindung assoziiert waren

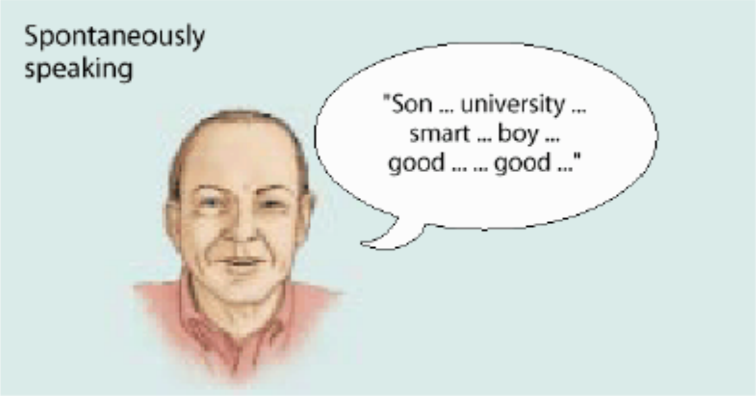
Broca‘s Patient Tan

Figure 9.24 **(a)** The preserved brain of Leborgne, Broca's patient "Tan," which is maintained in a Paris museum. **(b)** The area in the left hemisphere lesioned in Leborgne's brain and now known as *Broca's area* (in red). The dotted lines indicate the location of Wernicke's area.

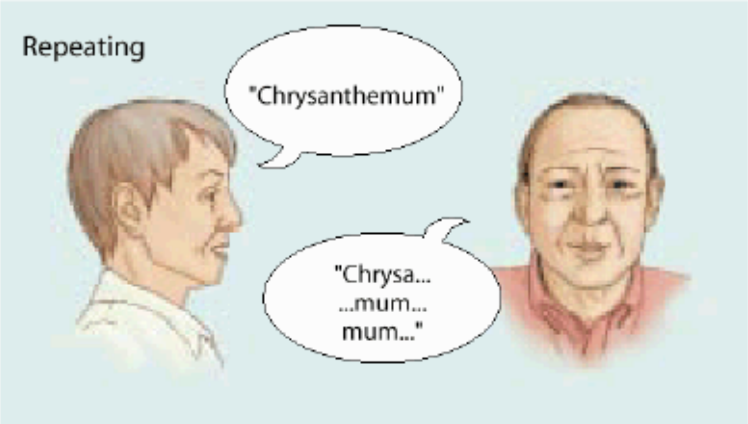


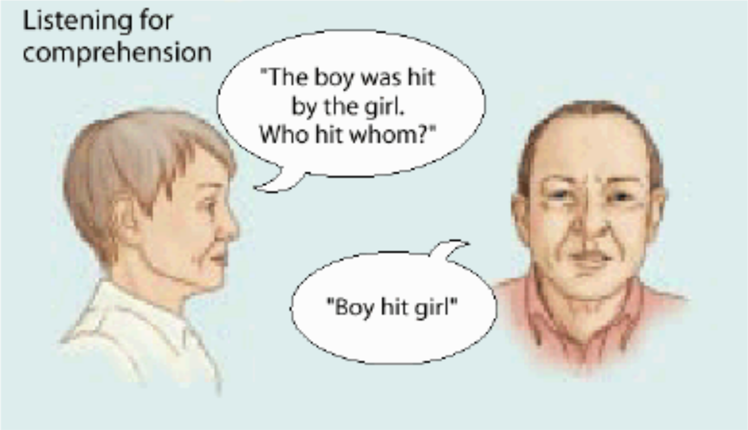


Broca - Aphasie



Expressive Sprachstörungen



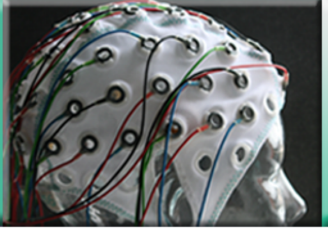


Carl Wernicke (1874)
10 Patienten mit Sprachstörungen

- Beschreibung von Aphasien nach Läsionen im temporo-parietalen Übergangsbereich,
- d.h. Sprachareal im linken Planum temporale

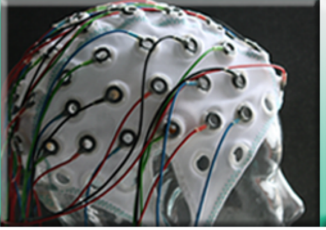
Carl Wernicke

(1848 – 1911)



Wernicke Aphasie

Rezeptive Sprachstörungen

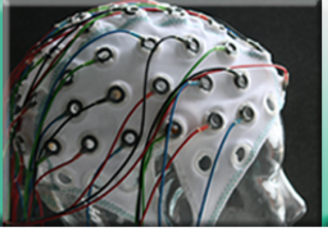


The mental lexicon

- includes
  - semantic information
  - syntactic information
  - word form information

- works highly efficient
  - no fixed content
  - frequency effects
  - neighbourhood effects

Organisation of the mental lexicon



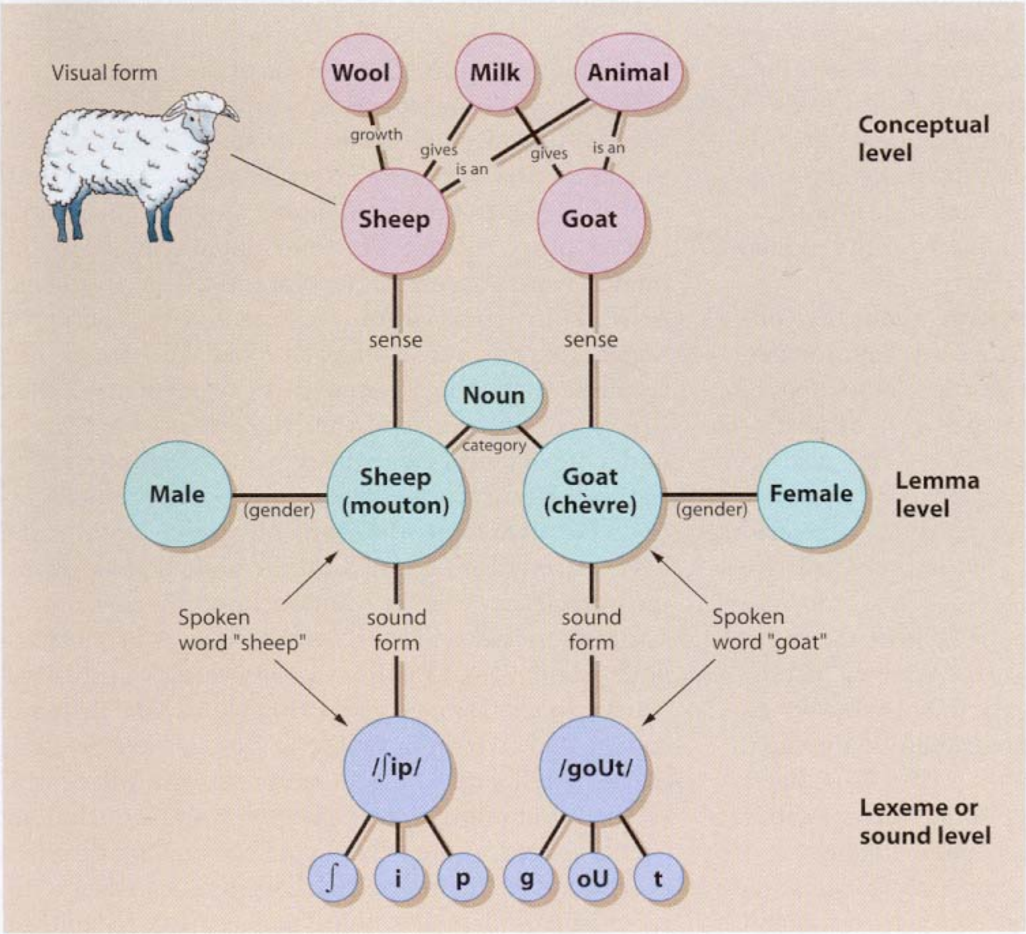


Figure 9.1 Fragment of a lexical network according to the Levelt model. See the text for a description. This model describes the processes for spoken word input, but a similar model applies to written word input. Adapted from Levelt (1994).

Spreading activation ?

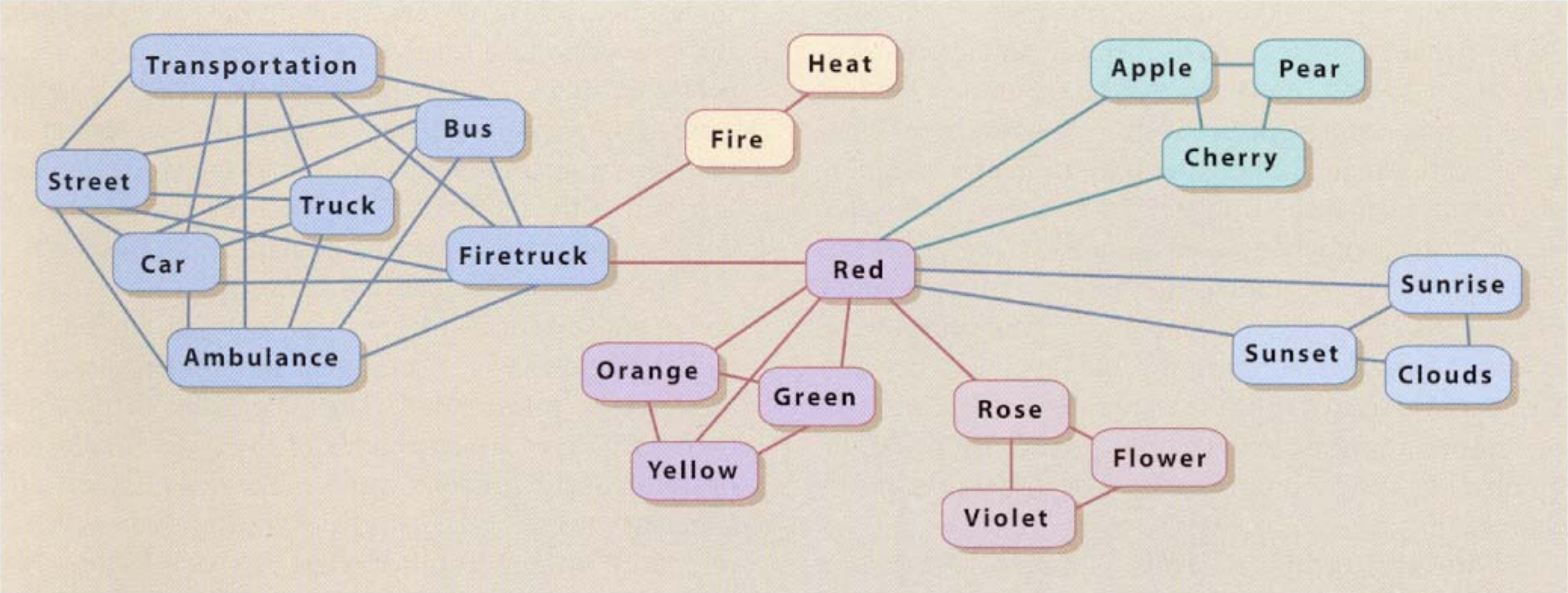
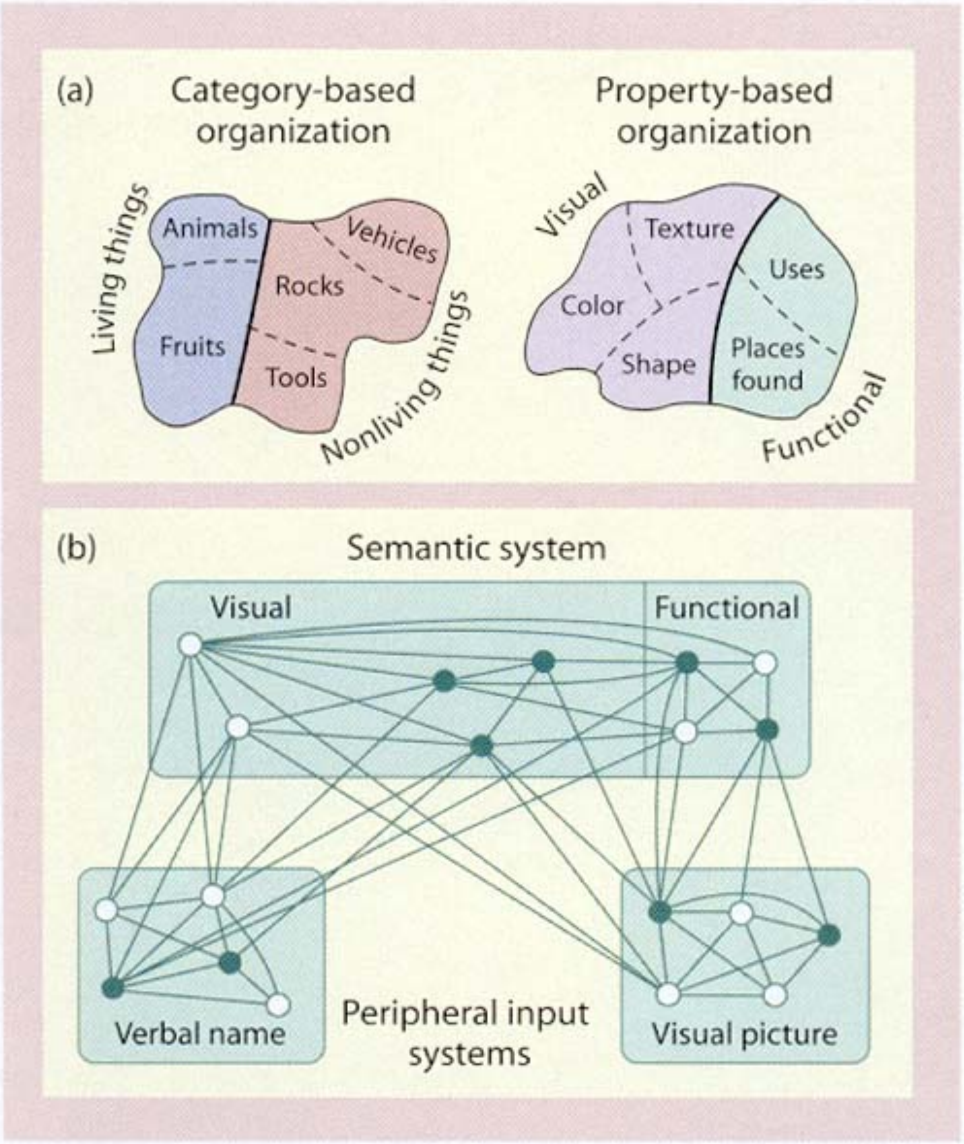


Figure 9.2. An example of a semantic network. Note that words that have strong associative or semantic relations are closer together in the network (e.g., *Car–Truck*) than are words that have no such relation (e.g., *Car–Clouds*). Semantically related words are colored similarly in the figure, and associatively related word (e.g., *Firetruck-Fire*) are closely connected.

Category-based vs feature-based models



Naming persons, animals and tools I

Hanna Damasio*†, **Thomas J. Grabowski***, **Daniel Tranel***, **Richard D. Hichwa**‡ **& Antonio R. Damasio***†

* Department of Neurology, Division of Behavioral Neurology and Cognitive Neuroscience, and ‡ Positron Emission Tomography Imaging Center, University of Iowa College of Medicine, Iowa City, Iowa 52242, USA
† The Salk Institute for Biological Studies, La Jolla, California 92186, USA

Two parallel studies using positron emission tomography, one conducted in neurological patients with brain lesions, the other in normal individuals, indicate that the normal process of retrieving words that denote concrete entities depends in part on multiple regions of the left cerebral hemisphere, located outside the classic language areas. Moreover, anatomically separable regions tend to process words for distinct kinds of items.

