LSci 51/CogS 56L:
Acquisition of Language

Lecture 6

Biological bases of language acquisition III

Announcements

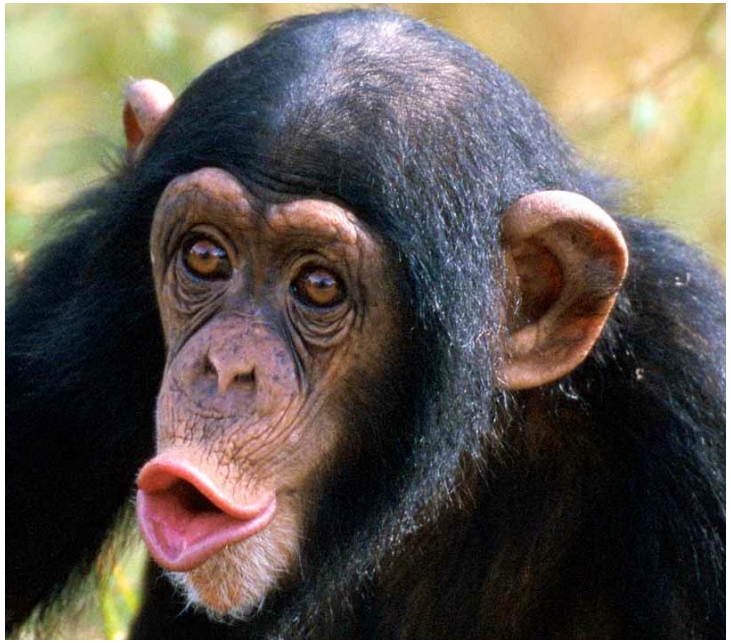
Be working on review questions for biological bases of language acquisition

Be working on HW2 and comments for the review session (due: 10/20/25)

Non-human animals

What are animal communication systems capable of?

Are other animals capable of learning human language?



Qualitative differences

Jane Goodall:

http://www.ted.com/talks/jane_goodall_on_what_separates_us_from_the_apes

"The one thing we have, which makes us so different from chimpanzees and other living creatures is this sophisticated spoken language — a language with which we can tell children about things that aren't here. We can talk about the distant past, plan for the distant future, discuss ideas with each other, so that the ideas can grow from the accumulated wisdom of a group."

Qualitative differences

Michael Corballis:

https://www.ted.com/talks/michael_corballis_evolution_s_great_mystery_language

"Many researchers are convinced that only humans have language, that the calls and gestures other species use to communicate are not language. Each of these calls and gestures generally corresponds to a specific message, for a limited total number of messages that aren't combined into more complex ideas. For example, a monkey species might have a specific warning call that corresponds to a particular predator, like a snake— but with language, there are countless ways to say 'watch out for the snake.' So far no animal communication seems to have the open-endedness of human language. We don't know for sure what's going on in animals' heads, and it's possible this definition of language, or our ways of measuring it, don't apply to them. But as far as we know, only humans have language."

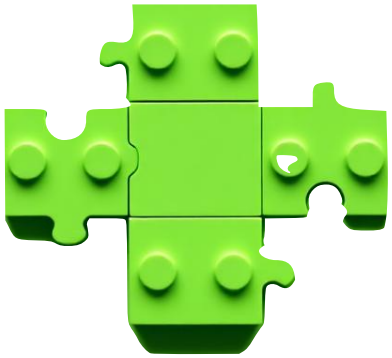
Qualitative differences

Michael Corballis:

https://www.ted.com/talks/michael_corballis_evolution_s_great_mystery_language

One way human languages do this kind of combination: syntax

productive system for combining symbols to express new meaning



Qualitative differences

Michael Corballis:

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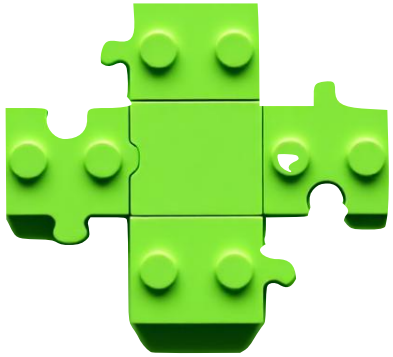
syntax: productive system for combining symbols to express new meaning

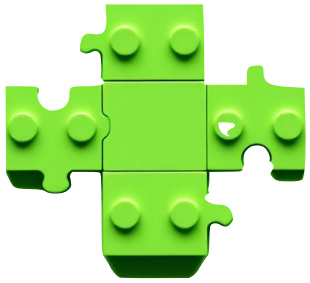


So how good are non-humans animals at doing this in their systems of communication?

Primate communication

Campbell's monkeys

https://www.sciencedaily.com/releases/2016/07/160706091606.htm

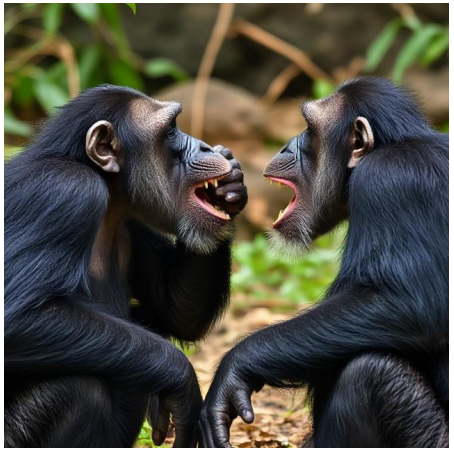


Campbell's monkeys seem to have a rudimentary combinatorial system.

"…make a distinction between roots (especially 'hok' and 'krak') and suffixes ('-oo'), and their combination allows the monkeys to describe both the nature of a threat and its degree of danger."

