Piera Filippi - CTF '12

A Comparative Approach on the Faculty of Syntax: Towards an Operative Definition of Language

Are nonhuman animals rational?

How did language evolve?

Are humans the only “linguistic” species?

What is language?

Methodology of inquiry

A. Focus on a core constitutive trait of the ability of language:

“Syntax”

meaning from the greek ***“syntaxein”***:

connect different elements according to structural rules.

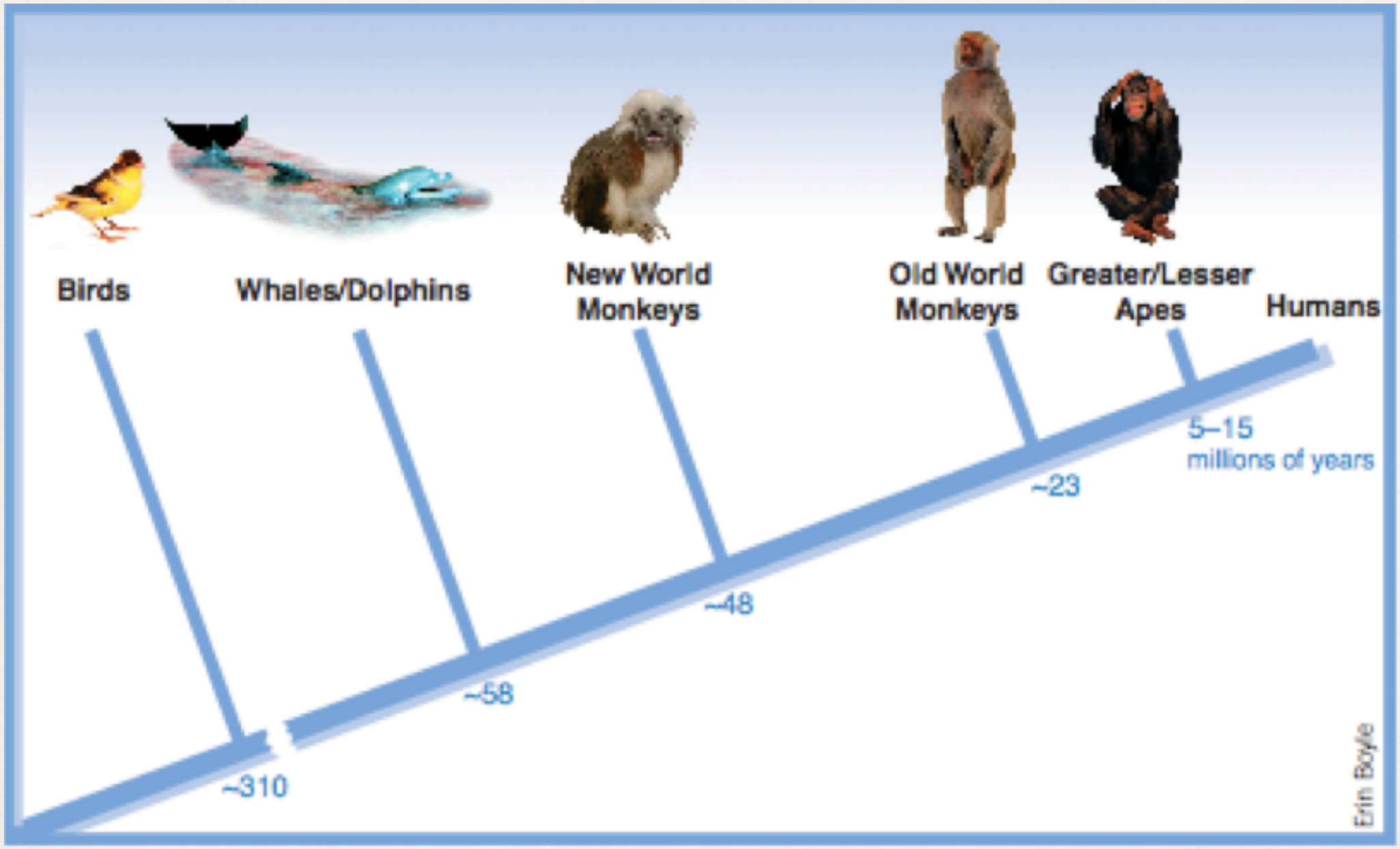
The faculty of language (broad sense)

B. Apply a comparative approach on the **phylogenetic evolution of** ~~language~~ **syntax**

→ core cognitive operations **shared among animal species**

→ **species-specific traits** of human language

The evolution of the ability to recognize syntactic structures



The faculty of language

Comparative approach
on the **phylogenetic evolution**
of ~~language~~ syntax

core cognitive operations
shared among animal species

species-specific traits of
human language

- brief review of the current state of art of the literature
- critics
- alternative hypothesis / research question

REVIEW: NEUROSCIENCE

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

Marc D. Hauser,[1]* Noam Chomsky,[2] W. Tecumseh Fitch[1]

We hypothesize that FLN [faculty of language narrow sense] only includes **recursion** and is the only uniquely human component of the faculty of language.

Recursion

strings are embedded within other strings of the same kind, creating complex **hierarchical structures** and **long-distance dependencies**.

Do animals have the ability to process recursive structures?

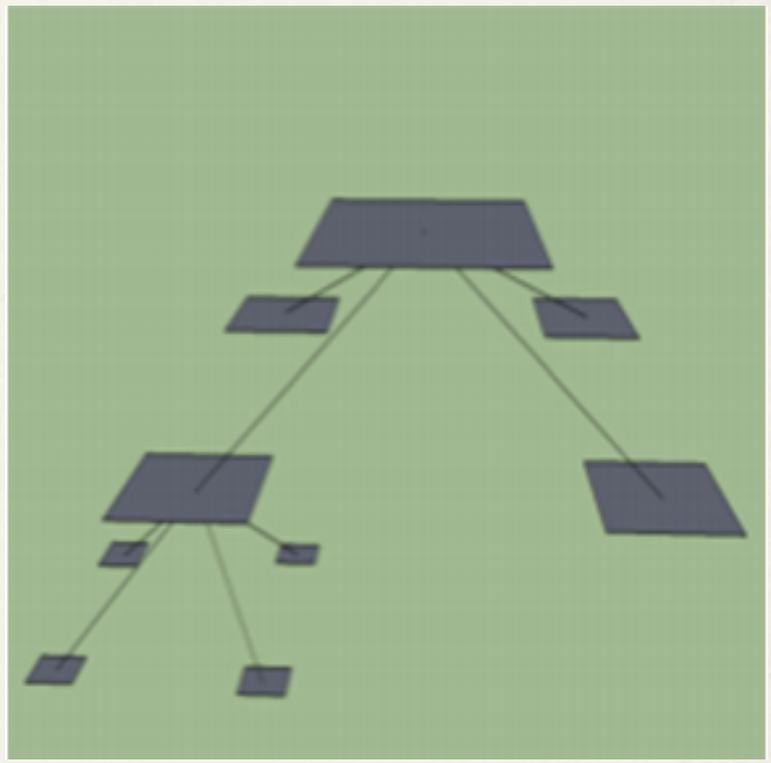
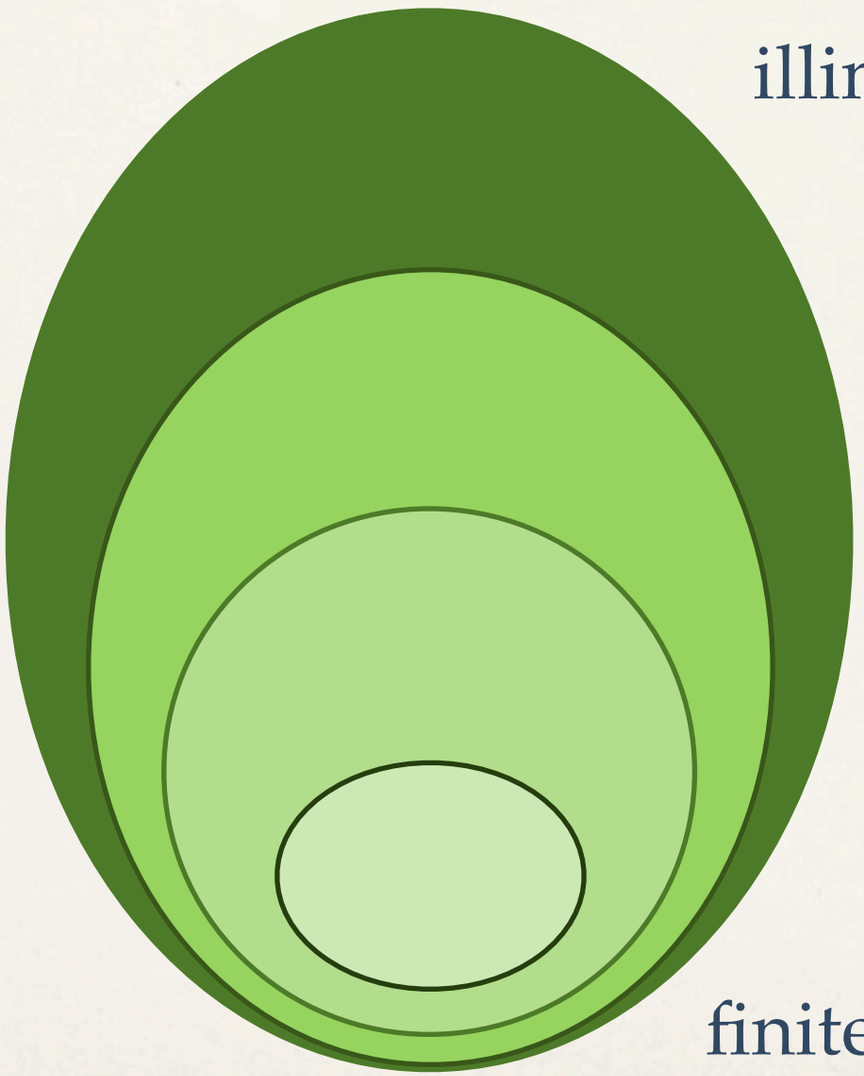


