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Animal linguistics: A case of semantic compositionality and signal reduction in wild chimpanzees

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CONTENTS

- Introduction
  - Human evolution and language evolution
  - When did language „emerge”?
- Continuity
  - Animal communication and language evolution
  - Animal semantics
  - Animal syntax
- Semantic compositionality in wild chimpanzees
  - Boesch’s (1991) study and Gabrić’s (2021) reanalysis
- Conclusions

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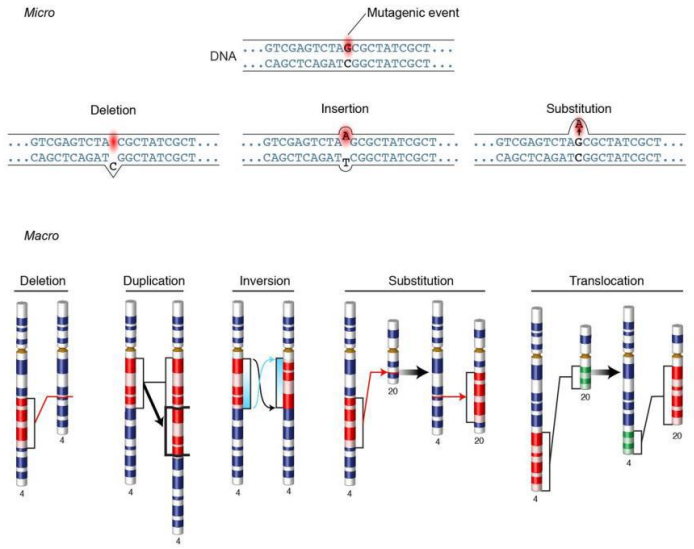
INTRODUCTION

Animal communication...

- Zoology
- Physiology
- Genetics
- Ethology (animal behavior)
- Comparative psychology
- Animal cognition
- Information and communication sciences
- Linguistics: e.g., **language evolution**

What is evolution?

- Changes in genetic variation in a given population
- Mutations: source of genetic variation
- Natural selection,
- Genetic drift,
- Gene flow,
- Etc.



Source: Genome.gov

We are limited in studying human evolution

- Paleoanthropology and archaeology
  - Fossils, DNA, artefacts
- Limitations:
  - Small „samples”
  - Current fossil and artefact records are not representative,
  - Limitations of current dating techniques,
  - Etc.

Source: Wikipedia

We are even more limited in studying language evolution

- Methods of historical linguistics are time-limited.
- Methods and techniques of evolutionary linguistics are currently in development.

- **What is language?**

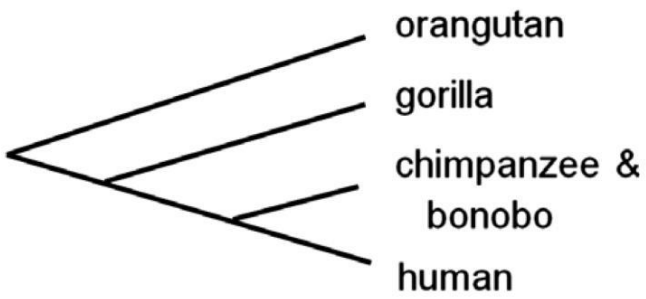
= part of humans' communication system not evidenced in other known living beings