A CENTRAL question in the neurobiology of language concerns the neural structures that become active when the word that denotes a person or object is recalled, and is either silently verbalized or vocalized; that is, when an item from the lexicon of a given language is retrieved and explicitly represented in the mind. The traditional answer, based largely on more than a century of aphasia studies, invokes a set of left cerebral hemisphere structures around the Sylvian fissure, among which Broca and Wernicke areas figure prominently[1]. This assumes that the classic language areas are activated directly by non-language areas which support the concept for which a pertinent word is being retrieved. Studies of neurological patients[2-7] have led to an alternative answer, however. Although perisylvian structures (including early auditory and somatomotor cortices) are indeed involved in the transient reconstruction and explicit phonemic representation of word forms, additional neural sites mediate between those that support conceptual knowledge and the perisylvian structures, thus triggering and conducting the process of reconstruction[8]. We propose that there would not be a single mediational site for all words, but rather that there are separable regions within a large network which would preferentially assist with the processing of words denoting varied kinds of entities. Specifically, we considered that the retrieval of words denoting entities belonging to three distinct conceptual categories—unique persons, non-unique animals, and non-unique tools—depends on separable regions in higher-order cortices of the left temporal lobe. The two studies reported below were designed to test this hypothesis. In the first study of 127 subjects with focal brain lesions, we found a reliable relationship between category-related word-retrieval defects and neural sites within the left temporal lobe. In the second study, of 9 normal subjects who participated in a positron emission tomography (PET) word-retrieval experiment, we found differential activation of left temporal sites, comparable to those revealed by the lesion study.

Lexical retrieval in subjects with lesions

The lesion test of the hypothesis used a visual naming experiment in 127 adults with single and stable focal brain lesions. We used subjects with lesions throughout the telencephalon, allowing for sampling in both hemispheres, within and outside the temporal region.

The task required the naming of 327 visually presented items: (1) photographs of the faces of well-known people, to be named at unique (subordinate) level; (2) animals, and (3) tools, both of which were to be named at non-unique (basic object) level. The subject was asked to provide the specific and most adequate word denoting each entity. A response was scored as correct if it conformed to that of normal controls matched for age and education. Responses were only scored as incorrect when the subject had appropriately recognized the item, so that scores reflected true word-retrieval ability (Table 1(*a*)). For example, if a subject failed to recognize the 'skunk' stimulus (as exemplified in the response "Some kind of animal; I don't know what . . . just an animal"), then that item was not included in the naming score. If the subject recognized the item (as exemplified in the response "Oh, that animal makes a terrible smell if you get too close to it; it is black and white, and gets squashed on the road by cars sometimes"), the item was included in the naming score, either as a correct response if the name was provided ('skunk'), or as a failure response if the name was not provided. Thus whenever a naming response was counted as incorrect, we were certain that the subject knew the item that they failed to name. We cannot claim that the subjects' concept retrieval was as normal as in the premorbid state, but we can affirm that the concept was retrieved specifically enough to provide a notion of what the stimulus was.

We tested two predictions. (1) The disruption of word retrieval for all three categories would be correlated with regions in left but not right hemisphere. (2) The disruption of word retrieval for each category would be consistently correlated with separable neural sites within left higher-order cortices of the temporal region, namely, temporal pole (TP) and inferotemporal (IT) sectors (Fig. 1*a*).

The subjects were first classified according to their task performance, which was normal in 97 subjects (47 with left-hemisphere damage, 50 with right) and abnormal in 30). All but one of the latter had damage in the left hemisphere, thus supporting the first prediction. The scores of brain-damaged subjects who performed abnormally in each of the three word categories were significantly lower ($P < 0.001$ in each case) than those of the brain-damaged subjects who performed normally (Table 1*b*).

In addition to isolated word-retrieval defects for unique persons, animals or tools, the instances of two combined defects always involved 'persons/animals' or 'animals/tools', but never 'persons/tools' (Table 1*a*). When the naming of persons and tools was impaired in the same individual, the naming of animals was impaired as well. The non-occurrence of instances of the 'persons/tools' combination is statistically significant ($P < 0.001$; Table 1*a*). The anatomical evidence discussed below indicates why this combination of defects is not possible on the basis of a single lesion.

Each subject's lesion was reconstructed in three dimensions[9]. The lesions of the 29 left-hemisphere subjects with abnormal performance were analysed using MAP-3, a technique which allows the determination of the volumetric overlap of lesions from multiple subjects (Fig. 1*b*). The overlaps revealed that: (1) abnormal retrieval of words for persons was correlated with

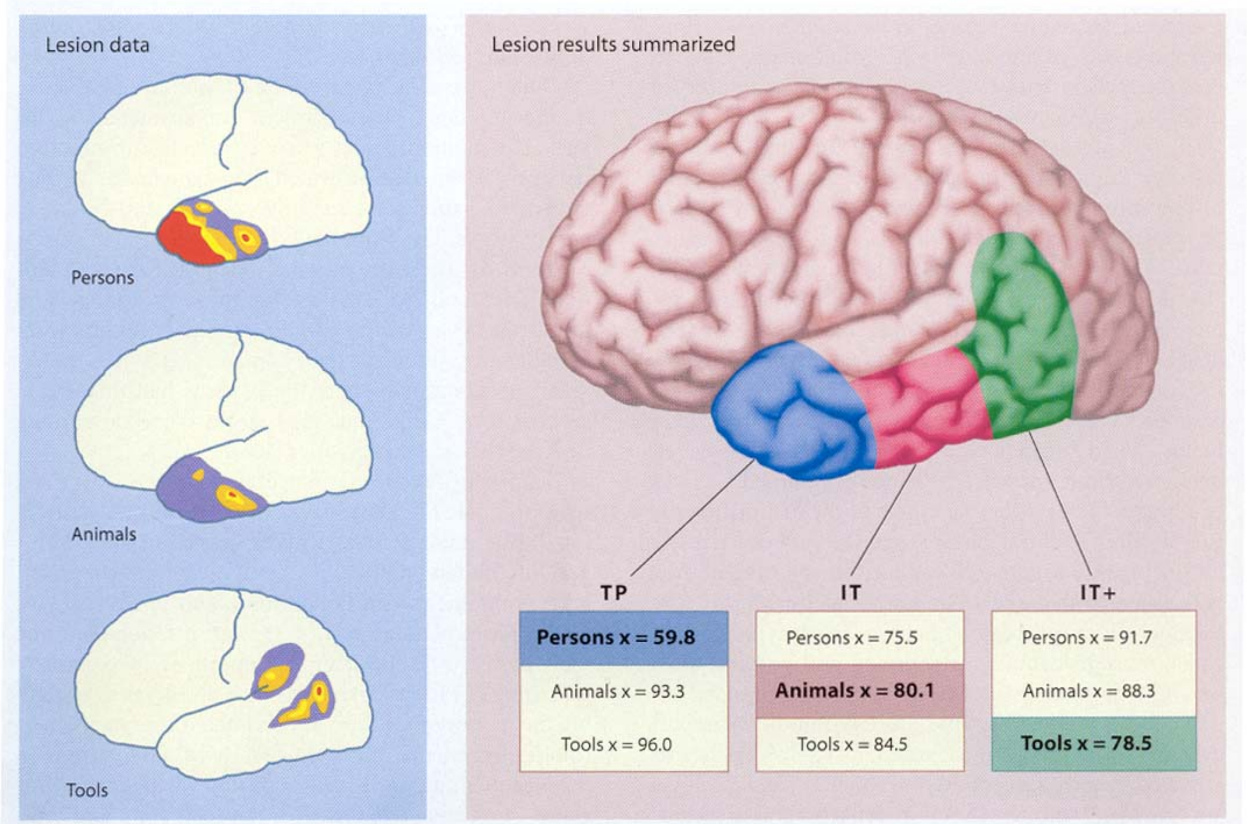


Figure 9.3 Locations of brain lesions that are correlated with selective deficits in naming persons, animals, or tools. On the left, the actual averaged lesion data are displayed for patients that had person-naming **(top)**, animal-naming **(middle)**, or tool-naming **(bottom)** deficits. The colors indicate the percentage of patients with a given deficit whose lesion is located in the indicated area. Red indicates that most patients had a lesion in that area, whereas purple indicates that few had a lesion in that area. On the right, the lesion results are summarized. The blue area corresponds to the temporal pole (TP); the red area, to the inferotemporal region (IT); and the green area, to the posterior part of the inferotemporal lobe extending to the anterior part of the lateral occipital region (IT+). Scores in the boxes indicate the percentage of recognized items that were correctly named. Patients with TP lesions scored lowest on naming persons (59.8%), patients with IT lesions scored lowest on naming animals (80.1%), and patients with IT+ lesions scored lowest on naming tools (78.5%). Adapted from Damasio et al. (1996).

Damasio et al (2006)

Naming persons, animals and tools II

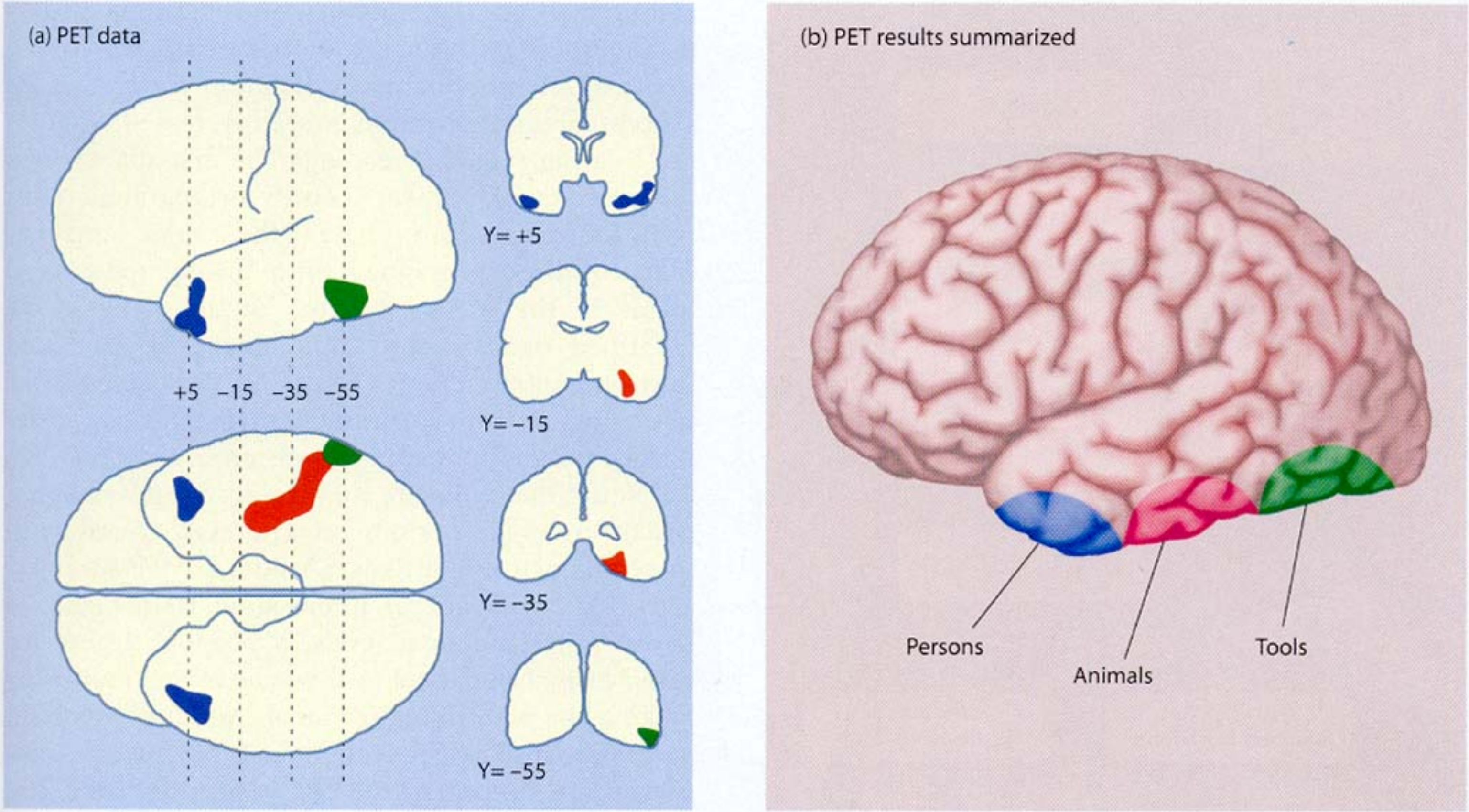
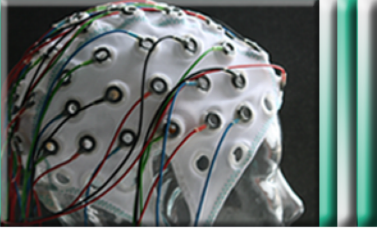


Figure 9.4 Activations in neurologically unimpaired subjects during naming of persons, animals, or tools as determined by positron emission tomography (PET). **(a)** The PET activations in lateral and ventral views (left), and in four coronal sections at the levels indicated by the dashed lines. The values correspond to millimeters in anterior and posterior directions from a zero point in the brain defined by a stereotactic coordinate system. **(b)** The summarized PET results. Naming persons mostly activated the temporal pole, naming animals mostly activated the middle portion of the inferior temporal gyri, and naming tools mostly activated the posterior portions of the inferior temporal gyrus. Adapted from Damasio et al. (1996).

Damasio et al 2006



The Damasio model

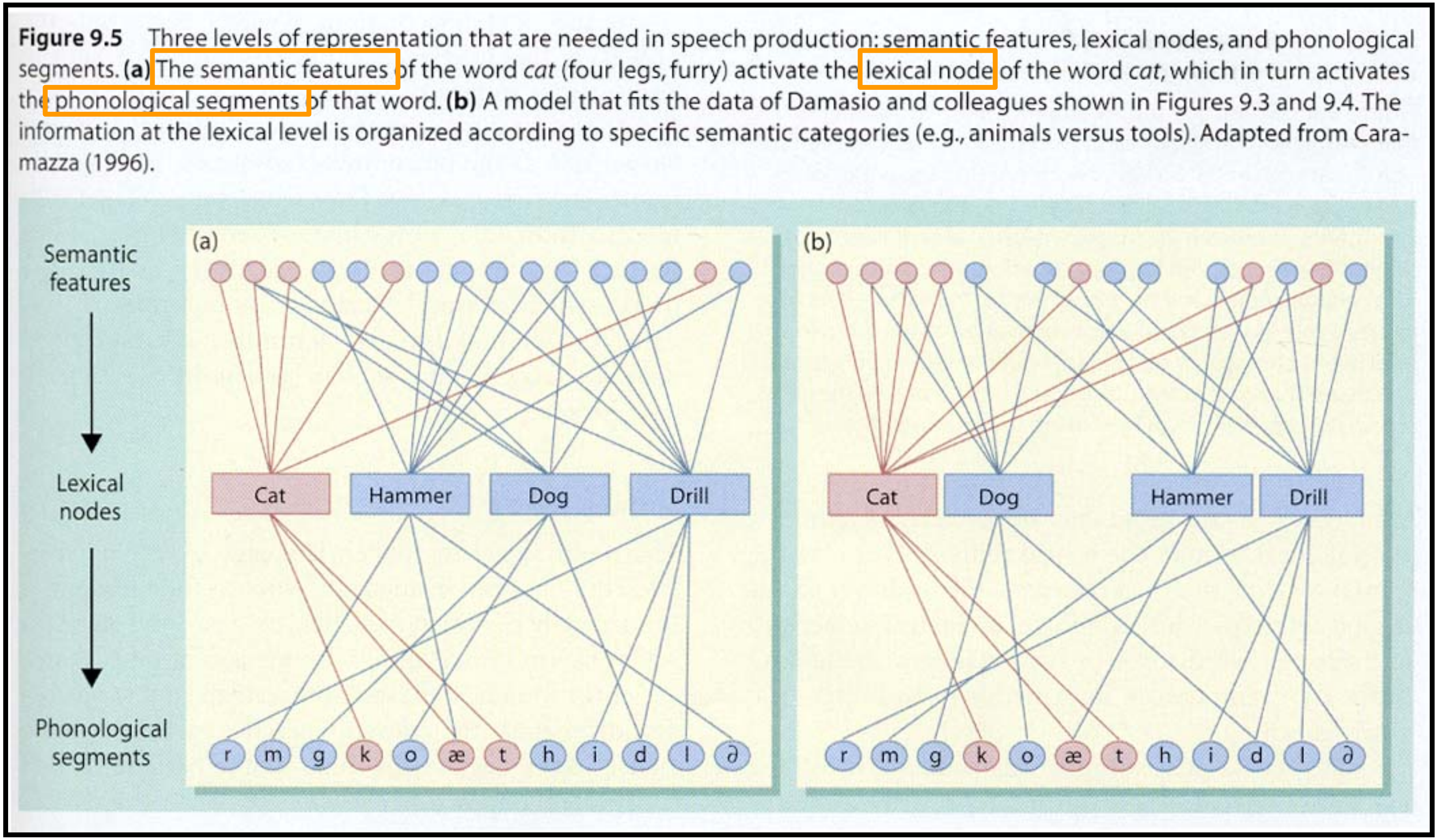
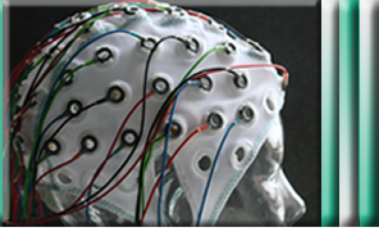
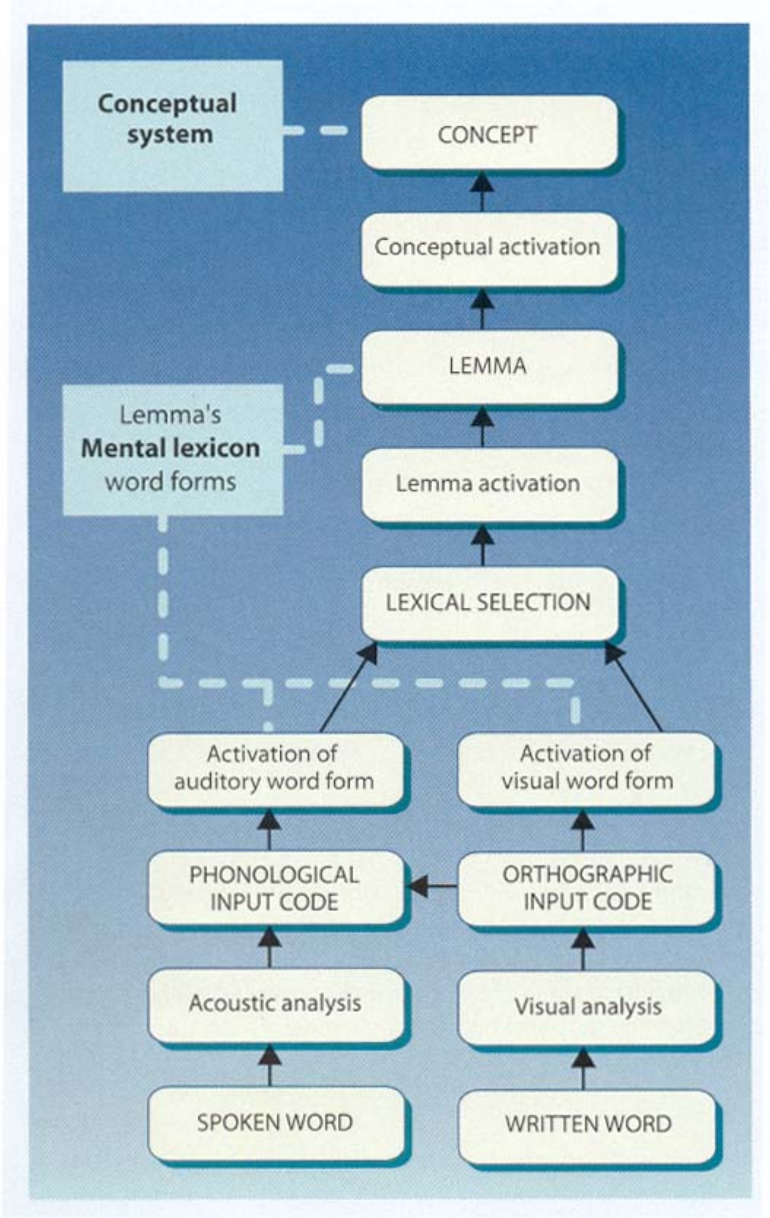