Image modified from Martins Dias, M. 2012

Theory of formal language: a comparative approach

Chomsky hierarchy



illimited

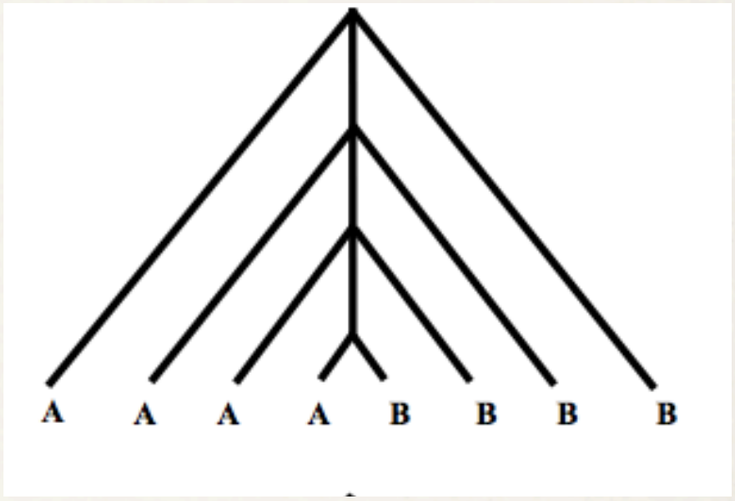
context-dependent grammar

context free grammar

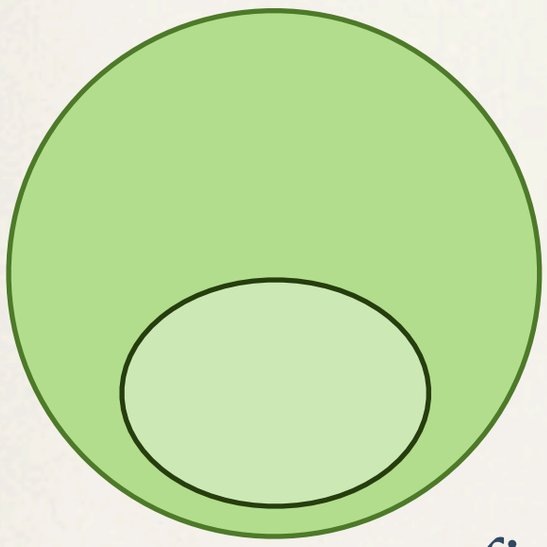
finite state grammar

Perception of phono-syntactical patterns: the chomskyan paradigm

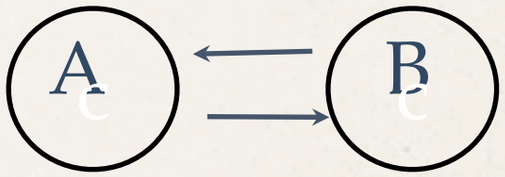
A^nB^n
(and/or recursive structures)



context free grammar



finite state grammar $(AB)^n$



n times

Finite State grammars

AB^n

This is the rat that ate the malt that lay in the house that Jack built

a1 b1 a2 b2 ... ...

as many As as Bs

n times

Context free grammars

A^nB^n

"the cheese that the mouse that the cat

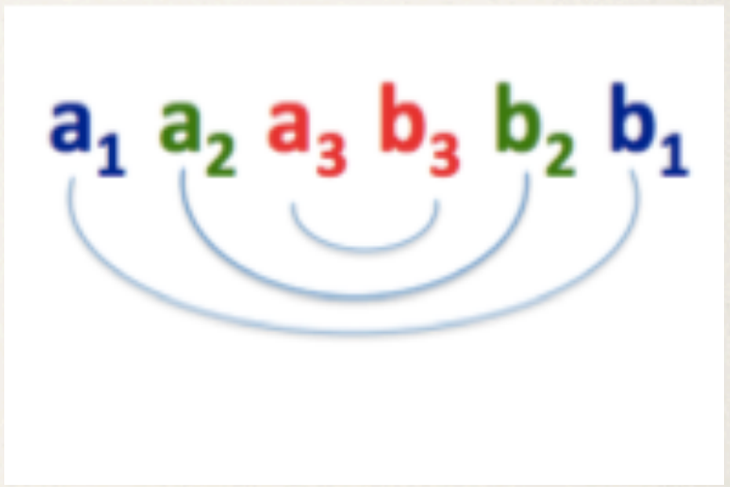
chased ate is in John's house "

A^nB^n

a1 the cheese ⟶ b1 is in John's house

a2 that the mouse ⟶ b2 ate

a3 that the cat ⟶ b3 chased



Do animals have the ability to process context free grammars?

How can we test it?

