The primitive of semantics in human infants and baboons (*Papio papio*)

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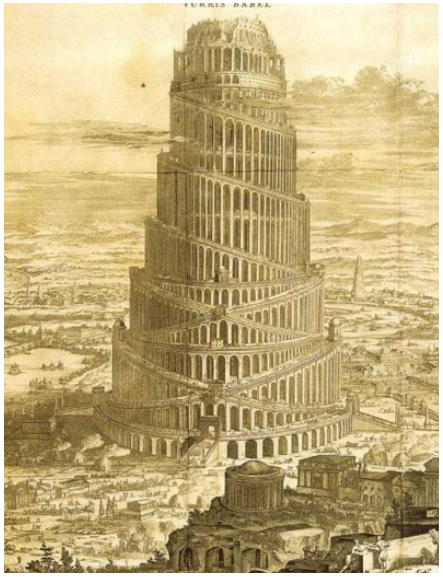
16/10/2024

About languages

Languages differ at all levels (sounds, words, grammar)

But they also share important similarities:

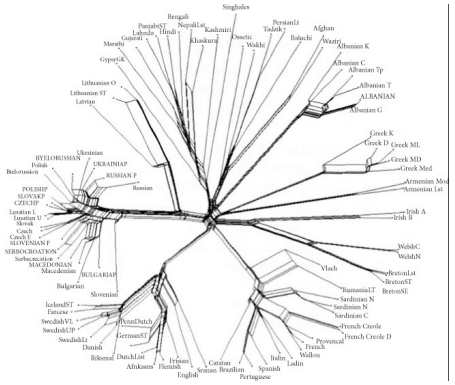
- Architecture: symbolic systems that combine the same units to convey an infinity of meanings.
- Statistical tendencies (e.g., SO preference)



General challenge

Why do languages look the way they are?

- Features of our cognition (general learning mechanisms, memory)
- Language-specific constraints
- Language function (communication)
- External factors (geography, language contact, history)



General challenge

Why do languages look the way they are?

- Features of our cognition (general learning mechanisms, memory)
- Language-specific constraints
- Language function (communication)
- External factors (geography, language contact, history)

Evidence comes from:

- Typological data
- (rarely) experimental work with human adults

Cognitive foundations

Why do languages look the way they are?

- New sources of evidence to investigate the cognitive foundations of meaning
  - > in human infants
  - > in non-human animals

Roadmap

Evidence for the existence of cognitive foundations

1. Lexical meanings
2. Compositionality
3. Word order

Roadmap

Evidence for the existence of cognitive foundations

1. Lexical meanings
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Connectedness: A constraint on lexicons

The meaning a word is generally connected (convex):