Figure 9.5 Three levels of representation that are needed in speech production: semantic features, lexical nodes, and phonological segments. **(a)** The semantic features of the word *cat* (four legs, furry) activate the lexical node of the word *cat*, which in turn activates the phonological segments of that word. **(b)** A model that fits the data of Damasio and colleagues shown in Figures 9.3 and 9.4. The information at the lexical level is organized according to specific semantic categories (e.g., animals versus tools). Adapted from Caramazza (1996).

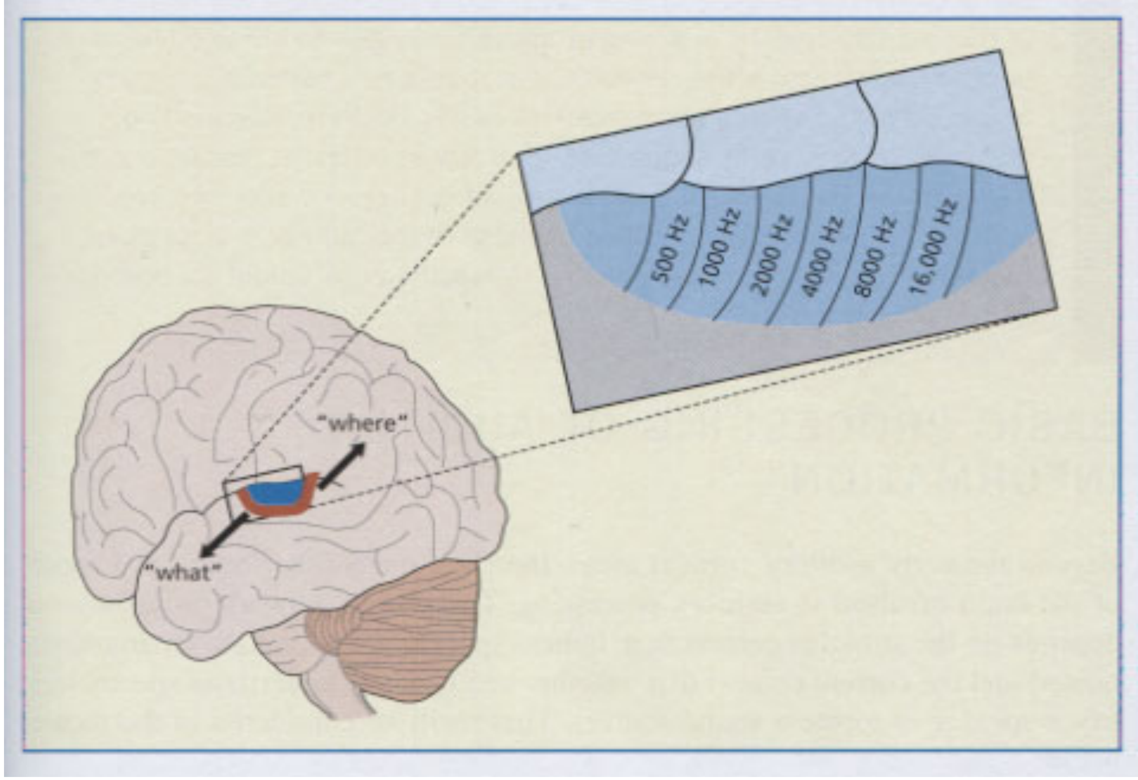
Komponenten des Sprachverstehens



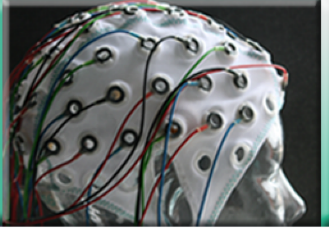


Die Sprachwahrnehmung im Gehirn

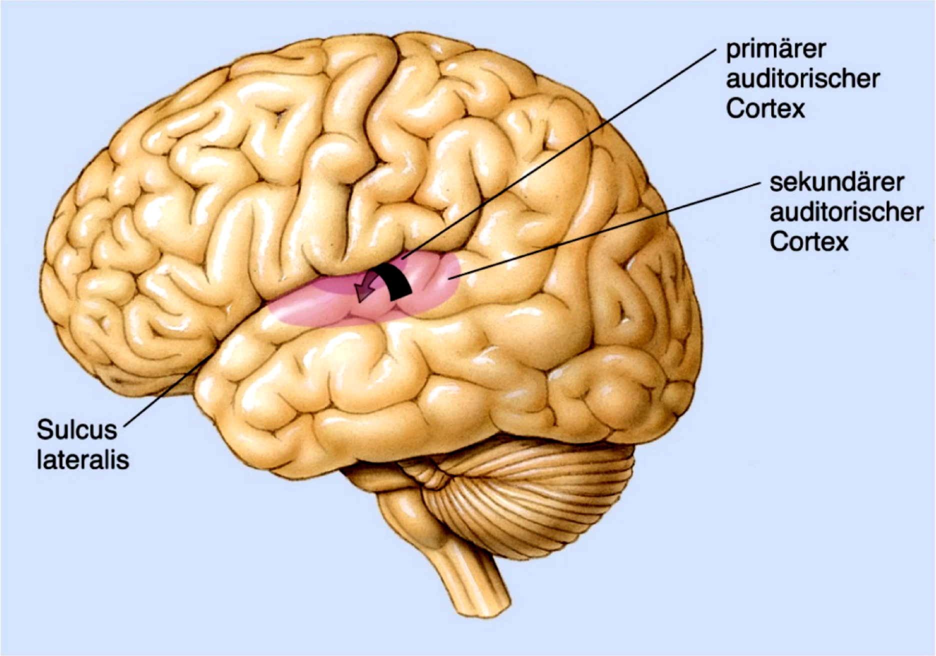
Wo werden Sprachsignale anders verarbeitet als andere auditive Signale?

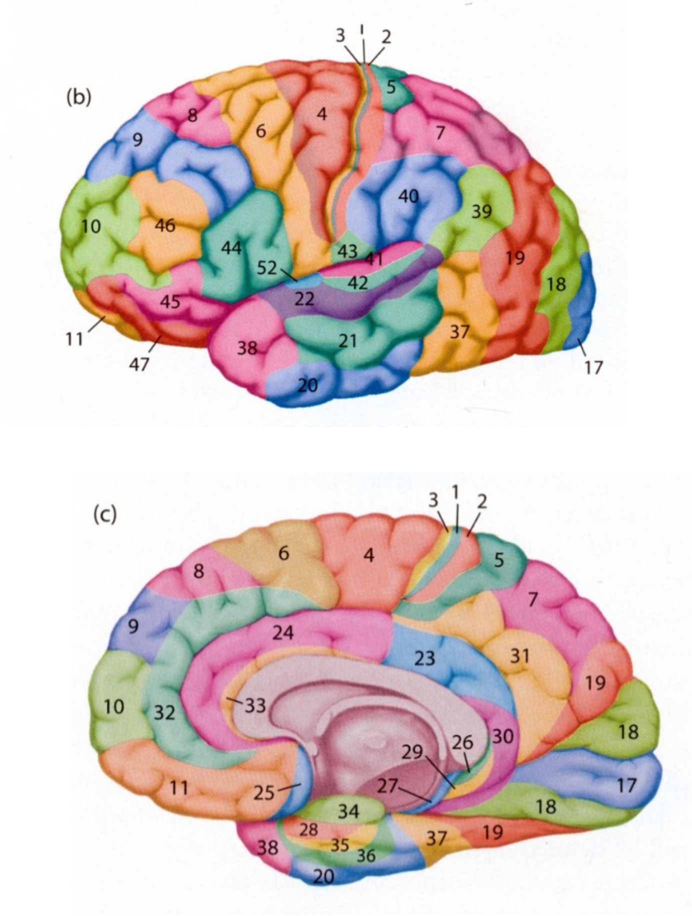


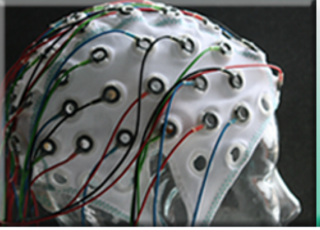
- **What-Route:** Linke Temporal-Region separiert zwischen deutlicher und undeutlich gesprochener Sprache und Klängen mit und ohne Vokale.
- Worttaubheit: Links temporale Regionen.



Neural substrates of spoken word processing







Speech vs non-speech

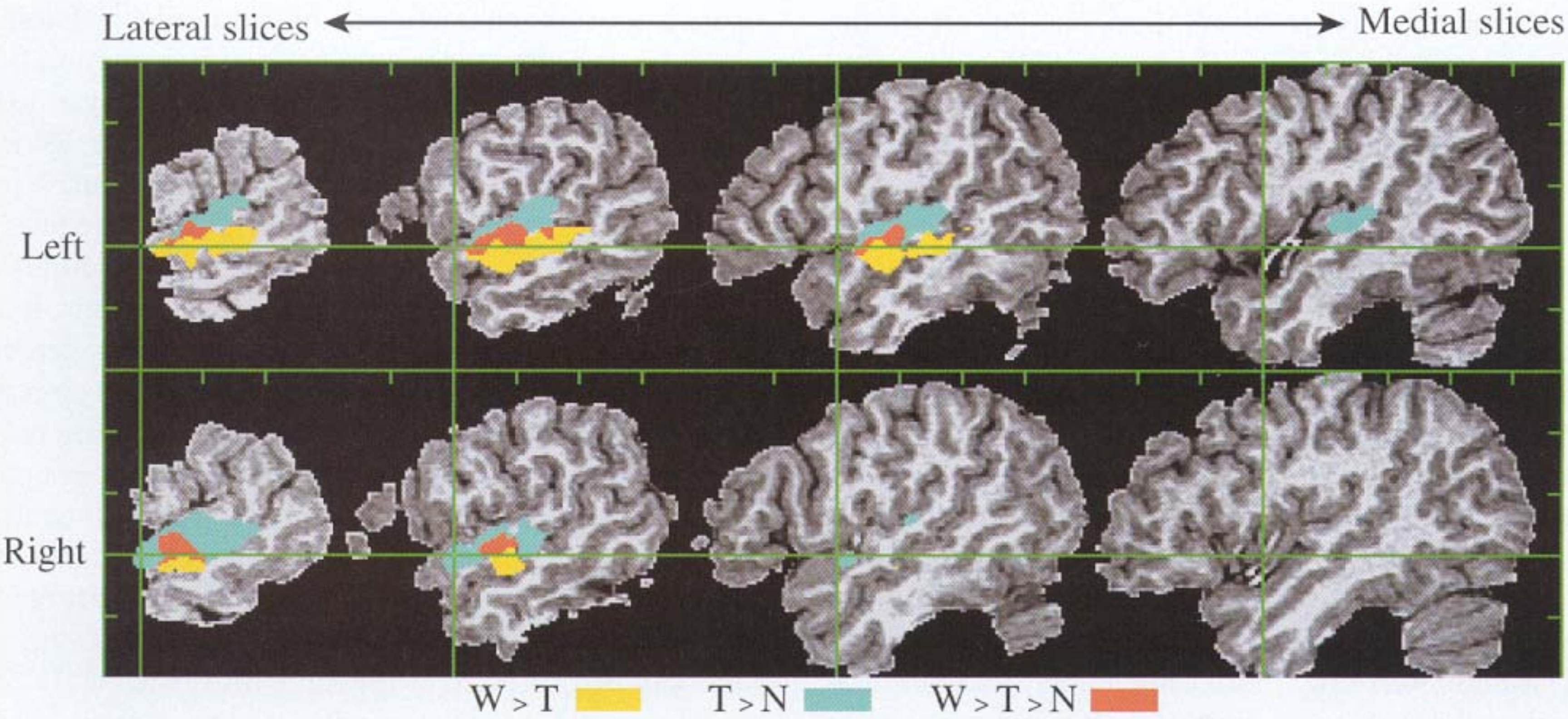
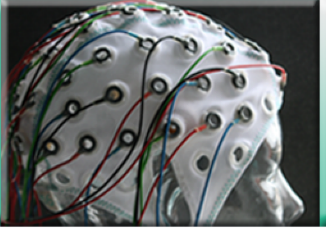


Figure 9.10 Superior temporal activations to speech and nonspeech sounds. Four sagittal slices are shown for each hemisphere. The posterior areas of the superior temporal gyrus are more active bilaterally for frequency-modulated sounds than for simple noise (in blue), whereas areas that are more sensitive to speech sounds are located ventrolateral to this area (in yellow), in or near the superior temporal sulcus. This latter activation is somewhat lateralized to the left. Areas that are more active for words (W) and tones (T) than for noise (N) are also indicated (in red). Adapted from Binder et al. (2000).