Using shapes, colors and sounds

Finite State grammars

Context free grammars

AB^n

A^nB^n

a1 b1 a2 b2 ... ...

a1 ⟶ b1

a2 ⟶ b2

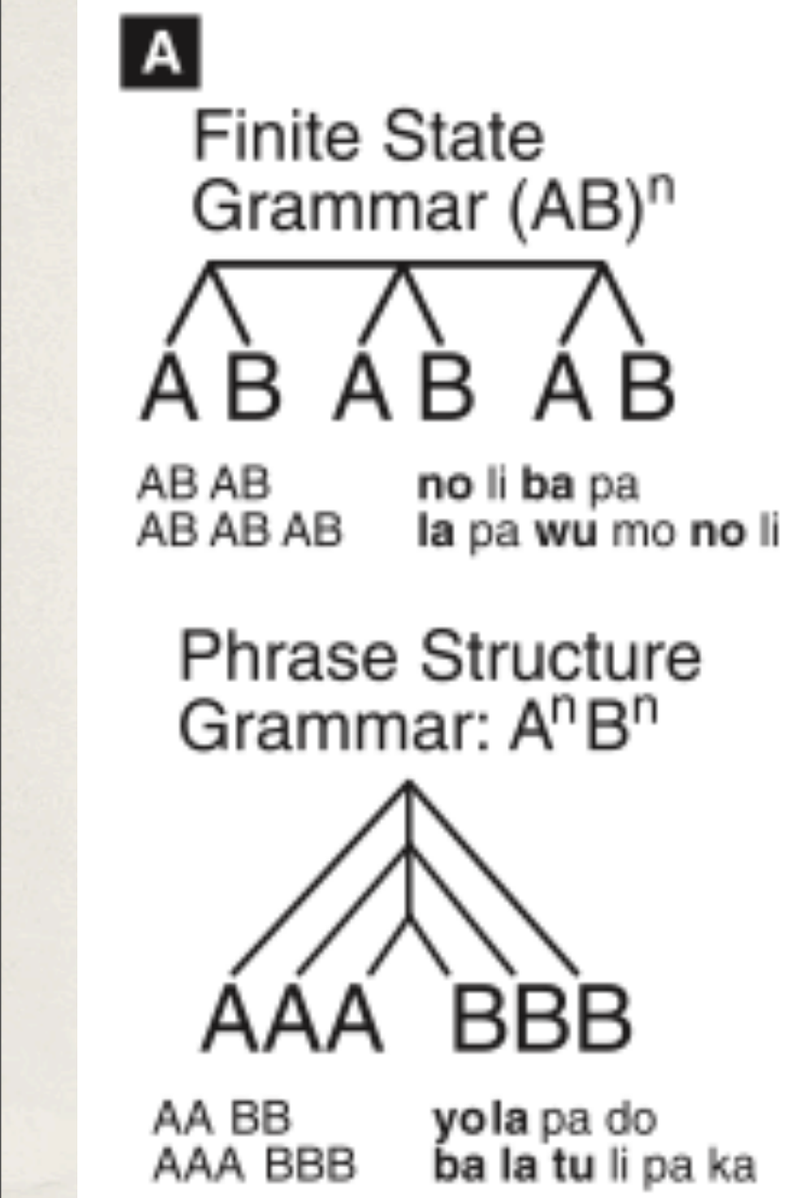
a3 ⟶ b3

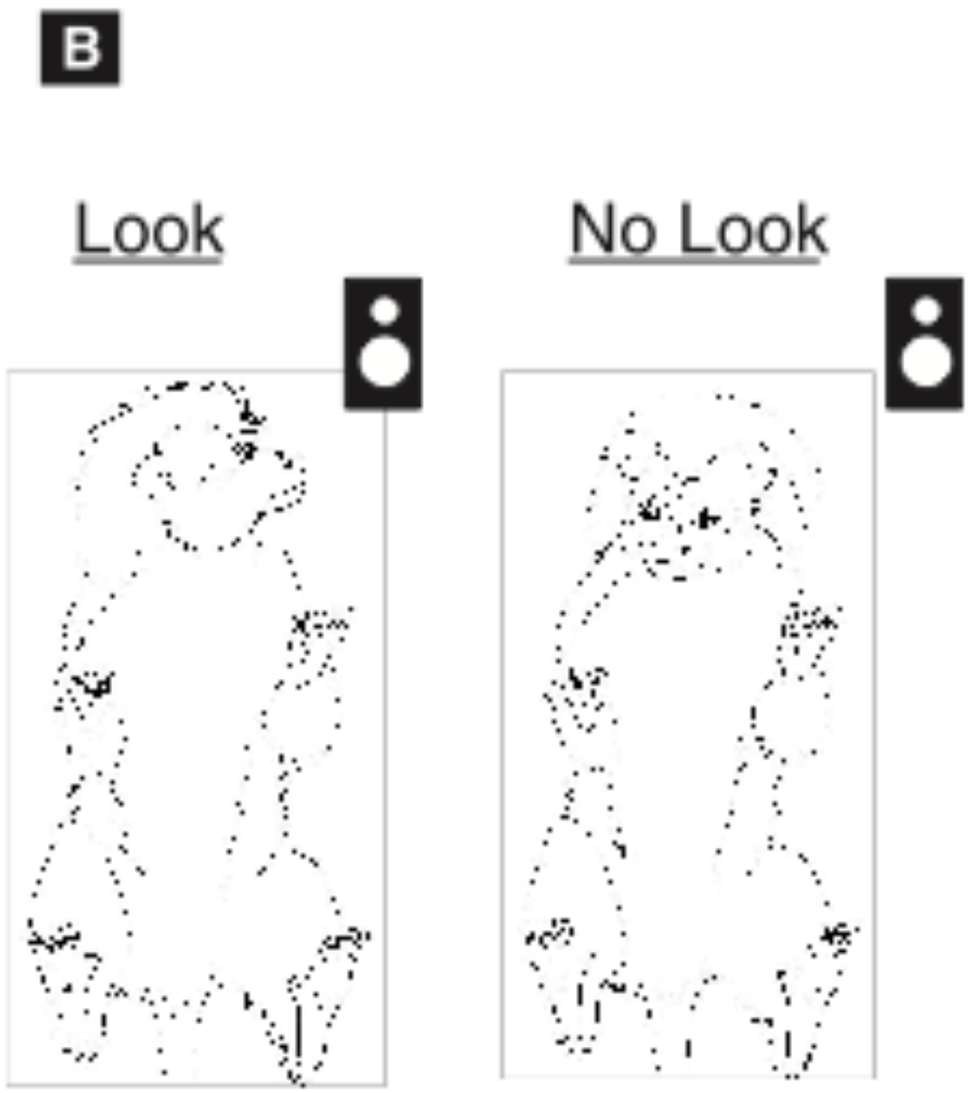
Examples in the acoustic domain

ba nu di do mi ka

la no yo mo bi gu

Fitch, Hauser, 2004





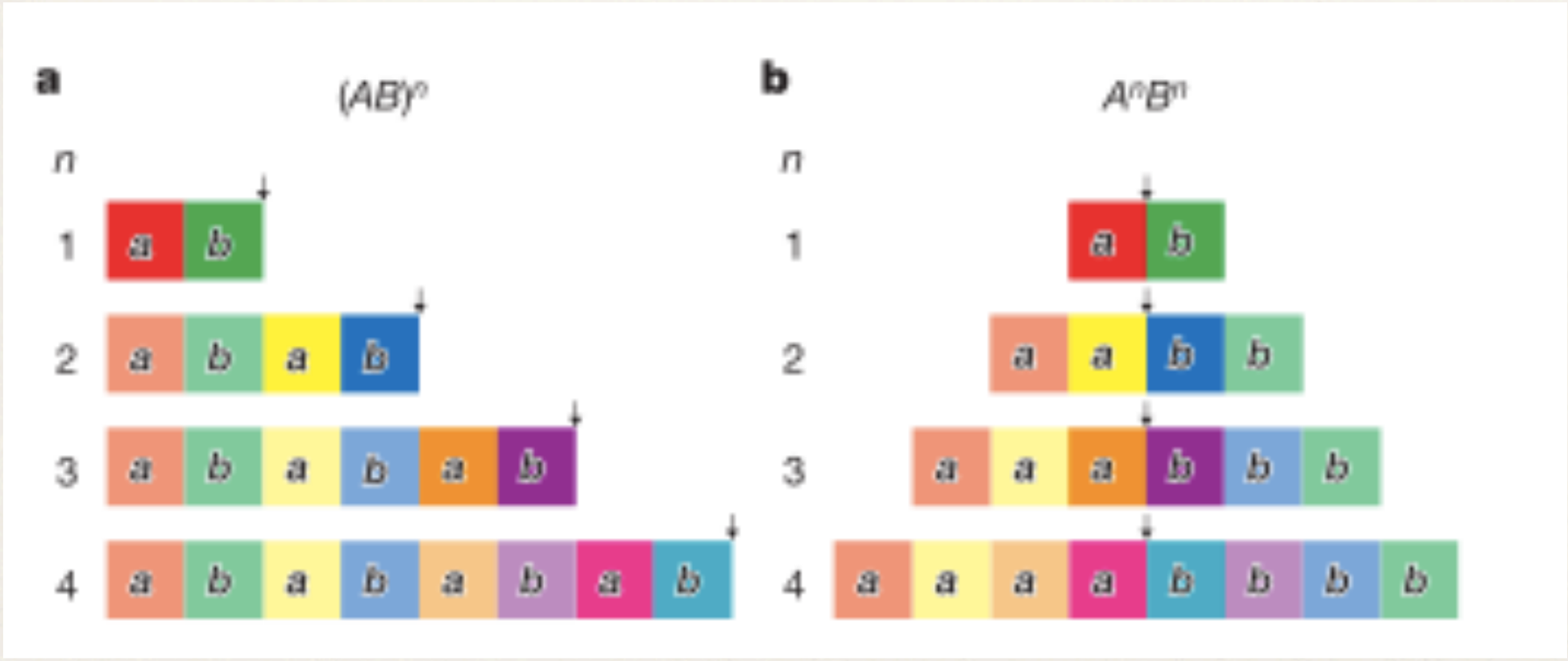
grammars were matched for acoustic features: A and B stimulus classes were spoken by different speakers, a female and a male

nature Vol 440|27 April 2006|doi:10.1038/nature04675