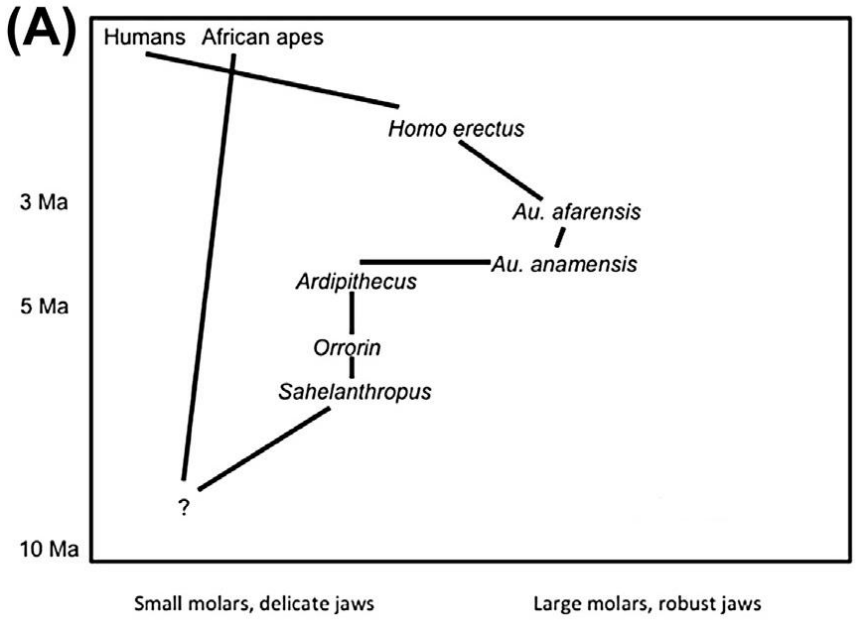
  - Concepts: semantic memory
  - Words (phrases): lexicalization
  - Syntax and semantic compositionality (sentences)
  - Utterances
  - Productivity

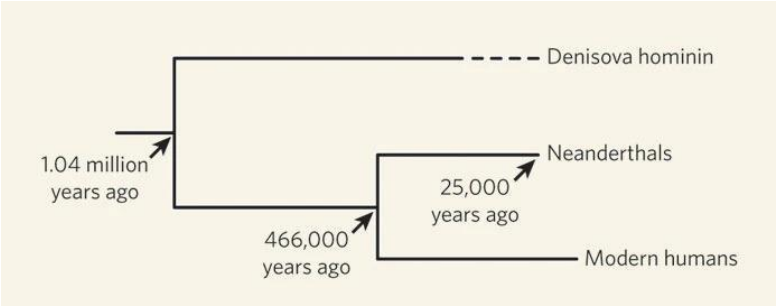
When did language „emerge”?

- Humans are the only known living beings possessing language.
- In normal circumstances, all humans acquire at least one language before a certain developmental phase.
  - Language has emerged no later than the *Homo sapiens* speciation, but not before the split between humans and chimpanzees.
  - If language did not emerge as a „package”, it is plausible that some linguistic capacity might have been extant in the last common ancestor of humans and Neanderthals.

When did language „emerge”?







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Brown. (2010). *Nature, 464*, 838–839.

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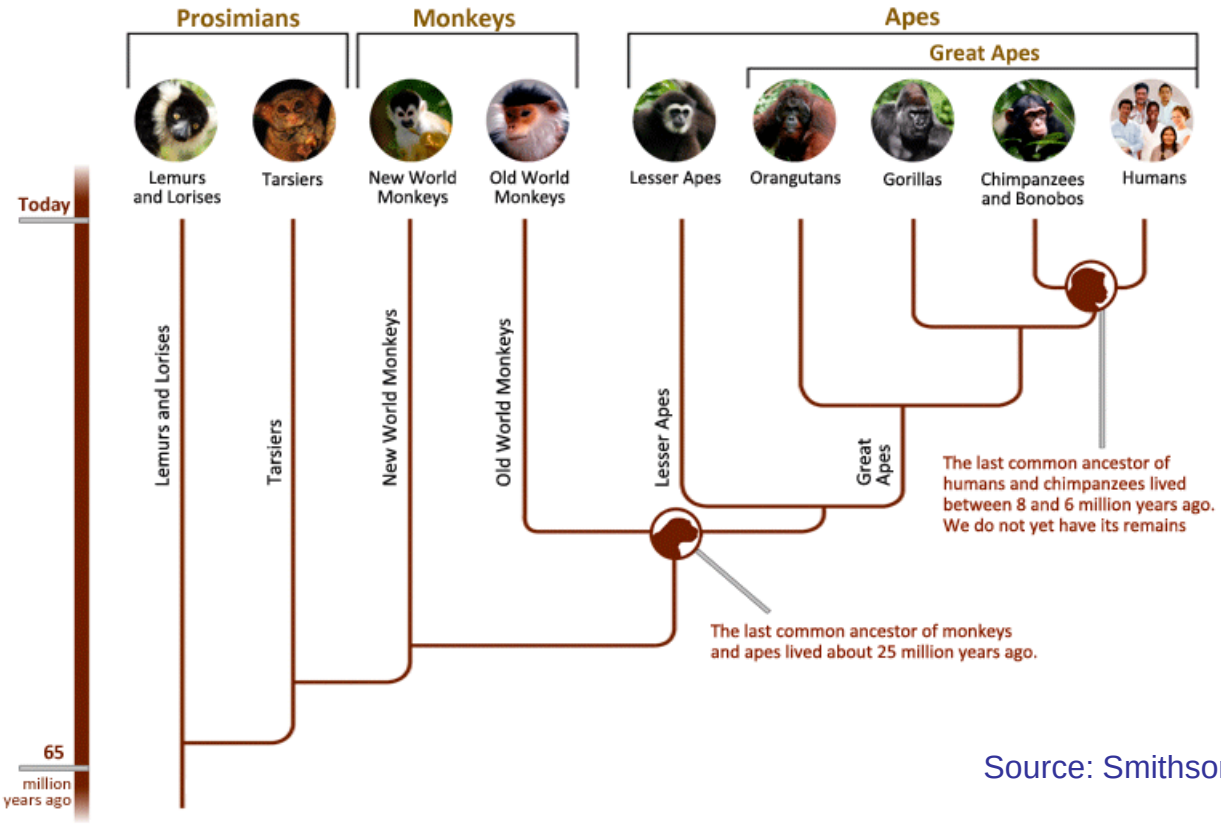
CONTINUITY