Word recognition

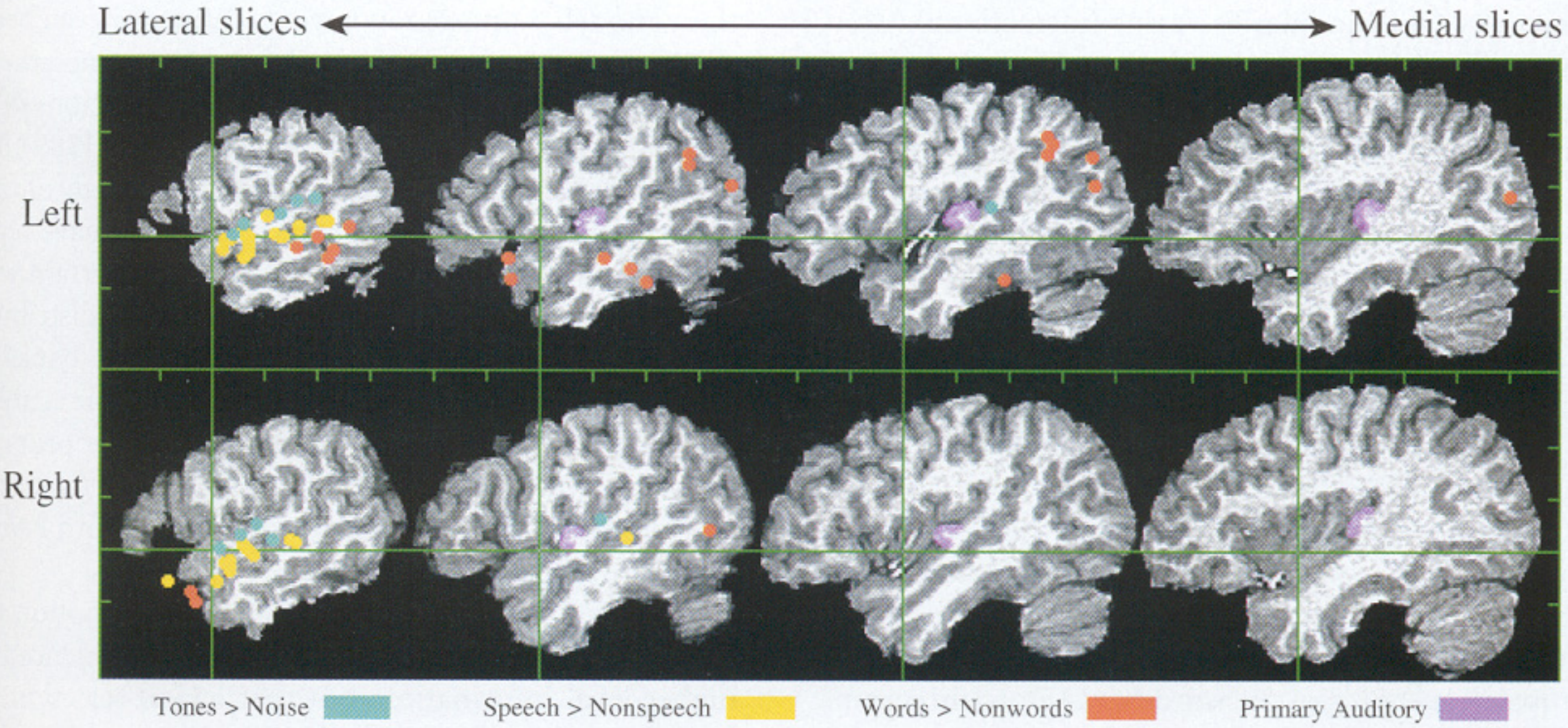
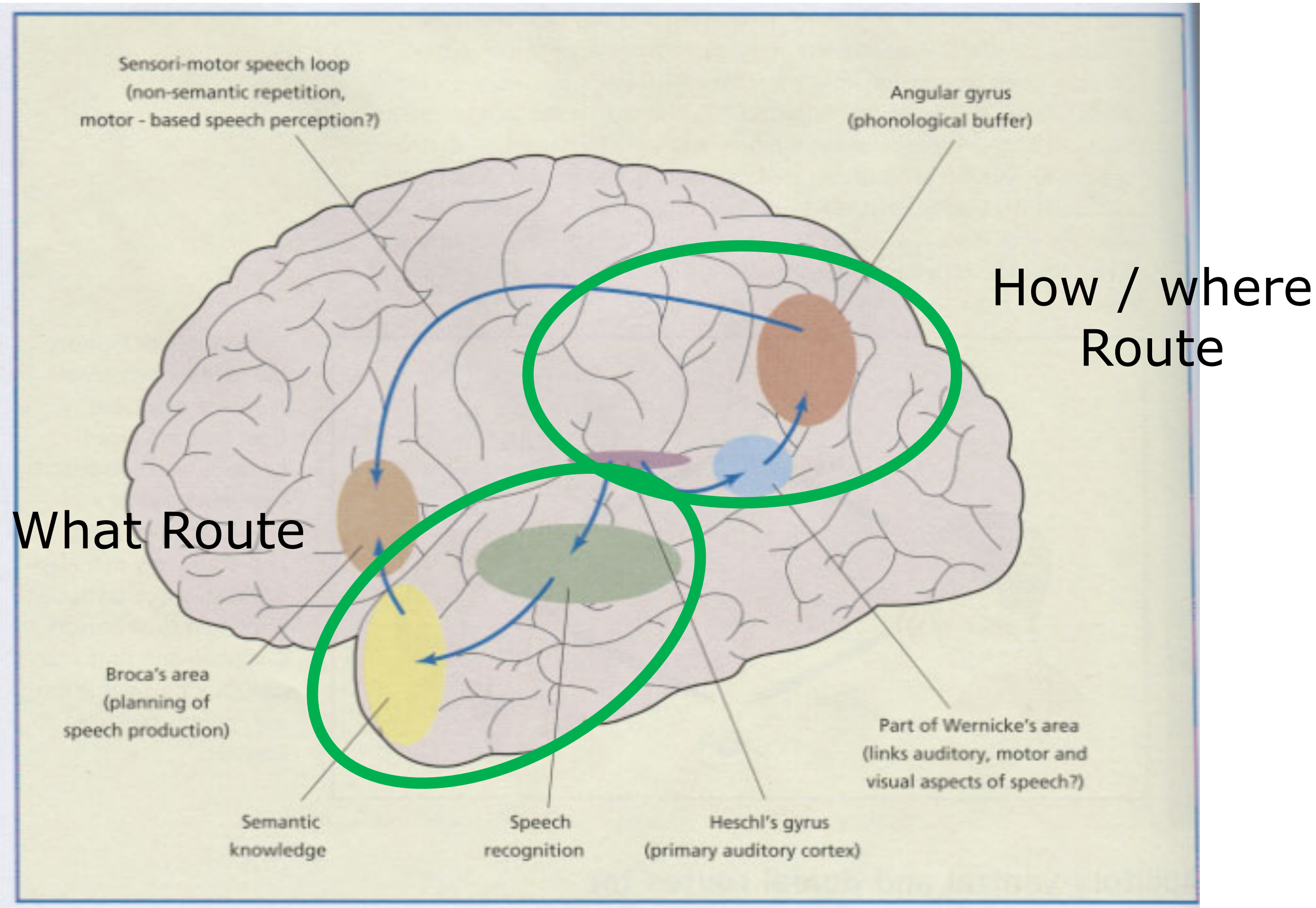
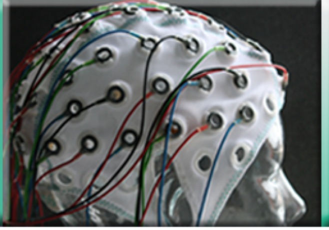


Figure 9.15 A hierarchical processing stream for speech processing (see text for explanation). Four slices are shown for the left and right hemispheres. Heschl's gyri, the site of primary auditory cortex, are indicated in purple. Indicated in blue are areas of the dorsal superior temporal gyri that are activated more by frequency-modulated tones than by random noise. Yellow areas are clustered in superior temporal sulcus and are speech specific; that is, they show more activation for speech sounds (words, pseudowords, or reversed speech) than for nonspeech sounds. Finally, red areas include regions of the middle temporal gyrus, inferior temporal gyrus, angular gyrus, and temporal pole and are more active for words than for pseudowords or nonwords. Note that these "word" areas mostly are lateralized to the left. The latter areas were identified in a number of studies (Démonet et al., 1992, 1994; Perani et al., 1996; Binder et al., 1999, 2000). From Binder et al. (2000).

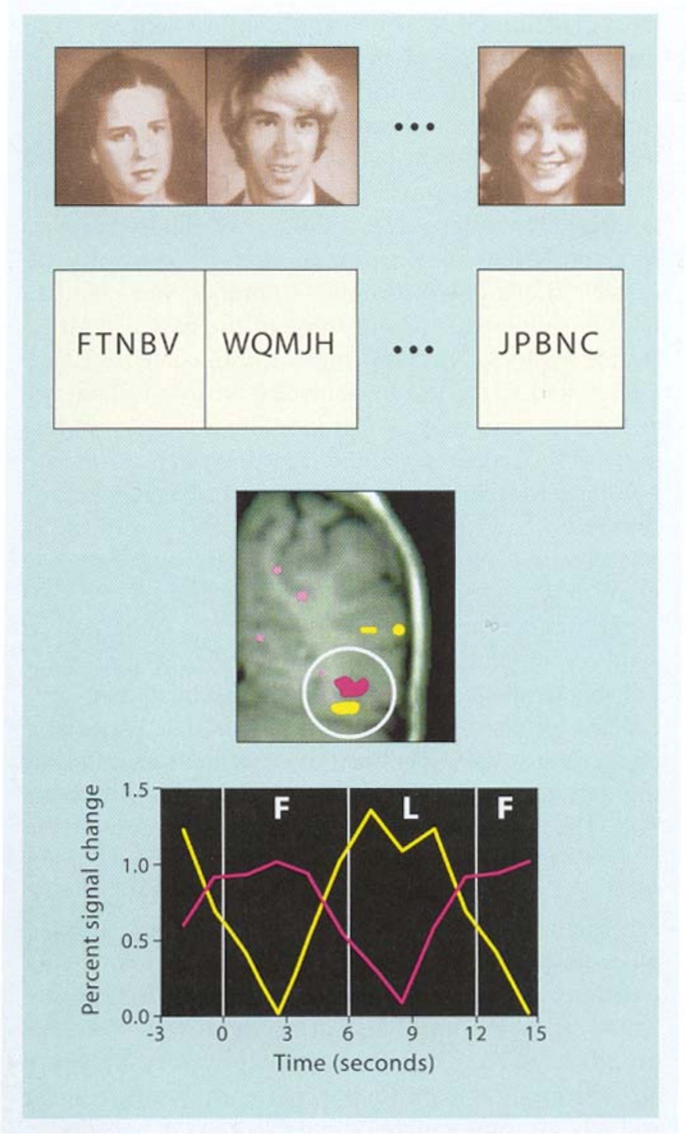
Motor Theory of Speech Perception

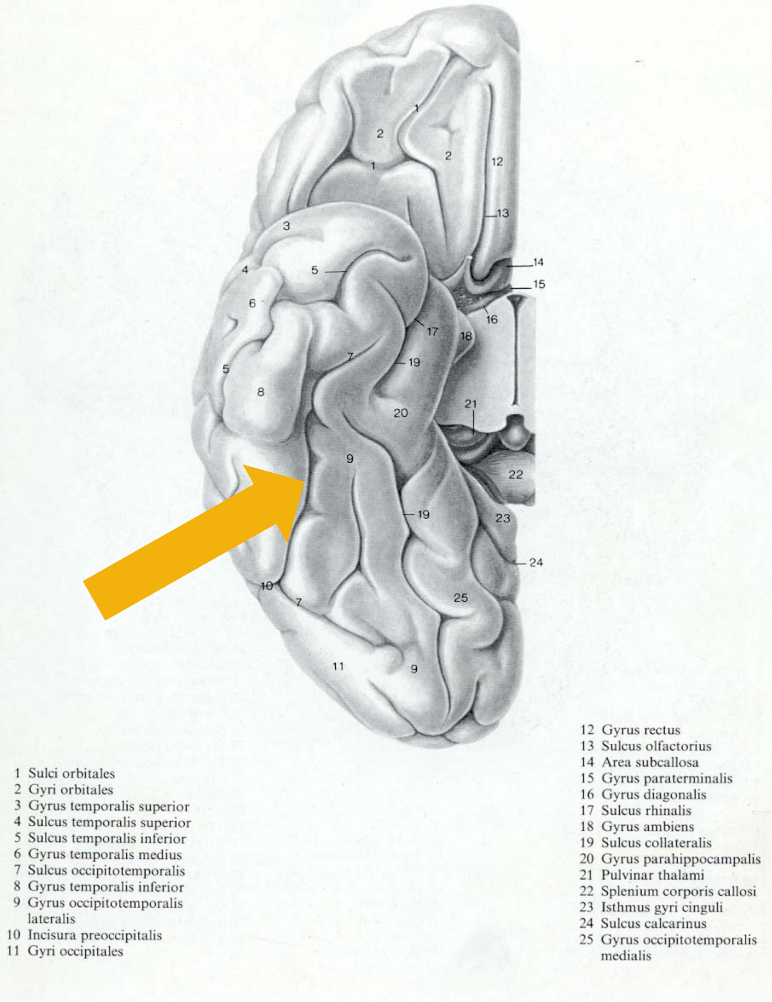


There may be two routes for perceiving and repeating speech: one that is based on lexical-semantic processing and one that is based on auditory-motor correspondence. These have been termed the ventral "what" route and the dorsal "how" route, respectively.



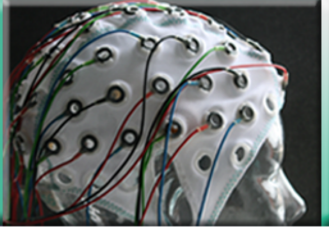
Neural substrates of written word Processing: The visual word form area





Puce et al. (1986)

The developing visual word form area



Fine Neural Tuning for Orthographic Properties of Words Emerges Early in Children Reading Alphabetic Script

Jing Zhao[1,2,3], Kerstin Kipp[4], Carl Gaspar[2,3], Urs Maurer[5,6],
Xuchu Weng[2,3], Axel Mecklinger[6], and Su Li[1]

Abstract

■ The left-lateralized N170 component of ERPs for words compared with various control stimuli is considered as an electrophysiological manifestation of visual expertise for written words. To understand the information sensitivity of the effect, researchers distinguish between coarse tuning for words (the N170 amplitude difference between words and symbol strings) and fine tuning for words (the N170 amplitude difference between words and consonant strings). Earlier developmental ERP studies demonstrated that the coarse tuning for words occurred early in children (8 years old), whereas the fine tuning for words emerged much later (10 years old). Given that there are large individual differences in reading ability in young children, these tuning effects may emerge earlier than expected in some children. This study measured N170 responses to words and control stimuli in a large group of 7-year-olds that varied widely in reading ability. In both low and high reading ability groups, we observed the coarse neural tuning for words. More interestingly, we found that a stronger N170 for words than consonant strings emerged in children with high but not low reading ability. Our study demonstrates for the first time that fine neural tuning for orthographic properties of words can be observed in young children with high reading ability, suggesting that the emergent age of this effect is much earlier than previously assumed. The modulation of this effect by reading ability suggests that fine tuning is flexible and highly related to experience. Moreover, we found a correlation between this tuning effect at left occipitotemporal electrodes and children's reading ability, suggesting that the fine tuning might be a biomarker of reading skills at the very beginning of learning to read. ■

INTRODUCTION

Literate people possess a special form of visual expertise that allows their visual system to process words efficiently (McCandliss, Cohen, & Dehaene, 2003; Rayner & Pollatsek, 1989). A negative component of the ERP, peaking about 170 msec after orthographic stimulus onset and termed N170 (N1 in some studies), is believed to be an electrophysiological marker for such word expertise. This orthographic N170 is typically more pronounced over the left than over the right hemisphere (Maurer, Zevin, & McCandliss, 2008; Maurer, Brandeis, & McCandliss, 2005). In various ERP studies, the early electrophysiological activity evoked by visually presented words were compared with that of two types of control stimulus—symbol strings (Maurer et al., 2008; Maurer, Brandeis, et al., 2005; Wong, Gauthier, Woroch, DeBuse, & Curran, 2005; Bentin, Mouchetant-Rostaing, Giard, Echallier, & Pernier, 1999) and consonant strings (alphabetic scripts; Proverbio, Vecchi, & Zani, 2004; McCandliss, Posner, & Givon, 1997) or false characters (logographic scripts; Zhao et al., 2012; Lin et al., 2011). These studies suggest that, although the N170 amplitude difference between words and symbol strings may reflect coarse neural tuning for print (Maurer et al., 2006), the N170 amplitude difference between words and consonant strings or between real and false Chinese characters may reflect fine neural tuning within orthographic patterns (Lin et al., 2011; Posner & McCandliss, 2000).

