



# Language Evolution WiSe 2023/2024

## Lecture 7: Language Evolution Theories

14/11/2023, Christian Bentz



# Overview

## Introduction

### Section 1: Definitions of Language

- The Chomsky Hierarchy
- Faculty of Language
- Minimalism
- Usage-Based Grammar

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- Vocal Communication
- Gestural Communication
- Social Bonding
- Thinking
- No Function

### Section 3: Evolutionary Scenarios

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- The Saltational Theory
- The Gradual Theory
- The Co-Evolution Theory

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# Introduction



# What is unique about human language?



“If a Martian scientist [...] received from Earth the broadcast of an extensive speech [...] what criteria would [...] determine whether the reception represented the effect of an animate process on Earth, or merely the latest thunderstorm on Earth?”

Zipf (1936). The psycho-biology of language, p. 187.

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## ***How and why did this uniqueness evolve?***



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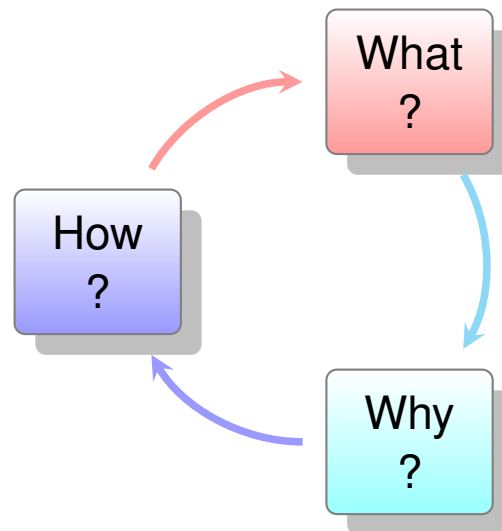
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# Three Questions

1. **What** evolved, i.e. what is “language” in the first place?
2. **Why** did it evolve, i.e. did it have particular functions?
3. **How** did it evolve?



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## Section 1: Definitions of Language (*What?*)



# What is Language?



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# Competing Definitions of *Language*

- ▶ **Formal Language Theory**
- ▶ **Faculty of Language**
  - ▶ Recursion
  - ▶ Rich Language Faculty (Narrow Sense)
- ▶ **Minimalism**
  - ▶ Strong Minimalist Thesis
  - ▶ Minimalist Layers Hypothesis
- ▶ **Usage-Based Grammar**

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# Formal Language Theory

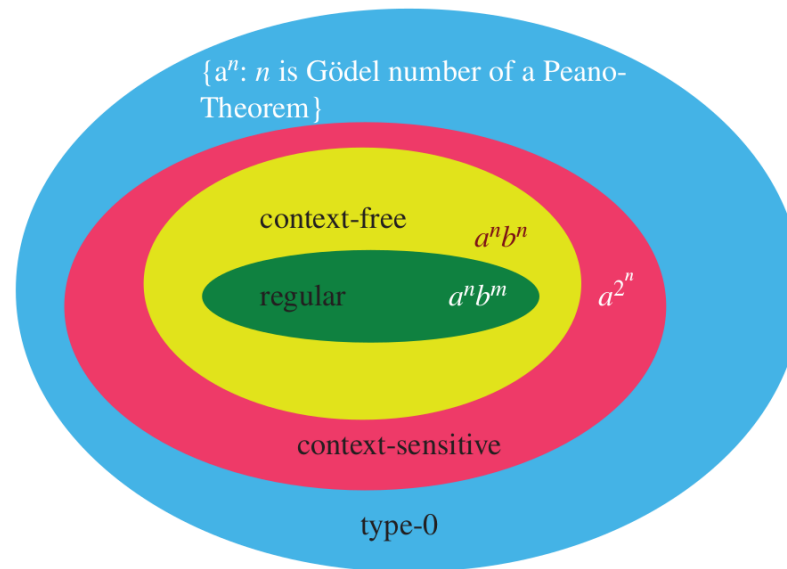


## Definition (Chomsky Hierarchy)

A **grammar**  $\mathcal{G}$  in formal language theory is a quadruple consisting of the set of terminal symbols, non-terminal symbols, a starting symbol  $S$ , and a set of rewrite rules  $R$ :

$$\langle T, NT, S, R \rangle \quad (1)$$

**Language:** “The set of all strings that [a grammar]  $\mathcal{G}$  can generate is called the **language** of  $\mathcal{G}$ , and is notated  $L(\mathcal{G})$ .”



Chomsky (1956). Three models for the description of language.

Jäger & Rogers (2012). Formal language theory: refining the Chomsky hierarchy, p. 1957.

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# The Faculty of Language



## Definition (Faculty of Language)

“In the varieties of modern linguistics that concern us here, the term “language” is used [...] to refer to an **internal component of the mind/brain** (sometimes called “internal language” or “**I-language**”). We assume that this is the primary object of interest for the study of the evolution and function of the **language faculty**.”

Hauser, Chomsky & Fitch (2002).  
The faculty of language: What is it, who has it, and how did it evolve?  
p. 1570.



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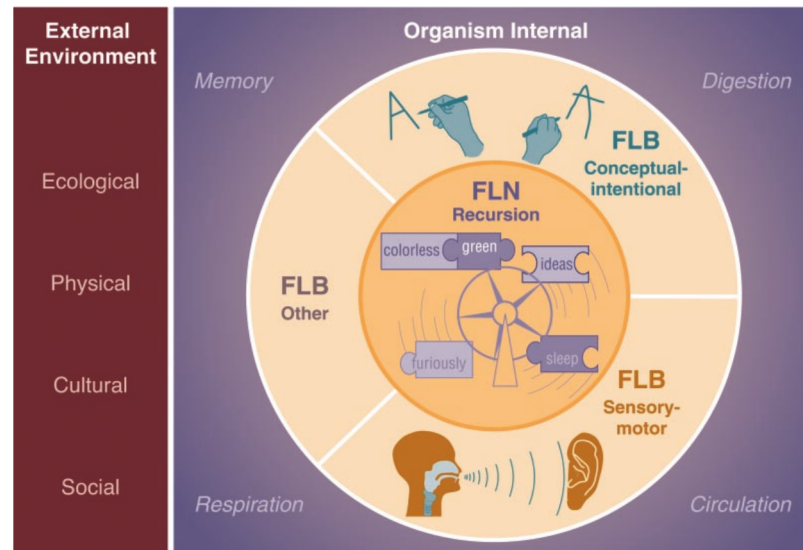


## Definition (FLN: Recursion)

“**FLN** is the abstract linguistic computational system alone, independent of the other systems with which it interacts and interfaces. [...]”

[...] a core property of FLN is **recursion** [...] FLN takes a finite set of elements and yields a potentially infinite array of discrete expressions.”

Hauser, Chomsky & Fitch (2002).  
The faculty of language: What is it, who has it, and how did it evolve?  
p. 1571.