If

a is a blicket

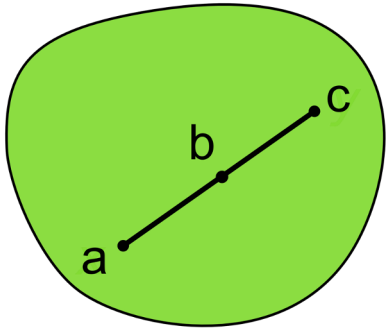
c is a blicket

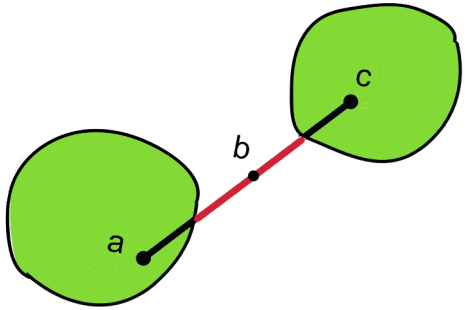
b is 'between' *a* and *c*

Then

b is also a blicket

No 'gaps' in the meaning of words





Connectedness: cross-linguistically

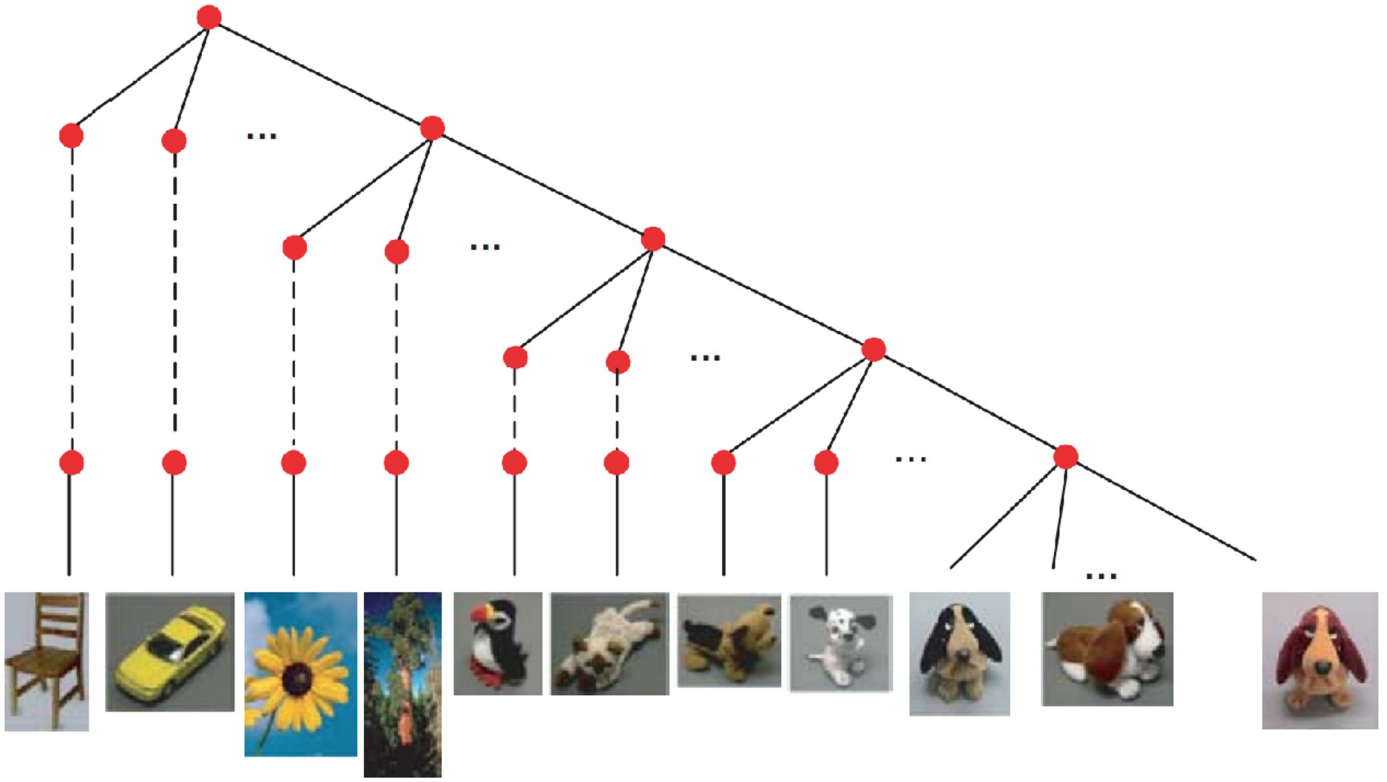
No (content) word means:

‘dog or mushroom’

‘table or sofa’