A number of ERP studies in children attempt to examine the emergence and developmental trajectory of N170 tuning effects for words, showing that these effects appear to emerge and develop sequentially during children`s acquisition of reading skill. The coarse tuning for words is established rapidly and shortly after children begin to learn to read. Maurer and colleagues found that the N170 amplitude difference between words and symbol strings was absent in nonreading preschool children (6.5 years old) (Maurer, Brem, Bucher, & Brandeis, 2005), but a larger N170 for words than symbol strings quickly developed in the same group of children after only 1.5 years of reading training in primary school (8.3 years old; Maurer et al., 2006). However, the fine tuning for

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Journal of Cognitive Neuroscience 26:11, pp. 2431–2442
doi:10.1162/jocn_a_00660

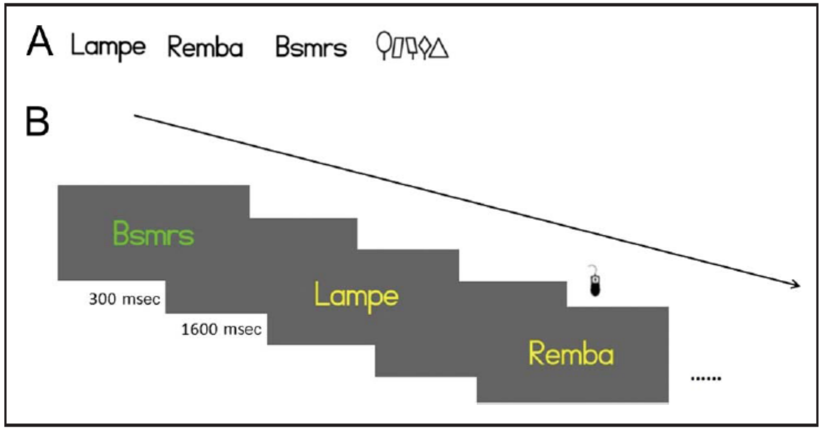
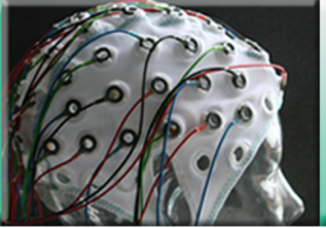


Figure 1. (A) Examples of stimuli: word, pseudoword, consonant string, and symbol string from the left side to the right side. (B) Sketch map of the 1-back color repetition detection task.

The developing visual word form area



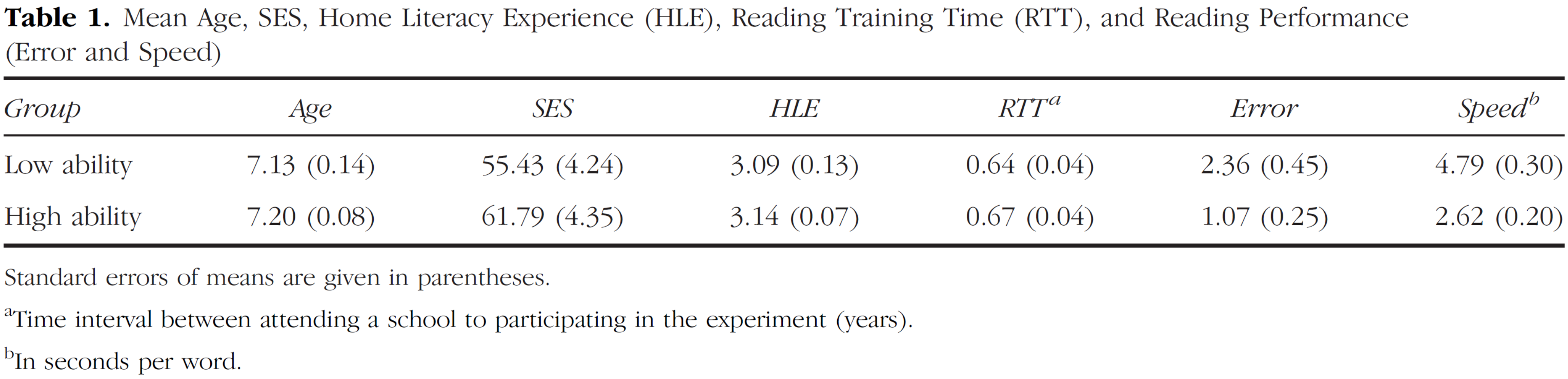


Table 1. Mean Age, SES, Home Literacy Experience (HLE), Reading Training Time (RTT), and Reading Performance (Error and Speed)

Group	*Age*	*SES*	*HLE*	*RTT*[a]	*Error*	*Speed*[b]
Low ability	7.13 (0.14)	55.43 (4.24)	3.09 (0.13)	0.64 (0.04)	2.36 (0.45)	4.79 (0.30)
High ability	7.20 (0.08)	61.79 (4.35)	3.14 (0.07)	0.67 (0.04)	1.07 (0.25)	2.62 (0.20)

Standard errors of means are given in parentheses.

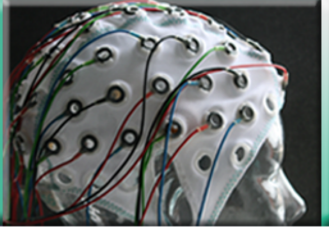
[a] Time interval between attending a school to participating in the experiment (years).

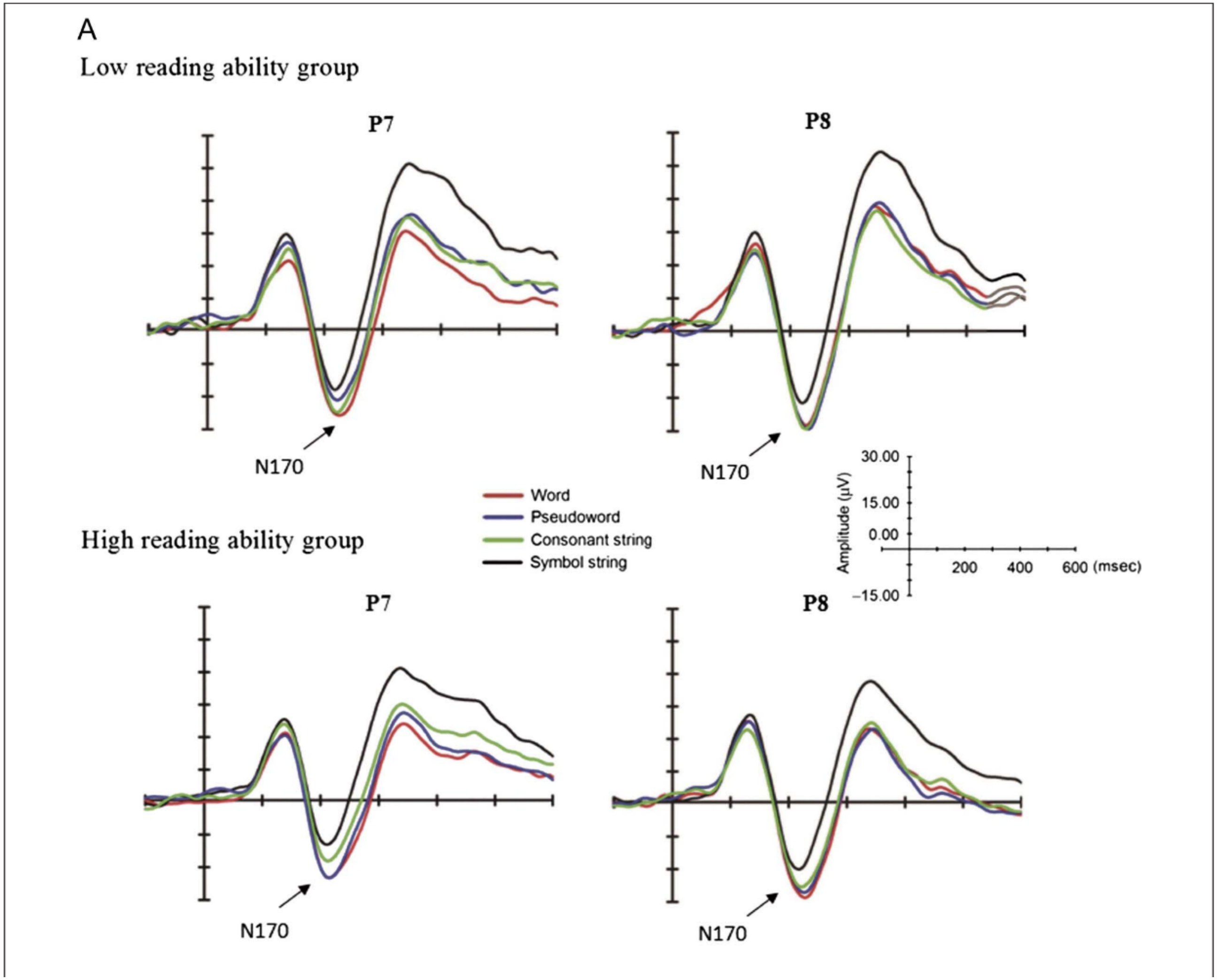
[b] In seconds per word.

N170 evidence for two stages of reading development:

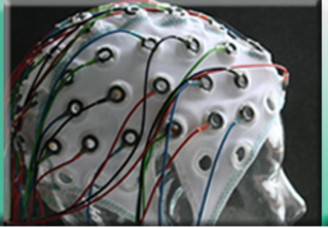
Coarse tuning: words > symbol strings

Fine tuning: words > consonant strings





Two stages of reading development:
Coarse tuning: words > symbol strings
Fine tuning: words > consonant strings



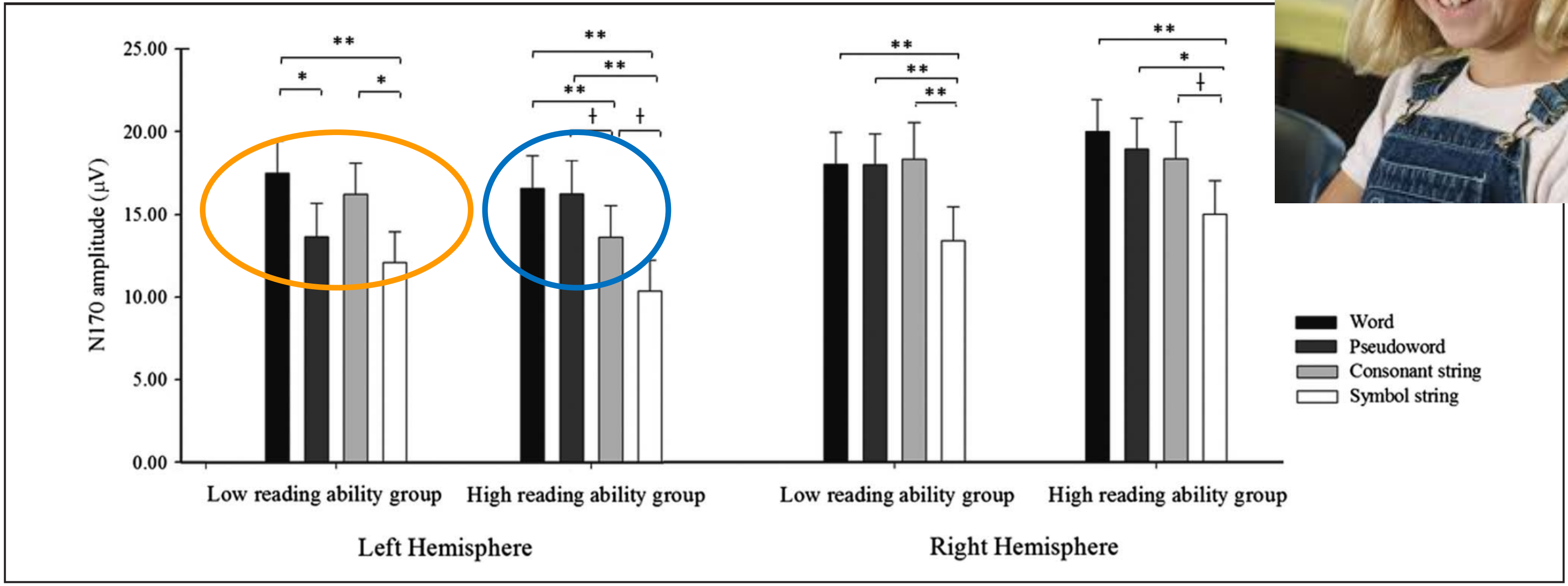
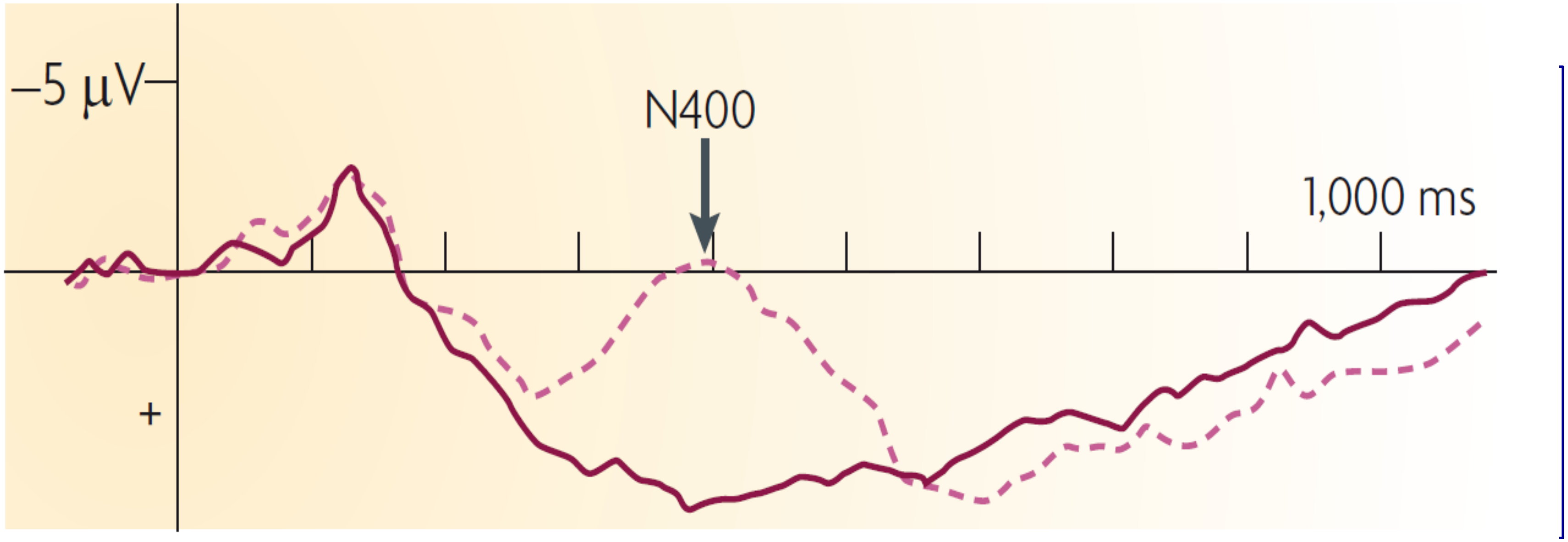


Figure 3. The mean of N170 amplitude for the four stimulus categories at P7/P8 in each children group. $^{\dagger}p < .1$, $^{*}p < .05$; $^{**}p < .01$.

A cortical network for semantics



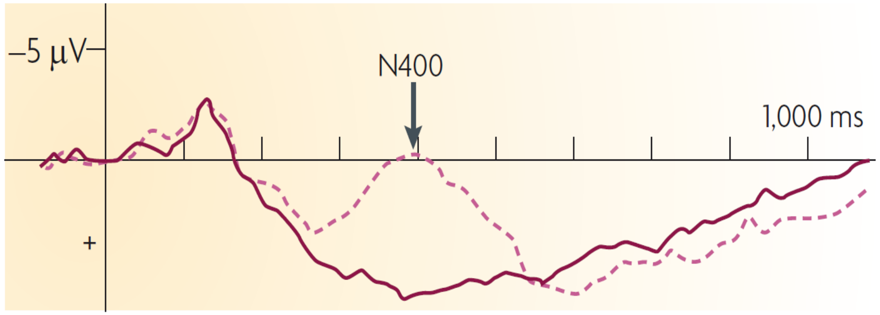
Lau et al. (2008)

A cortical network for semantics
The prediction vs integration views

The N400 is sensitive to semantic expectancies ….