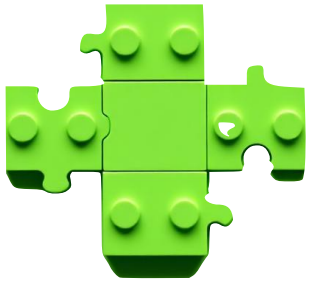
Primate communication

Wild chimpanzees



https://www.sciencedaily.com/releases/2022/05/220517094810.htm

Girard-Buttoz, Zaccarella, Bortolato, Friederici, Wittig, & Crockford 2022

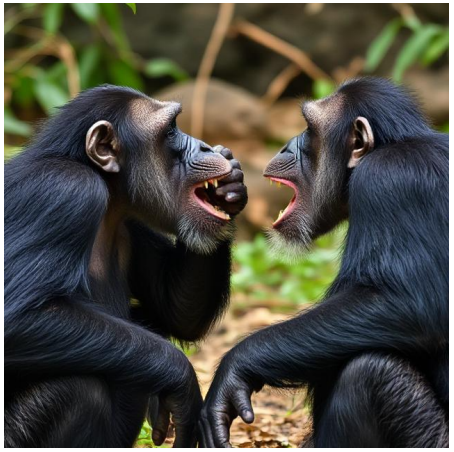


Wild chimpanzees also seem to have a rudimentary combinatorial system.

"…chimpanzees communicate with each other using hundreds of different sequences, combining up to ten call types…calls -- in combination with specific other calls -- predictably occurred in certain positions in the sequence, following adjacency rules. These adjacency rules applied also to sequences with three call types."

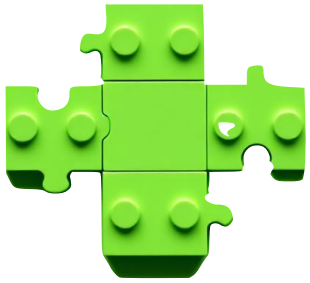
Primate communication

Wild chimpanzees



https://www.sciencedaily.com/releases/2023/05/230504094942.htm

Leroux, Schel, Wilke, Chandia, Zuberbühler, Slocombe, & Townsend 2023



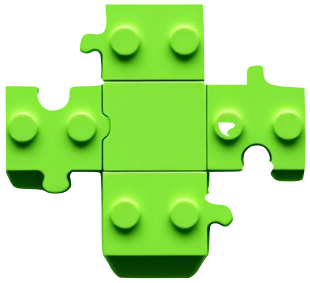
Wild chimpanzees also seem to have a rudimentary combinatorial system.

"Chimpanzees produce 'alarm-huus' when surprised and 'waa-barks' when potentially …during aggression or hunting…chimpanzees combine these calls when exposed to a threat where recruiting group members is advantageous, such as when encountering a snake…"''

Primate communication

Putty-nose monkeys

https://www.sciencedaily.com/releases/2016/07/160706091606.htm



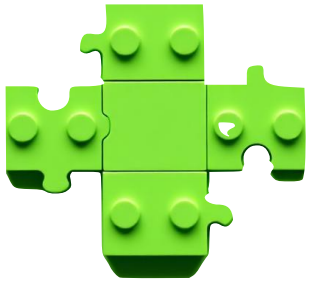
Putty-nose monkeys also seem to have a rudimentary combinatorial system.

> "…'pyows' are used as general calls ('there is an alert'), while 'hacks' are usually raptor-related (e.g. 'there is an eagle'). But a small number of 'pyows' followed by a small number of 'hacks' have a distinguished status and trigger group movement ('let's move!')..."

Primate communication

Titi monkeys

https://www.sciencedaily.com/releases/2016/07/160706091606.htm



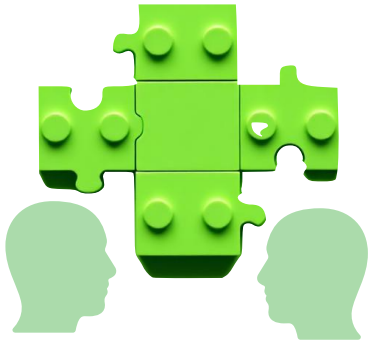
Titi monkeys also seem to have a rudimentary combinatorial system.

"…with just two calls (A and B), they encode information about both predator type and predator location, so that 'raptor in the canopy' (e.g. AAAA...), 'raptor on the ground' (e.g. AAA...BBBB...), 'cat in the canopy,' (e.g. ABBBB...), and 'cat on the ground' (e.g. BBBBB...) give rise to four distinct sequence types...."

Primate communication

Titi monkeys

https://www.sciencedaily.com/releases/2016/07/160706091606.htm



Titi monkeys also seem to be sensitive to how informative the call is — using something that looks like pragmatic reasoning.

Human pragmatic reasoning (implicature):

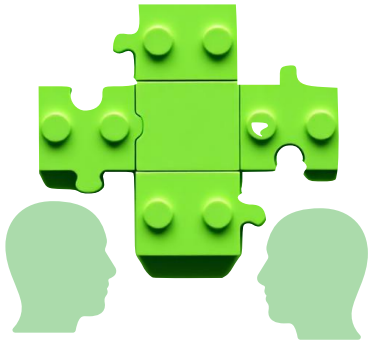
"Some of the apples are red." vs. **"All of the apples are red."**

???

Primate communication

Titi monkeys

https://www.sciencedaily.com/releases/2016/07/160706091606.htm



Titi monkeys also seem to be sensitive to how informative the call is — using something that looks like pragmatic reasoning.

Human pragmatic reasoning (implicature):

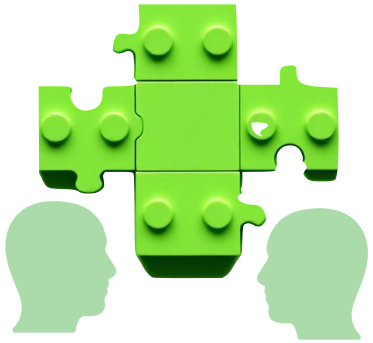
"All of the apples are red."