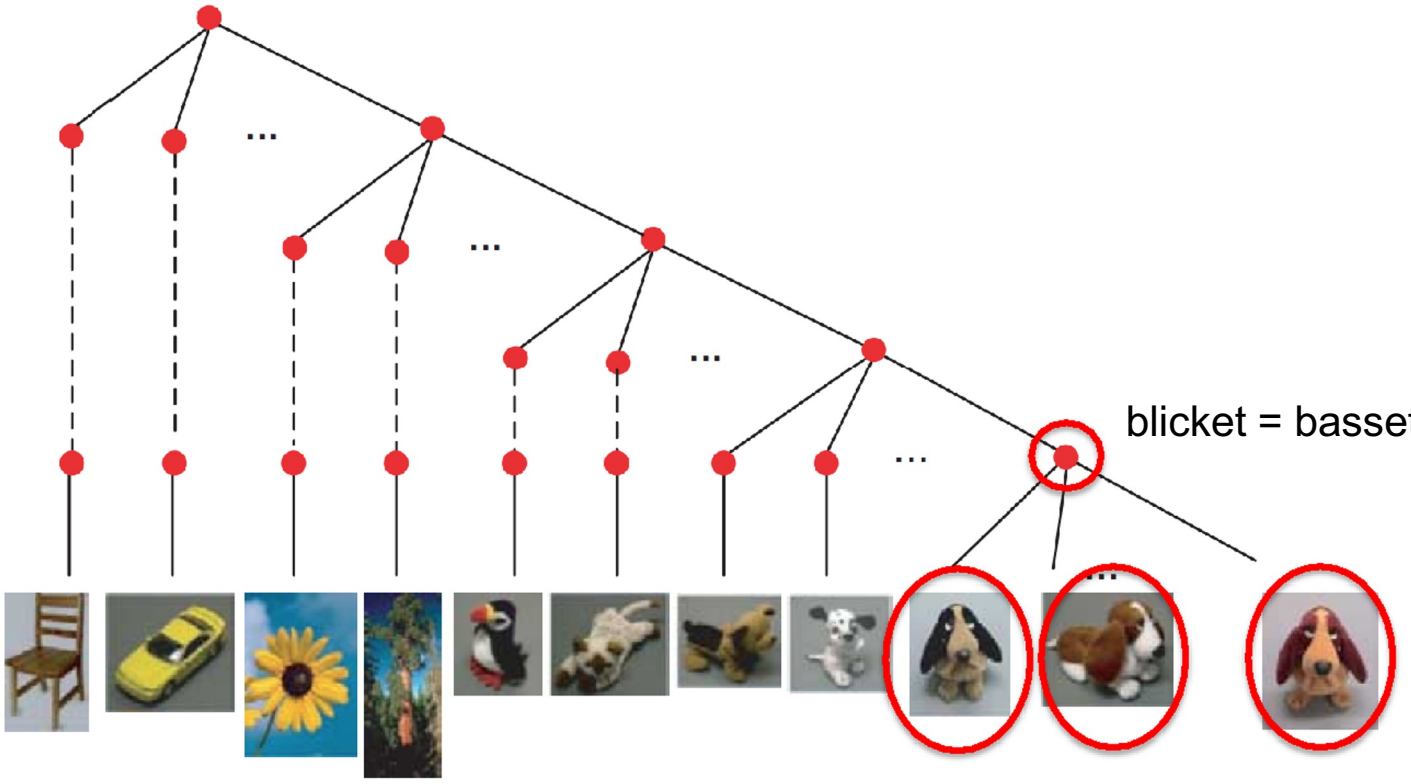
‘blue or red’

Connectedness: in children and adults



Xu & Tenenbaum, 2007

Connectedness: in children and adults



Xu & Tenenbaum, 2007

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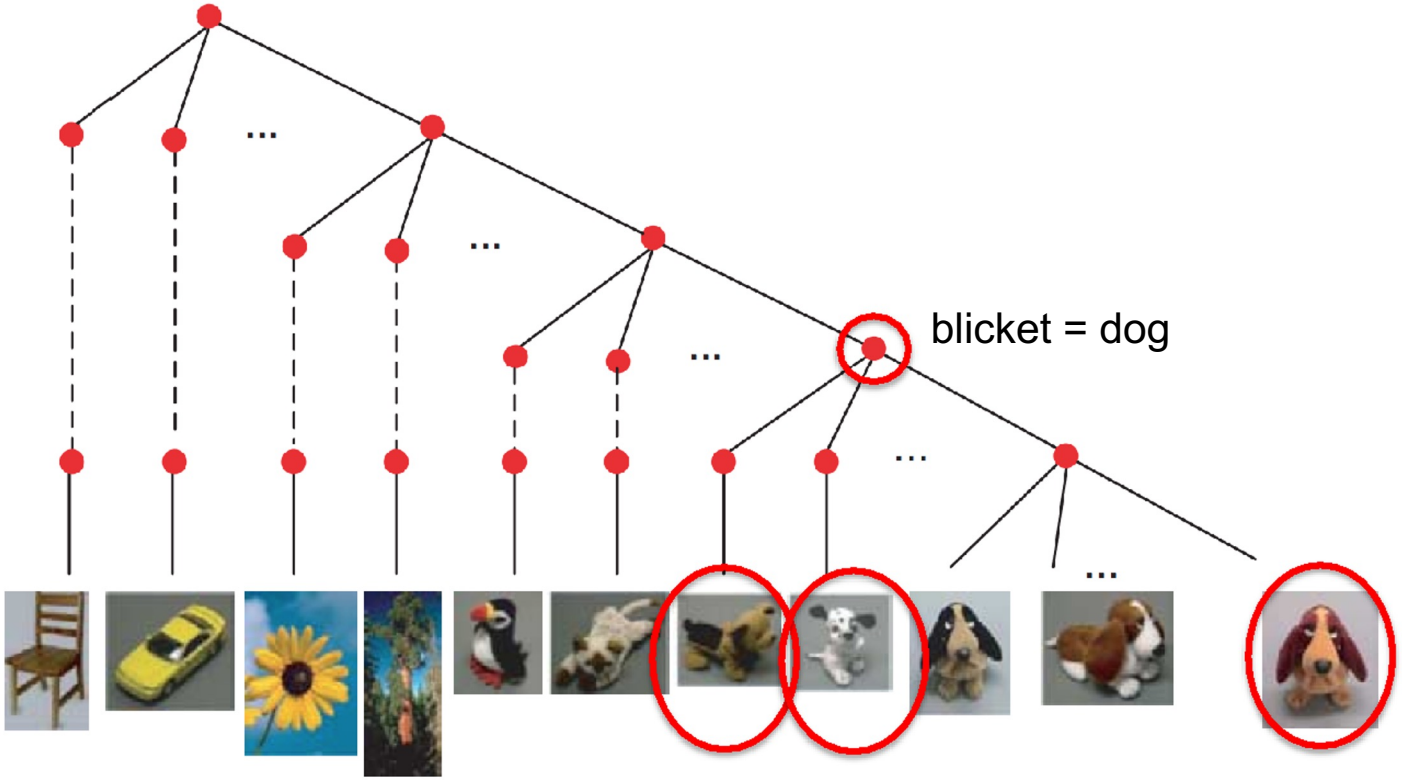

