

Language and language development

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1. The Question
2. Language as a brain system
3. The ontogeny of language
4. The phylogeny of language

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Nature or Nurture ?

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1. The Question

2. Language as a brain system

 Language as a specific cognitive system

 A brain-based language comprehension model

3. The ontogeny of language

4. The phylogeny of language

Language as a specific cognitive system

Language + · · ·

Language + · · ·

- Language + communication: Gestures, facial expression

Language + · · ·

- Language + communication: Gestures, facial expression
- Language + speech: Sign language, writing system

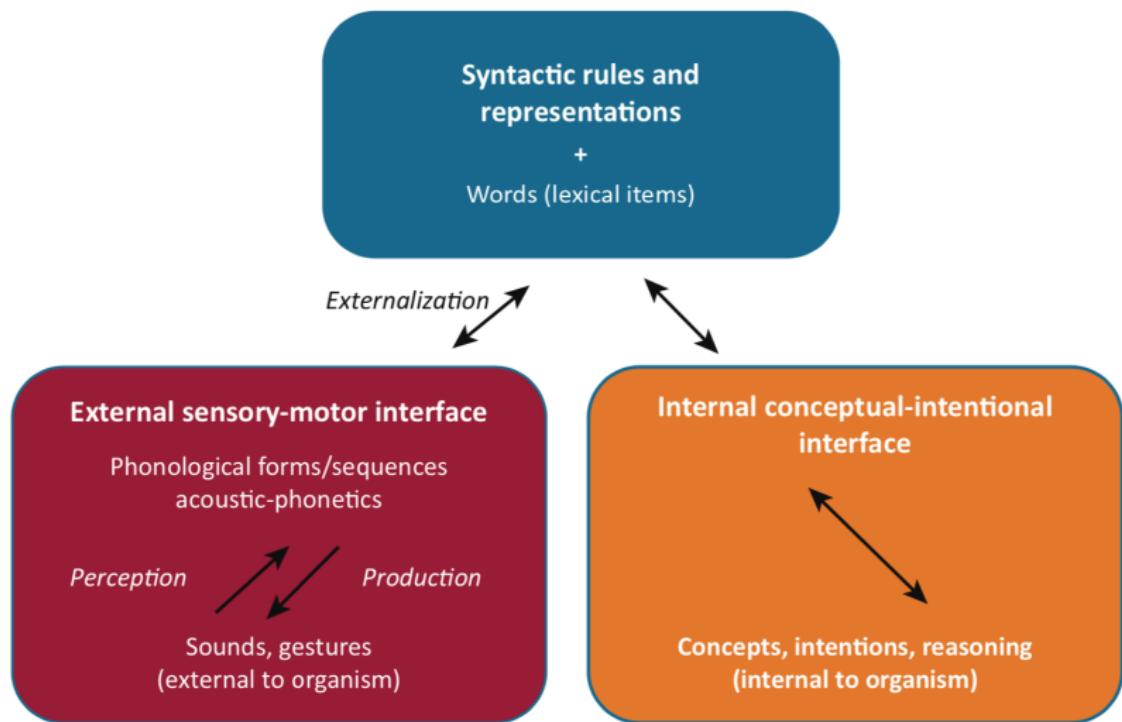
Language + · · ·

- Language + communication: Gestures, facial expression
- Language + speech: Sign language, writing system
- Language + human: Animals

Language + . . .

- Language + communication: Gestures, facial expression
- Language + speech: Sign language, writing system
- Language + human: Animals
- Language + learning: Nature and nurture

Language as a specific cognitive system

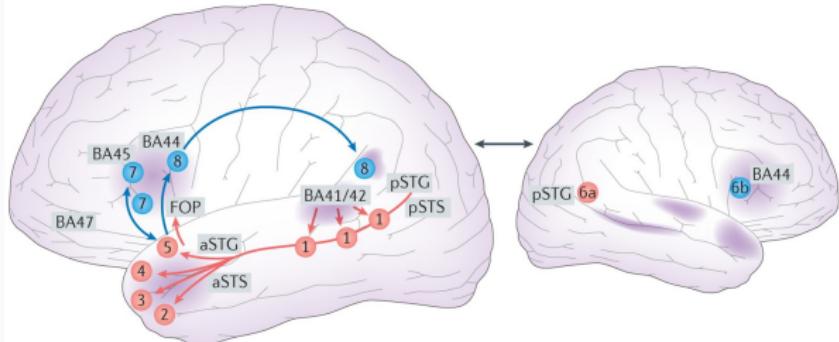


(Berwick, Friederici, Chomsky, & Bolhuis, 2013, p.91)

A brain-based language comprehension model

A brain-based language comprehension model

a Language comprehension in adults



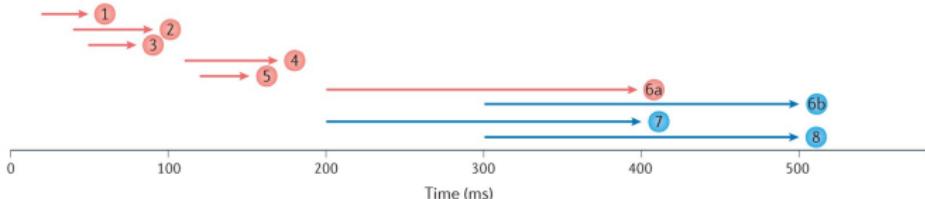
Bottom-up processes

- 1 Phonological word form detection
- 2 Morphosyntactic categorization
- 3 Lexical–semantic categorization
- 4 Lexical access and retrieval
- 5 Phrase structure reconstruction
- 6a Prosodic processing

Top-down processes

- 6b Prosodic processing
- 7 Analysis of semantic relations
- 8 Analysis of syntactic relations

b



Nature Reviews | Neuroscience

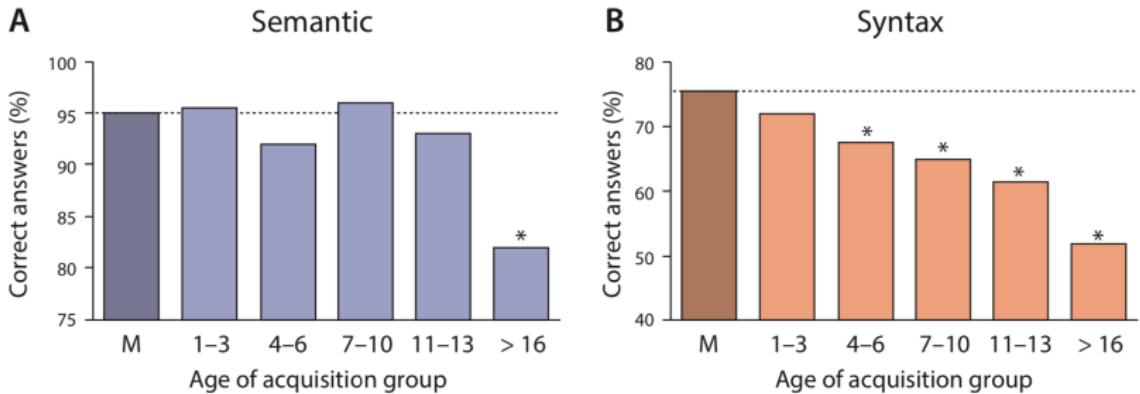
(Skeide & Friederici, 2016)

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 - Language in the first three years of life
 - Language beyond age 3
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The critical period for language acquisition

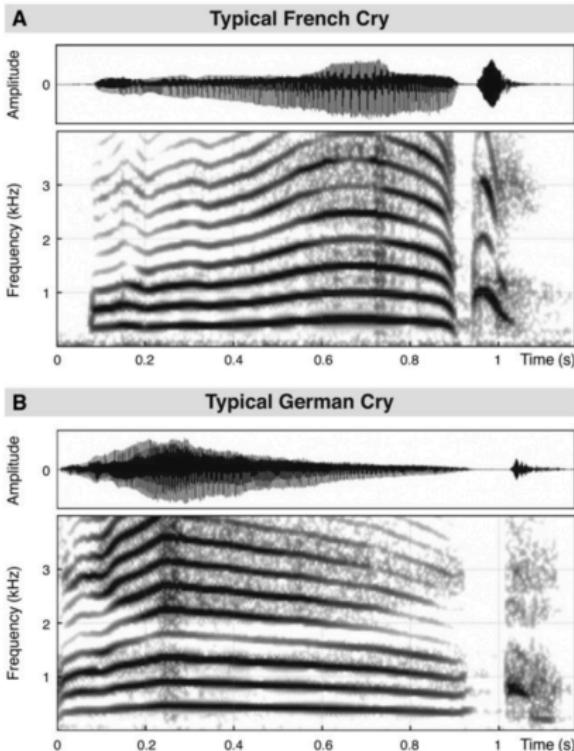
The critical period for language acquisition



(Weber-Fox & Neville, 1996)

Language in the first three years of life

The melody of baby cries



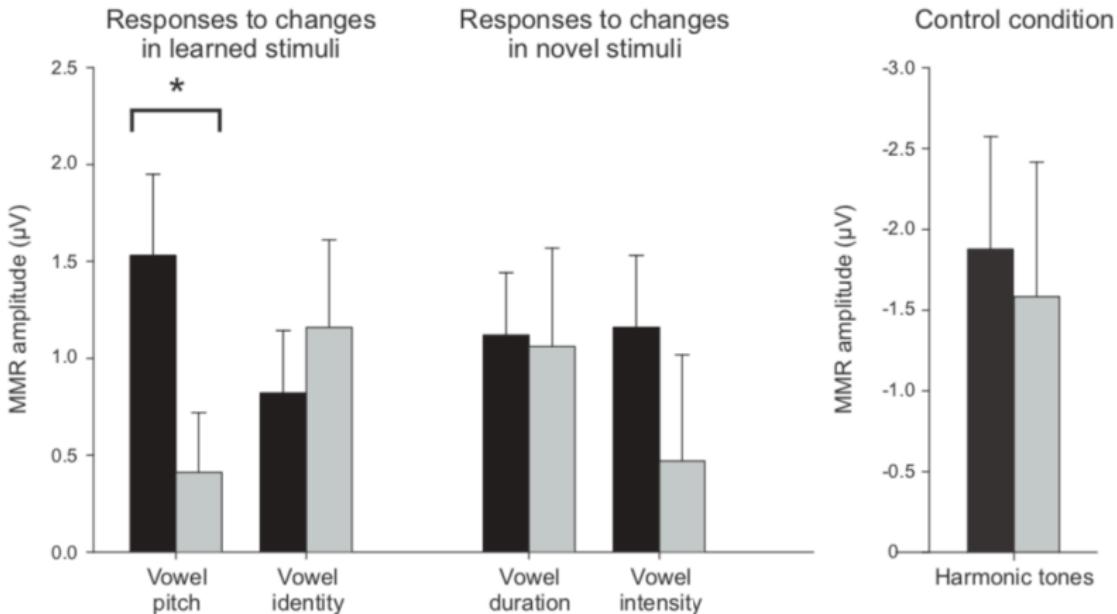
(Mampe, Friederici, Christophe, & Wermke, 2009)

Syllabic discrimination in premature infants

The ontogeny of linguistic functions in the human brain remains elusive. Although some auditory capacities are described before term, whether and how such immature cortical circuits might process speech are unknown. Here we used functional optical imaging to evaluate the cerebral responses to syllables at the earliest age at which cortical responses to external stimuli can be recorded in humans (28- to 32-wk gestational age). At this age, the cortical organization in layers is not completed. Many neurons are still located in the subplate and in the process of migrating to their final location. Nevertheless, we observed several points of similarity with the adult linguistic network. First, whereas syllables elicited larger right than left responses, the posterior temporal region escaped this general pattern, showing faster and more sustained responses over the left than over the right hemisphere. Second, discrimination responses to a change of phoneme (ba vs. ga) and a change of human voice (male vs. female) were already present and involved inferior frontal areas, even in the youngest infants (29-wk gestational age). Third, whereas both types of changes elicited responses in the right frontal region, the left frontal region only reacted to a change of phoneme. These results demonstrate a sophisticated organization of perisylvian areas at the very onset of cortical circuitry, 3 mo before term. They emphasize the influence of innate factors on regions involved in linguistic processing and social communication in humans.