LETTERS

Recursive syntactic pattern learning by songbirds

Timothy Q. Gentner[1]†, Kimberly M. Fenn[2], Daniel Margoliash[1,2] & Howard C. Nusbaum[2]



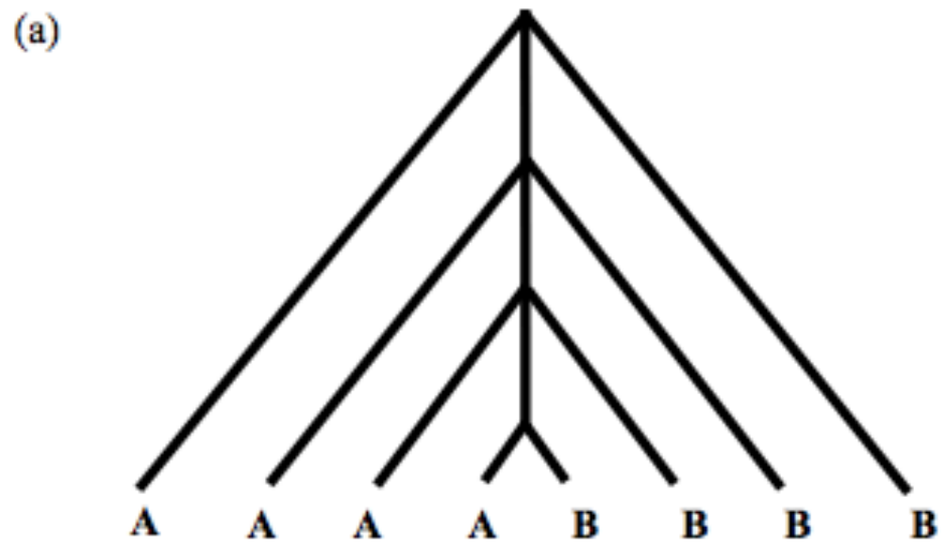


Fig. 1. Tree structure for (a) center-embedded recursion, and (b) double iteration.

- double iteration
- subitation
- no structural dependence

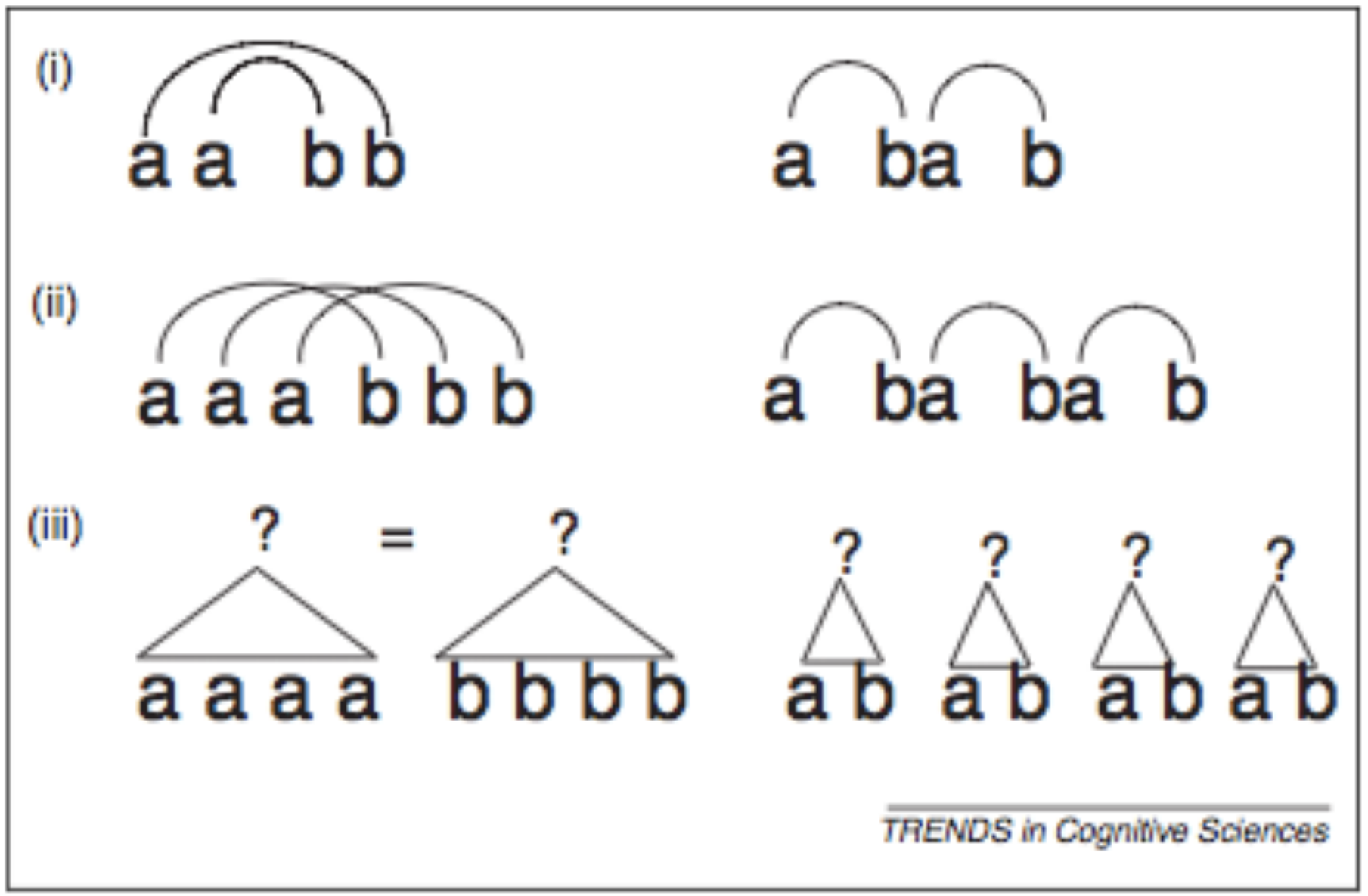


Figure 1. Strategies to check whether sentences are members of the formal languages **a"b"** and **(ab)"** (see text for details).