Continuity and discontinuity



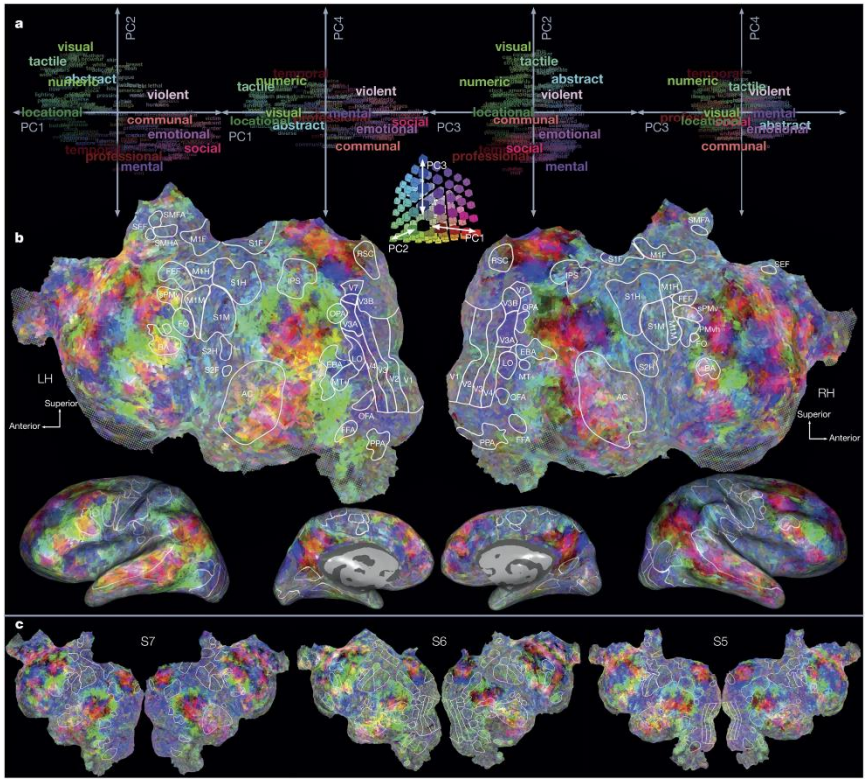
Source: Smithsonian Institution

- „[T]here is no fundamental difference between man and the higher mammals in their mental faculties.” (Darwin, 2013: 29–30)

Streetlight effect (or drunkard's search principle)

Animal semantics

- Concepts and the mental lexicon



Huth et al. (2016). *Nature, 532*(7600), 453–458

Animal semantics: Kanzi (*Pan paniscus*)

- When asked to „Put
  tossing the carrot ou
  his action resulted in
  applied the water inc
  carrot" appeared to b
  during the test did he
  noteworthy that no o
  to Kanzias a means
  times during the test
  both the hose and th
  water if a request rec
  to obtain water.