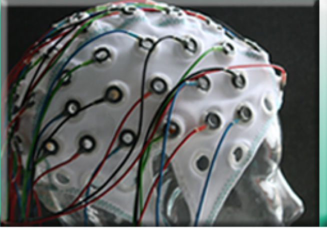
- Do readers use context to generate expectancies for upcoming events? Prediction view (PV)

- Are readers forced by the words to devote more resources to integrate words? Integration view (IV)

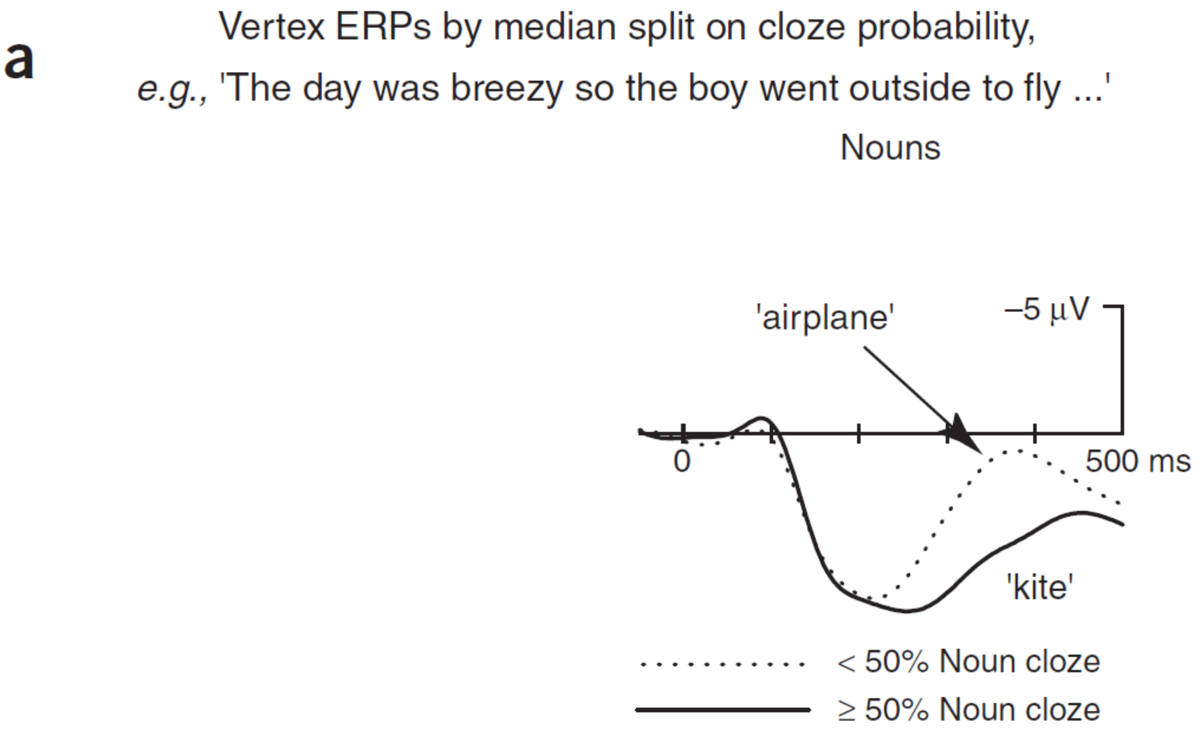


DeLong, Urbach & Kutas, 2005; Nature NS

A cortical network for semantics:
The prediction vs integration views



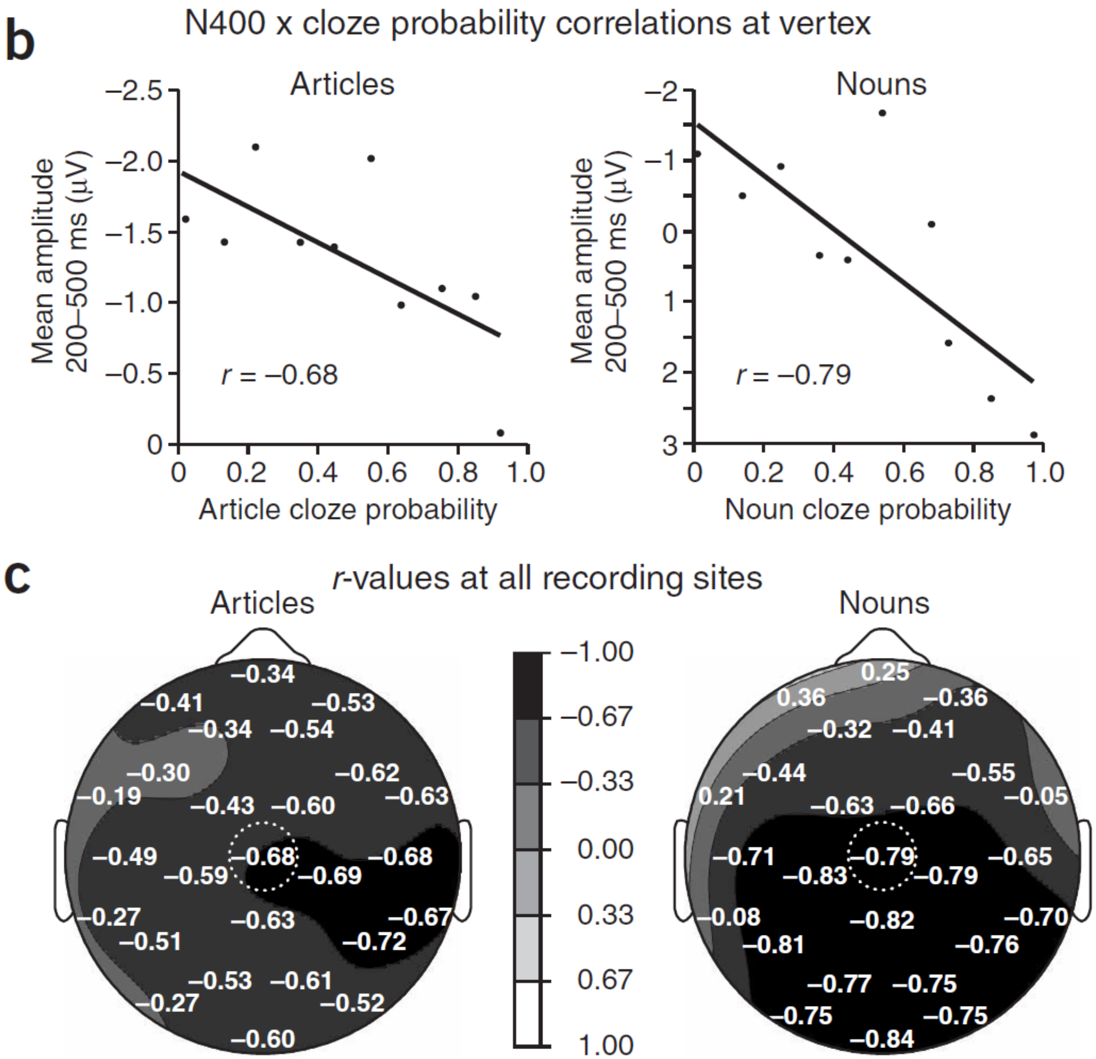
The N400 to articles and nouns …

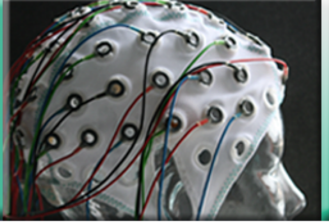


DeLong, Urbach & Kutas, 2005; Nature NS

N400 (articles) = N400 (words)

Evidence for the prediction view





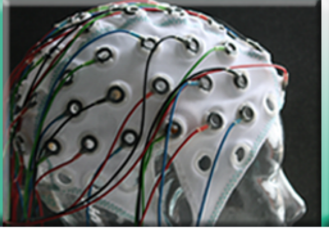
Von Wörtern zu Sätzen

The pianist rose to the applause of the audience

The tall man planted an apple tree on the bank

The little old lady bites the gigantic dog

Von Wörtern zu Sätzen



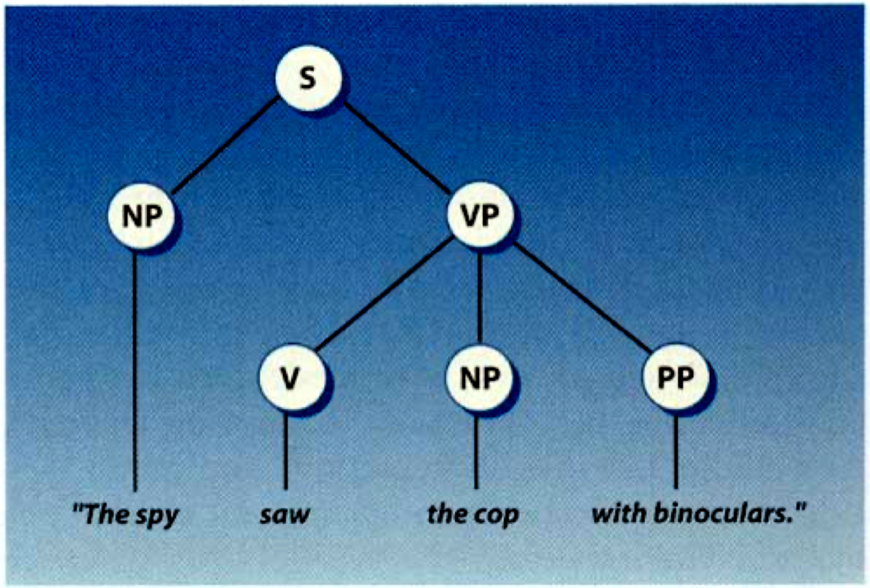
- Thematic role assignments
- Parsing = The immediate assignment of syntactic structure to incoming words

The cat eats the food

The cat cries

How does parsing work?

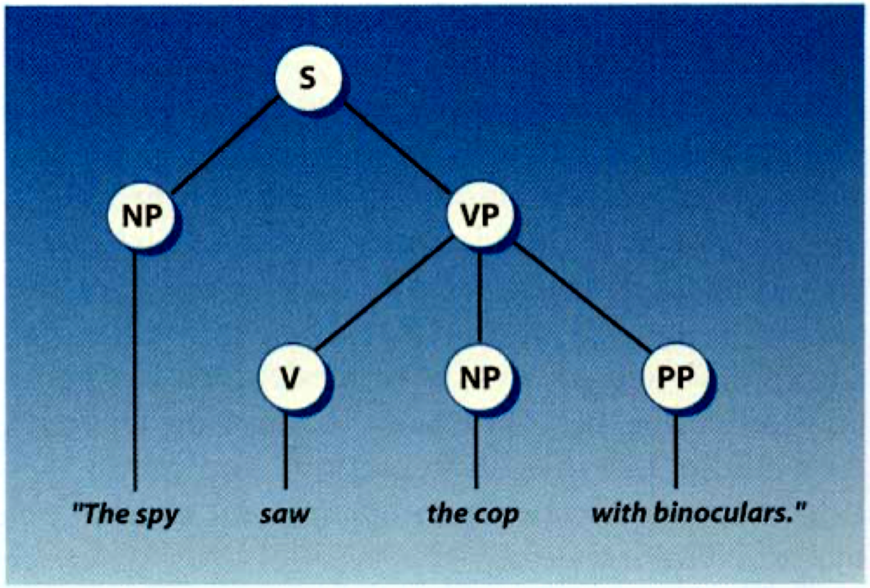
- „Garden-path-model“ Frazier (1987)
  - Minimal attachment
  - Late closure

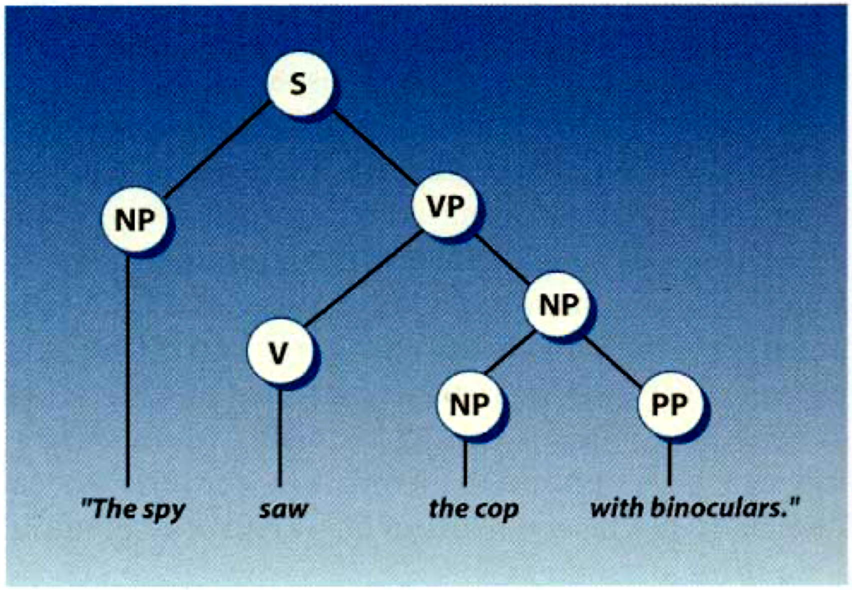


How does parsing work?

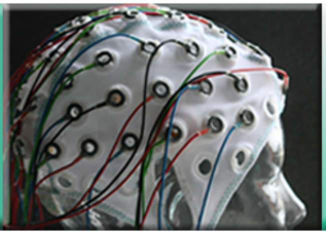
- „Garden-path-model“ Frazier (1987)
    - Minimal attachment
    - Late closure

Nonminimal attachment





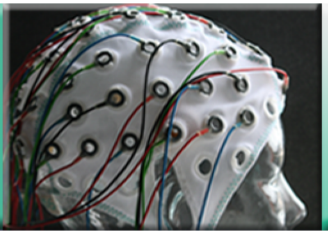
Minimal attachment & late closure



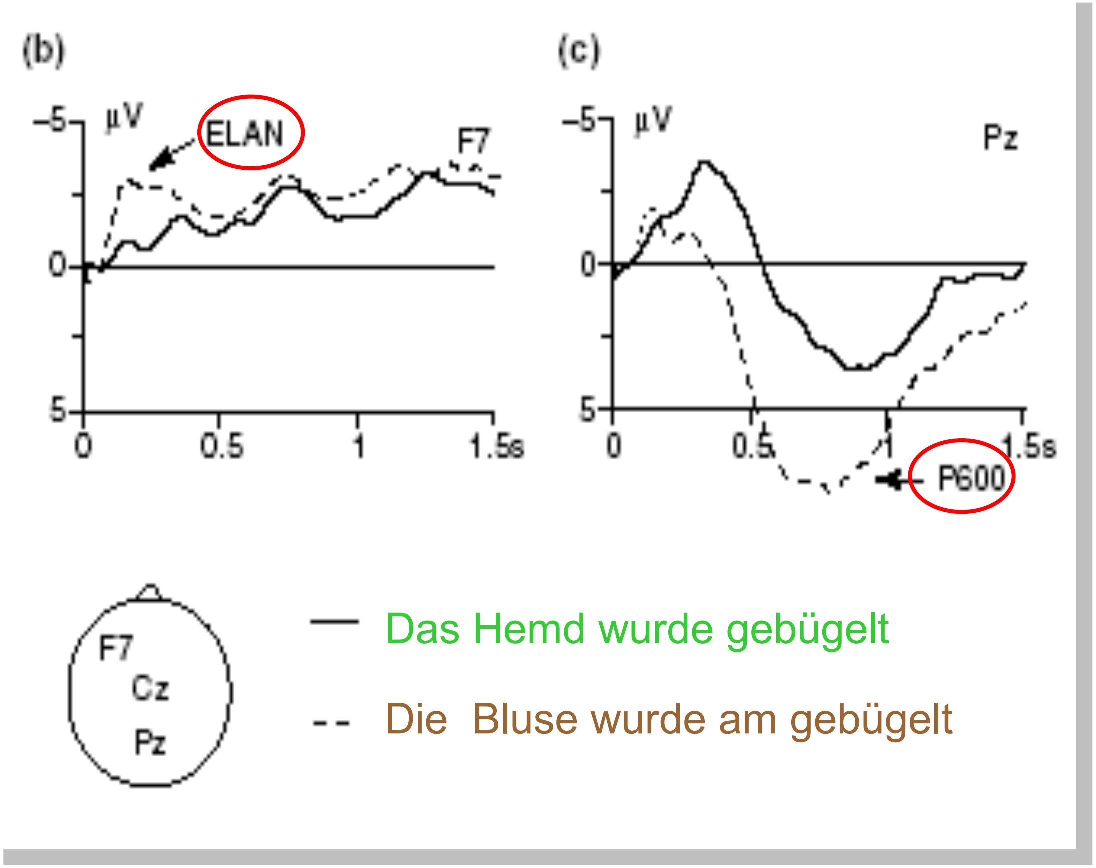
Late closure = Anbindung an aktuell verarbeitete Phrase