Why? "All" is more specific (only applies to situation where all of the apples are red), and therefore more informative to the listener.

Primate communication

Titi monkeys

https://www.sciencedaily.com/releases/2016/07/160706091606.htm



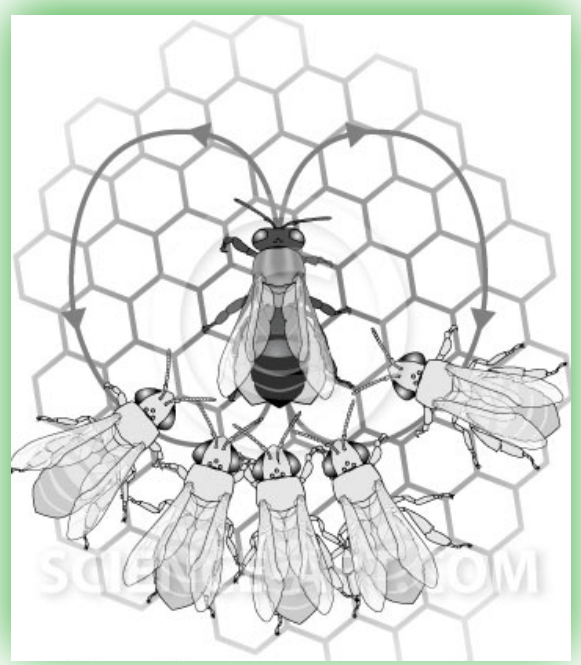
Titi monkeys also seem to be sensitive to how informative the call is — using something that looks like pragmatic reasoning.

"…in many cases a general call -- for instance the Titi B-call, for 'general alerts' -- competes with a more specific call -- for instance the Titi A-call, for 'serious danger up.' If a threat licenses the specific call (for instance the A-call because a raptor appeared), monkeys don't normally start sequences with the general call (e.g. B), and thus they seem to prefer the more informative alternative ..."

Bee communication

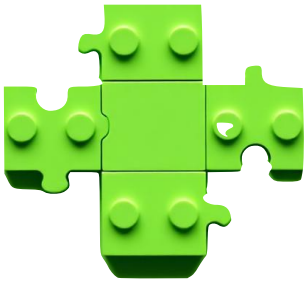
Bee communication

Honey Bees

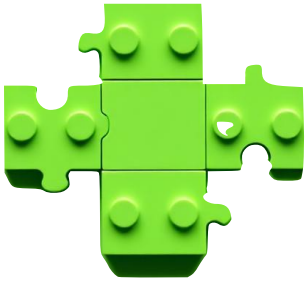


Dance to communicate the location of food (nectar)

Can indicate: nearby vs. far, direction, richness of the food source (dance harder for the good stuff)



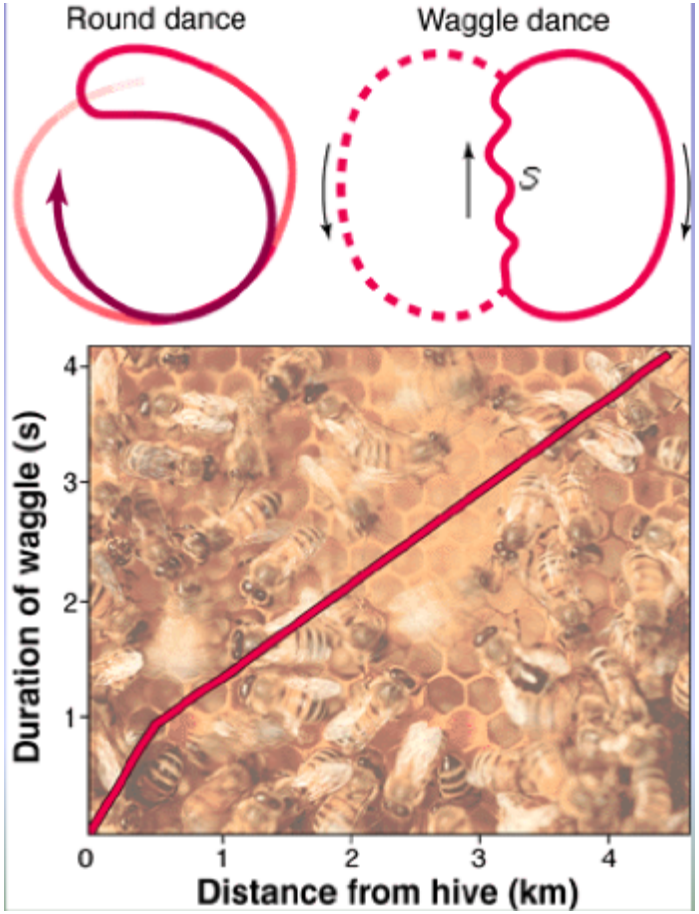
Though bees can create novel messages, they're always about the location of food.



Bee communication

Under 50m away

The angle from the sun indicates direction of food source. The duration of the waggle part of the dance signifies the distance. Approximately 1 second of dance = 1 km distance.



Quantity:

(1) Ratio of waggle part to round part corresponds to quantity of food.
(2) More food = more energetic waggling.