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Savage-Rumbaugh et al.(1993). *Monographs of the Society for Research in Child Development, 58*(3–4), i+iii+v-vi+1–252.

Animal semantics: Vervets

- Food and alarm calls: lexicalization
- Vervets have alarm calls for five species (predators): leopard, martial eagle, African rock python, baboons, and unfamiliar humans

Source: Schenfeld (Flickr)

Seyfarth RM, Cheney DL, & Marler P. (1980). *Science, 210*, 801–803.

Animal semantics: Vervets

- https://youtu.be/w7ZkPOLB0mk (eagle)
- https://youtu.be/BM7IoMcNj2k (snake)

Animal semantics: Vervets

- The alarm calls are semantic (denotative) and symbolic (word-like)

Source: Schenfeld (Flickr)

Seyfarth RM, Cheney DL, & Marler P. (1980). *Science, 210*, 801–803.

Animal semantics: Food and alarm calls

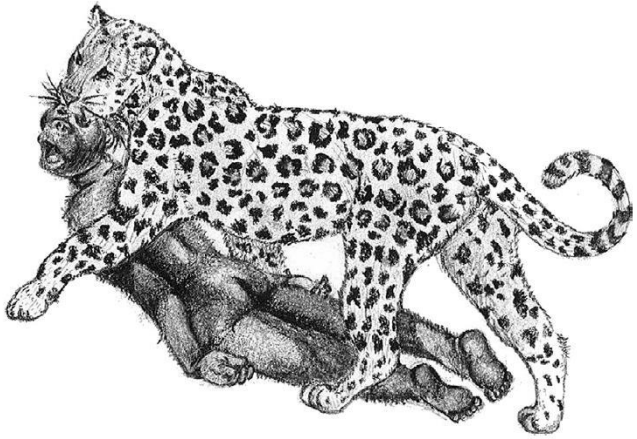
- There are other similar examples in other animals, and not only mammals:
  - White-faced capuchins (*Cebus capucinus*)
  - Pale-winged trumpeter (*Psophia leucoptera*)
  - Male domestic chickens (*Gallus gallus domesticus*)

Digweed SM, Rendall D, & Fedigan LM (2005). *Behaviour, 142*(8), 997–1021.

Seddon N, Alvarez A, & Tobias J (2002). *Behaviour, 139*(10), 1331–1359.

Karakashian SJ, Gyger M, & Marler P (1988). *Journal of Comparative Psychology, 102*(2), 129–135.

„One-word” utterances



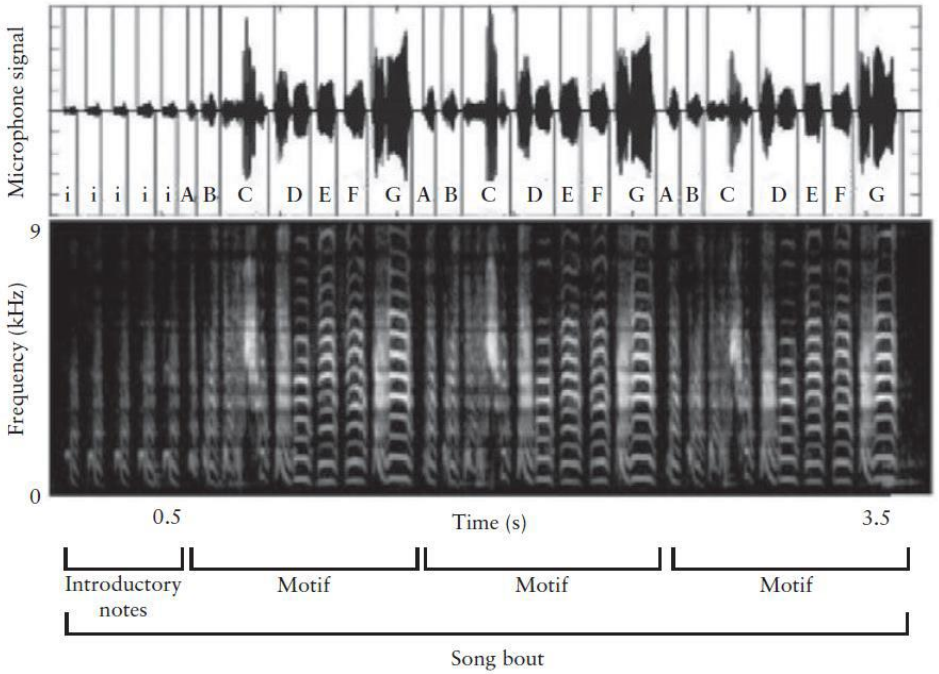
- Analogies in language:

- Fire!
- Thief!
- Killer!
- Snake!
- Spider!
- Hornet!

- Help!

Animal syntax

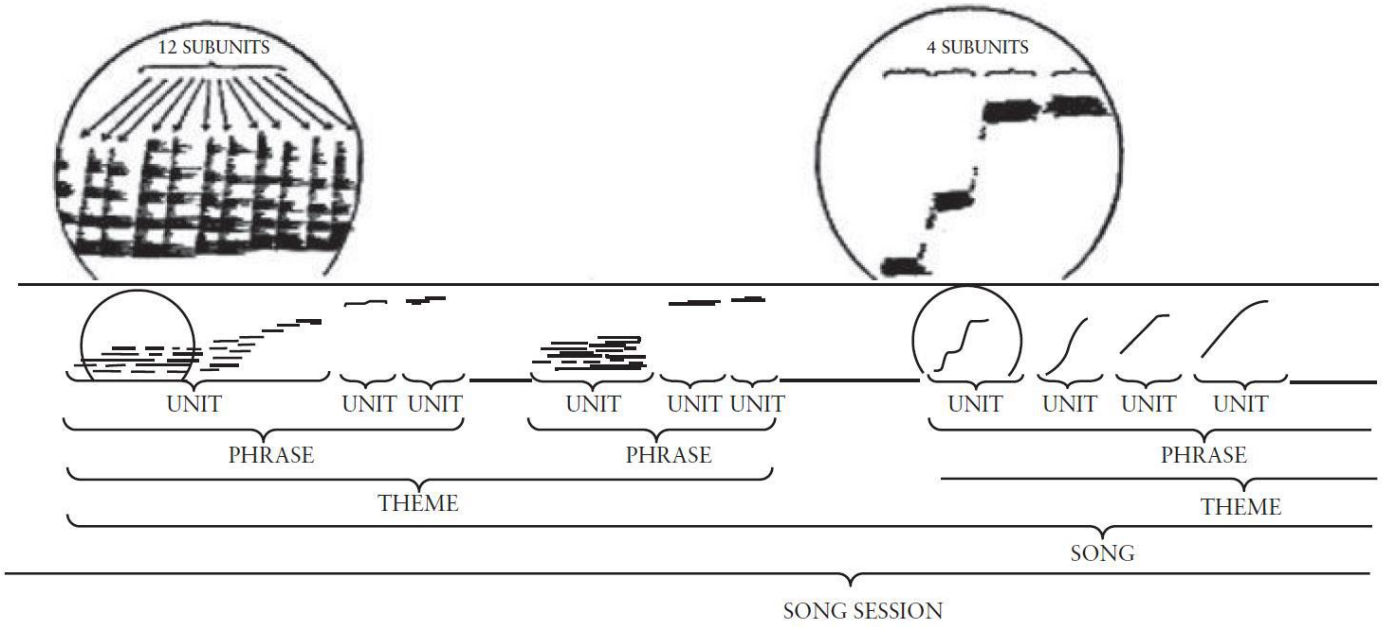
- Bees, ants, frogs, songbirds, whales...



Hurford JR. (2012). *The Origins of Grammar: Language in the Light of Evolution II*. Oxford University Press.

Animal syntax

- Bees, ants, frogs, songbirds, whales...



Hurford JR. (2012). *The Origins of Grammar: Language in the Light of Evolution II*. Oxford University Press.

Animal syntax

- Bees, ants, frogs, songbirds, whales...
- „Despite serious underexploitation of combinatoriality, […] whalesong and much birdsong exhibit a hierarchically layered structure formally similar to the hierarchical structure of human syntax.”