„Ron loves Holland and his mother enjoyed her trip to America“

„The manager sold the couch and the employee sold the desk“



EKP Korrelate der Syntaxverarbeitung: ELAN & P600

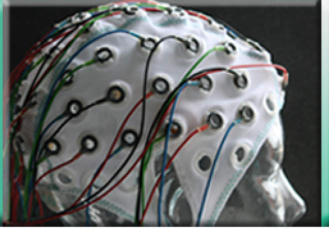


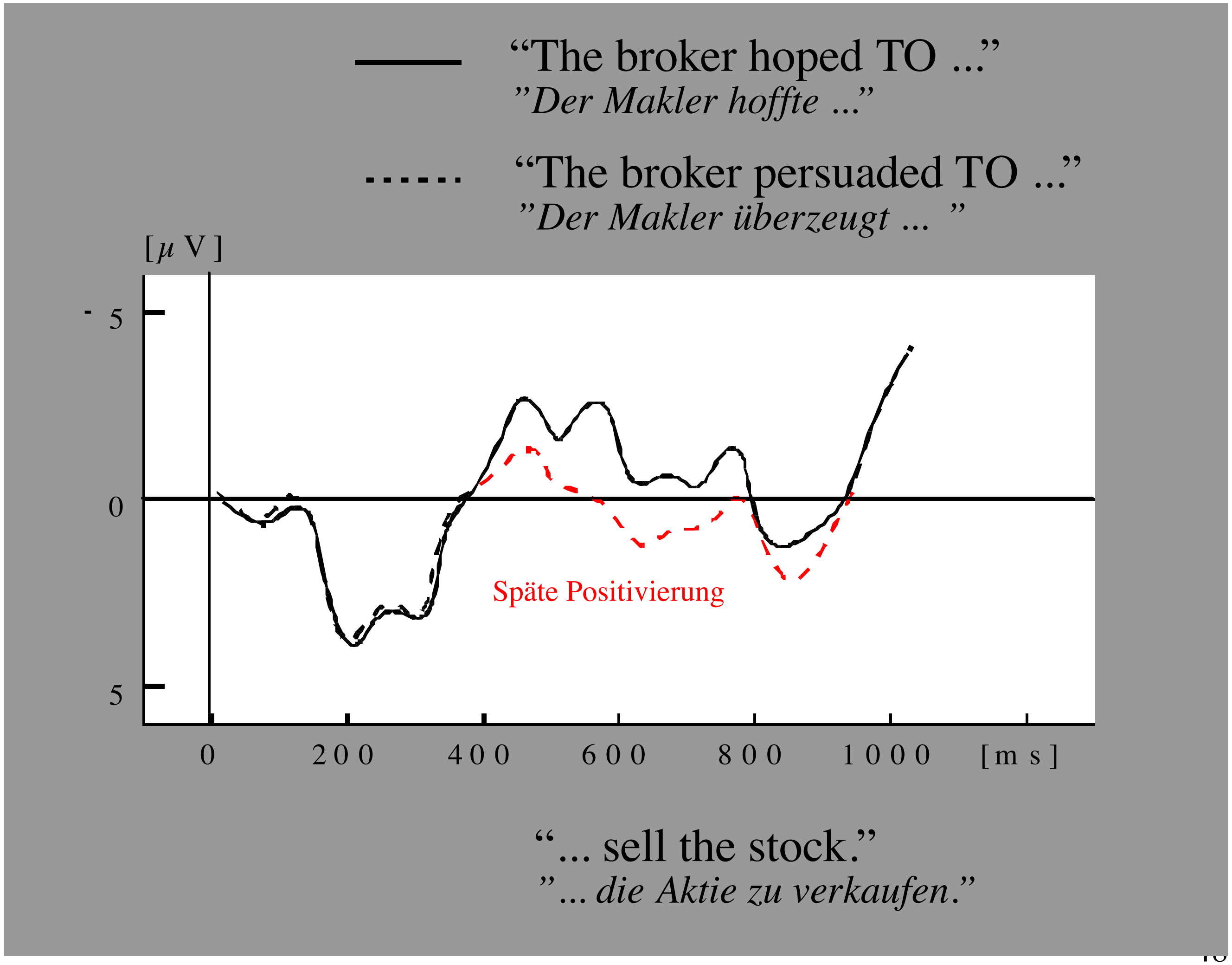
— Das Hemd wurde gebügelt

-- Die Bluse wurde am gebügelt

Friederici, 2002

Die P600 bei syntaktischer Disambiguierung





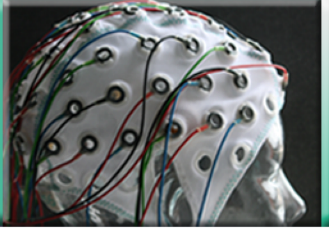
“The broker hoped TO ...”
”Der Makler hoffte ...”

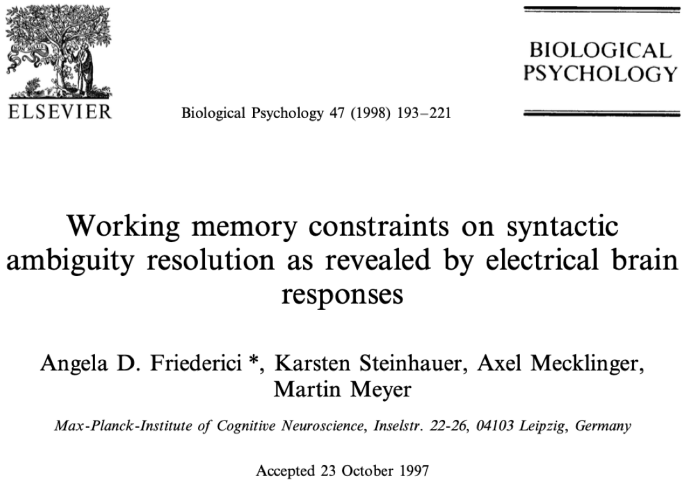
“The broker persuaded TO ...”
”Der Makler überzeugt ... ”

Späte Positivierung

“... sell the stock.”
”... die Aktie zu verkaufen.”

Disambiguierung beim Verstehen von Relativsätzen





ELSEVIER

Biological Psychology 47 (1998) 193–221

BIOLOGICAL
PSYCHOLOGY

Working memory constraints on syntactic ambiguity resolution as revealed by electrical brain responses

Angela D. Friederici *, Karsten Steinhauer, Axel Mecklinger, Martin Meyer

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Accepted 23 October 1997

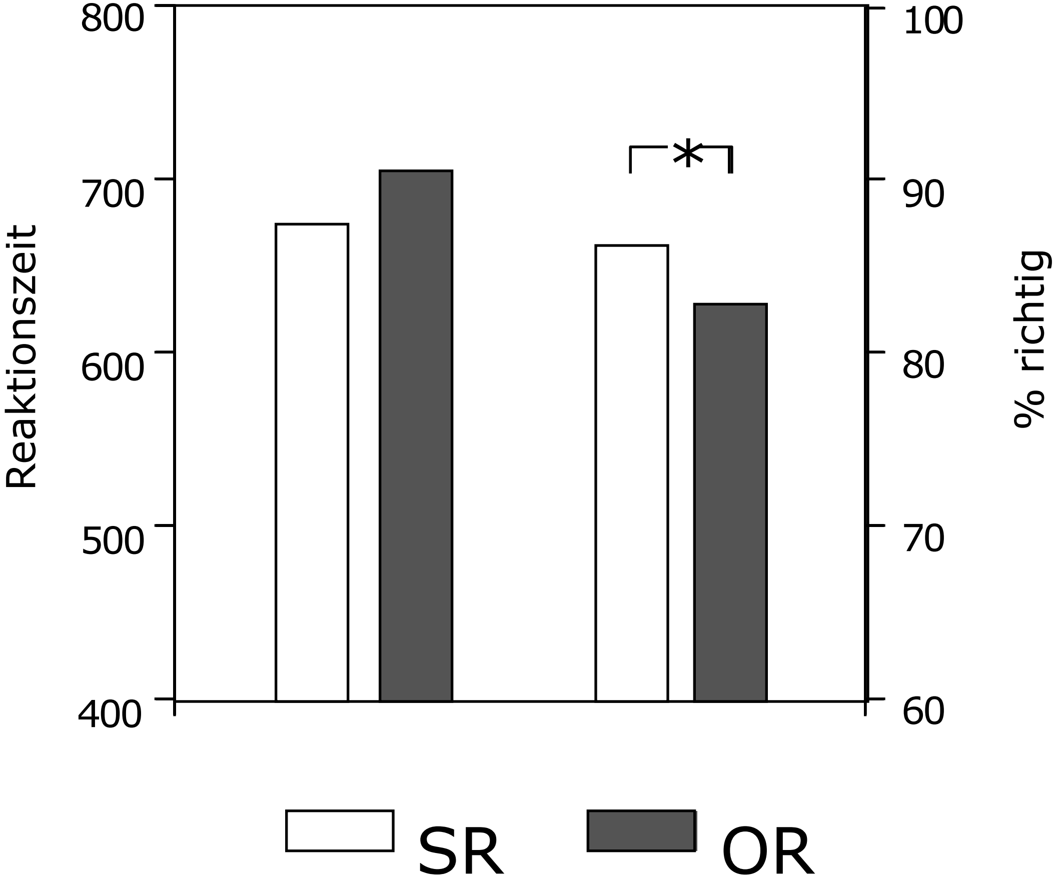
SubjektRelativSatz:

Das sind die Managerinnen, die die Arbeiterin gesehen haben.

ObjektRelativSatz:

Das sind die Managerinnen, die die Arbeiterin gesehen hat.

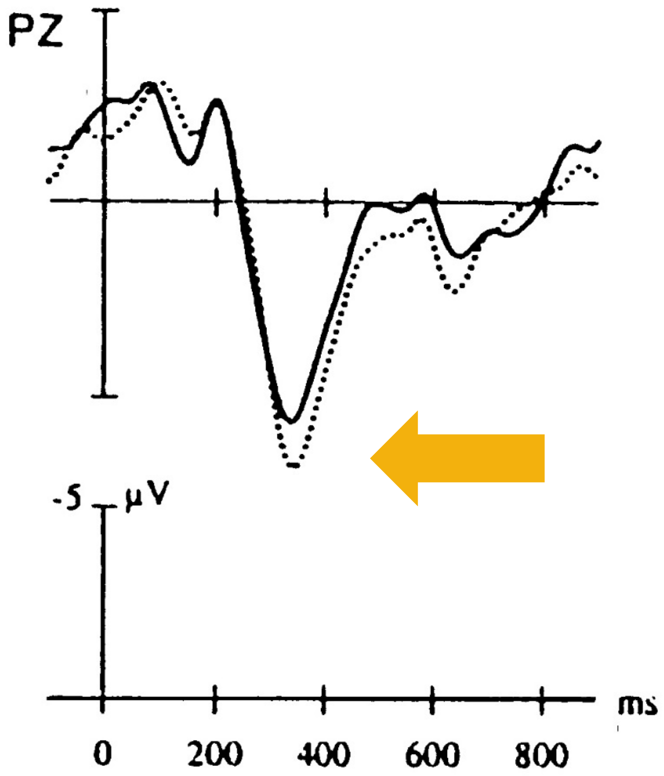
Disambiguierung beim Satzverstehen



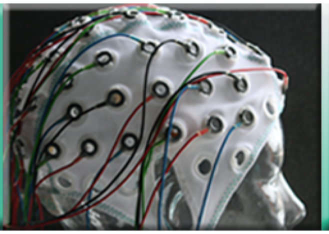
Späte Disambiguierung beim Satz-verstehen: P350

—— *SR: Das sind die Managerinnen, die die Arbeiterin gesehen HABEN.*

······· *OR: Das sind die Arbeiterinnen, die die Managerin gesehen HAT.*



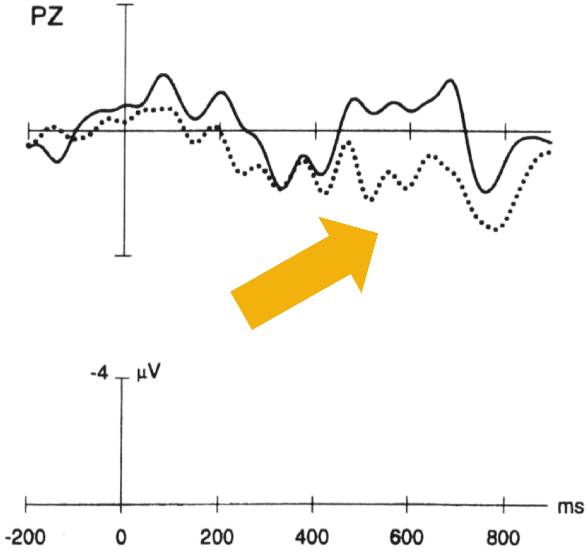
Frühe Disambiguierung: P600



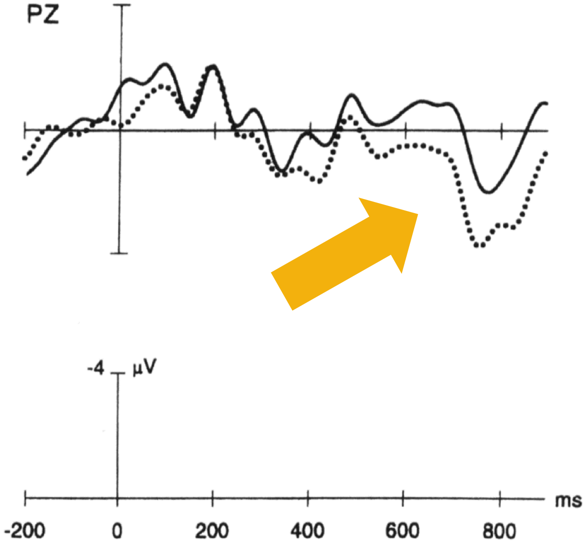
—— *SR: Das ist der Professor, DER ...*

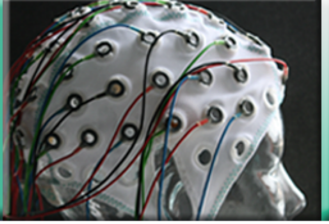
- - - *OR: Das ist der Professor, DEN ...*

hohe Lesespanne (LS)

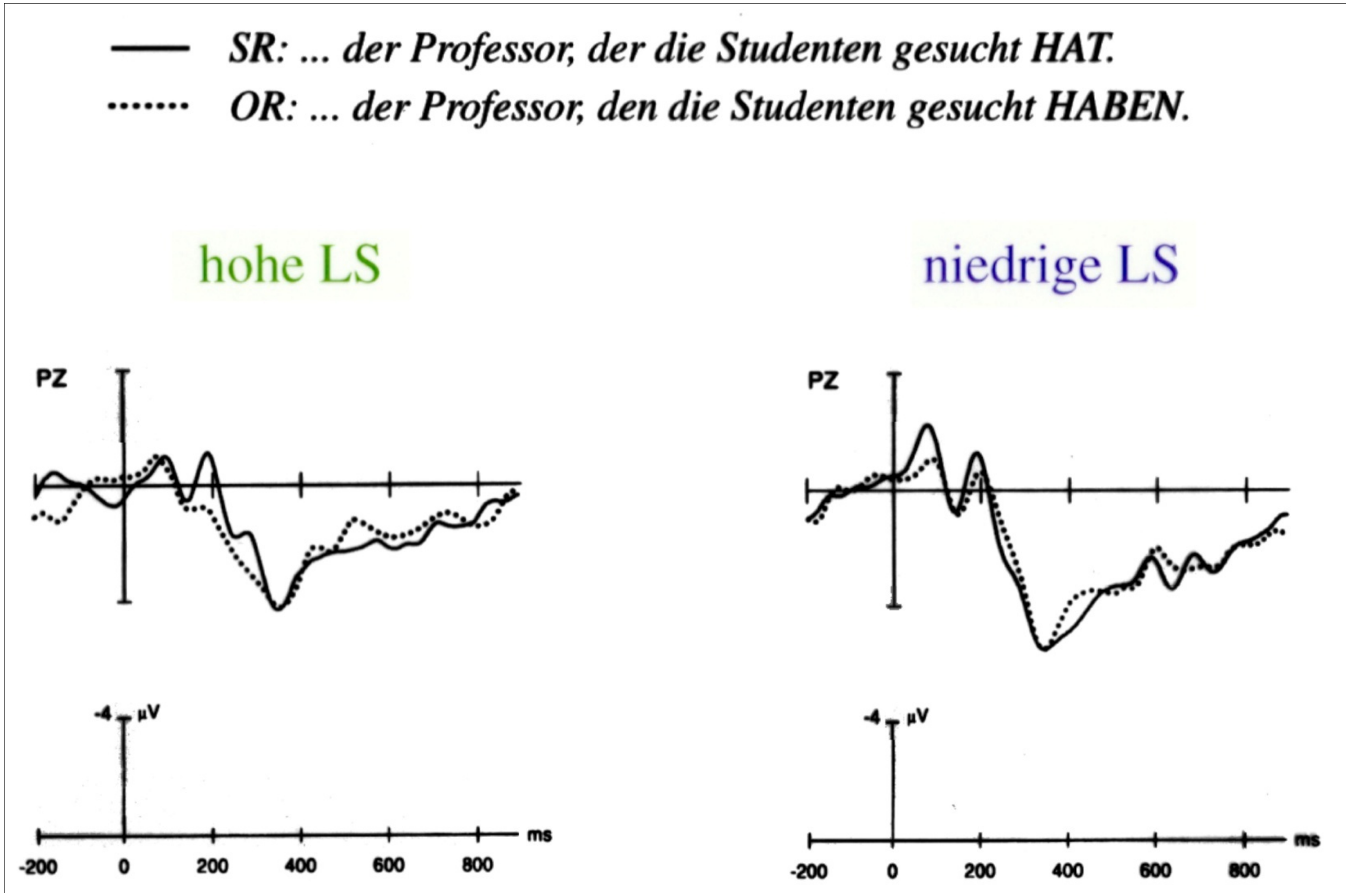


niedrige Lesespanne (LS)





Frühe Disambiguierung (Keine Effekte am Satzende)



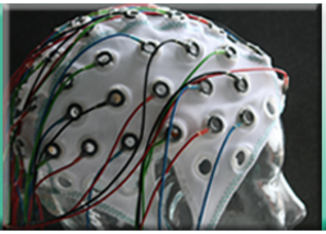
SR: ... der Professor, der die Studenten gesucht HAT.