Over 50m away:

encodes distance & direction - is encoding of 2D space (a bee's "mental map")

http://www.youtube.com/watch?v=-7ijI-g4jHg

'deciphered' by Karl von Frisch, 1919 & onward

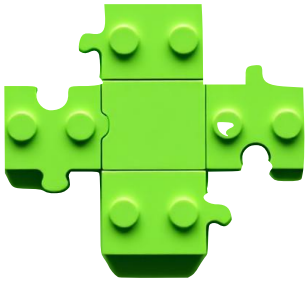
Bird communication

Bird communication

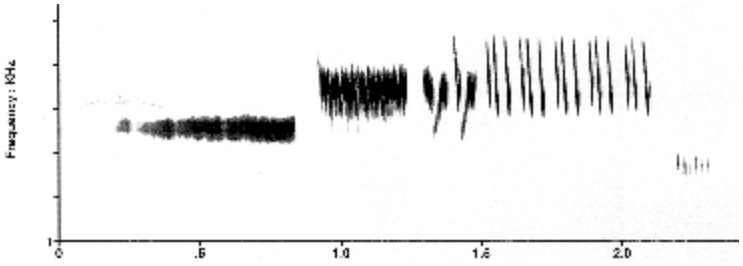
Sparrow song

song

call

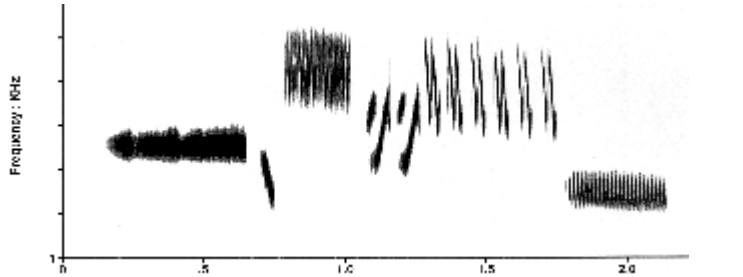


student



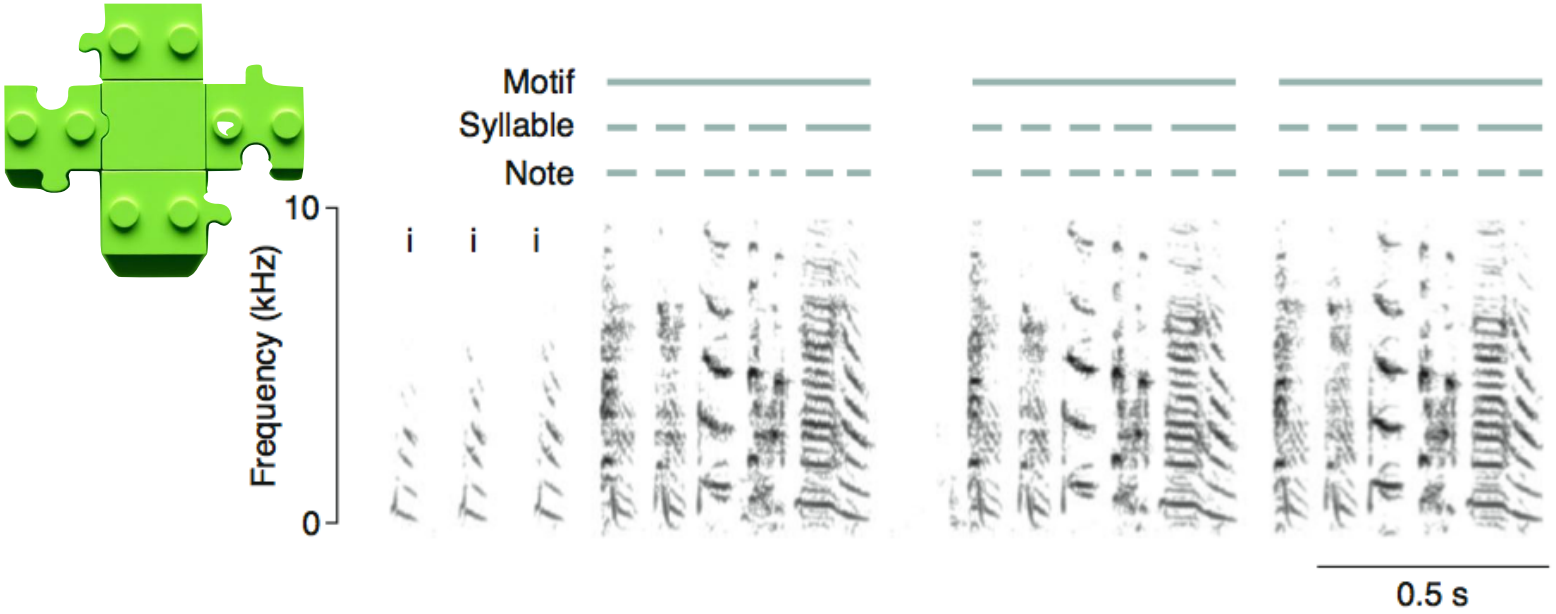
Song is highly structured (combinatorial system) - notes, syllables, phrases (Kaplan 2014)

teacher



Bird communication: Hierarchical structure

Zebra finch song

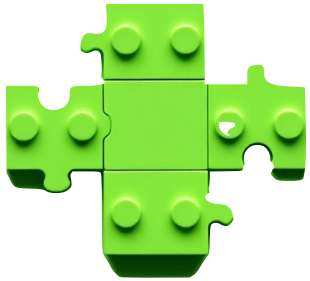


"Sound spectrogram of a typical zebra finch song depicting a hierarchical structure. Songs often start with 'introductory notes' (denoted by 'i') that are followed by one or more 'motifs', which are repeated sequences of syllables. A 'syllable' is an uninterrupted sound, which consists of one or more coherent time-frequency traces, which are called 'notes'. A continuous rendition of several motifs is referred to as a 'song bout'." – Berwick et al. 2012