Hurford JR. (2012). *The Origins of Grammar: Language in the Light of Evolution II*. Oxford University Press.

Animal syntax: Japanese tits

ABC	• scan for danger
D	• approach the caller
ABC-D	• scan and approach
D-ABC	• mostly no change in behavior

Source: Sergey Yeliseev

Suzuki TN, Wheatcroft D, & Griesser M. (2016). *Nature Communications, 7*, 10986.

Animal syntax: Japanese tits

- **Semantic compositionality**
- Communicational capacity to combine structures and their meanings into sequences with “derived” meanings, with the sequence’s meaning being a function of the meanings of its parts and the rule(s) applied to arrange the parts
- Present in apes?

Source: Sergey Yeliseev

Suzuki TN, Wheatcroft D, & Griesser M. (2016). *Nature Communications, 7*, 10986.

Semantic compositionality: captive apes

- **Kanzi (bonobo)**

- *Can you put your shirt on your ball?*
- *I think we need to give the balloon to Kelly.*
- *Can you put some tooth paste on yourball?*

- **Lana (common chimpanzee)**
- *? Lana want what eat? – Lana want eat bread*

- Captive apes are capable of semantic compositionality.

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SEMANTIC COMPOSITIONALITY IN WILD CHIMPANZEES

Boesch's (1991) study

- Behavior of a community of 80 wild chimpanzees in a tropical forest within the Taï National Park, Côte d'Ivoire
- Foraging
- **Drumming** (powerfully hitting and kicking of buttressed trees), typically preceded by loud pant-hooting

HUMAN EVOLUTION Vol. 6 - N. 1 (81-90) - 1991

C. Boesch

Department of Ethology and Wildlife Research, University of Zürich and Centre Suisse de Recherches Scientifiques Abidjan

Symbolic Communication in wild chimpanzees?

The language abilities of captive chimpanzees give rise to the question of the existence and use of similar capabilities in wild chimpanzees. In Taï forest, wild chimpanzees seem to use drumming on buttressed trees to convey information an changes of travel direction, resting periods or both information combined. This communication system is iconic and relies on some arbitrariness. Emergence of symbol-like communication in wild chimpanzees seems mainly dependent on a low visibility environment, a high predation pressure and a large group of males.

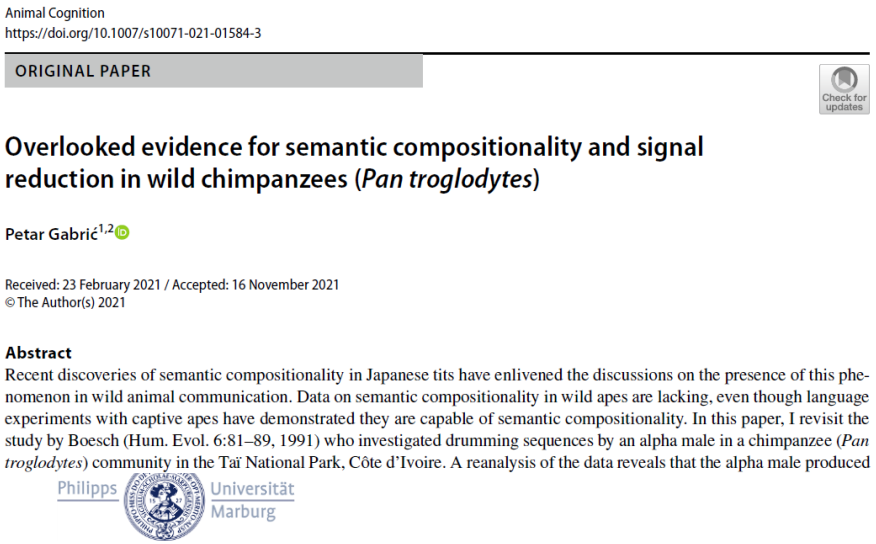
Boesch C. (1991). *Human Evolution, 6*, 81–89.