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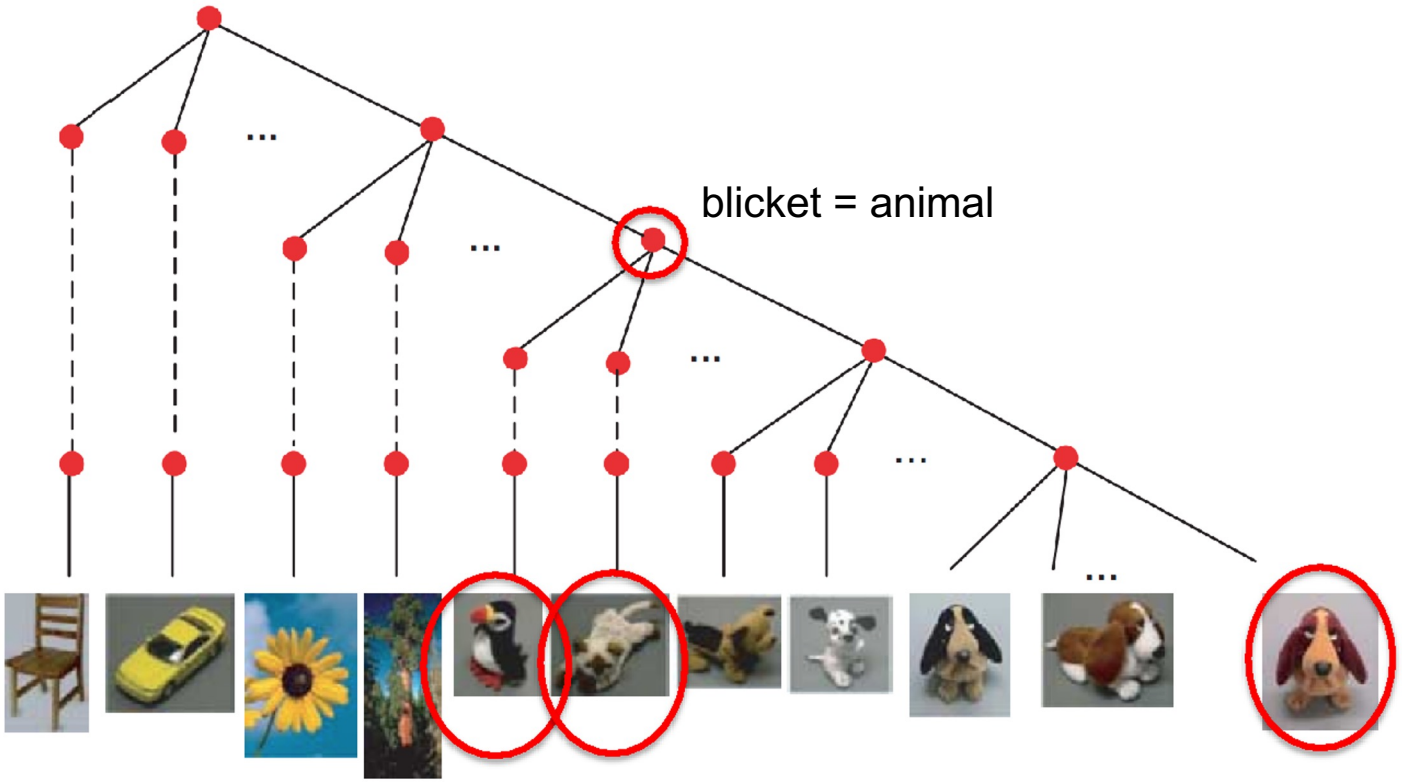