OR: ... der Professor, den die Studenten gesucht HABEN.

hohe LS

niedrige LS

EKP Komponenten bei der Satzverarbeitung:

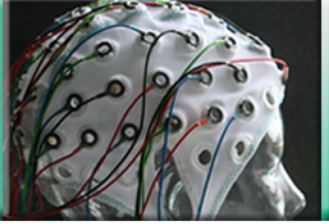


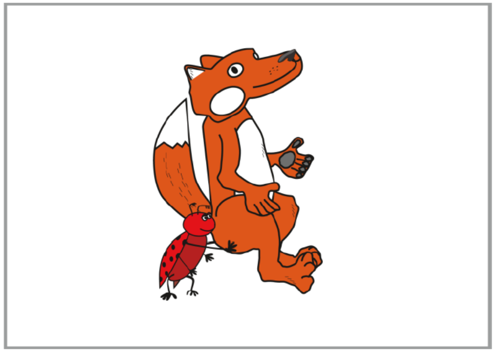
N400:	Semantic expectancy violations.
ELAN:	Syntactic expecatancy violations.
P600/P345:	Syntactic disambiguations

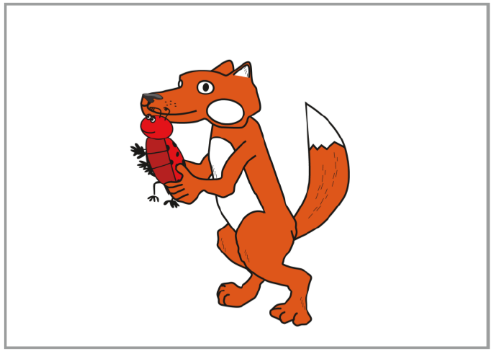
Semantische und syntaktische Disambiguierung bei 3-4 Jährigen ?

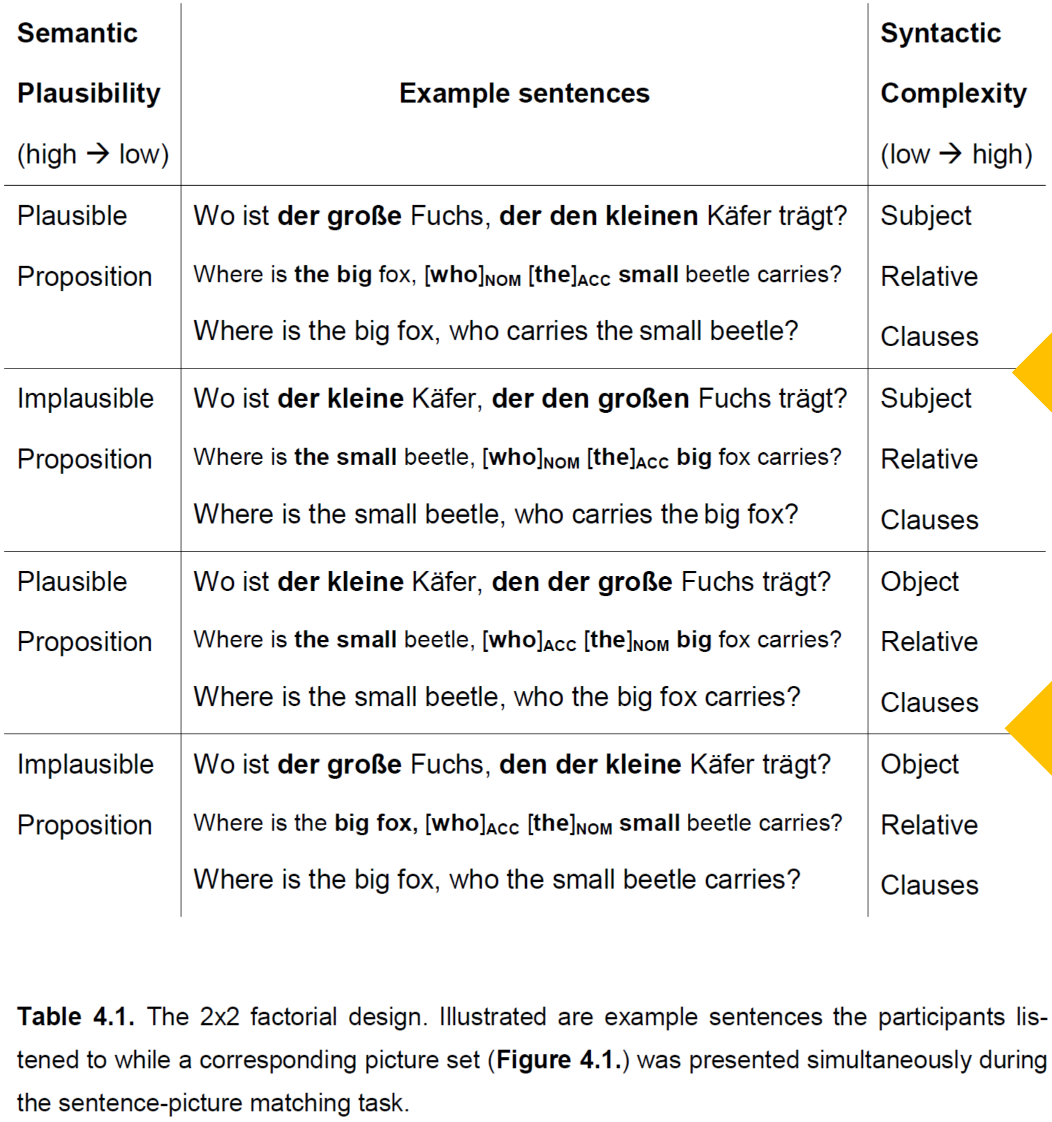
Figure 3.2. The mock scanner at the Max Planck Institute for Human Cognitive and Brain Sciences. Children go through a training session in which the real MR environment can be simulated playfully in order to familiarize them with the experimental procedures.

Semantische und syntaktische Disambiguierung bei 3-4 Jährigen









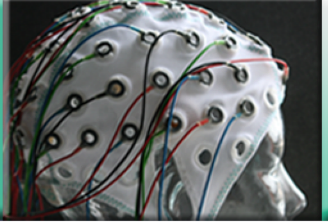
Semantic Plausibility (high → low)	**Example sentences**	**Syntactic Complexity** (low → high)
Plausible Proposition	Wo ist **der große** Fuchs, **der den kleinen** Käfer trägt? Where is **the big** fox, **[who]$_{\text{NOM}}$ [the]$_{\text{ACC}}$ small** beetle carries? Where is the big fox, who carries the small beetle?	Subject Relative Clauses
Implausible Proposition	Wo ist **der kleine** Käfer, **der den großen** Fuchs trägt? Where is **the small** beetle, **[who]$_{\text{NOM}}$ [the]$_{\text{ACC}}$ big** fox carries? Where is the small beetle, who carries the big fox?	Subject Relative Clauses
Plausible Proposition	Wo ist **der kleine** Käfer, **den der große** Fuchs trägt? Where is **the small** beetle, **[who]$_{\text{ACC}}$ [the]$_{\text{NOM}}$ big** fox carries? Where is the small beetle, who the big fox carries?	Object Relative Clauses
Implausible Proposition	Wo ist **der große** Fuchs, **den der kleine** Käfer trägt? Where is the **big fox, [who]$_{\text{ACC}}$ [the]$_{\text{NOM}}$ small** beetle carries? Where is the big fox, who the small beetle carries?	Object Relative Clauses

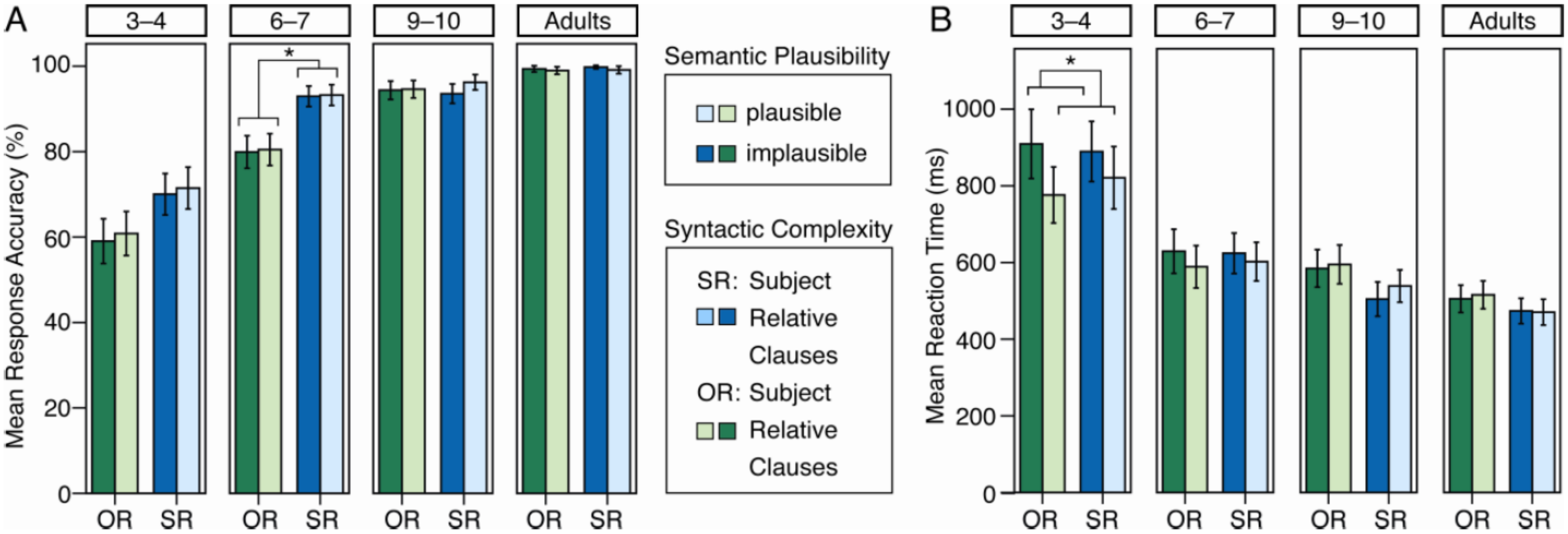
Table 4.1. The 2x2 factorial design. Illustrated are example sentences the participants listened to while a corresponding picture set (**Figure 4.1.**) was presented simultaneously during the sentence-picture matching task.

Low

High

Semantische und syntaktische Disambiguierung bei 3-4 Jährigen

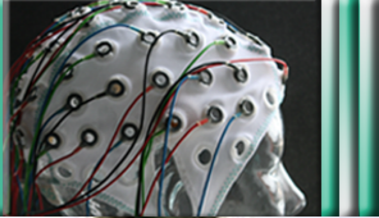




6-7 Jährige zeigen bessere Verarbeitung bei geringer syntaktischer Komplexität

3-4 Jährige zeigen schnellere Verarbeitungszeiten bei semantisch plausiblen Sätzen

Semantische und syntaktische Disambiguierung bei 3-4 Jährigen



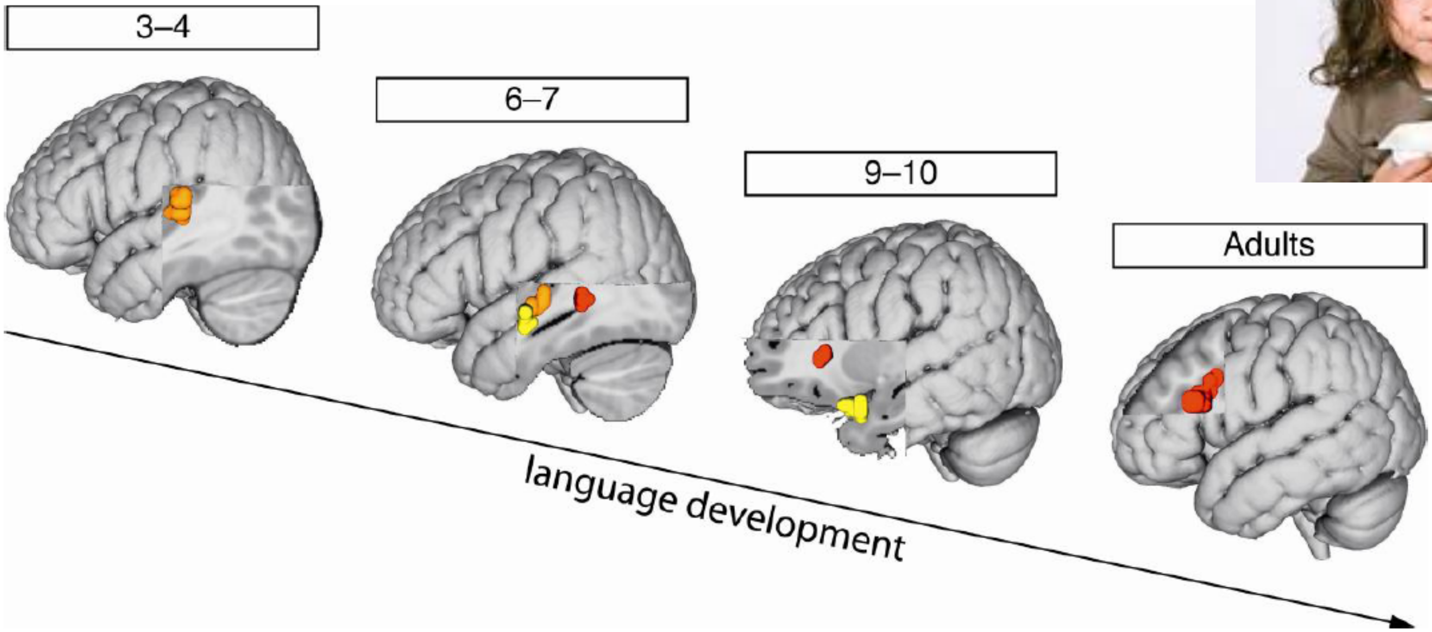


Figure 4.3. Whole-brain level fMRI results. Activation clusters indicate significant blood-oxygen-level-dependent (BOLD) main effects of syntactic complexity (red) and semantic plausibility (yellow) as well as the interaction of both factors (orange) thresholded at $P < 0.01$ (family-wise error corrected) in adults, and at $P < 0.005$ (cluster size corrected) in the 3 child groups. See **Table 4.2.** for cluster sizes, MNI coordinates and T_{Max} scores of all activated regions.

Danke für Ihre Aufmerksamkeit!