Pant-hooting and drumming

- https://youtu.be/U5BpFAL5GNo

Boesch's (1991) study

- Drumming sequences by the alpha male Brutus
- Differed in:
  - the number of drumming events within a drumming sequence,
  - the number of trees used for drumming (i.e., whether the drumming events within the drumming sequence were performed on a single tree or whether they were distributed across two trees)



Animal Cognition
https://doi.org/10.1007/s10071-021-01584-3

ORIGINAL PAPER

Check for updates

Overlooked evidence for semantic compositionality and signal reduction in wild chimpanzees (*Pan troglodytes*)

Petar Gabrić[1,2]

Received: 23 February 2021 / Accepted: 16 November 2021

Abstract
Recent discoveries of semantic compositionality in Japanese tits have enlivened the discussions on the presence of this phenomenon in wild animal communication. Data on semantic compositionality in wild apes are lacking, even though language experiments with captive apes have demonstrated they are capable of semantic compositionality. In this paper, I revisit the study by Boesch (Hum. Evol. 6:81–89, 1991) who investigated drumming sequences by an alpha male in a chimpanzee (*Pan troglodytes*) community in the Taï National Park, Côte d'Ivoire. A reanalysis of the data reveals that the alpha male produced

Boesch's (1991) study: classification of Brutus's drumming

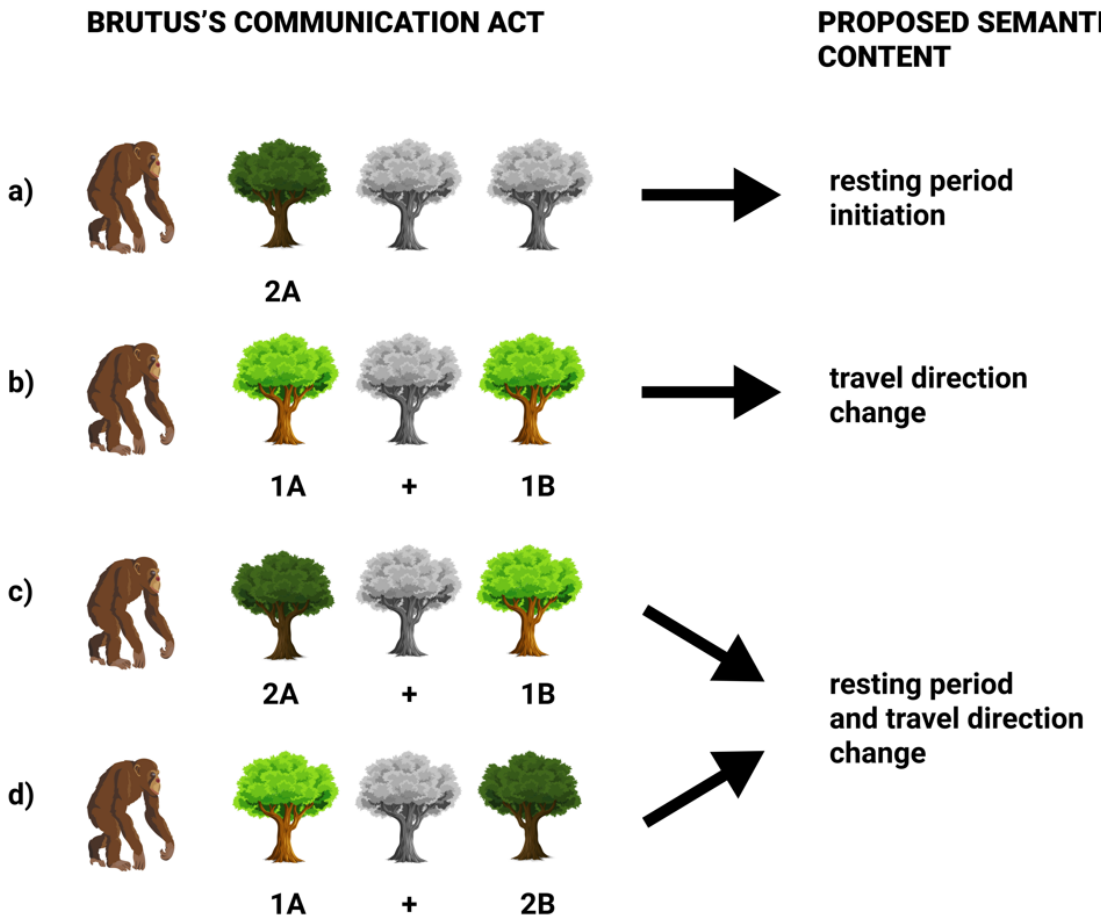
Category	Number of drumming events	Number of trees	Observations	Proposed semantic content
2A	2	1	8	RESTING PERIOD INITIATION
1A + 1B	2	2	8	TRAVEL DIRECTION CHANGE
3A†	3	1	None	–
1A + 2B or *2A + 1B*	3	2	6	RESTING PERIOD INITIATION AND TRAVEL DIRECTION CHANGE
4A	4	1	1	–
2A + 2B† or *1A + 3B*† or *3A + 1B*†	4	2	None	–