Image modified from O'Donnell *et al.*, 2005

nature neuroscience

Songbirds possess the spontaneous ability to discriminate syntactic rules

Kentaro Abe[1,2] & Dai Watanabe[1,3]

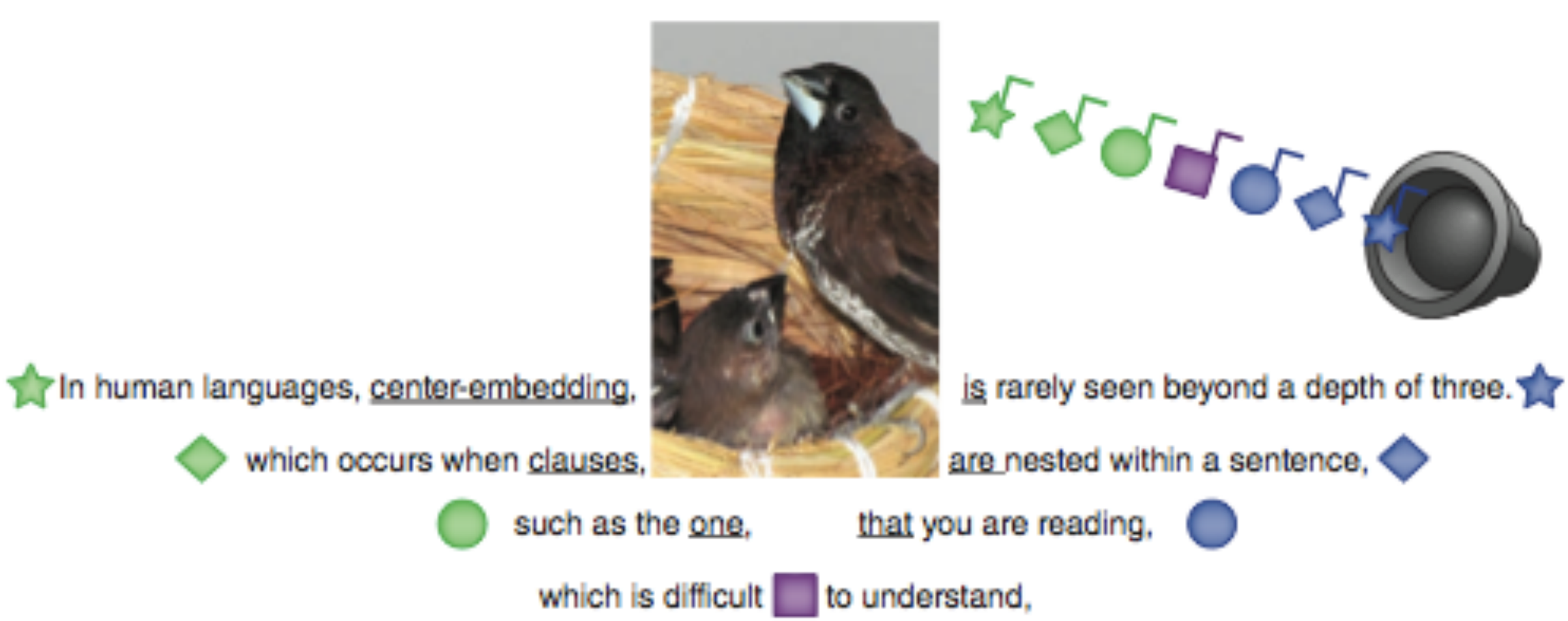


Image modified by Bloomfield, T. *et al.*, 2011

a

Center-embedding language

$S \rightarrow AP + BP$

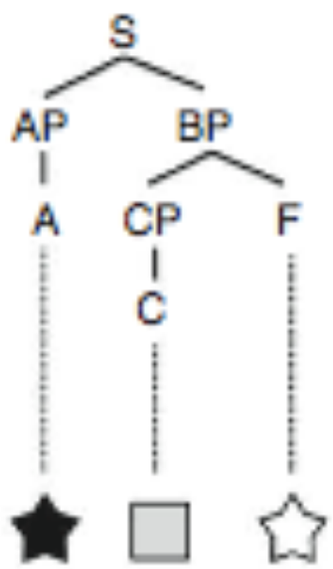
$AP \rightarrow A$

$BP \rightarrow CP + F$

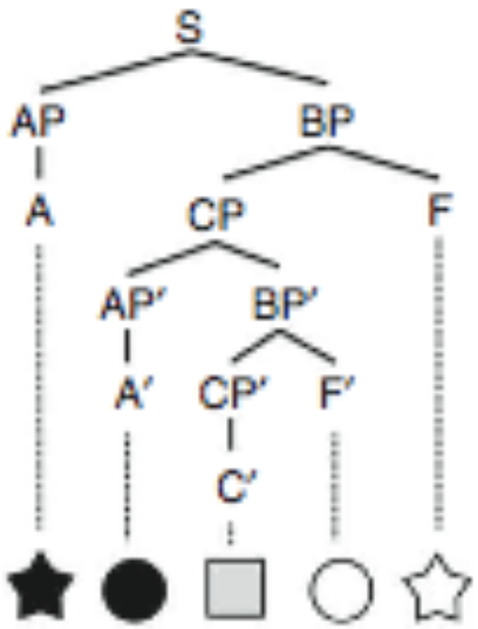
$CP \rightarrow C \text{ or } AP' + BP'$

Familiarization strings:

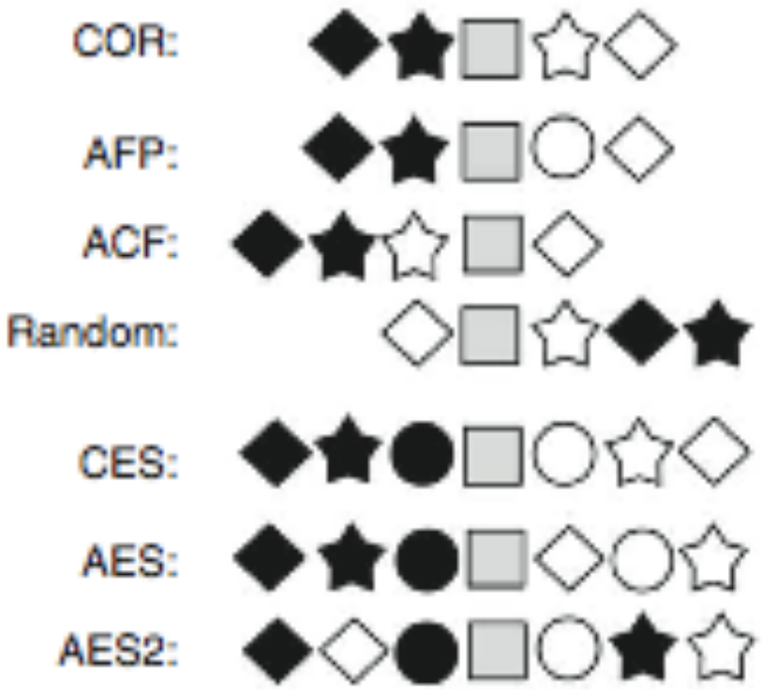
Non-embedded



Embedded



Test strings:



Abe, K., Watanabe, D., 2011

Contents lists available at SciVerse ScienceDirect

Cognition

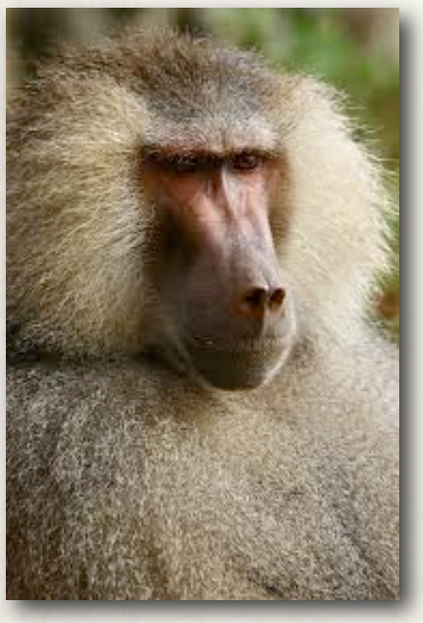
journal homepage: www.elsevier.com/locate/COGNIT

Brief article

Centre-embedded structures are a by-product of associative learning and working memory constraints: Evidence from baboons (*Papio Papio*)

Arnaud Rey [a,*], Pierre Perruchet [b], Joël Fagot [a]

[a] *Laboratoire de Psychologie Cognitive – CNRS, Aix-Marseille Université, Marseille, France*
[b] *Laboratoire d'Etude de l'Apprentissage et du Développement – CNRS, Université de Bourgogne, Dijon, France*



2.2. Material

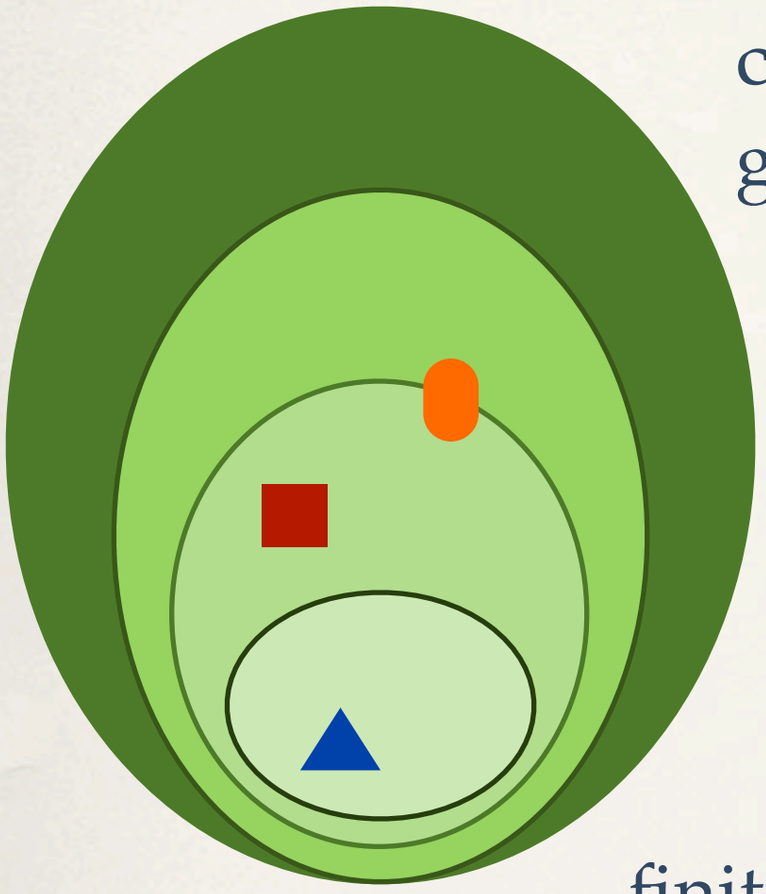
They were tested with learning devices equipped with a touch screen and a food dispenser. The main innovation of the test equipments is that the baboons participated at will, as they had a 24-h access to the computers from the outdoor enclosure, where they live in a social group (see Fagot & Bonté, 2010, for a detailed description of the testing apparatus). Twelve shapes (e.g. Δ, Φ, ϑ, Γ, Σ, Ω, ∗, ∋, ς, &, λ) were used to create six arbitrary pairs of stimuli, hereafter noted a_1b_1, a_2b_2, …, a_6b_6. A different set of 10 neutral shapes served as visual distractors ().

illimited grammars

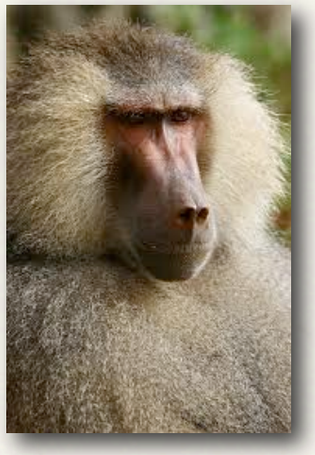
context-dependent grammars

context free grammar

finite state grammar

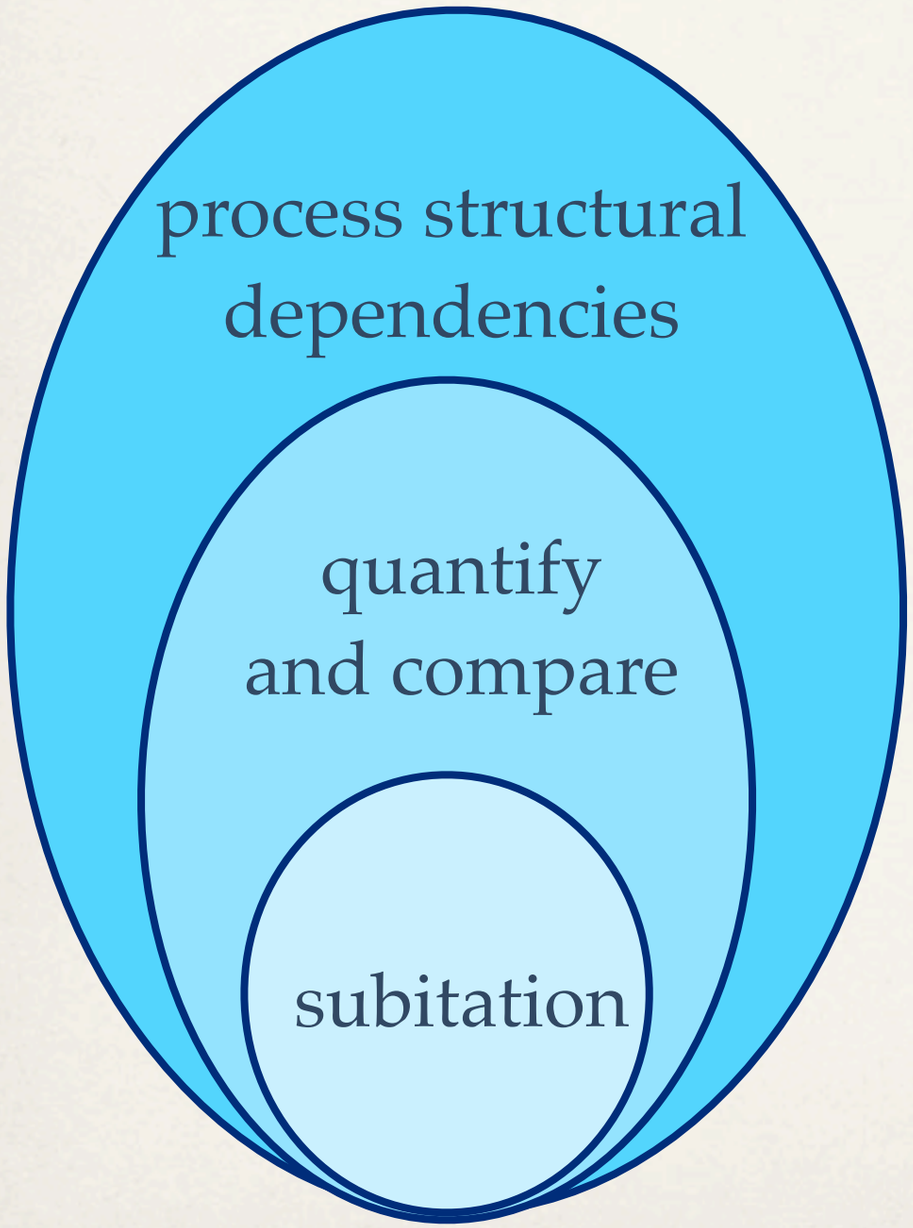


Gentner, T., *et al.* (2006), Abe, K., Watanabe, D. (2011), Rey, A. *et al.* (2012)