**FLB: Faculty of Language in a Broad sense.**

**FLN: Faculty of Language in a Narrow sense.**

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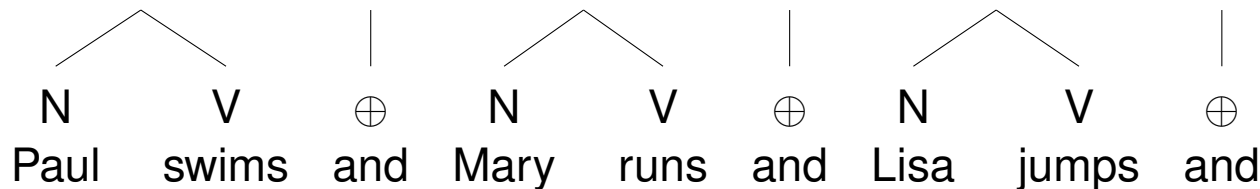
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## Types of Recursion: Tail Recursion

**Tail recursion** is a process whereby the same string of symbols (e.g. *ab*) is just appended to the end of itself, such that we get a string of the form  $(ab)^n$ , where  $n$  is potentially infinite. This is the “simple” way to **discrete infinity**.



Note: In this particular case, the  $ab^n$  pattern here actually refers rather to higher level categories (Noun, Verb), i.e. parts of speech, than the actual surface string (e.g. *and runs and runs and runs ...*).

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## Types of Recursion: “True” Recursion

“**True**” recursion is a process whereby a potentially infinite number  $n$  of instances of a symbol is followed by the same number of another symbol, such that we have  $a^n b^n$ . This is the “hard” way to **discrete infinity**.

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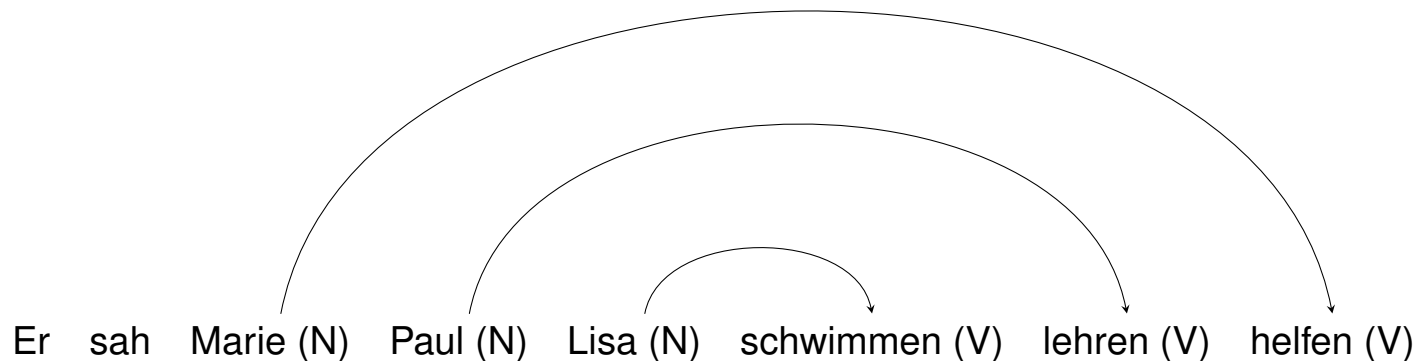
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“He saw Marie help Paul teach Lisa how to swim.”

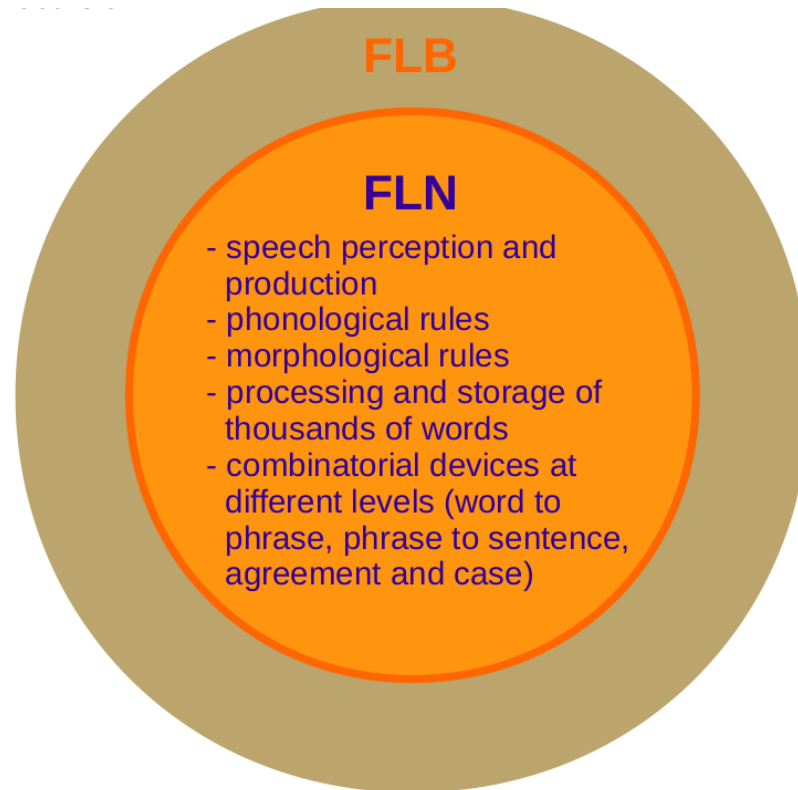
Note: The  $a^n b^n$  pattern here actually refers to higher level categories like parts of speech, rather than the actual surface string.



## Definition (Rich FLN)

“We find the [recursion only] hypothesis problematic. It ignores the many [unique] aspects of grammar that are not recursive, such as **phonology, morphology, case, agreement, and many properties of words.**”

Pinker & Jackendoff (2005). The faculty of language: what's special about it?



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# Minimalism

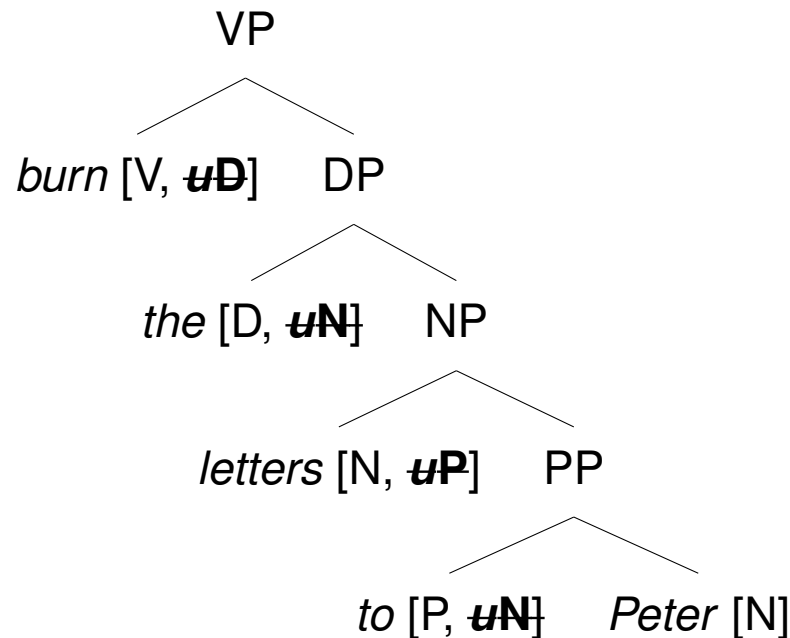




## Definition (Strong Minimalist Thesis)

“Within some small group from which we are all descended, a rewiring of the brain took place in some individual, call him Prometheus, yielding the operation of **unbounded Merge** [...]”