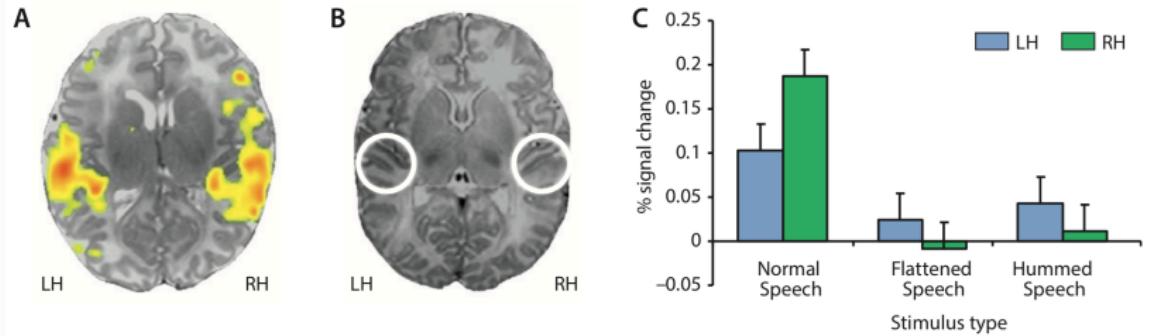
(Mahmoudzadeh et al., 2013)

Speech learning before birth



(Partanen et al., 2013)

Neural disposition for language in the newborn brain

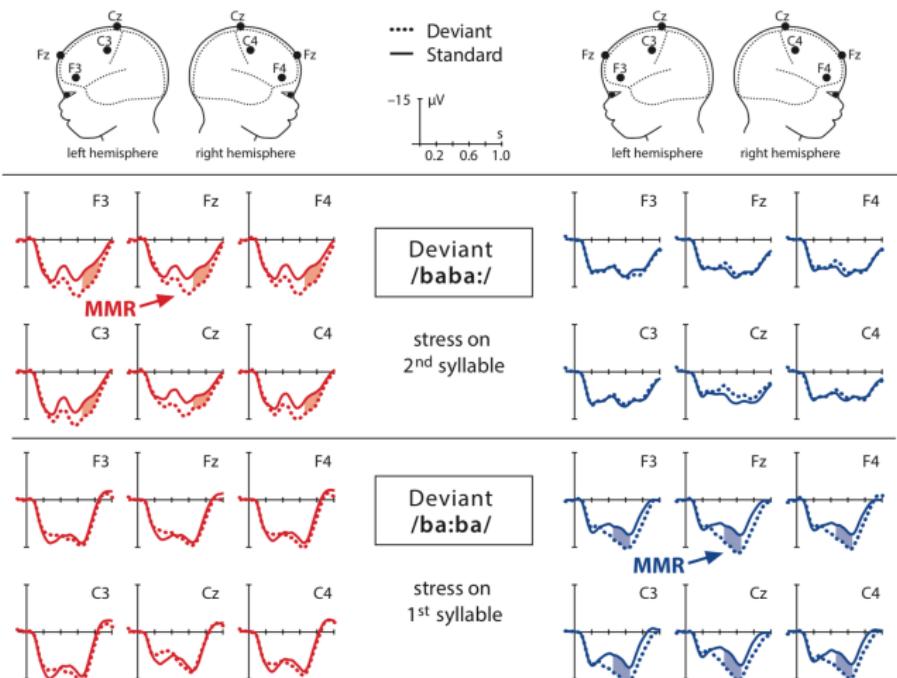


(Perani et al., 2011, 2-d-olds)

Perception of stress patterns in infants

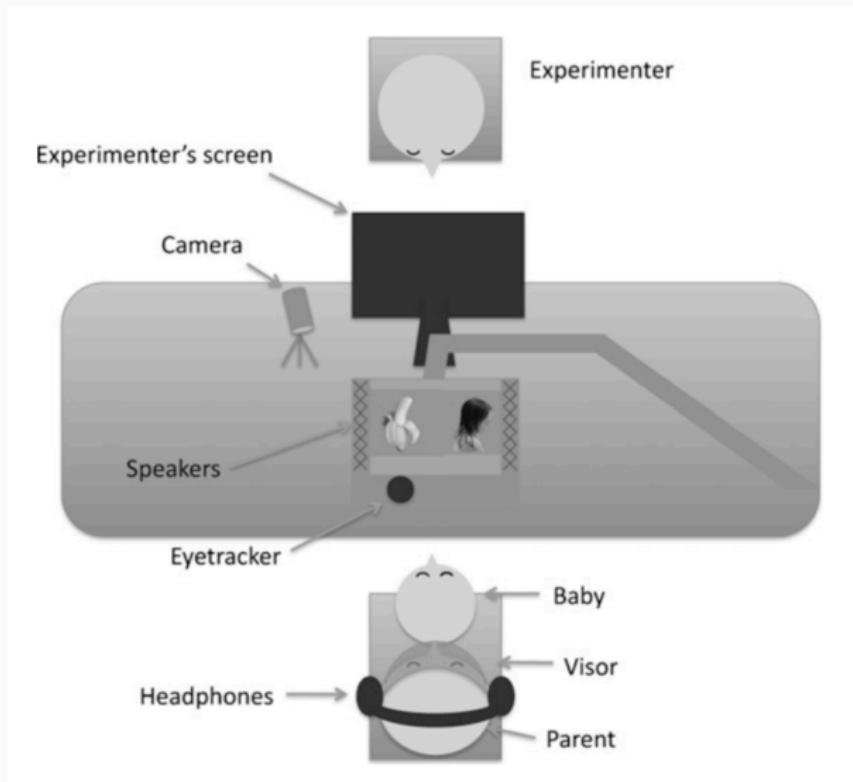
German (N=50)
4- & 5-month-old infants

French (N=50)
4- & 5-month-old infants



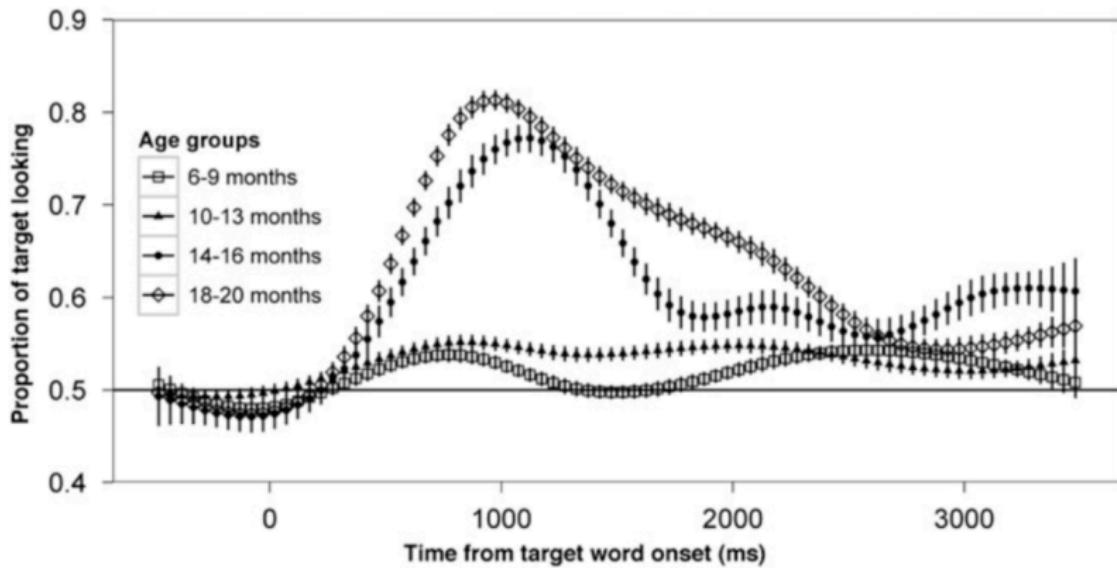
(Friederici, Friedrich, & Christophe, 2007)

Word level semantics



(Bergelson & Swingley, 2012)

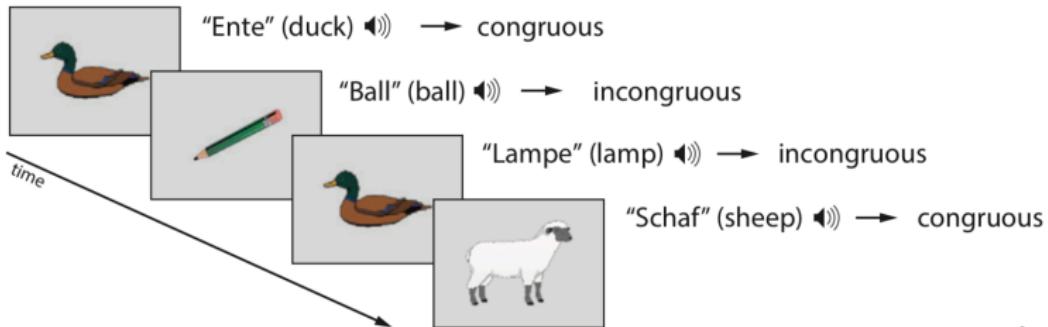
Word level semantics



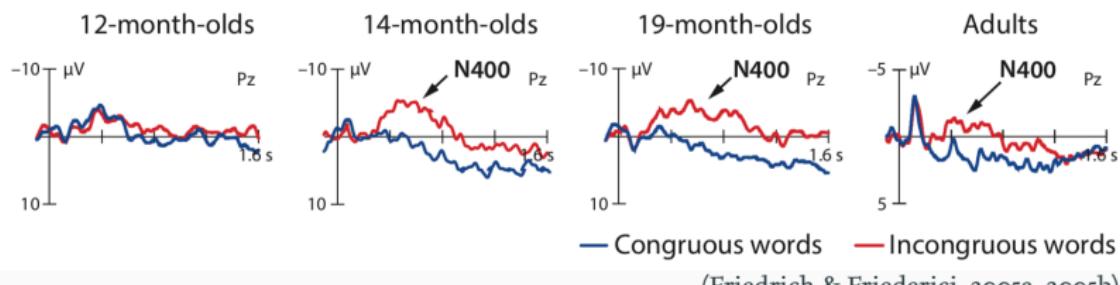
(Bergelson & Swingley, 2012)

Word level semantics

A Picture-word-priming paradigm

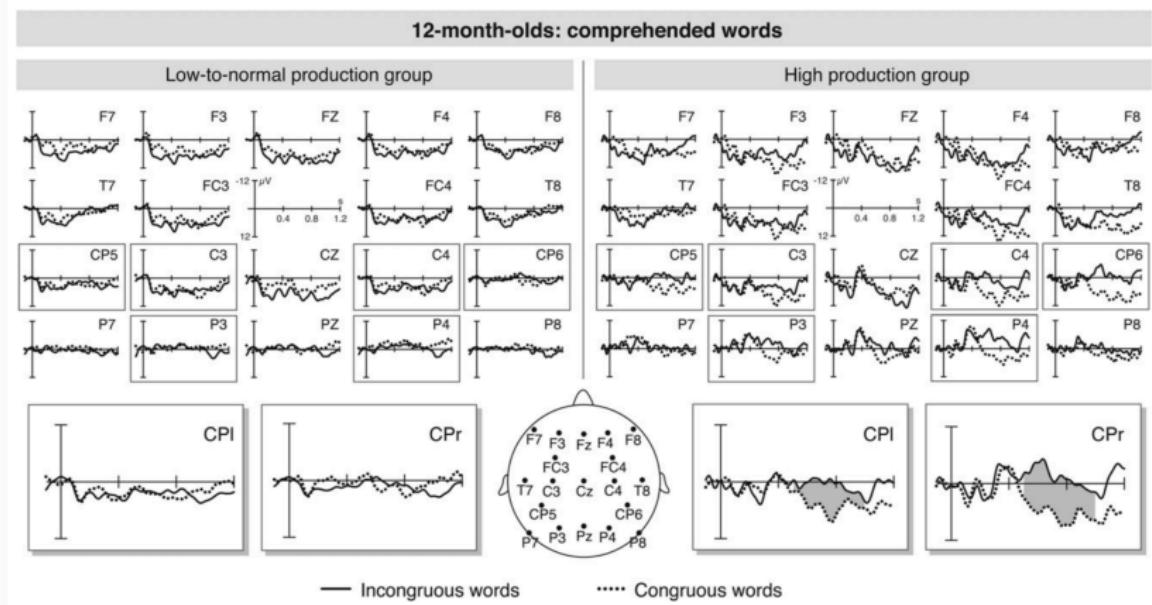


B Event-related brain potentials



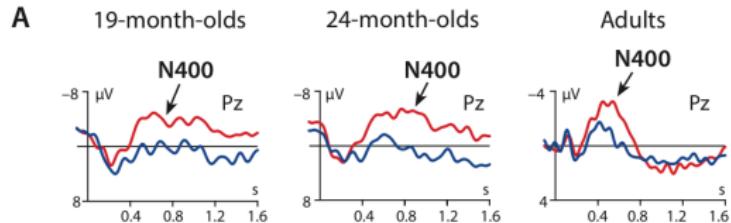
(Friedrich & Friederici, 2005a, 2005b)

Word level semantics



(Friedrich & Friederici, 2010)

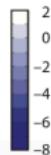
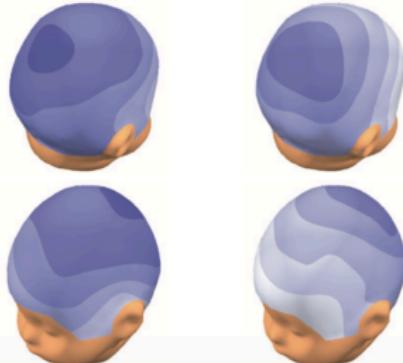
Sentence level semantics



- semantically correct: The child rolls the ball.
- semantically incorrect: The child drinks the ball.