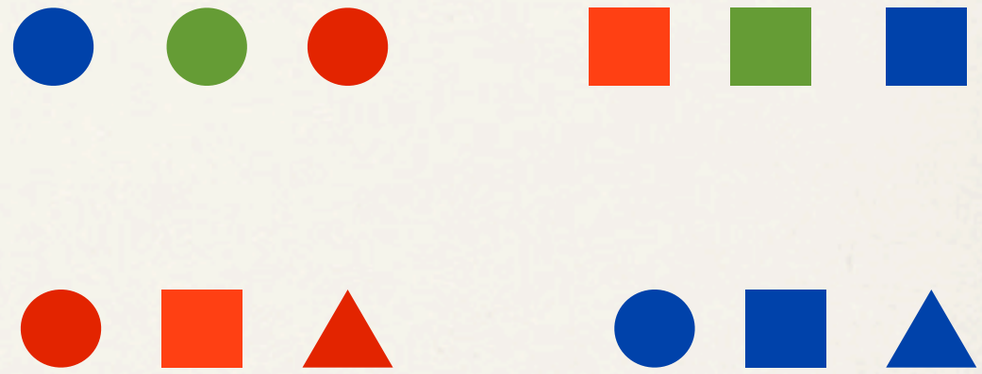


Fitch,W. T. & Hauser, M. (2004)

The faculty of language:
comparative studies on nonhuman species:

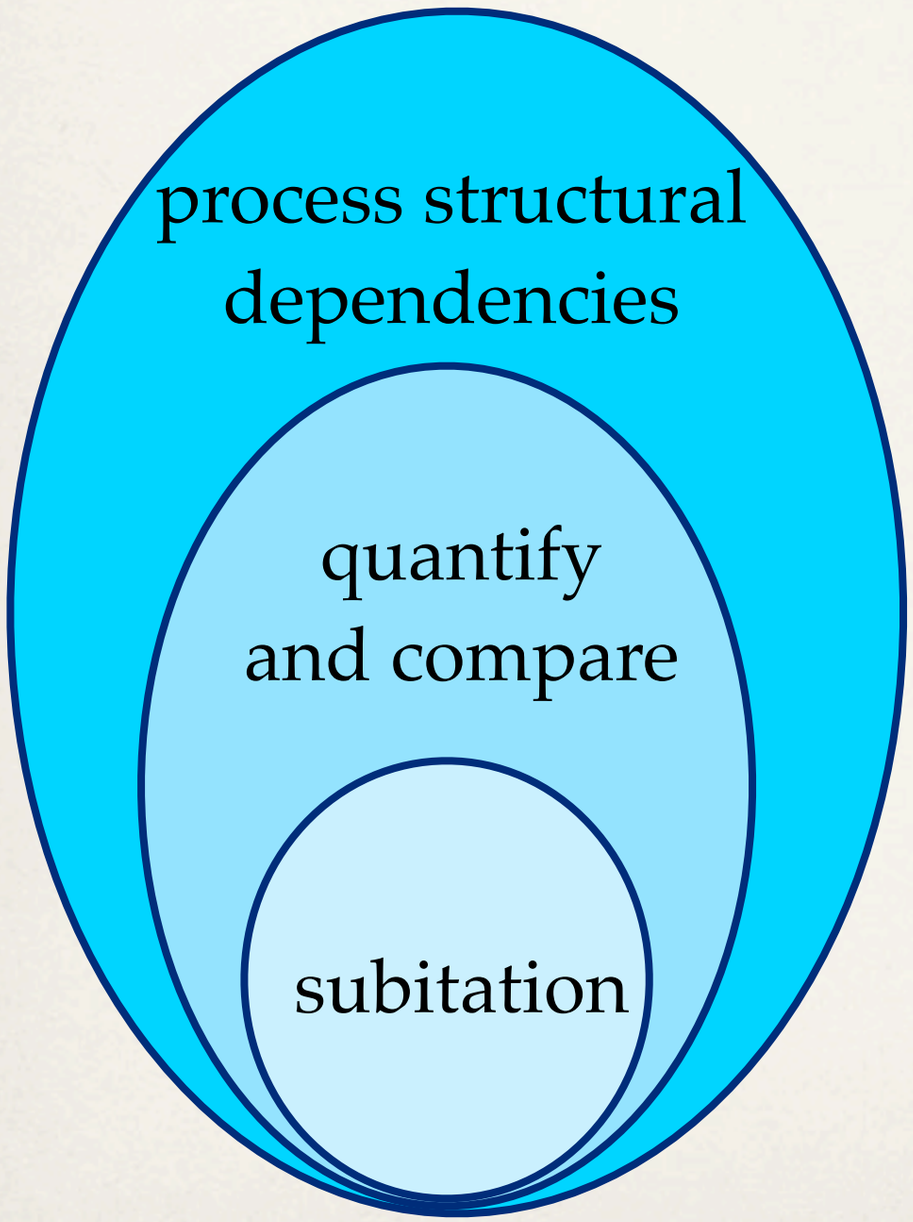


A^nB^n



AB^n

The faculty of language:
comparative studies on nonhuman species:



} Ability to process "perceptual syntax"

AB^n A^nB^n

Is the ability to process perceptual patterns
a pre-requisite for humans' faculty of language?

AB^n A^nB^n

Perceptual syntax

patterns in the perceptual domain

Propositional syntax

patterns ruled by logical, morphological connections

What's the difference?