Chomsky (2005). Some simple evo devo theses: how true might they be for language?



Adger (2003), p. 84.

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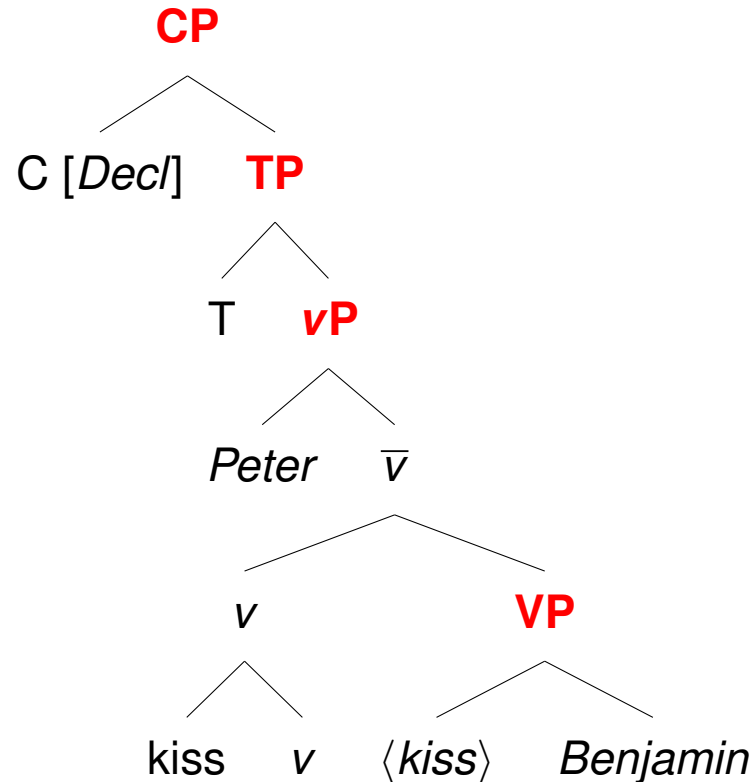
## Definition (Minimalist Layers)

In many minimalist accounts there is a **hierarchy of layers**:

$$CP \succ TP \succ vP \succ VP/SC \quad (2)$$

The capacity for full language involves everything from the VP/SC layer (small clause) to the CP layer.

Progovac (2015). Evolutionary syntax, p. 9.



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# Usage-Based Grammar



## Definition (Usage-Based)

“While all linguists are likely to agree that *grammar is the cognitive organization of language*, a **usage-based theorist** would make the more specific proposal that grammar is the cognitive organization of one’s **experience with language**.”

Bybee (2006). From usage to grammar: The mind’s response to repetition.



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## Definition (Usage-Based)

From the **usage-based** perspective **language** is ultimately a **mapping** from phonetic shapes (or hand shapes in sign language, or graphemes in writing) to semantic or pragmatic context. The strength of this mapping is determined by the **frequency of co-occurrence**.

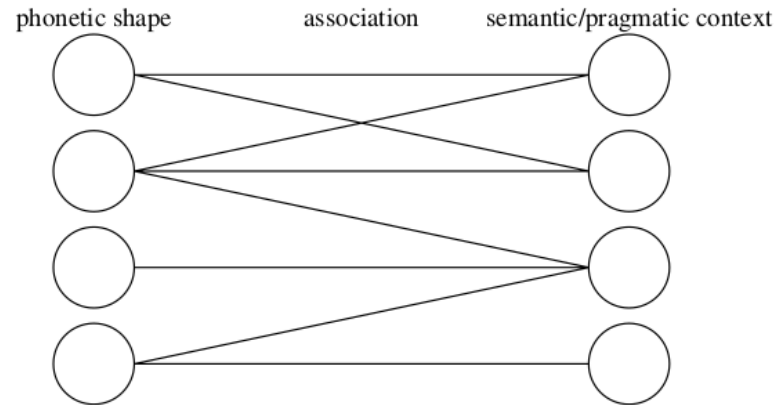


FIGURE 3. Variable associations of form and meaning in a linguistic sign.

Bybee (2006). From usage to grammar: The mind's response to repetition.

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## Section 2: Evolutionary Functions (*Why?*)



# Evolutionary Functions: *Why* did Language evolve?

- ▶ **Vocal Communication**
- ▶ **Gestural Communication**
- ▶ **Social Bonding** (Grooming/Gossiping)
- ▶ **Thinking**
- ▶ **No Function**

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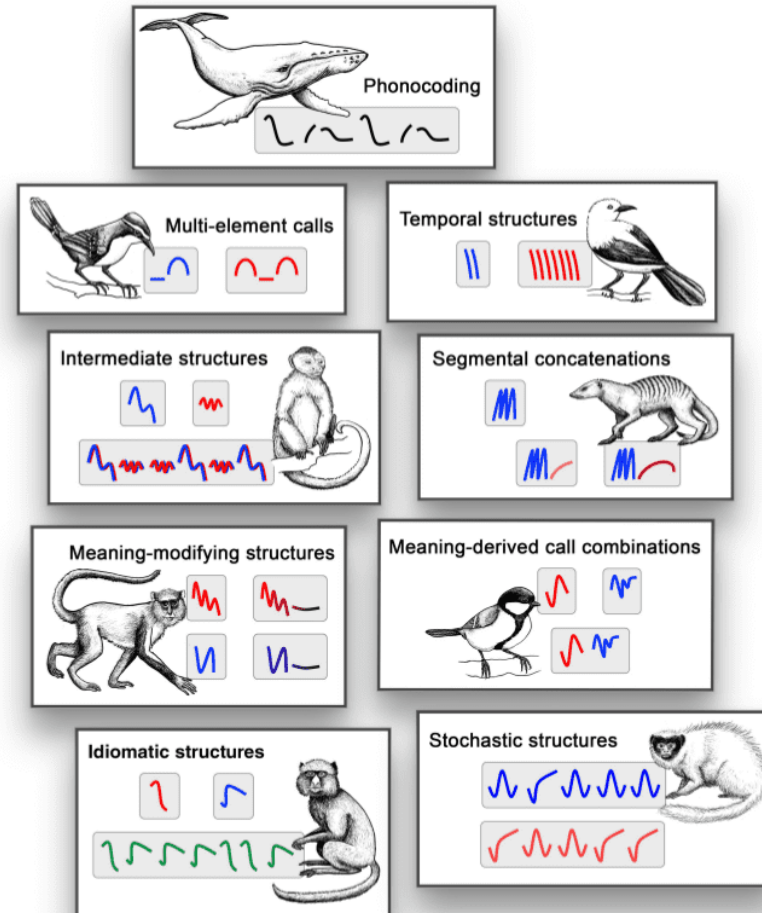




# Vocal Communication

A natural point of departure is to assume that human (spoken) language is an extension/complexification of **vocal communication** found in other primates and animals more generally.

Vocal communication for *mating*, and for *predator warning* seems quite clearly to confer an **evolutionary advantage** under selection.



Engesser and Townsend (2019).