Bird communication: variety

Variation in song

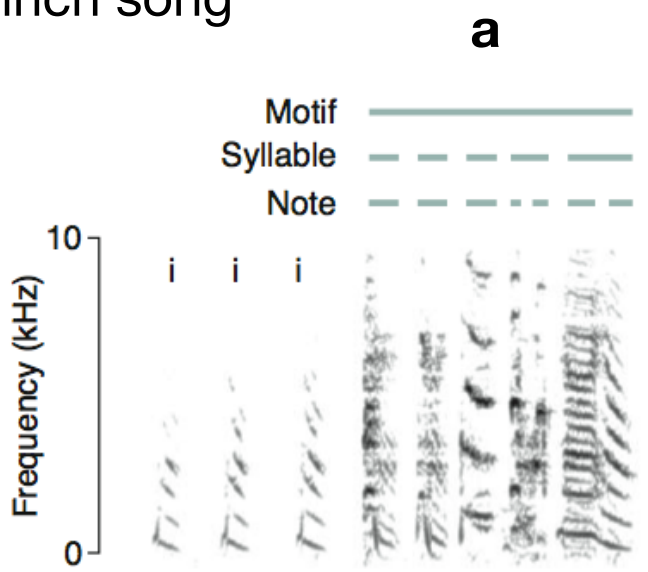
Bird 1

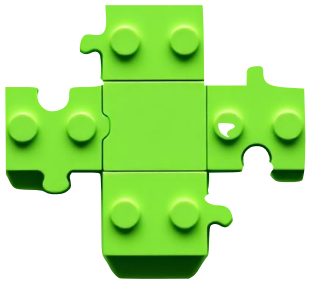


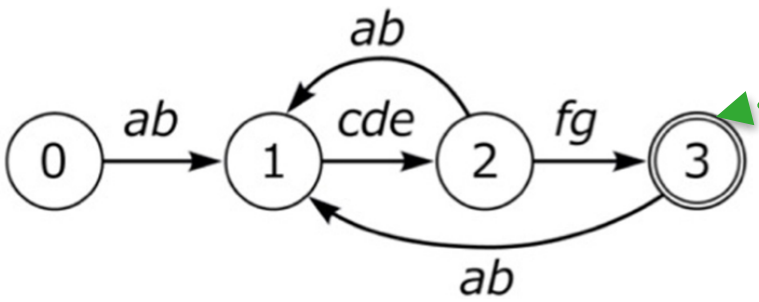
Bird 2

Bird communication: Variety of communication

Bengalese finch song







A **state diagram** of the sequence of motifs that can make up a Bengalese finch song.

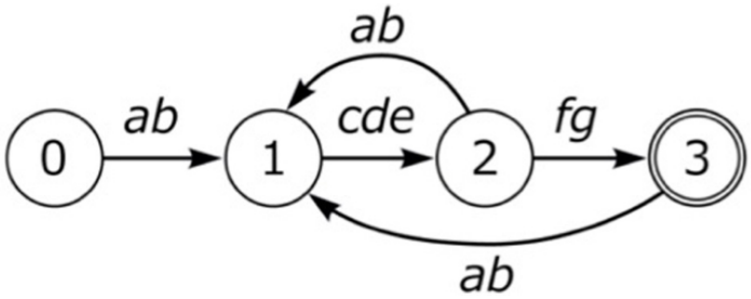
Miyagawa et al. 2014

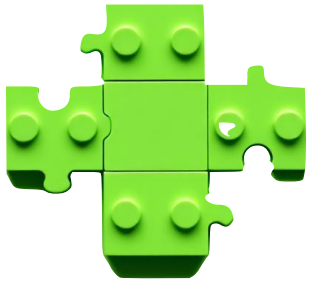
Bird communication: Variety of communication

Bengalese finch song

Important: An infinite number of valid sequences can be generated because we have these backward arrows. This aspect of bird song is similar to human language (which has infinite sentences).

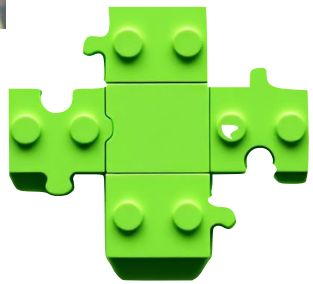
Allowed: abcdefg, abcdefgabcdefg, abcdefgabcdeabcdefg, …





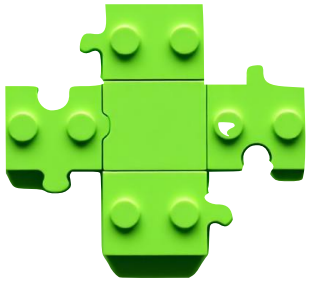
Miyagawa et al. 2014

Bird song combinatorics



Berwick et al. 2012: The combinatorial system of birdsong seems less complex than in human language. While human language has phonemes that make syllables that make words that make phrases that make sentences that make conversations (etc), birdsong often seems to stop at the “word” level (~motif).

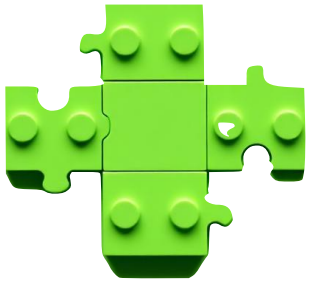
Bird song combinatorics



Berwick et al. 2012:
Also, while birds can reorder elements within their song, this doesn't seem to change the meaning of the entire song. Thus, their combinatorial system does not connect with meaning in the same way that human syntax does.

(For example, "Penguins eat fish" doesn't mean the same thing as "Fish eat penguins", but a song made of motif order A-B-C conveys the same meaning as a song made of motif order C-B-A.)

Bird song combinatorics



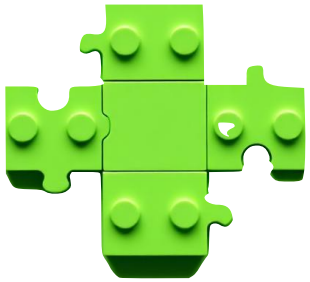
Or can it? Some evidence that order of elements matters

Chestnut-crowned babblers produce song "AB" when flying and song "BAB" when feeding chicks, and A and B are distinct units (Engesser, Savage, & Townsend 2015, Engesser, Holub, O'Neill, Russell, & Townsend 2019).