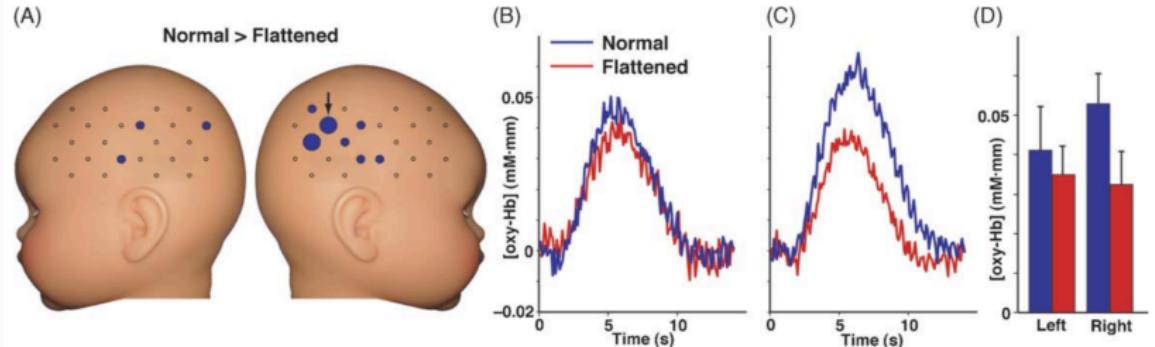


B



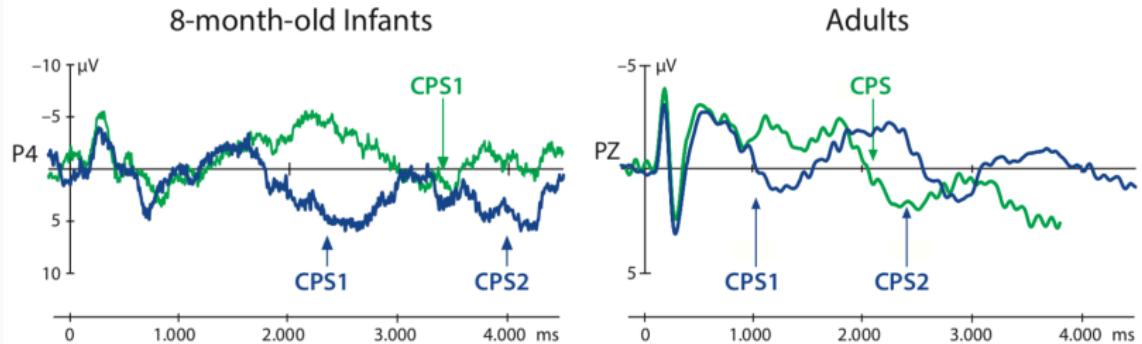
(Friedrich & Friederici, 2005c)

From prosodic cues to syntax



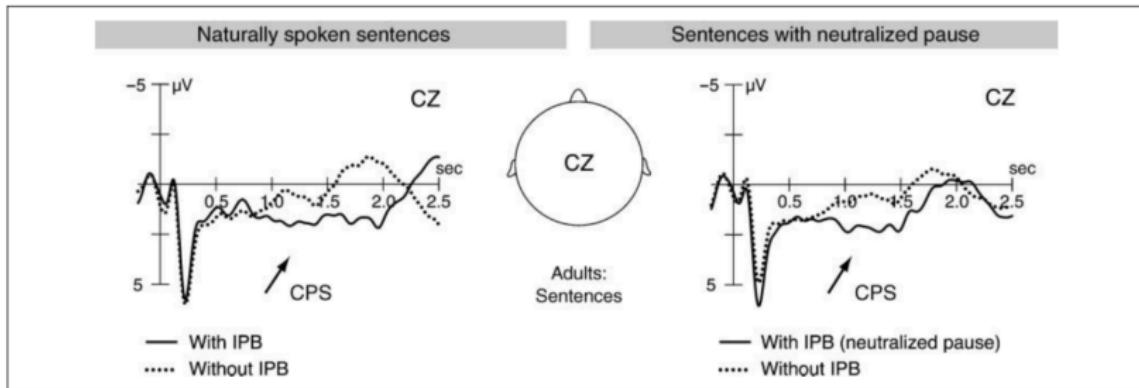
(Homae, Watanabe, Nakano, Asakawa, & Taga, 2006, 3-month-olds)

From prosodic cues to syntax



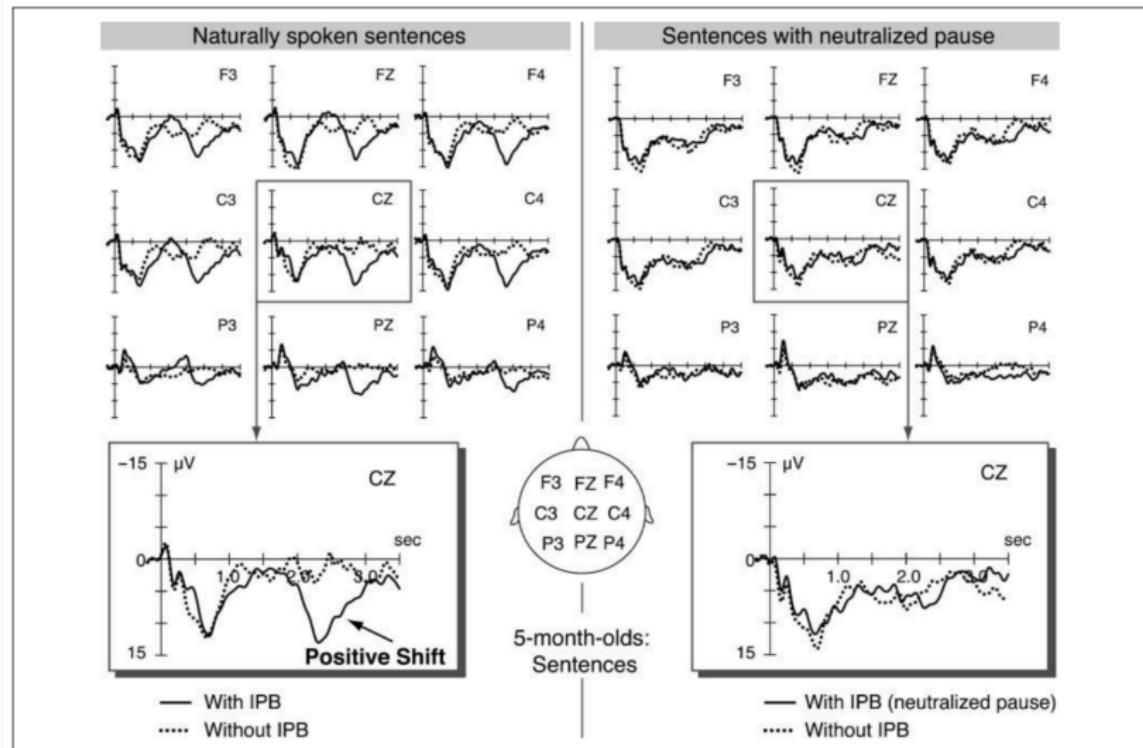
(Friederici, 2005; Steinhauer, Alter, & Friederici, 1999)

From prosodic cues to syntax



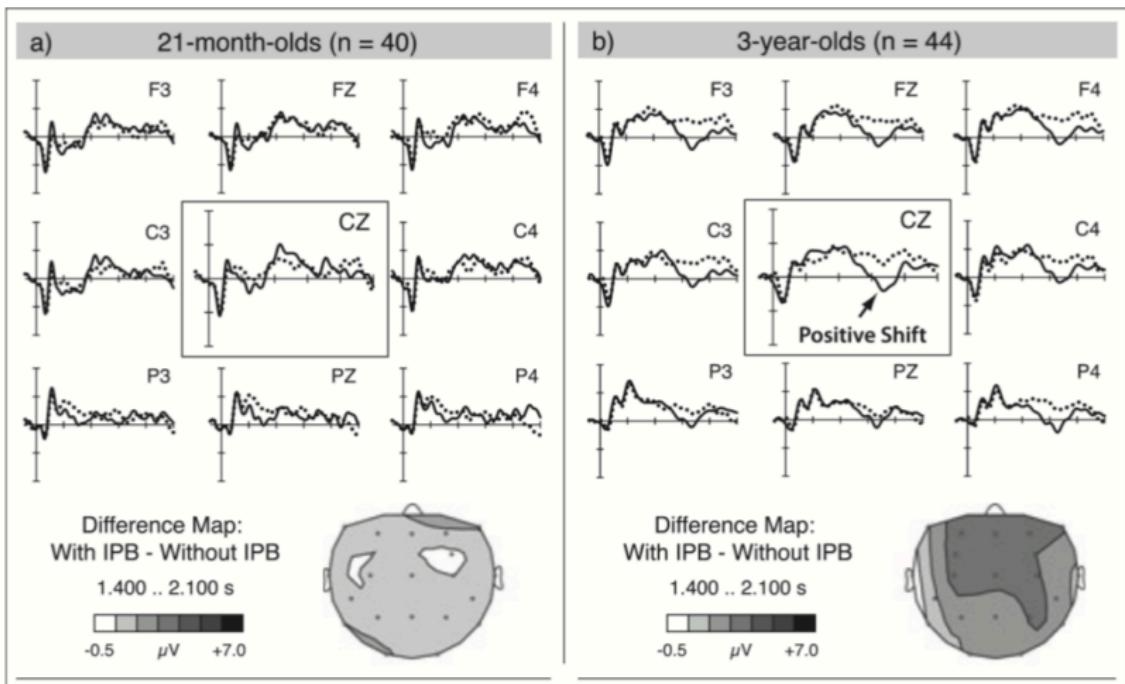
(Männel & Friederici, 2009)

From prosodic cues to syntax



(Männel & Friederici, 2009)

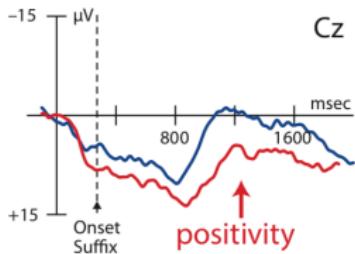
From prosodic cues to syntax



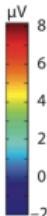
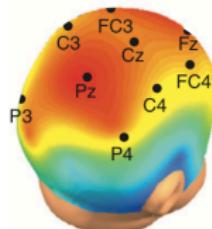
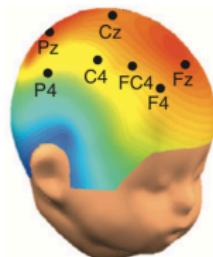
(Männel & Friederici, 2011)