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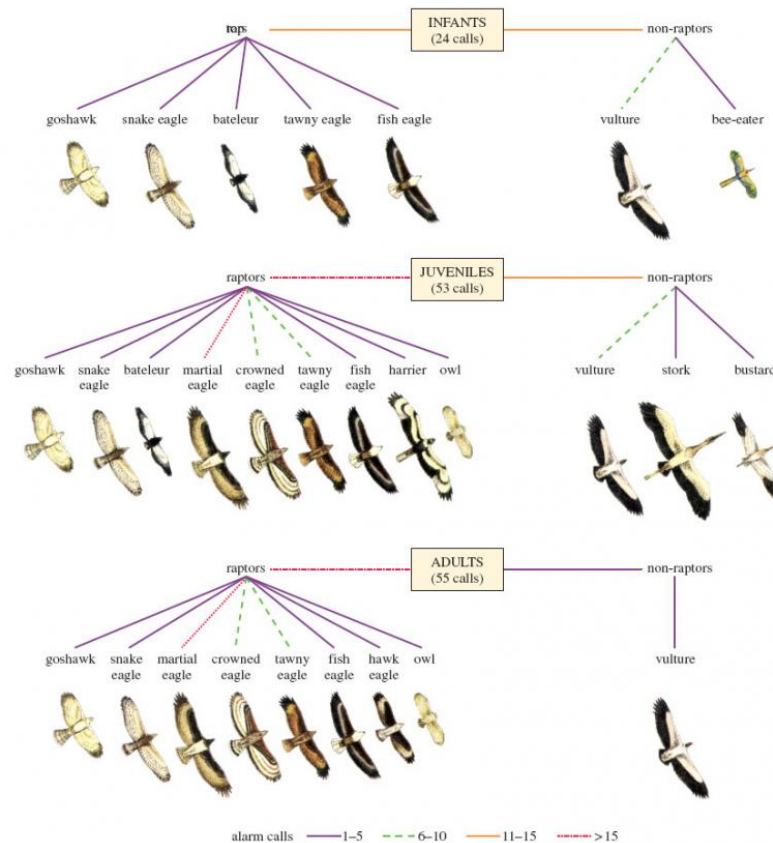
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# Vocal Communication

Indeed, some primates, e.g. *Vervet monkeys* (New World monkeys), have been shown to use vocal signals with different meanings.



Seyfarth et al. (1980a).

Seyfarth et al. (1980b).

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# Vocal Communication: Problem

While more distant relatives (i.e. New World monkeys) have been shown to use vocal communication, to what extent our closest relatives, i.e. **chimpanzees**, use **vocal communication in the wild** is an ongoing field of research.

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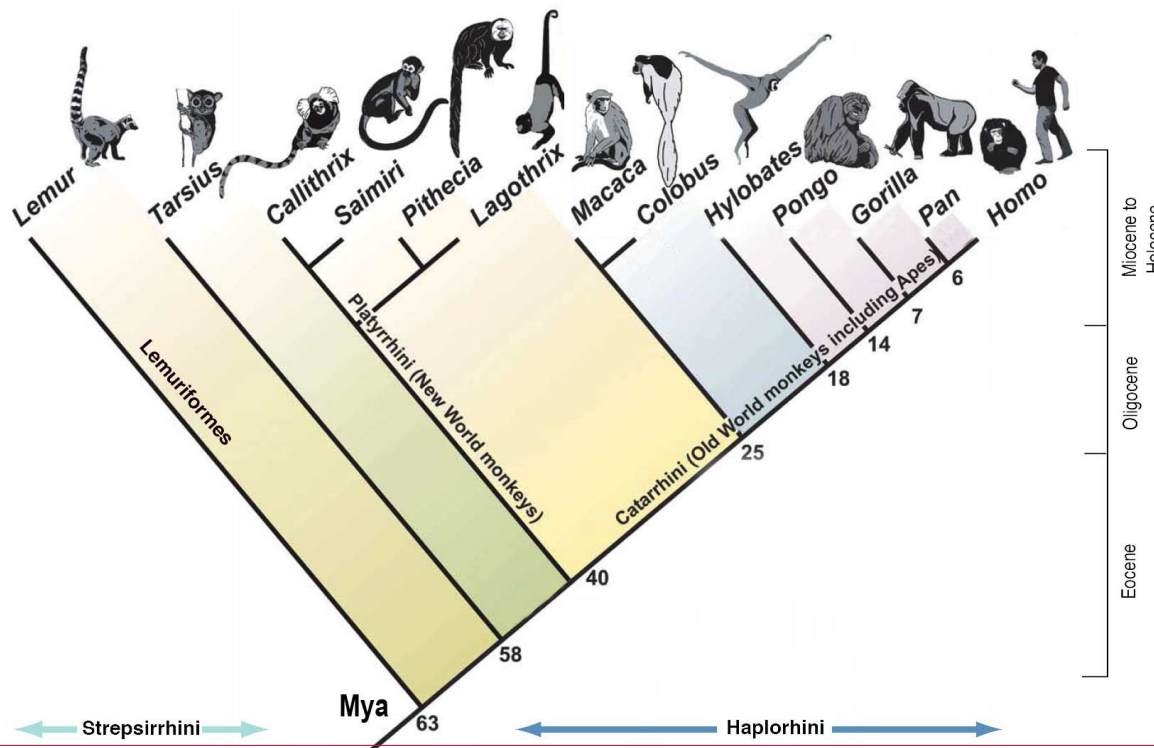
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# Gestural Communication

Our closest relatives (i.e. gorillas and chimpanzees) have demonstrated considerable **gestural** learning capacities **in captivity** (aculturated apes).

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Koko, a female gorilla, learned approximately 1000 words in American Sign Language (ASL).

Bonvillian and Patterson (1997).



Kanzi, a male Chimpanzee, learned approximately 500 symbols, and was able to combine these to sentences using a keyboard.

Savage-Rumbaugh et al. (1989).

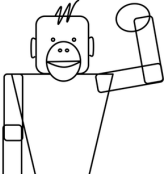
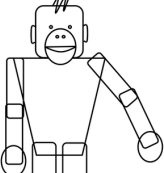
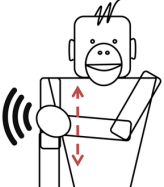
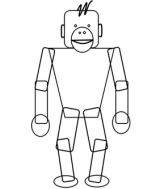




# Gestural Communication (Current Research)

While gestural communication has been studied extensively in the second half of the 20th century for primates **in captivity**. Only in the last decades have projects emerged which study natural gestures of primates **in the wild**.

See videos at:  
<https://greatapedictionary.ac.uk/gesture-videos2/>

Gesture Type	Bonobo ASOs	Chimpanzee ASOs
<b>Arm raise</b> 	<u>Climb on you</u> 34% Initiate grooming 22% Initiate copulation 20% Initiate GG-rubbing 16% Contact 6% Climb on me 2%  <i>Ambiguous</i> [9(50): $f=3.13$ , $df=12,96$ $p=0.0009$ ]	<u>Acquire object</u> 48% Move away 19% Move closer 15% Stop behaviour 11% <u>Climb on you</u> 7%  <i>Ambiguous</i> [ $\chi^2=65.71$ , $df=14$ $p<0.0001$ ]
<b>Arm up</b> 	Contact 80% Climb on me 20%  <i>Tight</i> [3(15): $f=85.14$ , $df=12,24$ $p<0.0001$ ]	-
<b>Big loud scratch</b> 	<u>Initiate grooming</u> 100%   <i>Tight</i> [10(41): $f=893.1$ , $df=12,108$ $p<0.0001$ ]	<u>Initiate grooming</u> 82% <sup>1</sup> Travel with me 16% <sup>1</sup> Follow me 2% Climb on me 1%  <i>Tight</i> [ $f=45.33$ , $df=14$ , 238 $p<0.001$ ]
<b>Bipedal stance</b> 	Initiate copulation 50%, Initiate GG-rubbing 50%  <i>Loose</i> [4(12): $f=4.46$ , $df=12,36$ $p=0.0002$ ]	-

Graham et al. (2018).