Co-author Townsend suggests this is "the first time that the capacity to generate new meaning from rearranging meaningless elements has been shown to exist outside of humans".

(http://www.sciencedaily.com/releases/2015/06/150629152230.htm)
(https://www.sciencedaily.com/releases/2019/09/190909160109.htm)

Bird song combinatorics



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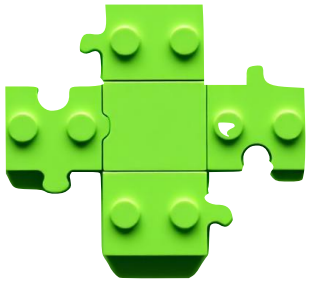
But is it really meaning (if so, what does each unit *mean*)?

Under debate…

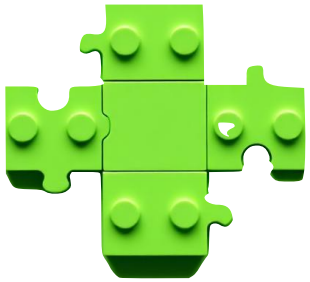
Bird song combinatorics



Or can it? Some evidence that order of elements matters

Japanese great tits use “ABC” calls to mean “watch out!” (in the presence of sparrow hawks), “D” calls to mean “come over here”, and “ABC-D” calls to indicate that they should all flock together and be alarmed. (This is something like “watch out” + “come over here”.) Notably, “D-ABC” doesn’t cause them to do this — so order matters. (Suzuki, Wheatcroft, & Griesser 2016).

(https://www.sciencedaily.com/releases/2016/03/160308134748.htm)



Other naturally-occurring animal communication systems have some ability to combine elements and create new meanings, like human language does.

But what about the ability of other animals to learn human language and its sophisticated combinatory properties?

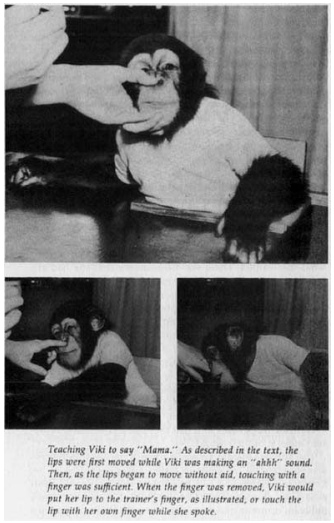
Can they do it or is that something only humans can do?

Teaching non-human primates

"He's pretty good at rote categorization and single-object relational tasks, but he's not so hot at differentiating between representational and associational signs, and he's very weak on syntax."

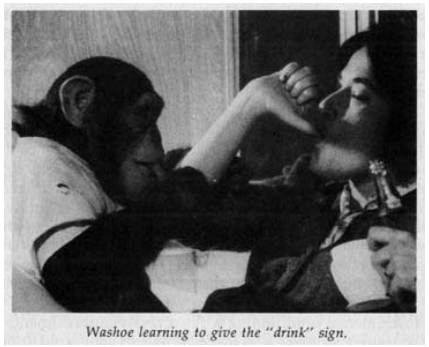
Spoiler alert

Teaching non-human primates



vicki

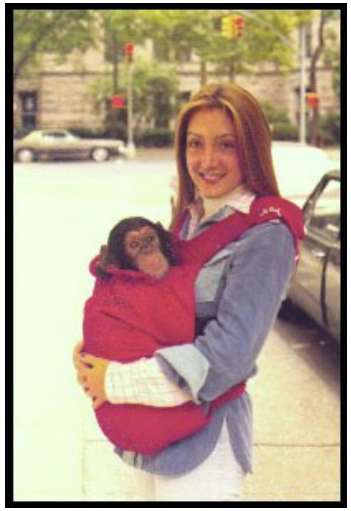
sarah & co.



washoe

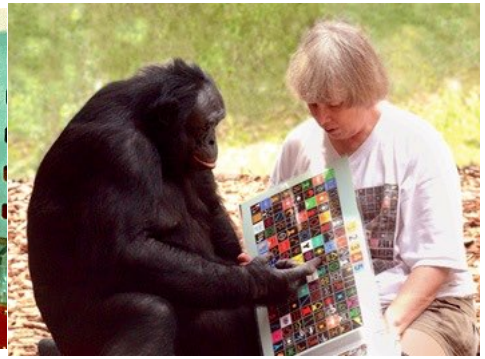
washoe & loulis

Koko



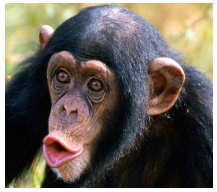
nim chimpsky

lana & co.



kanzi & co.

Teaching chimpanzees



Teaching chimpanzees to speak didn't work out very well

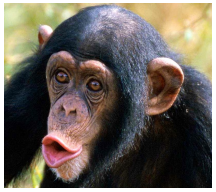
1930s: Gua, raised in a human home and treated like human infant along with the couple's son

- motor skills surpassed child's, but never learned to speak (while the child did)

1940s and 50s: Viki, raised in a human home and actively taught to produce words

- by 6, Viki could say "mama", "papa", "cup", and "up"

Teaching chimpanzees



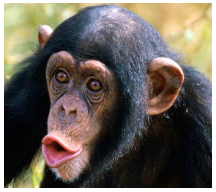
Why the problem with spoken language?

For a long time, researchers thought the issue was that chimpanzees have a vocal tract that makes speech production essentially impossible.