From syntactic regularities to syntax: Italian

A



B incorrect – correct



— correct sentences

La sorella
The sister sta cant ando

is singing

Il fratello
The brother puo cant are

can sing

— incorrect sentences

*Il fratello
*The brother sta cant are

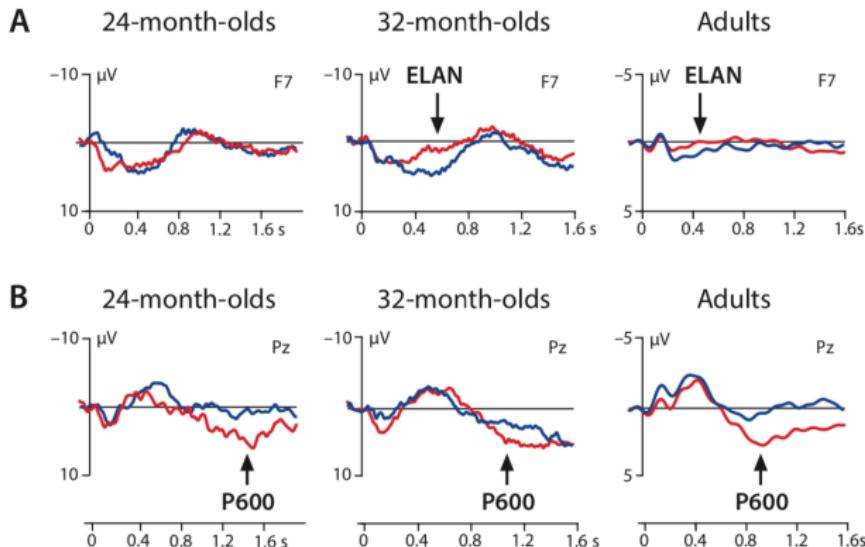
is sing

*La sorella
*The sister puo cant ando

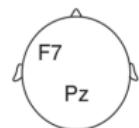
can singing

(Friederici, Mueller, & Oberecker, 2011, 4-month-olds)

From syntactic regularities to syntax: German



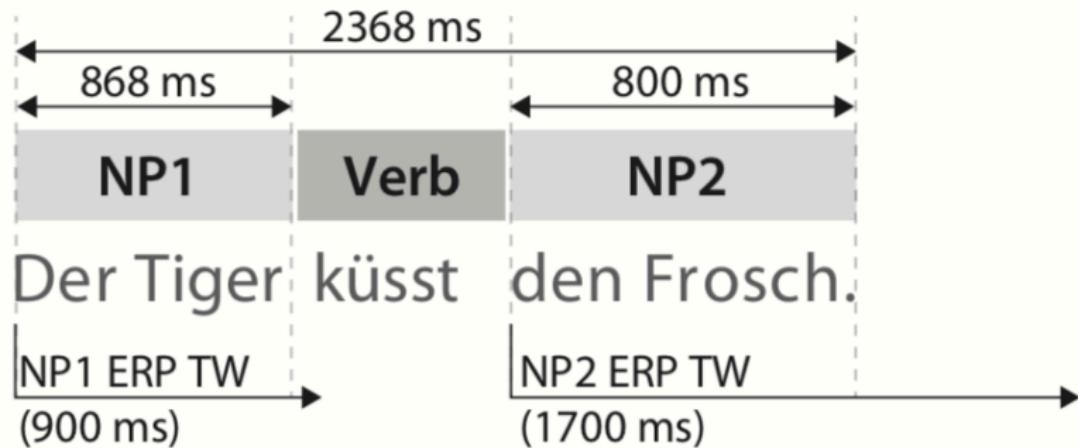
- syn correct: Der Löwe brüllt.
The lion roars.
- syn incorrect: Der Löwe im brüllt.
The lion in the roars.



(Oberecker, Friedrich, & Friederici, 2005; Oberecker & Friederici, 2006)

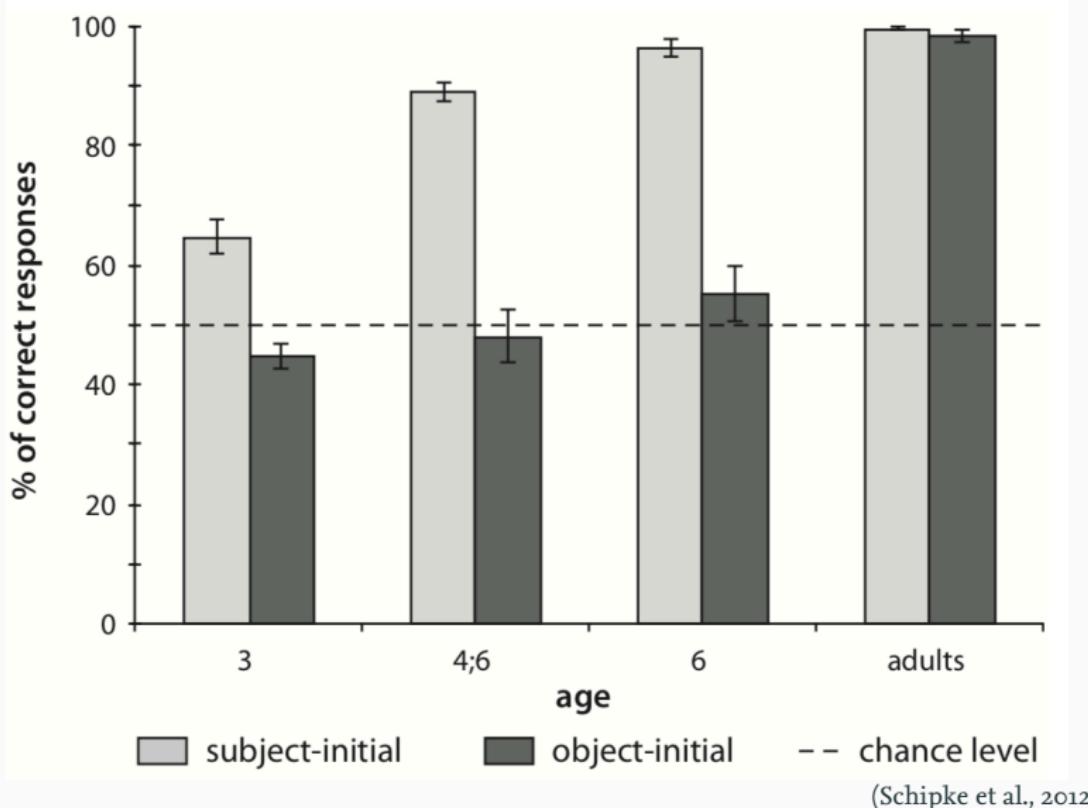
Language beyond age 3

The time course: ERP studies

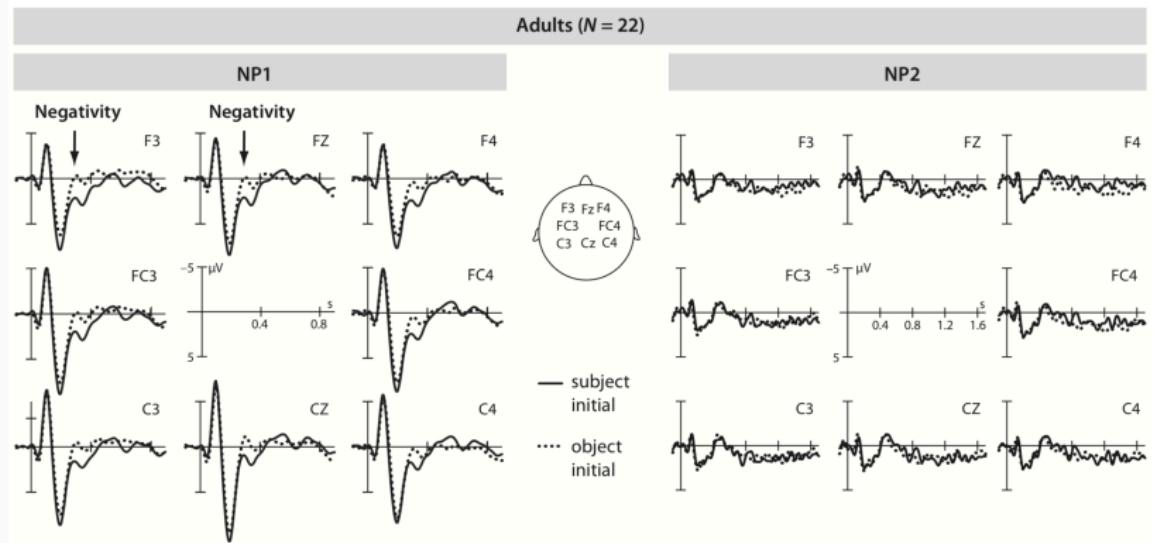


(Schipke, Knoll, Friederici, & Oberecker, 2012)

The time course: ERP studies

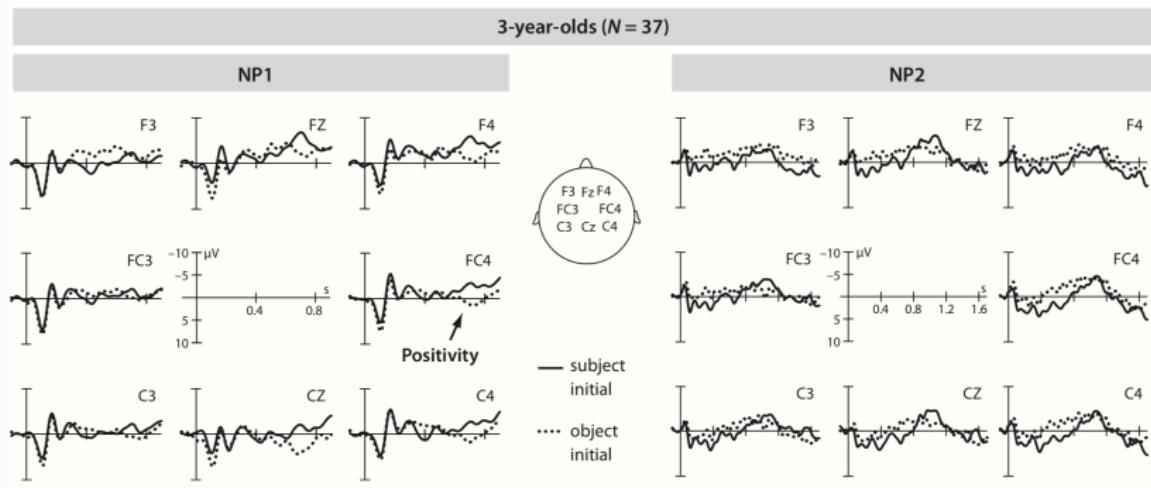


The time course: ERP studies



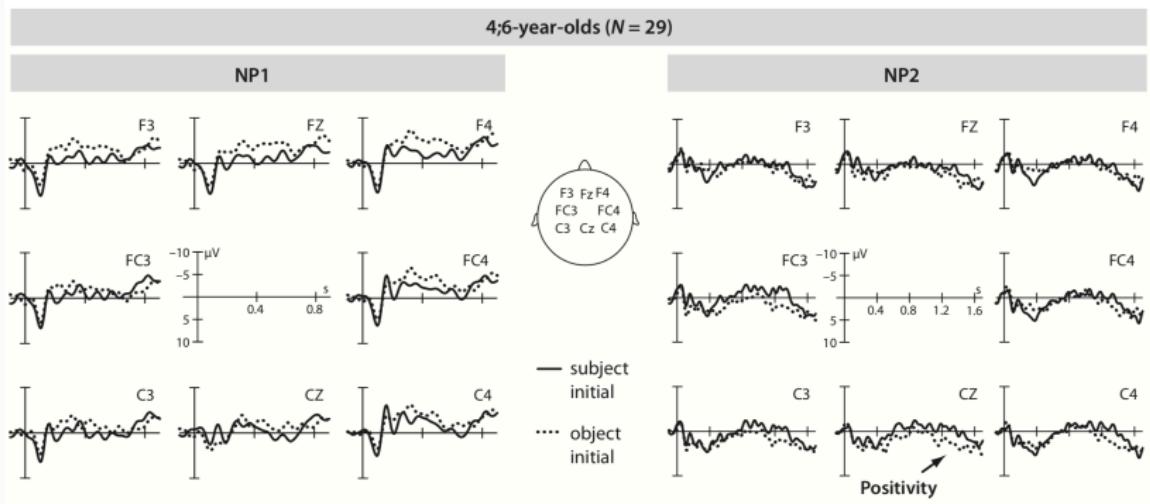
(Schipke et al., 2012)