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## Social Bonding

Language could also have evolved for **social bonding** purposes, such as

- ▶ Grooming
- ▶ Gossiping
- ▶ Mating

For example, wild gibbon songs “which function to repel conspecific intruders, advertise pair bonds, and attract mates.”

Clarke (2006), p. e73.  
Dunbar (2003).



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# Thinking

“[...] language is not properly regarded as a system of communication. It is a **system of expressing thought**, something quite different. It can of course be used for communication, as can anything people do – manner of walking or style of clothes or hair, for example. But in any useful sense of the term, communication is not the function of language, and may even be of no unique significance for understanding the functions and nature of language. (Chomsky, 2000b, p. 75)”

Chomsky cited in Pinker & Jackendoff (2005), p. 223.

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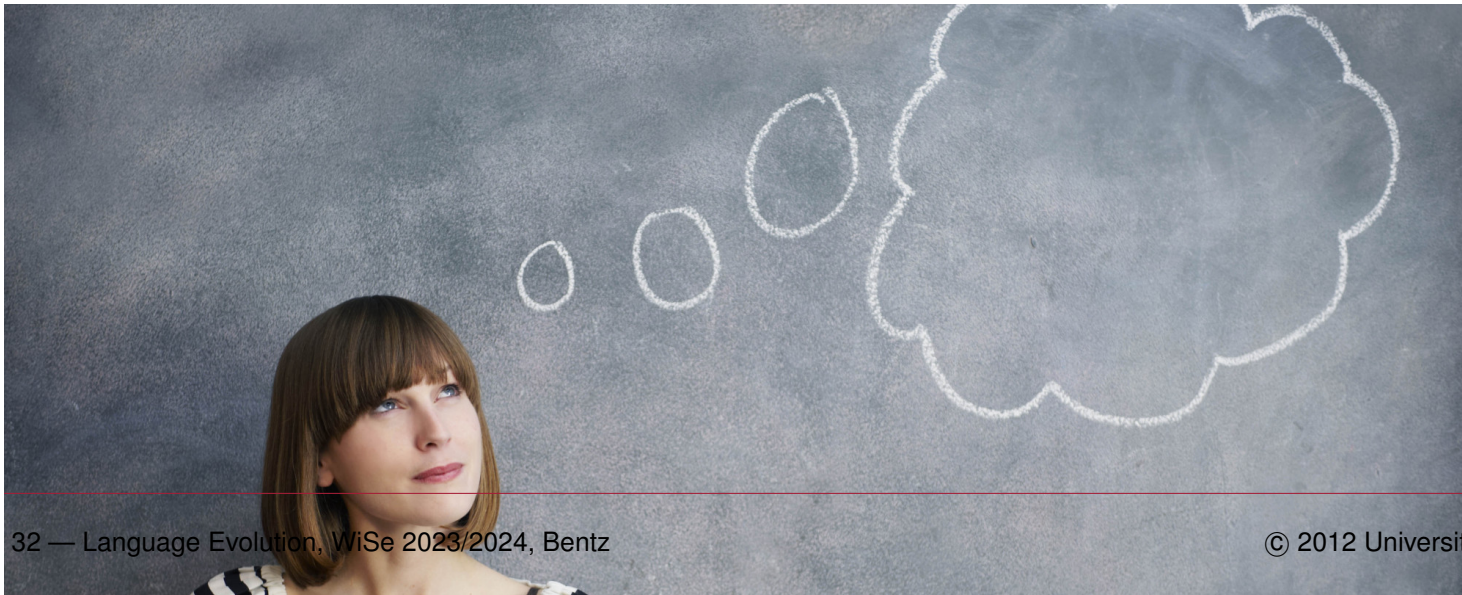
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## No Function (?)

“Language design as such appears to be in many respects **“dysfunctional”**, yielding properties that are not well adapted to the function language is called upon to perform.”

Chomsky (1995), p. 162 cited in Pinker and Jackendoff (2005), p. 223.



Definite Articles				Definite Article-Like Words				Unpreceded Adjectives				Relative Pronouns							
	M	N	F	P		M	N	F	P		M	N	F	P		M	N	F	P
N	er	as	ie	ie	N	er	es	e	e	N	er	es	e	e	N	er	as	ie	ie
A	en	as	ie	ie	A	en	es	e	e	A	en	es	e	e	A	en	as	ie	ie
D	em	em	er	en	D	em	em	er	en	D	em	em	er	en	D	em	em	er	enen
G	es	es	er	er	G	es	es	er	er	G	en	en	er	er	G	essen	essen	eren	eren

Indefinite Articles & Possessive Pronouns				Adjectives After Indefinite Articles				Adjectives after Definite Articles				3 <sup>rd</sup> Personal Pronouns (w/ Poss in place of Gen)							
	M	N	F	P		M	N	F	P		M	N	F	P		M	N	F	P
N	ø	ø	e	e	N	er	es	e	en	N	e	e	e	en	N	er	es	ie	ie
A	en	ø	e	e	A	en	es	e	en	A	en	e	e	en	A	n	es	ie	ie
D	em	em	er	en	D	en	en	en	en	D	en	en	en	en	D	m	m	r	nen
G	es	es	er	er	G	en	en	en	en	G	en	en	en	en	G	(P)	-	-	r-