Fitch, De Boer, Mathur, & Ghazanfar (2016) showed that this wasn't true:
"…looked inside monkeys' vocal tracts with x-rays, and found them to be much more flexible than thought…"

https://www.sciencedaily.com/releases/2016/12/161209144919.htm

Teaching chimpanzees



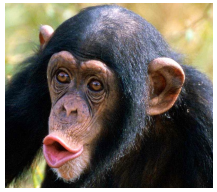
Why the problem with spoken language?

Fitch, De Boer, Mathur, & Ghazanfar (2016)

Not really a vocal tract issue

"The key conclusion from our study is that the basic primate vocal production apparatus is easily capable of producing five clearly distinguishable vowels (for example, those in the English words "bit," "bet," "bat," "but," and "bought"). Five vowels are the worldwide norm for human languages, and many of the world's languages make do with only three vowels."

Teaching chimpanzees



Why the problem with spoken language?

Fitch, De Boer, Mathur, & Ghazanfar (2016)

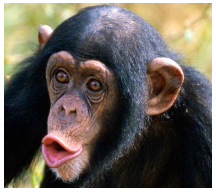
Not really a vocal tract issue

“Will you marry me?”

Synthesized human female
with noisy background

Synthesized macaque
with noisy background

Teaching chimpanzees



Why the problem with spoken language?

Dichter, Brechers, Leonard, & Chang 2018

> …but humans *are* able to consciously control the pitch of their voices, while other primates can't. This allows them to stress particular syllables in order to change meaning, among other things.

These have different implications because of which word is *stressed*…

"*Will* you marry me?"

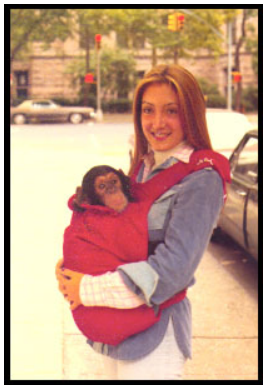
"Will *you* marry me?"

"Will you *marry* me?"

"Will you marry *me*?"

https://www.sciencedaily.com/releases/2018/06/180628151903.htm

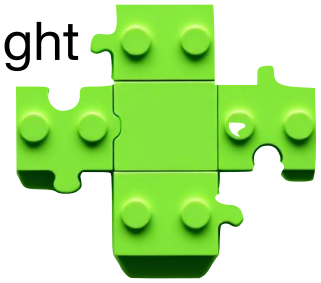
Teaching chimpanzees



Teaching chimps to sign using ASL

1979: Nim Chimpsky, raised in private home, taught signs by having hands molded into them

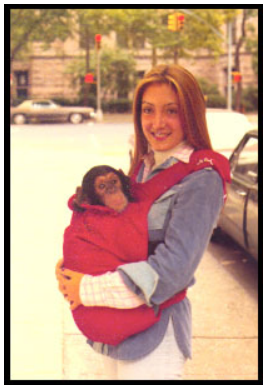
- learned 100 signs and produced some combinations



But combinations produced are very different from those of a human child - very repetitive, no additional complexity:

2-sign	3-sign	4-sign
“eat drink”	“eat me Nim”	“eat drink eat drink”
“tickle me”	“me Nim eat”	“play me Nim play”

Teaching chimpanzees



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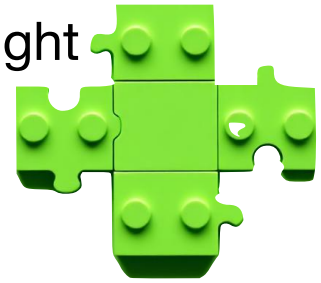
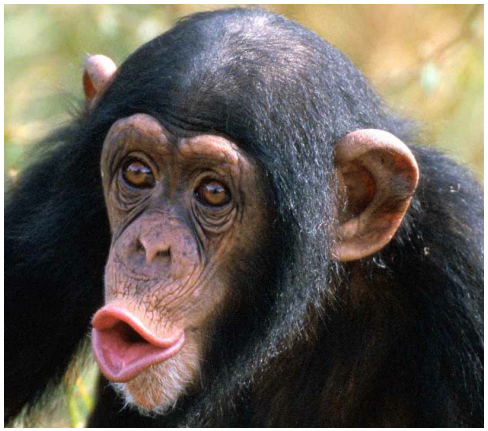


A quantitative analysis of combinatorial ability (called *productivity*) from Yang (2013) also demonstrates that Nim's productions are *not* compatible with a combinatorial system. Instead, they are much more likely to be imitations of whole chunks from the surrounding input. This is corroborated by reports of how Nim's sign combinations originated: All of them were imitations of his teachers - no novel combinations, unlike human children.