The time course: ERP studies



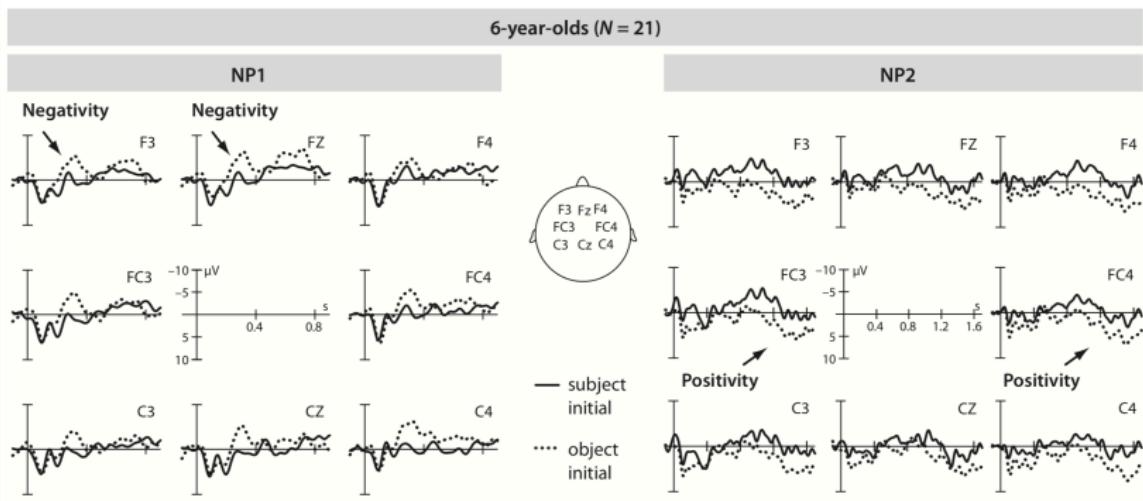
(Schipke et al., 2012)

The time course: ERP studies



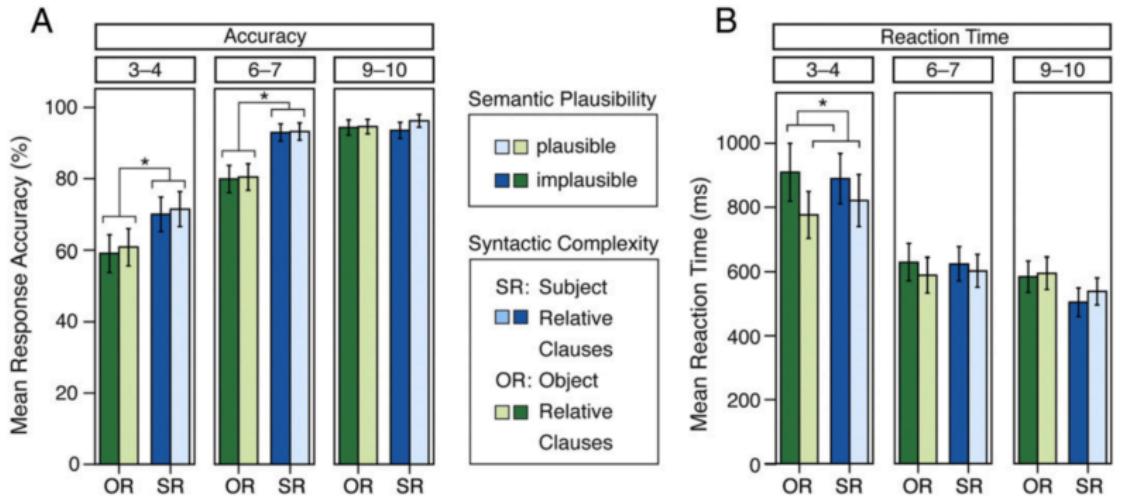
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The time course: ERP studies



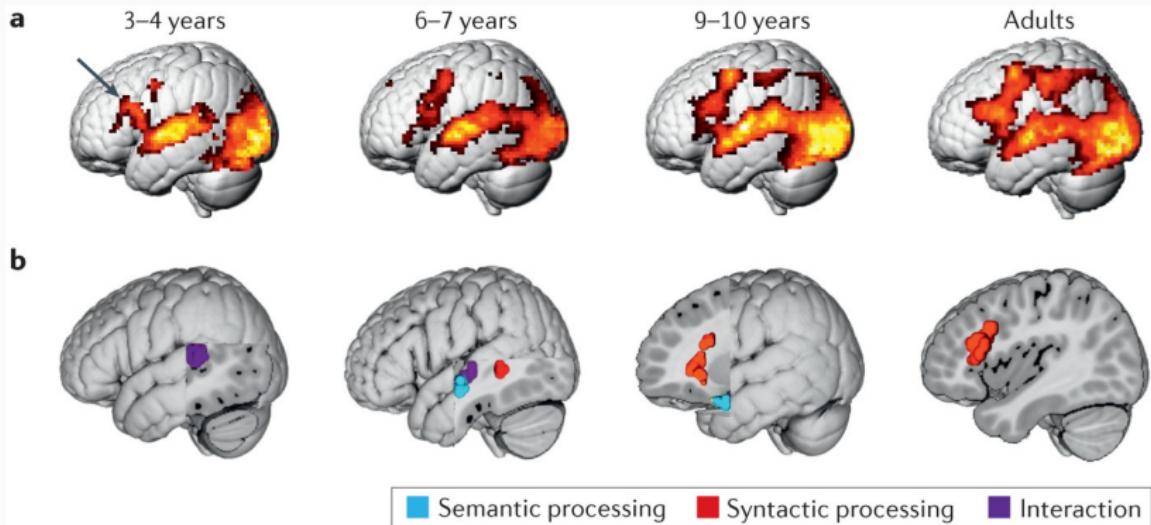
(Schipke et al., 2012)

The segregation of syntax from semantics



(Skeide, Brauer, & Friederici, 2014)

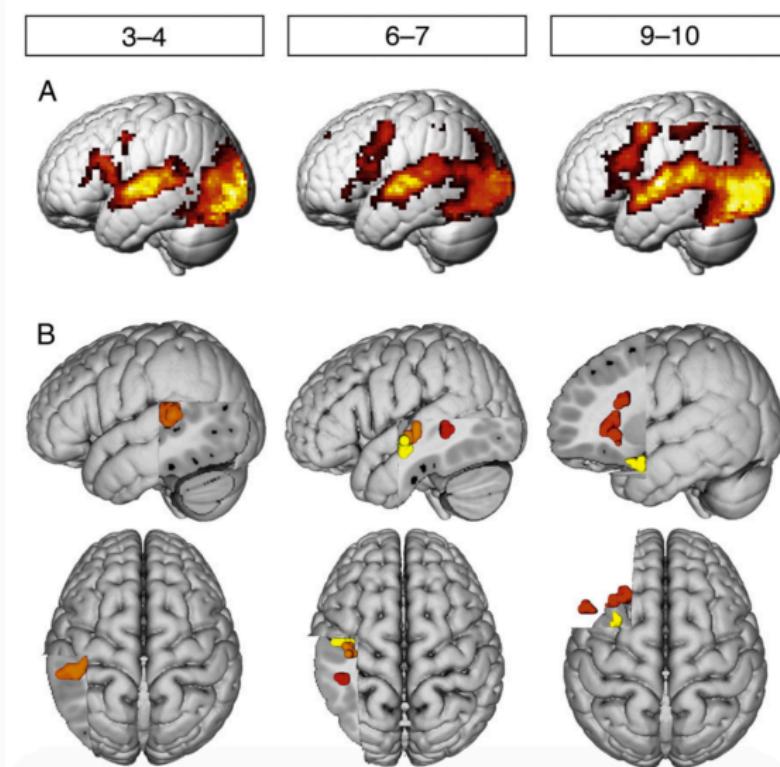
The segregation of syntax from semantics



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(Skeide et al., 2014)

The segregation of syntax from semantics



(Skeide et al., 2014)

Language-related brain areas across development

Subject relative clauses (simple)

Wo ist **der große Fuchs, der den kleinen Käfer trägt?**

Where is the big fox, [who]_{NOM} [the]_{ACC} small beetle carries?

Where is the big fox, who carries the small beetle?



Object relative clauses (complex)

Wo ist **der kleine Käfer, den der große Fuchs trägt?**

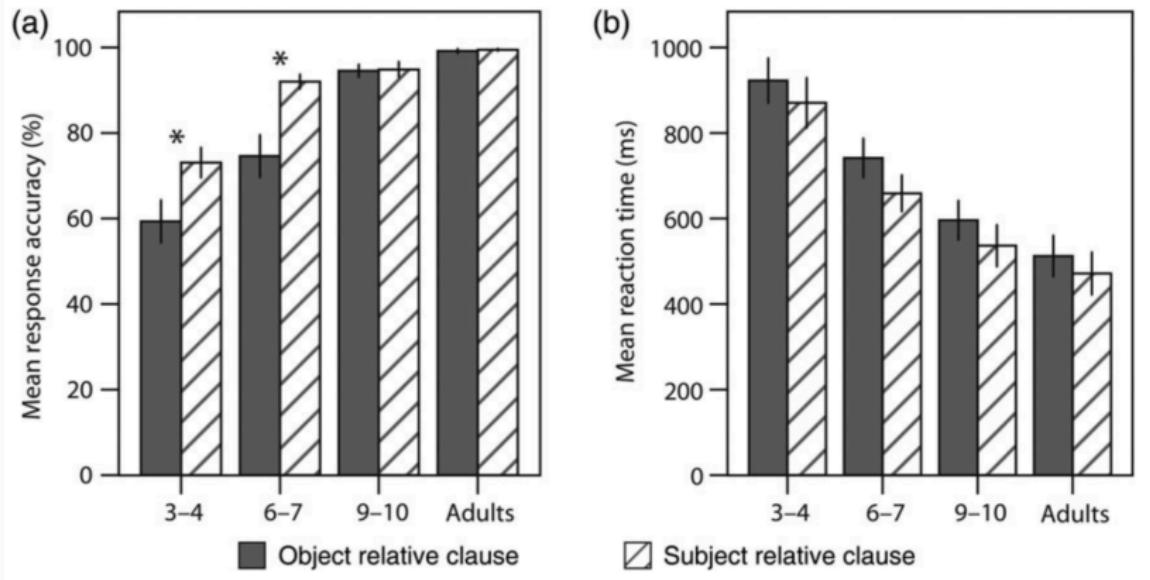
Where is the small beetle, [who]_{ACC} [the]_{NOM} big fox carries?

Where is the small beetle, who the big fox carries?