Modified from Boesch (1991)

- 22 observations which can be classified into three categories: *2A*, *1A + 1B*, and *1A + 2B/2A + 1B*
- Single drumming events by Brutus evoked "no special reaction"

Gabrić P. (2021). *Animal Cognition*.

Boesch's (1991) study: classification of Brutus's drumming



Matijaš A, & Gabrić P (2022). *Zenodo*.

Boesch's (1991) study: semantic compositionality

- Tentative evidence for semantic compositionality:
  - Sequences *2A* + *1B* and *1A* + *2B* are composed of parts of otherwise meaningful sequences
  - There is at least one rule for combining these two sequences

- What kind of semantic relationship is established between parts of the unitary messages when they are combined into *2A* + *1B* or *1A* + *2B*?
  - cumulatively conjunctive (i.e., *and*-like)
  - *Let's rest and then go that way!*

Boesch's (1991) study: semantic compositionality

- What kind of rule(s) govern(s) the combinatoriality of *2A* + *1B* or *1A* + *2B*?
- The unitary drumming sequences are not simply juxtaposed:
  - *3A* + *1B*† or *1A* + *3B*†
  - Signal reduction (by one drumming event)
- Economy principle of language: in linguistic communication, humans strive to exchange as much information as possible using as little effort as possible

Signal reduction

- *1A* + *2B*
- *1A* is non-meaningful
- *2B* codes information on both the travel direction change and resting period initiation

- Fusion
  - *Ich bin **im** Supermarkt.* (vs. *Ich bin **in dem** Supermarkt.*)

- Blending
  - *motel* (*motor* × *hotel*), *smog* (*smoke* × *fog*), *Brangelina* (*Brad Pitt* × *Angelina Jolie*)

Brutus and language

- Brutus is combining two semantically imperative and verb-like messages

- Verb-verb constructions:
  - *sjedi i plači*
  - *povuci-potegni*
  - *veži-dreši*

- Paratactic combinations of clauses:
  - *Come one, come all.*, *Monkey see, monkey do.*, *Easy come, easy go.*
  - *Došla, ošla.*, *Sam pao, sam se ubio.*

Alternative hypothesis

- We must show that other individuals in the community responded to the auditory stimuli and their proposed semantic content and not, for example, by visually observing Brutus's behavior after the drumming sequences.

Alternative hypothesis

- We must show that other individuals in the community responded to the auditory stimuli and their proposed semantic content and not, for example, by visually observing Brutus's behavior after the drumming sequences.

- "[The] receivers [were] often out of visual contact with Brutus"
- Low visibility in the Taï rainforest with the "visibility on the ground rarely exceeding 20 m"

- The visual hypothesis does not explain why Brutus produced different drumming sequences before initiating the specific behaviors.

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CONCLUSIONS

Conclusions

- The alpha male Brutus produced semantically compositional combined messages of travel direction change and resting period initiation.
- Unlike the Japanese tits, the elements of the compositional expression were not simply juxtaposed but displayed structural reduction, while one of the two elements in the expression coded the meanings of both elements. These processes show relative resemblance to blending and fusion in human languages.
- Because the elements of the expression appear to carry verb-like meanings, the compositional expression also resembles simple verb-verb constructions and short paratactic combinations of two clauses found across languages.

Conclusions

- Semantic compositionality and phenomena resembling paratactic combinations of two clauses might have been present in the communication of the last common ancestor of chimpanzees and humans, although not necessarily in the vocal modality.

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