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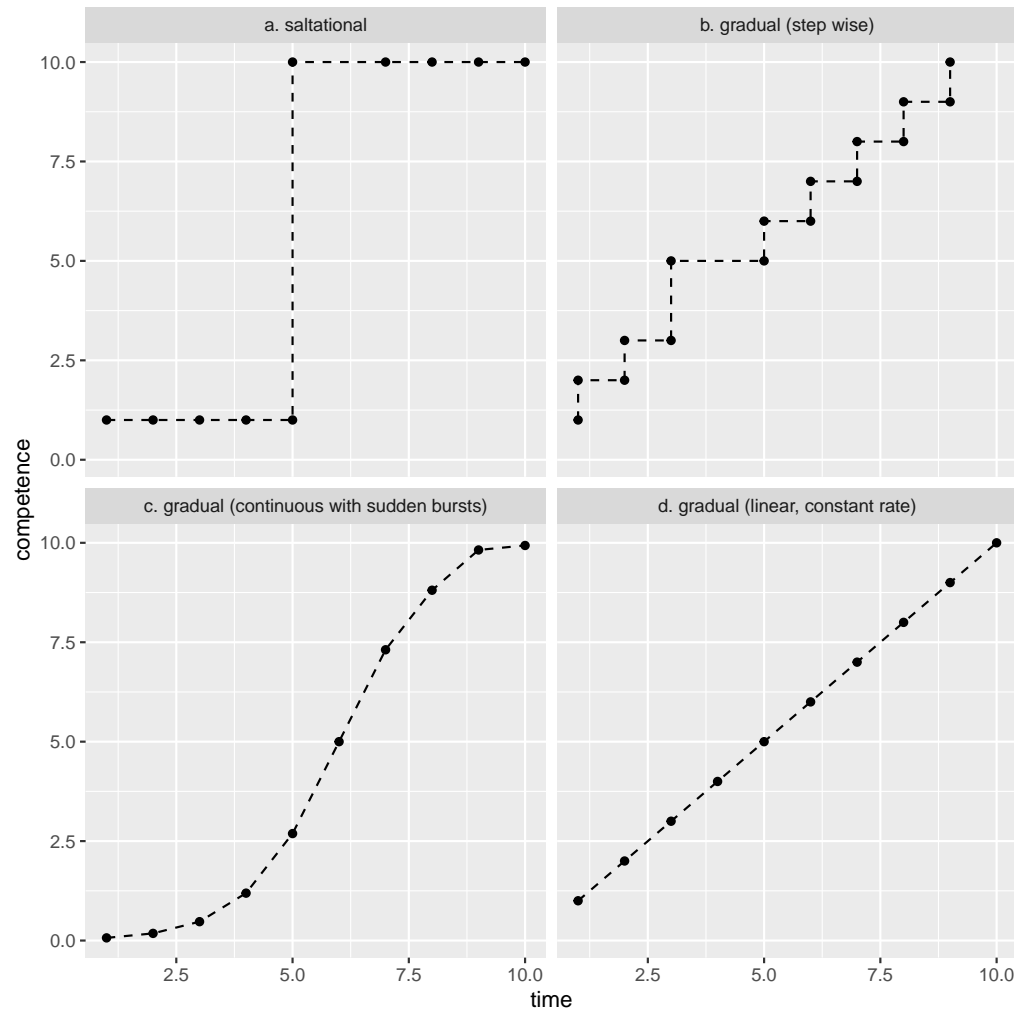
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## Section 3: Evolutionary Scenarios



# Evolutionary Scenarios



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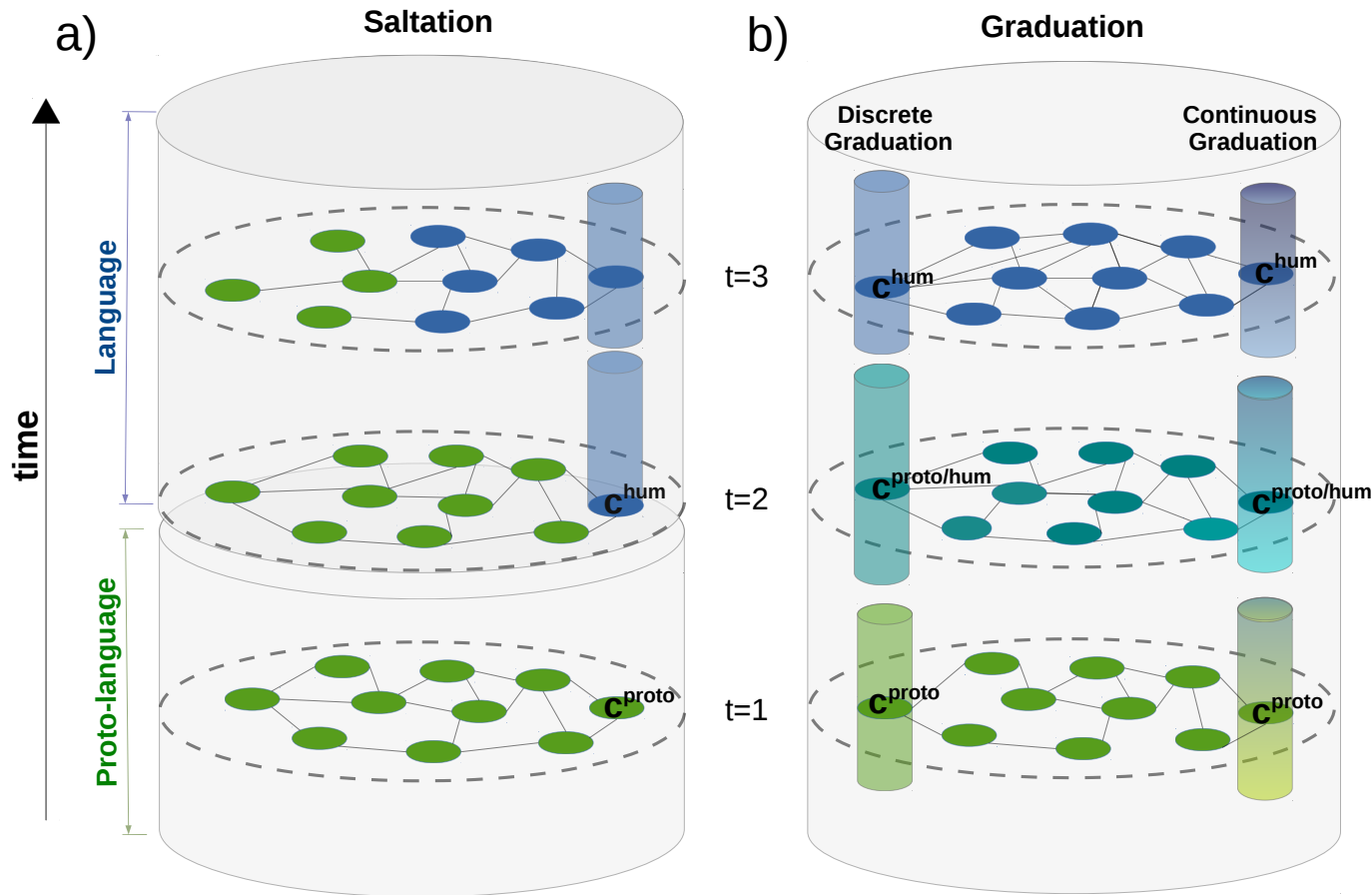
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# Evolutionary Scenarios (Population Level)



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## Section 4: Language Evolution Theories



# The Saltational Theory



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SCIENCE'S COMPASS



• REVIEW

REVIEW: NEUROSCIENCE

## The Faculty of Language: What Is It, Who Has It, and How Did It Evolve?

Marc D. Hauser,<sup>1\*</sup> Noam Chomsky,<sup>2</sup> W. Tecumseh Fitch<sup>1</sup>

OPEN ACCESS Freely available online

PLOS BIOLOGY

Essay

### How Could Language Have Evolved?

Johan J. Bolhuis<sup>1,2\*</sup>, Ian Tattersall<sup>3</sup>, Noam Chomsky<sup>4</sup>, Robert C. Berwick<sup>5</sup>

<sup>1</sup> Cognitive Neurobiology and Helmholtz Institute, Departments of Psychology and Biology, Utrecht University, Utrecht, The Netherlands, <sup>2</sup> Department of Zoology and Sidney Sussex College, University of Cambridge, Cambridge, United Kingdom, <sup>3</sup> Division of Anthropology, American Museum of Natural History, New York, New York, United States of America, <sup>4</sup> Department of Linguistics and Philosophy, MIT, Cambridge, Massachusetts, United States of America, <sup>5</sup> Department of Electrical Engineering & Computer Science and Brain and Cognitive Sciences, MIT, Cambridge, Massachusetts, United States of America