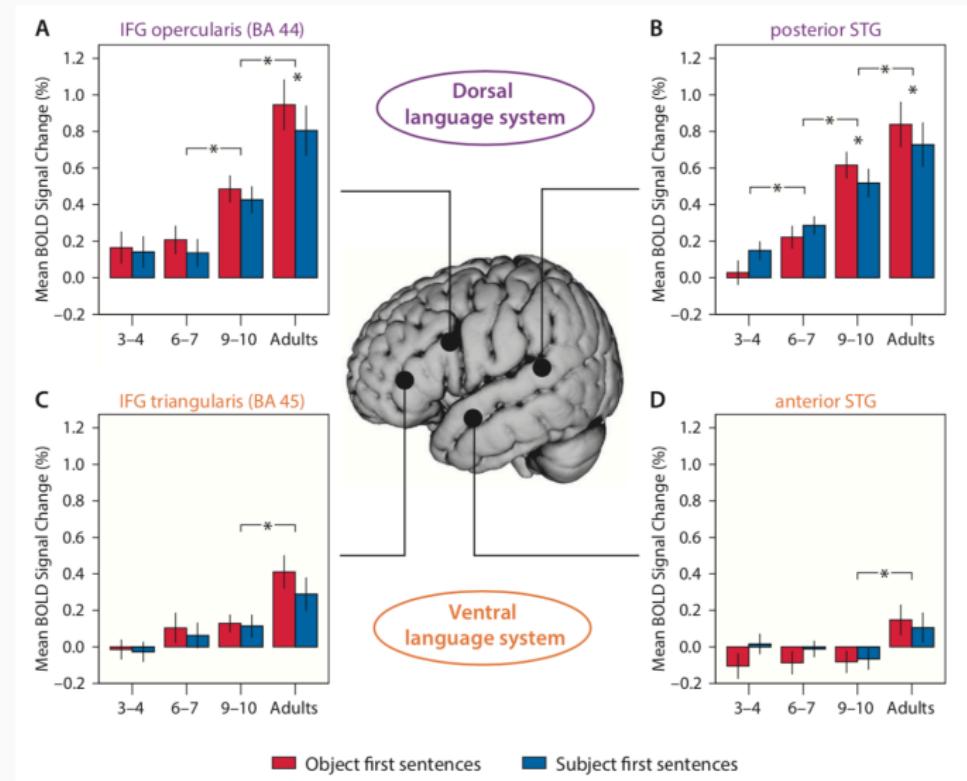
(Skeide, Brauer, & Friederici, 2016)

Language-related brain areas across development



(Skeide et al., 2016)

Language-related brain areas across development

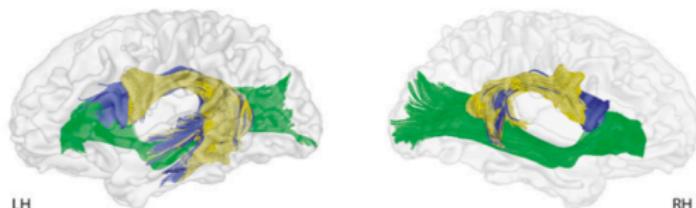


(Skeide et al., 2016)

Structural connectivity during development

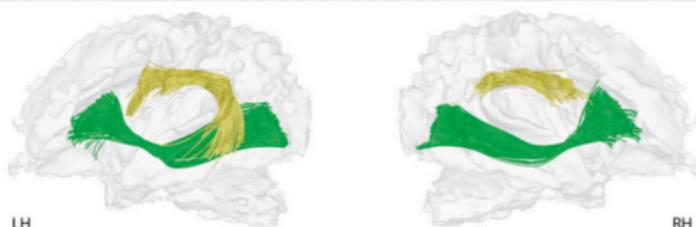
A

Adults



B

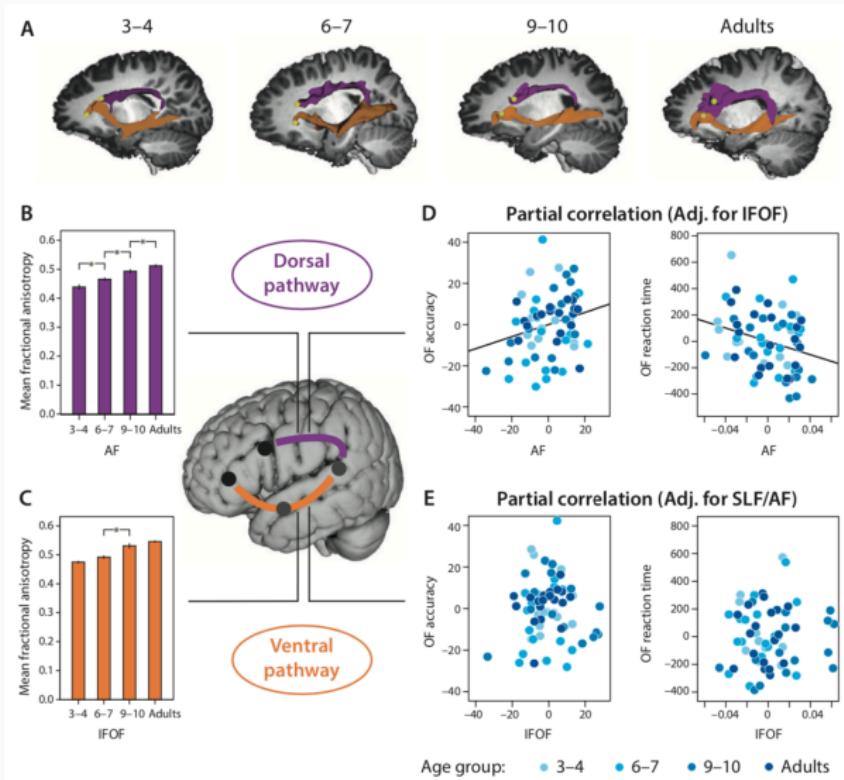
Newborns



- Dorsal pathway: Part of the AF/SLF connecting to Broca's area
- Dorsal pathway: Part of the AF/SLF connecting to precentral gyrus premotor cortex
- Ventral pathway connecting the ventral portion of the inferior frontal gyrus to the temporal cortex via the extreme fiber capsule system

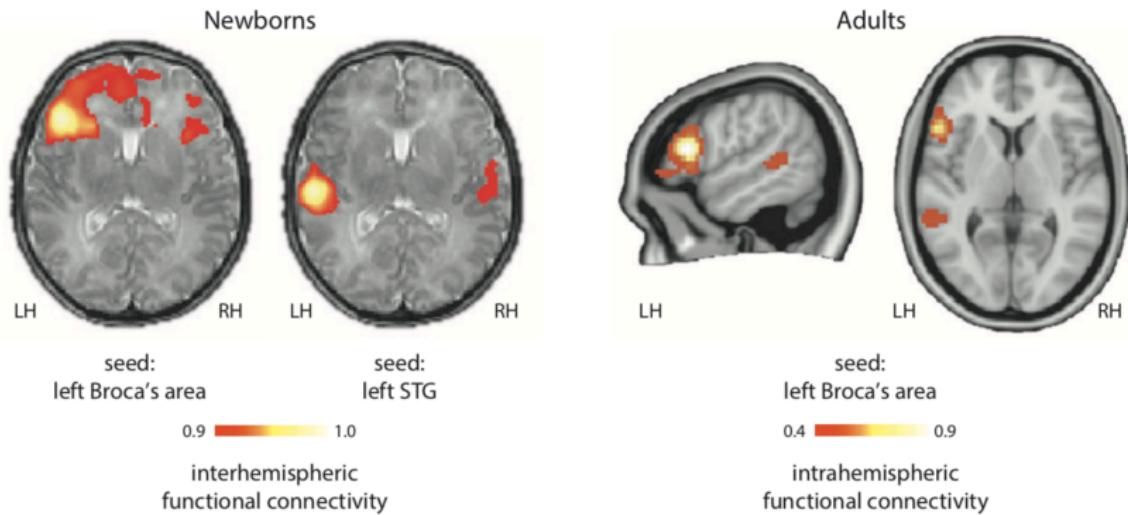
(Perani et al., 2011)

Structural connectivity during development



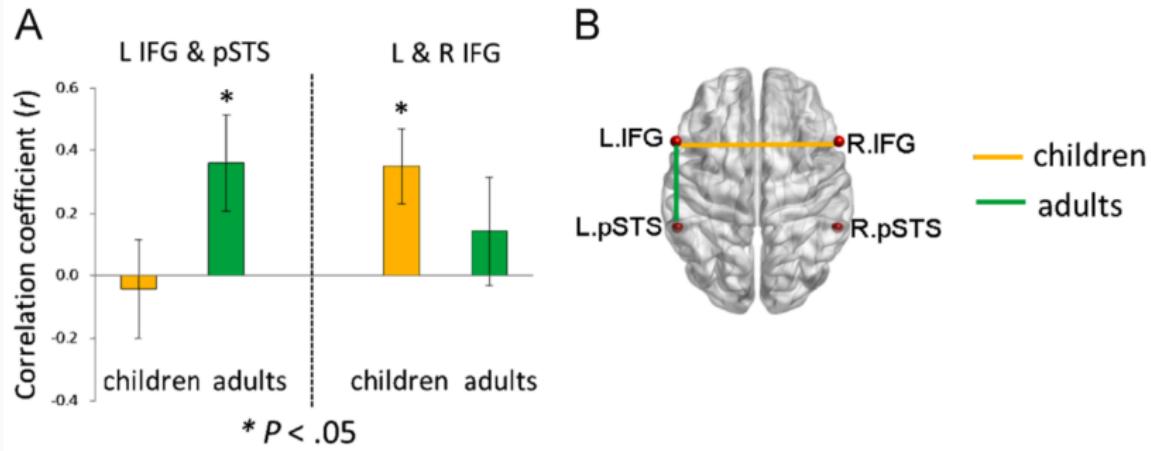
(Skeide et al., 2016)

Functional connectivity during development



(Perani et al., 2011)

Functional connectivity: Resting-state

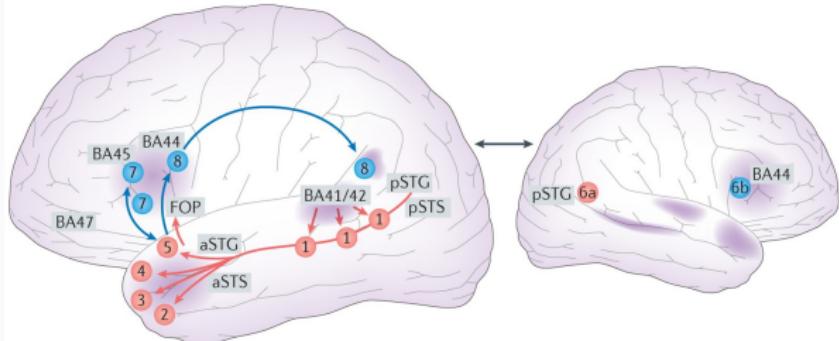


(Xiao, Friederici, Margulies, & Brauer, 2016)

A brain-based language acquisition model

A brain-based language acquisition model

a Language comprehension in adults



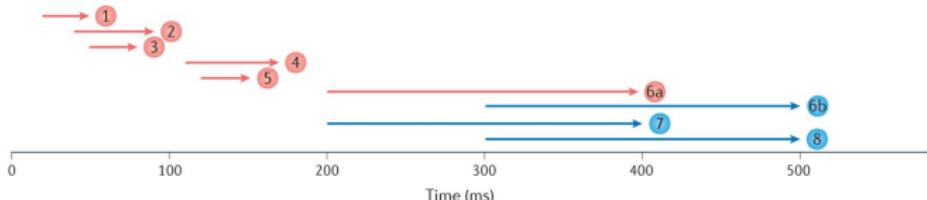
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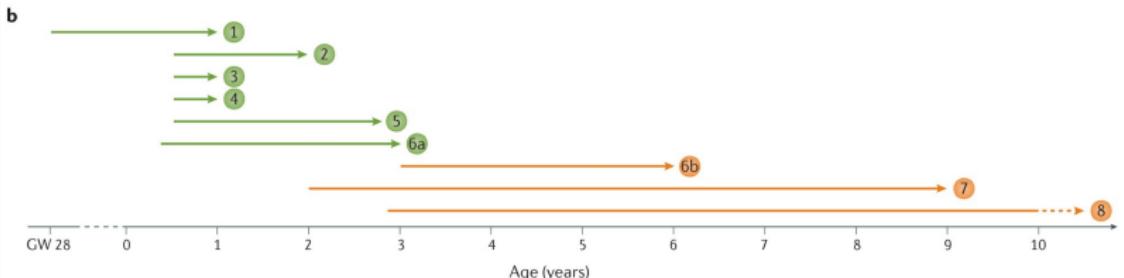
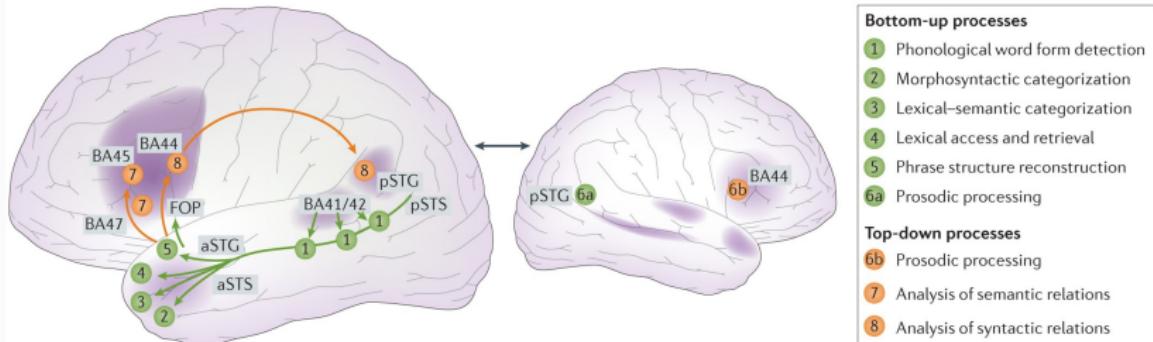