Teaching chimpanzees

Teaching chimps to sign using ASL

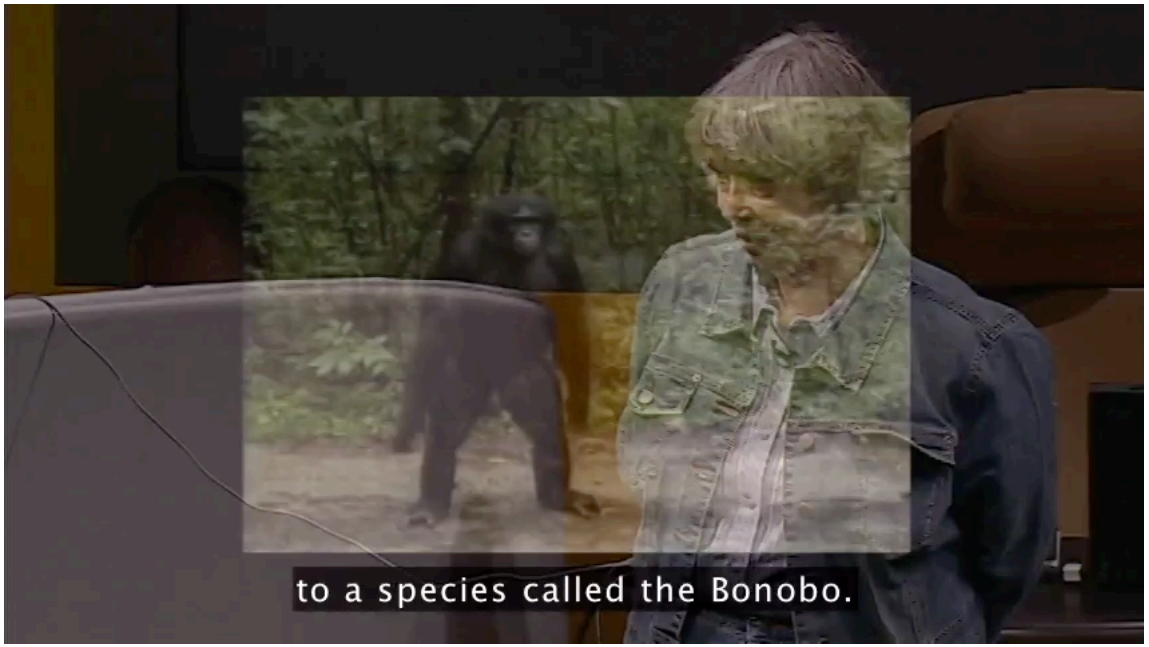
Nim's longest utterance: "give orange me give eat orange me eat orange give me eat orange give me you"



Teaching bonobos

http://www.ted.com/talks/susan_savage_rumbaugh_on_apes_that_write?language=en

Total length = 17:25, look at 2:32 - 7:32 especially



Teaching bonobos

Bonobos (pygmy chimpanzees) vocalize in communication more frequently than common chimps do.

1981: adult bonobo Matata instructed with an artificial language and utterly failed

However, her infant bonobo Kanzi - who wasn't explicitly instructed in anything, but accompanied his mother when she was instructed - learned the artificial language and was also able to understand some spoken English (presumably because he was within the critical/sensitive period).

http://www.youtube.com/watch?v=wRM7vTrIIis (Lexigrams)

http://www.youtube.com/watch?v=2Dhc2zePJFE (Novel Sentences)

Teaching bonobos

Kanzi's spoken English: comparable to a 2-year-old child's performance (but a 2-year-old's syntactic knowledge is fairly limited)

Also, Kanzi was 8 years old when he was tested, and was unlikely to improve his performance any further with age….unlike human children.

So what's the problem?

Not a lack of intelligence - chimpanzees are highly intelligent.

One answer: language is an expression of a domain-specific mental faculty that humans have and other primates do not (linguistic nativist, generativist).

So what's the problem?

Not a lack of intelligence - chimpanzees are highly intelligent.

Another answer: language results from better domain-general abilities (non-linguistic nativist, constructionist).

"…humans have evolved a superior capacity to deal with sequential information…"

https://www.sciencedaily.com/releases/2017/06/170620200012.htm

So what's the problem?





data from 108 experiments on birds and mammals

"…humans have evolved a superior capacity to deal with sequential information…"

https://www.sciencedaily.com/releases/2017/06/170620200012.htm

"We found that the limited capacities of non-human animals can be explained by a simpler kind of memory that does not faithfully represent sequential information."

So what's the problem?



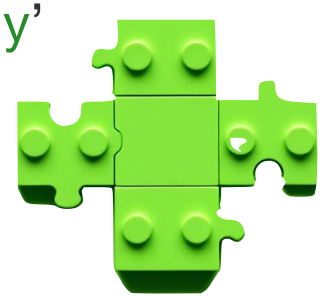


data from 108 experiments on birds and mammals

"…humans have evolved a superior capacity to deal with sequential information…"

https://www.sciencedaily.com/releases/2017/06/170620200012.htm

"…can explain why no language-trained animal has successfully mastered sequential aspects of language, such as the difference between 'the dog bit the lady' and 'the lady bit the dog.'"



Language-like structure

But…macaques can be trained to learn recursive structures (Ferrigno, Cheyette, Piantadosi, & Cantlon 2020), which involve nesting chunks inside of other chunks, a property that human language uses a lot.

A B B A

the monkeys sitting together are happy

"Our data suggest that, with sufficient training, monkeys can learn to represent a recursive process, meaning that this ability may not be as unique to humans as is commonly though."

https://www.sciencedaily.com/releases/2020/06/200629090018.htm

Language-like structure

Both common marmosets and chimpanzees can detect non-adjacent dependencies (Watson, Burkart, Schapiro, Lambeth, Mueller, & Townsend 2020), another structural relationship that human language uses.

A B B A

the monkeys sitting together are happy

"This suggests that this crucial element of language already existed in our most recent common ancestors with these species."

https://www.sciencedaily.com/releases/2020/10/201021180740.htm

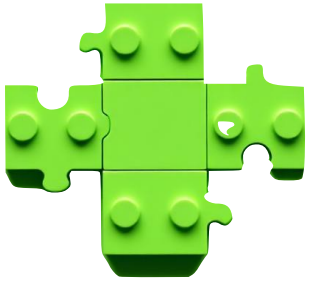
Language-like structure

Dautriche, Buccola, Berthet, Fagot, & Chemla 2022:
Baboons can learn to combine two elements together
to make a meaningful new concept

A + B = AB

not + blue = not blue

Recap: Animal communication



One key aspect of human language is its ability to combine meaningful elements into larger structures that communicate much more sophisticated meanings.

Other non-human communication systems have this ability to a lesser extent.

When non-human animals try to learn human language, they struggle to learn this combinatory property. While they can sometimes be trained to learn some relevant combinations, they're not as good as humans (and especially not as good as human children).

Questions?

Remember: You should be able to do all the questions in HW2 and the review questions for the biological bases of language acquisition.