Review

Cell  
PRESS

Feature Review

## Evolution, brain, and the nature of language

Robert C. Berwick<sup>1</sup>, Angela D. Friederici<sup>2</sup>, Noam Chomsky<sup>3</sup>, and Johan J. Bolhuis<sup>4</sup>

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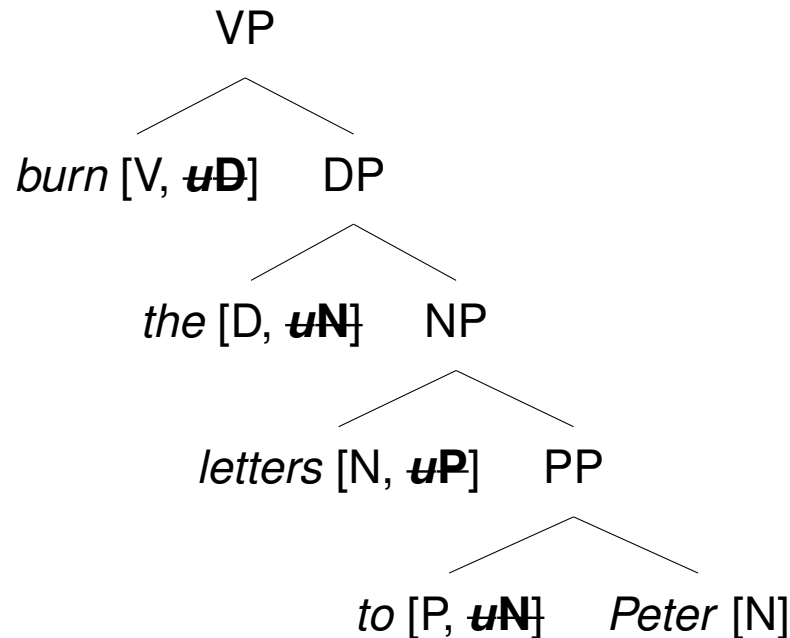
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# Saltational Theory

## What is language?

– A human specific cognitive/computational ability to process “infinite discreteness”, e.g. *recursion* (FLN) or *Merge* (Minimalism).



“[...] The simplest such operation takes a pair of *syntactic objects* ( $SO_i$ ,  $SO_j$ ) and replaces them by a new combined syntactic object ( $SO_{ij}$ ).”

Chomsky (1995), p. 207-208.

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## Saltational Theory

### Why did it evolve?

– Potentially independent of communication, e.g. for *number cognition, mental planning, thought*.

“The quality of language that makes it unique does not seem to be so much its role in communicating directives for action” or other common features of animal communication, Jacob continued, but rather “its role in symbolizing, in evoking cognitive images,” in “molding” our notion of reality and yielding our capacity for thought and planning, [...]”

Chomsky (2005), citing Jacob (1982).

“A complex train of thought can be no more carried out without the use of words, whether spoken or silent, than a long calculation without the use of figures or algebra.”

Bolhuis et al. (2014), citing Charles Darwin.

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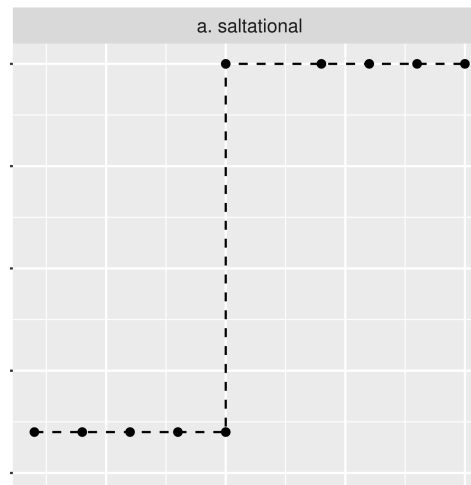
## Saltational Theory

### How did it evolve?

- Most likely via a *sudden mutation (saltation)*, not necessarily with any adaptive advantage.

“The simplest account of the “Great Leap Forward” in the evolution of humans would be that the brain was rewired, perhaps by some slight mutation, to provide the operation Merge, at once laying a core part of the basis for what is found at that dramatic “moment” of human evolution [...]”

Chomsky (2005).



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# The Gradual Theory



# Some References

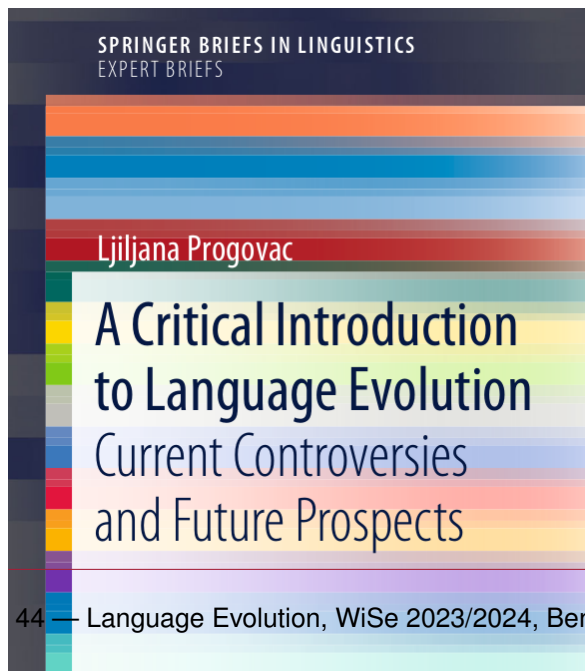
BEHAVIORAL AND BRAIN SCIENCES (1990) 13, 707–784  
*Printed in the United States of America*

## Natural language and natural selection

**Steven Pinker<sup>a</sup> and Paul Bloom<sup>b</sup>**

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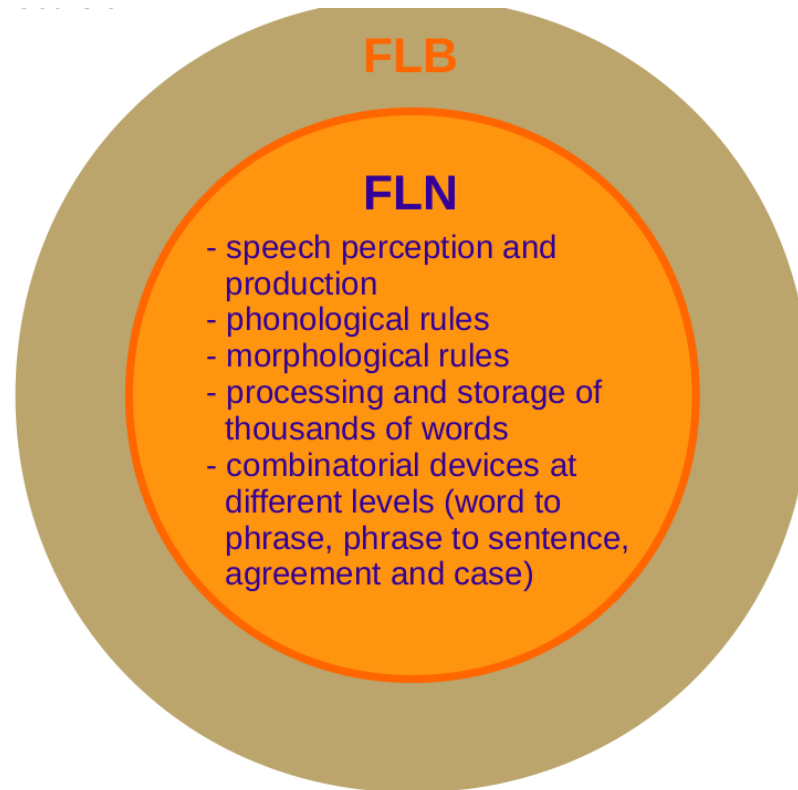
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## Gradual Theory

### What is language?

– A toolbox of different *cognitive abilities specific to humans and language* (e.g. Pinker and Bloom, 1990).  
Within a minimalist framework: the different *layers of minimalist syntax* (e.g. Progovac, 2015).