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(Skeide & Friederici, 2016)

A brain-based language acquisition model

a Developmental trajectories of language and comprehension



Nature Reviews | Neuroscience

(Skeide & Friederici, 2016)

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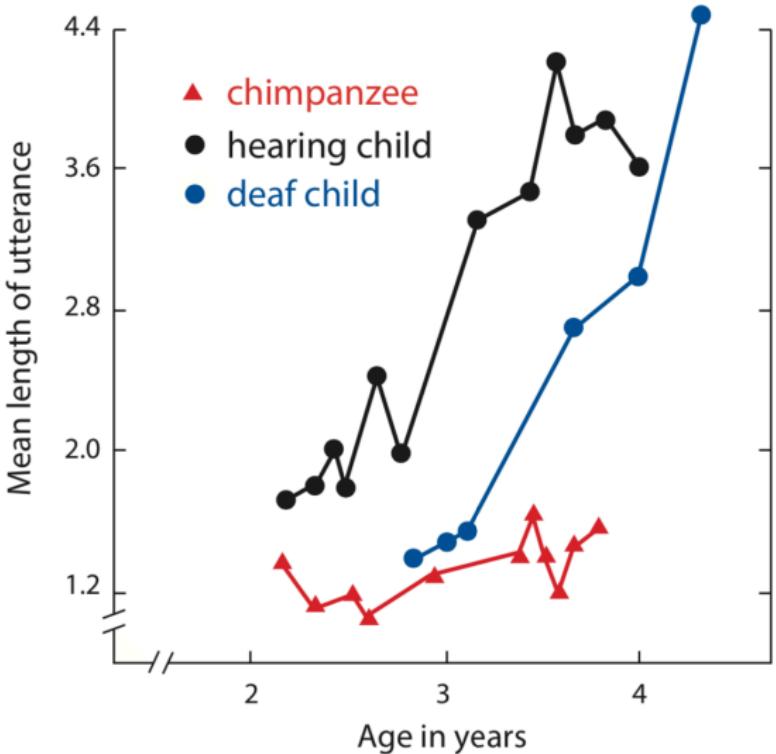
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Language as a uniquely human trait

The biological basis of language faculty

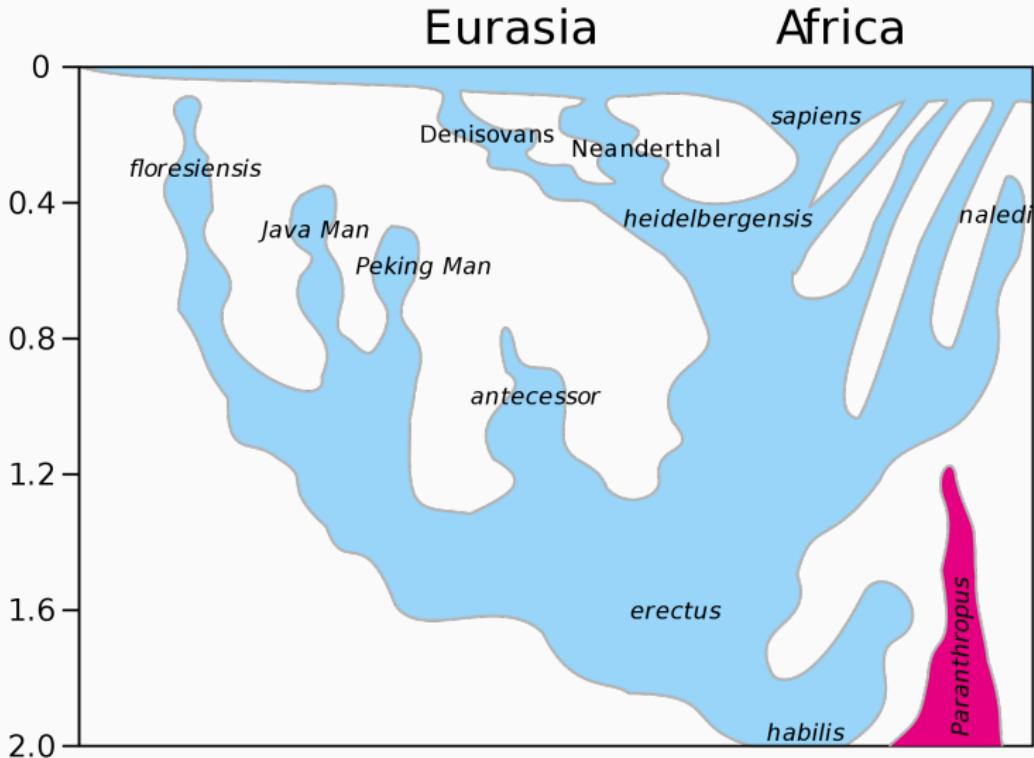
Language as a uniquely human trait

Language as a uniquely human trait



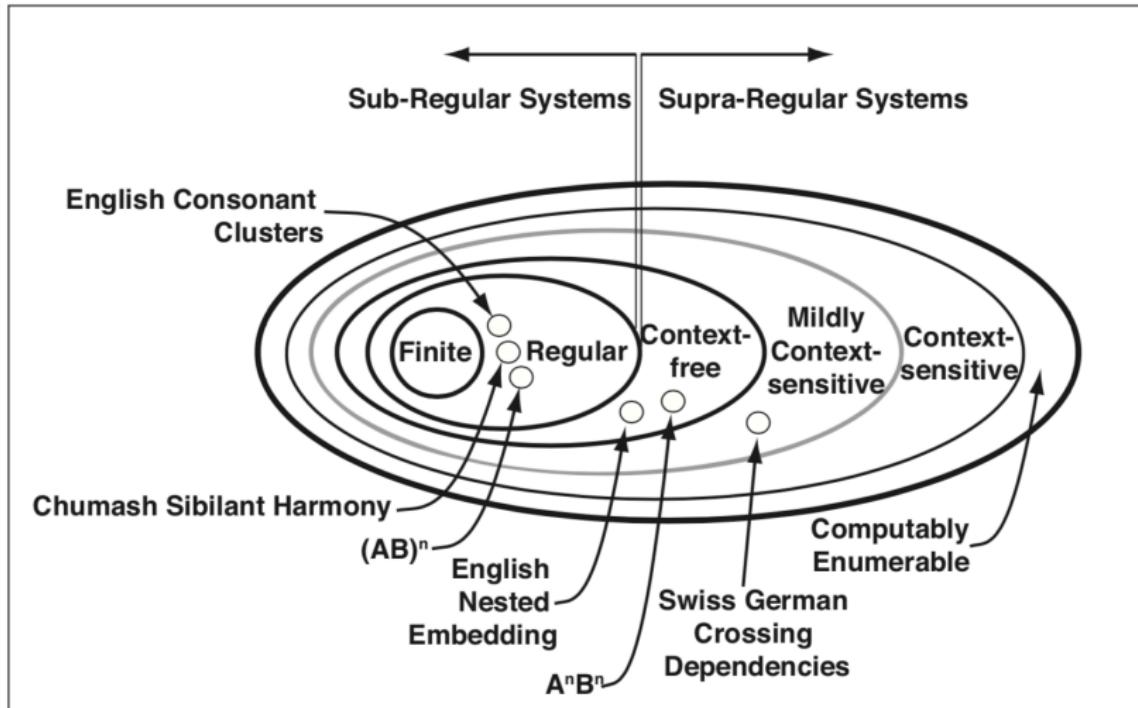
(Friederici, 2017, p.208)

Language as a uniquely human trait



wikipedia

Language as a uniquely human trait



(Fitch, 2018)

Language as a uniquely human trait

A

Finite State
Grammar $(AB)^n$



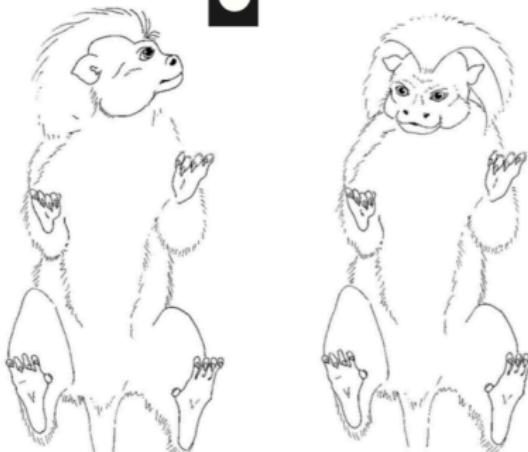
AB AB no li ba pa
AB AB AB la pa wu mo no li

B

Look



No Look



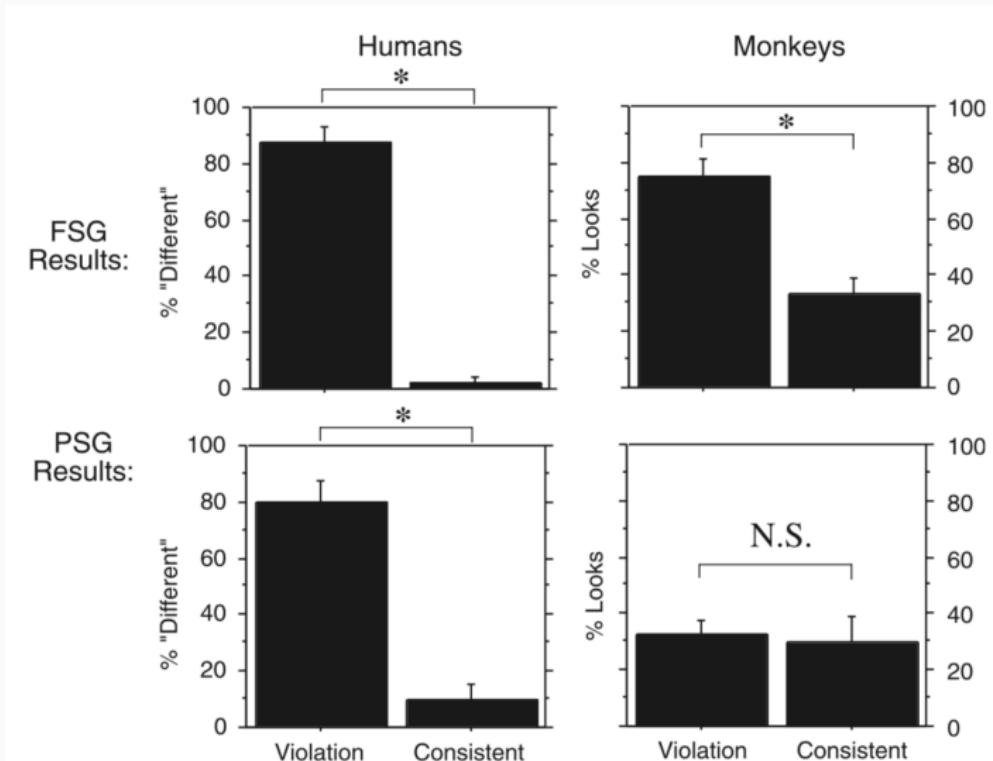
Phrase Structure
Grammar: A^nB^n



AA BB yola pa do
AAA BBB ba la tu li pa ka

(Fitch & Hauser, 2004)

Language as a uniquely human trait

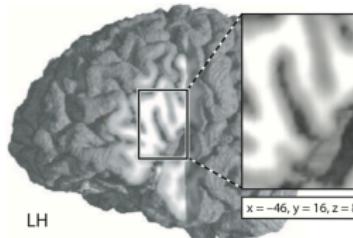
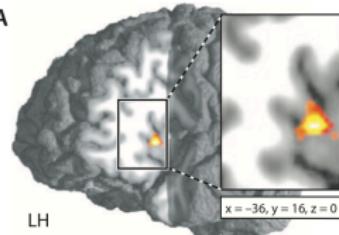


(Fitch & Hauser, 2004)