- **recognizing** a language - **perceptual syntax**

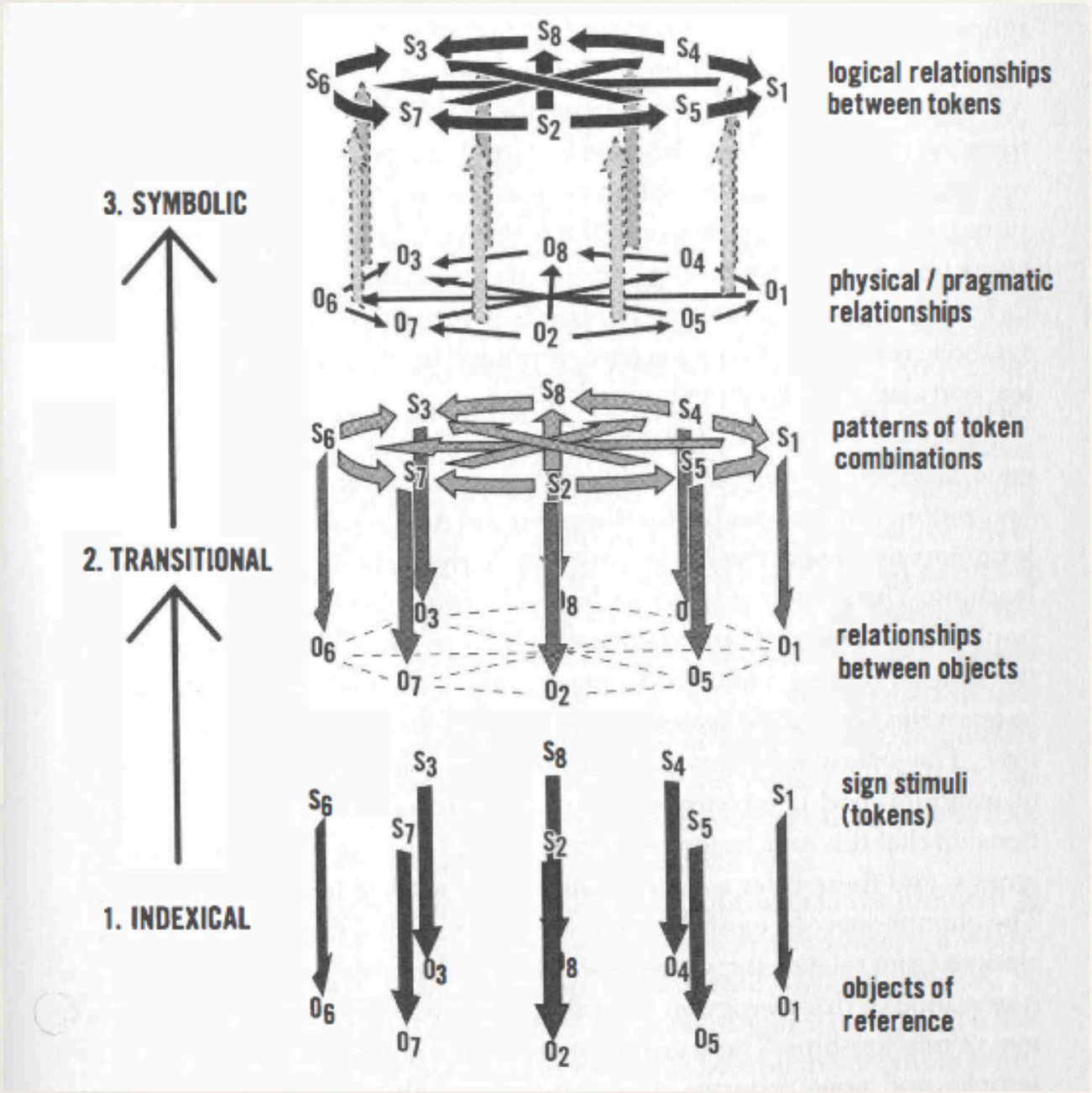
- **understanding** a **propositional syntax**

↓

1) elements that have internal logical dependencies

2) linked to external objects (existent or not): meanings

Uniquely human?



The **indexical power** is *distributed,* so to speak, in the relationships between words.

Symbolic reference derives from *combinatorial* possibilities and impossibilities [...].

Deacon T., *The Symbolic* Species, 1997

Hypothesis

Humans are the only species able to categorize the units of a pattern going beyond its perceptual characteristics:

- combine different elements within a network of combinatorial logical relationships

- link them to a referential state of affairs.

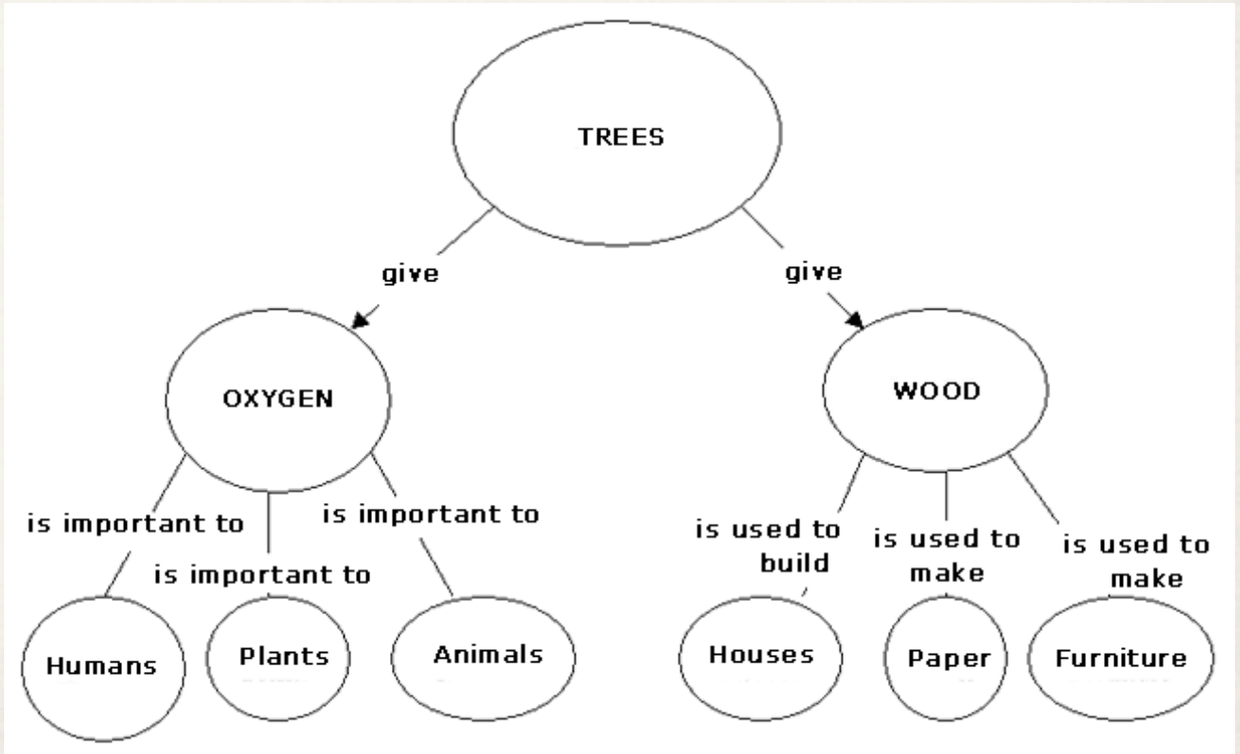
Humans can associate a combinatorial pattern to a structural combination among external objects or categories of objects.

compute mathematical expressions

$[(2+6) : 3] - 5 = \ldots$

draw conceptual maps

...



New suggested methodology for a comparative approach

Address the ability of nonhuman animals to

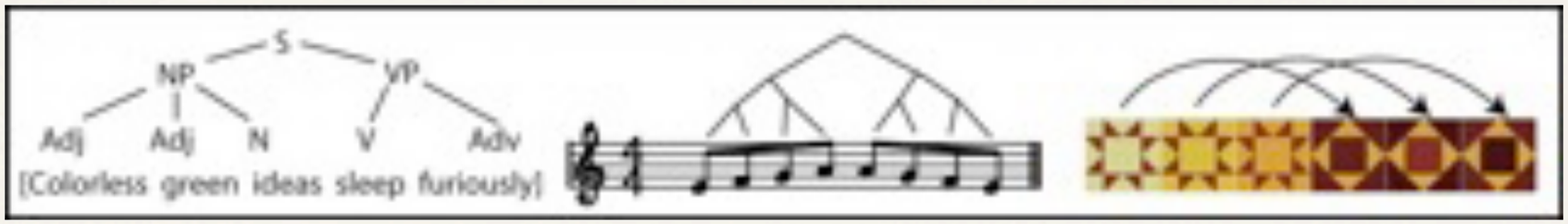
a) process simple perceptual patterns with internal dependencies between the elements

b) refer these basic structures to a pattern of external objects of reference

↓

what makes a species-typical human linguistic expression out of a pattern of perceptual stimuli

zoon logikon



European Research Council Advanced Grant SOMACCA (**"The Syntax of Mind: A Computational, Comparative Approach"**) awarded to Prof. W. Tecumseh Fitch

Questions or comments?

Thank you!