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Pinker and Jackendoff (2005).



## Gradual Theory

### Why did it evolve?

– As an *adaptation for more explicit communication of complex propositions.*

“Moreover the design of language – a mapping between meaning and sound – is precisely what one would expect in a system that evolved for the communication of propositions. We cannot convey recipes, hunting techniques, gossip, or reciprocal promises by “manner of walking or style of clothes or hair,” because these forms of behavior lack grammatical devices that allow propositions to be encoded in a recoverable way in details of the behavior.”

Pinker and Jackendoff (2005), p. 224.



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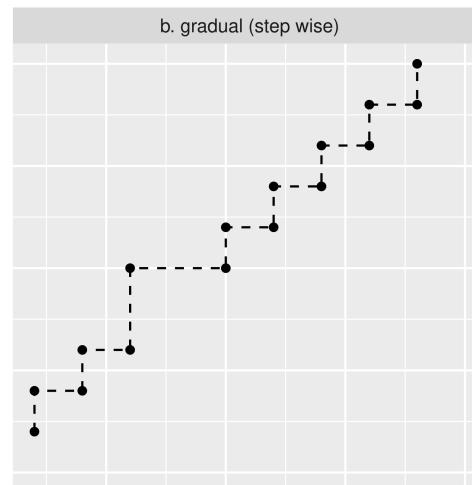
## Gradual Theory

### How did it evolve?

– *Gradually* via several mutations and selection (here called *discrete graduation*). The term “piecemeal” is also used sometimes. Strictly speaking this is still different from continuous evolution, as it involves **discrete mutations** which lead to phenotypes under selection.

“[...] the language faculty evolved gradually in response to the adaptive value of **more precise and efficient communication** [...]. Gradual emergence implies that later stages had to build on earlier ones in the contingent fashion characteristic of natural selection [...]”

Pinker and Jackendoff (2005), p. 223.



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# The Co-Evolution Theory





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BEHAVIORAL AND BRAIN SCIENCES (2008) 31, 489–558  
*Printed in the United States of America*  
doi:10.1017/S0140525X08004998

## Language as shaped by the brain

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## Language Is a Complex Adaptive System: Position Paper

### The “Five Graces Group”

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#### Richard Blythe

University of Edinburgh

#### Joan Bybee

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#### Morten H. Christiansen

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#### Nick C. Ellis

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#### John Holland

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# Co-Evolution Theory

## What is language?

– The *empirical* sounds, graphemes and signs produced and used by a speaker, hearer, or signer populations in communicative interactions.

“We propose [...] to invert the perspective on language evolution, shifting the focus from the evolution of *language users* to the evolution of *languages*.

[...] linguistic adaptation allows for the evolution of increasingly expressive languages that can nonetheless still be learned and processed by *domain-general* mechanisms.”

Christiansen and Chater (2008), p. 497.

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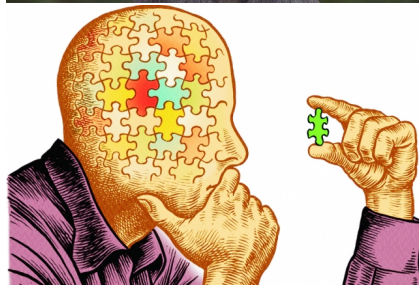
# Co-Evolution Theory

## Why did it evolve?

– As a *communicative and social tool* (similar to the gradual account).

“Language is used for human *social interaction*, and so its origins and capacities are dependent on its role in our social life [...] To understand how language has evolved in the human lineage [...] we need to look at the combined effect of many interacting constraints, including the structure of thought processes, perceptual and motor biases, cognitive limitations, and socio-pragmatic factors.”

Beckner et al. (2009), p. 3.



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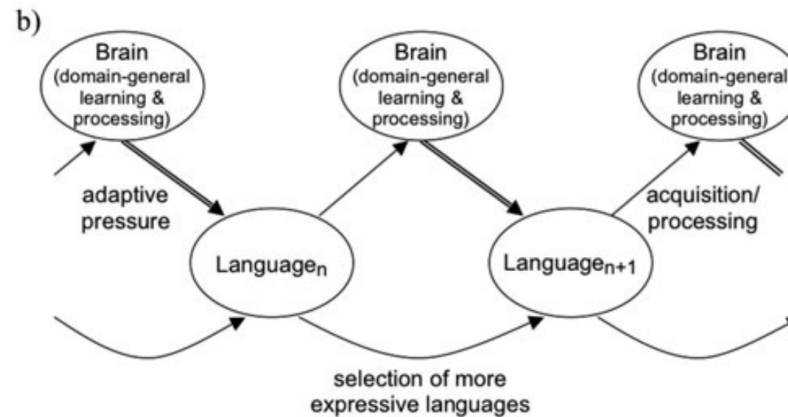
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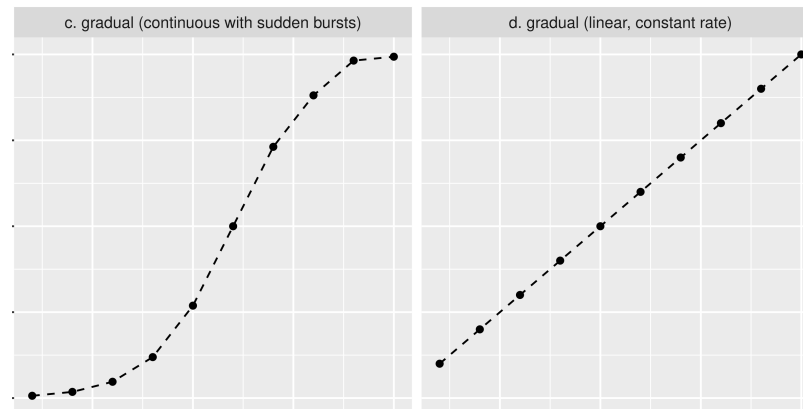
# Co-Evolution Theory

## How did it evolve?

– In a continuous *co-evolution* of the human brain and the empirical usage data.



Christiansen and Chater (2008).



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# Summary



# Summary

Is language more like growing a wing, or like learning to play chess?



Saltational Account



Gradual Account



Co-evolution Account



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# Thank You.

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