Language as a uniquely human trait

Finite State Grammar

A



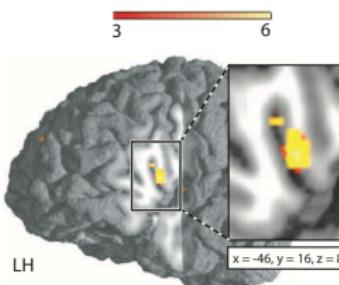
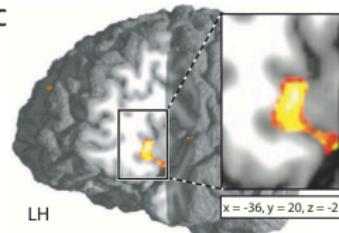
B

$(AB)^n$ Sequence



Phrase Structure Grammar

C



3 6

Frontal Operculum

Broca's Area

A^nB^n Sequence



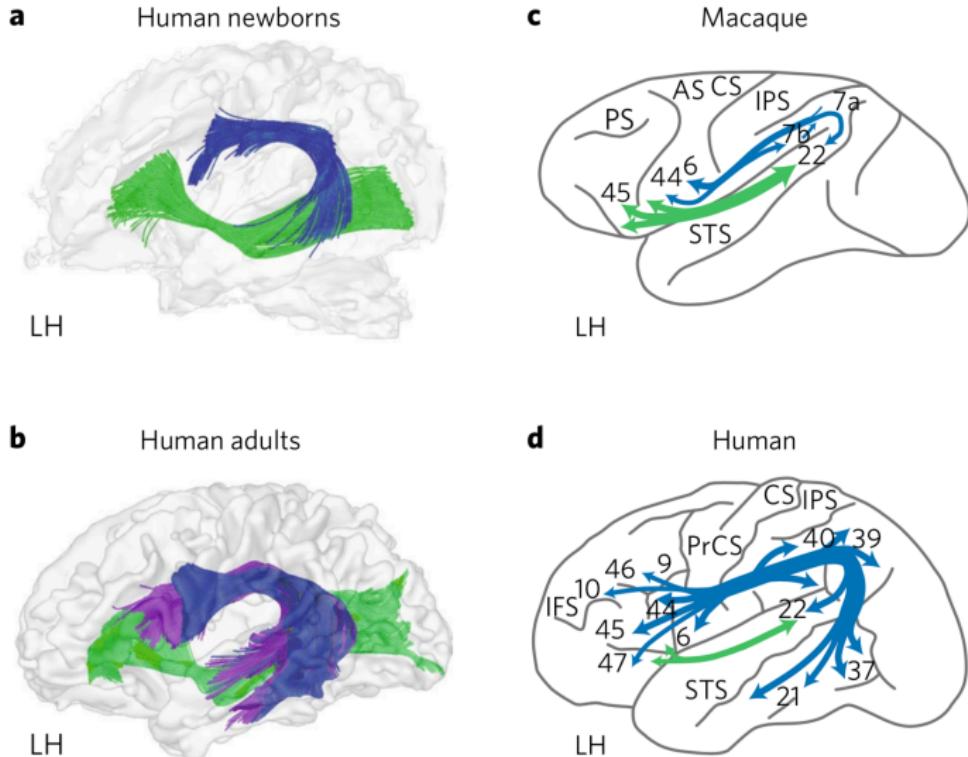
Category A: de, gi, le, mi, ne, ri, se, ti

Category B: bo, fo, gu, ku, mo, pu, to, wu

(Friederici, Bahlmann, Heim, Schubotz, & Anwander, 2006)

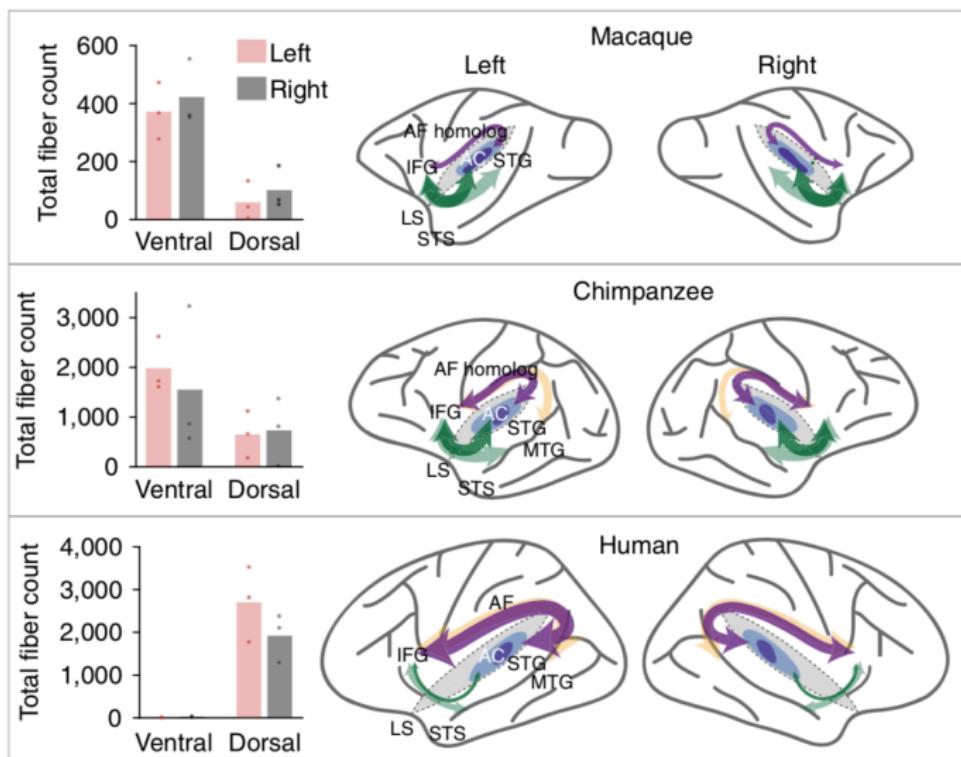
The biological basis of language faculty

White matter fiber tracts in phylogeny and ontogeny



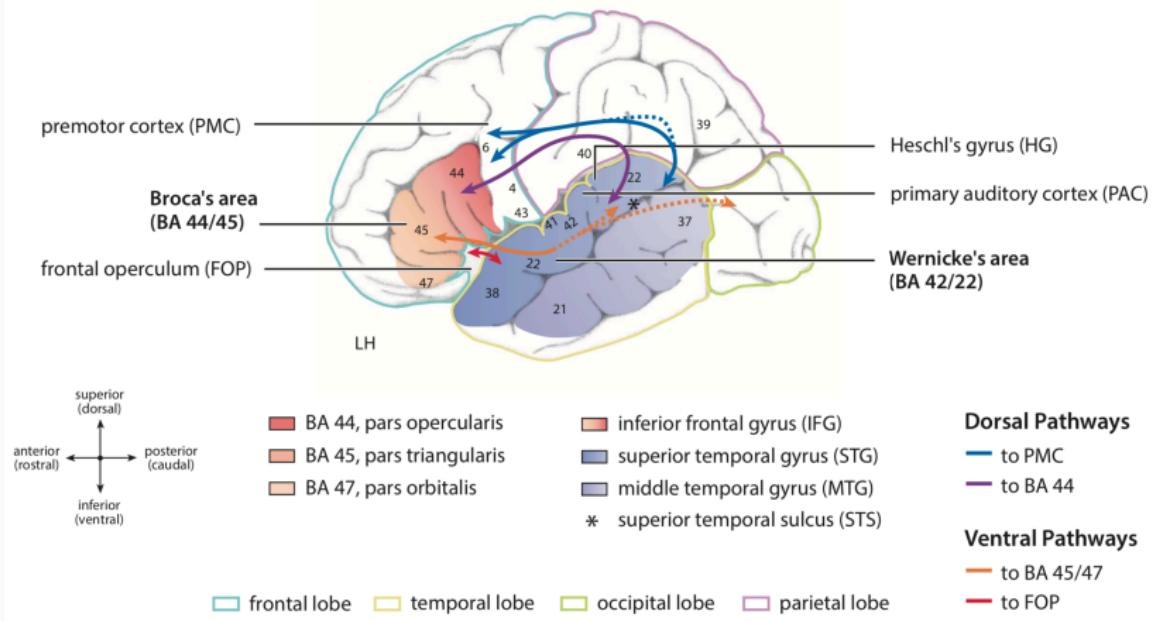
(Rilling et al., 2008; Perani et al., 2011; Friederici, Chomsky, Berwick, Moro, & Bolhuis, 2017)

White matter fiber tracts in phylogeny and ontogeny



(Balezeau et al., 2020)

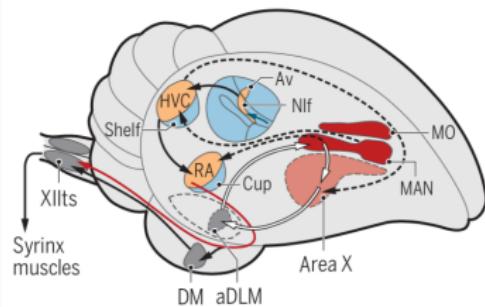
An integrative view of the language network



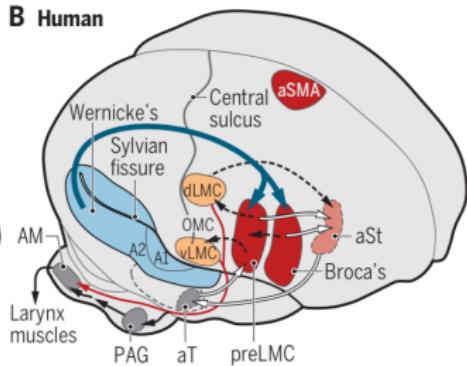
(Friederici, 2017, p.6)

Vocal learning: Not the whole story

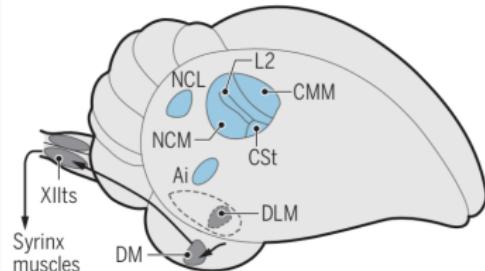
A Songbird



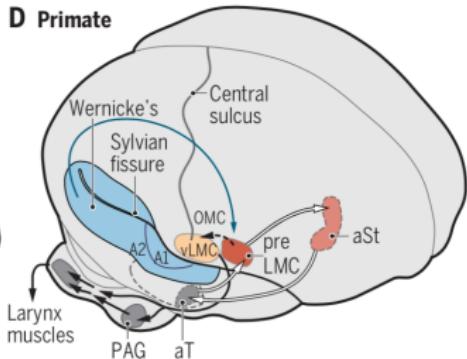
B Human



C Vocal birds



D Primate



(Jarvis, 2019)

The multifold property of language

MORE THAN A TOOL FOR COMMUNICATION

By Pamela J. Hines and Peter Stern

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(Hines & Stern, 2019)

The multifold property of language

How disorienting would it be to travel to a country where you do not know the language and cannot read the street signs because the letters are unfamiliar? You would not even be able to distinguish an exit sign from a stop sign. Language enables the sharing of information, knowledge, and predictions about the world around us. Language also gives us poetry and fiction through which to express feelings and speculate about things or events that are not and may never become real.

Humans and animals communicate through multiple modalities, such as sight, odor, and touch. In this special issue, we focus on the communication of sound—particularly language. What is language? Is human language special, or is it simply at the extreme end of an evolutionary spectrum? How does the brain produce and interpret language? Given the fundamental importance of

communication in our society, it is no surprise that such a large part of the brain is engaged in the processing of language. Syntax, grammar, and word selection define common ground and differentiate distinct human languages. How do the young learn to make sense of the cacophony?

Language is central to our existence as humans. With language we entertain, agitate, and encourage each other; we build community. Without language we are each islands unto ourselves. Language turns us into social beings. Some argue that the capacity for language is crucial to the runaway success of our species. Both the human brain and the language it enables help shape the world we inhabit today.

Simplified forms of language are useful for linguistic study. Two-word phrases can vary the conceptual specificity of nouns and how functional elements of the language fit together. The words in the background (in English and German) are examples that have been used in research.

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(Hines & Stern, 2019)

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