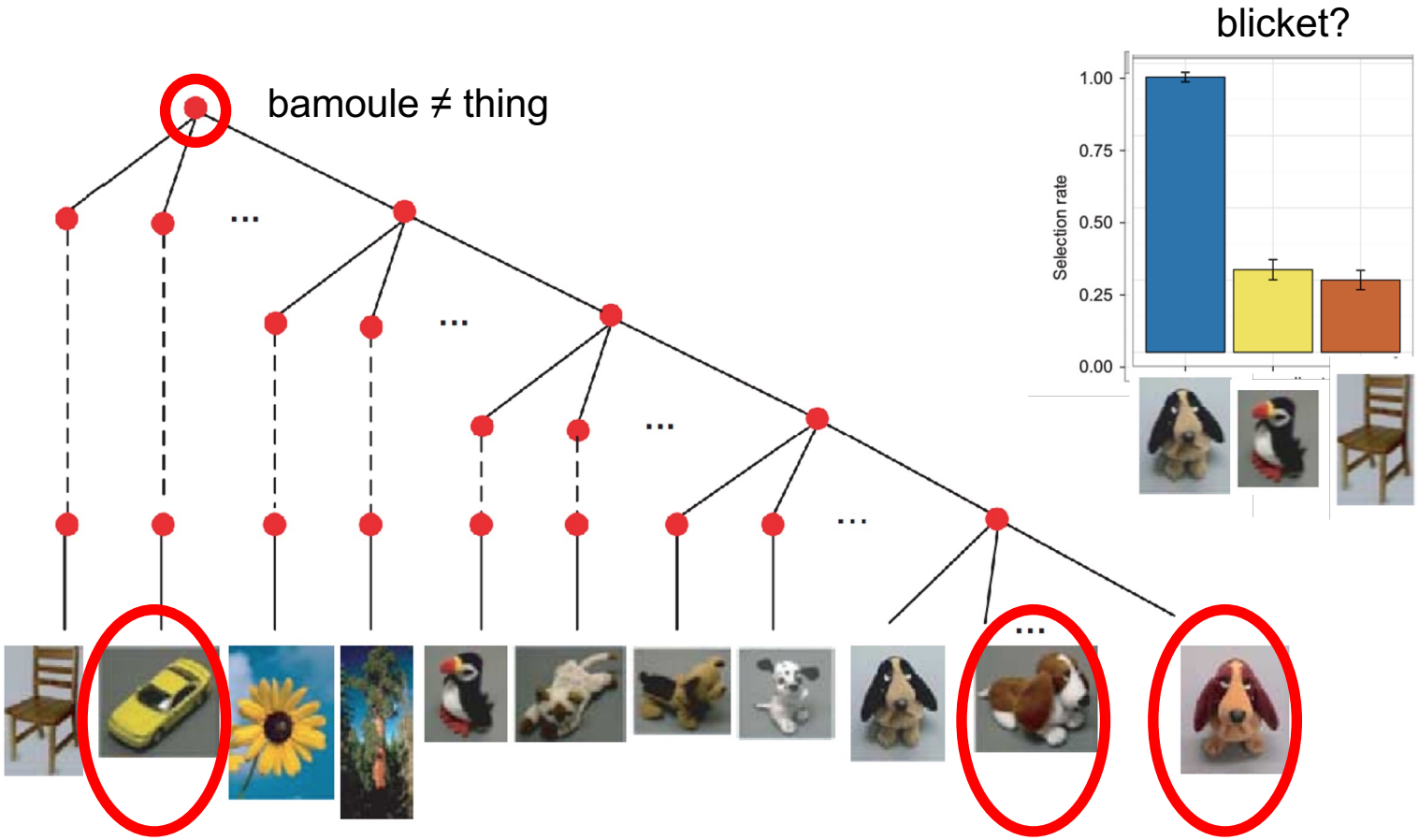
Connectedness: in children and adults



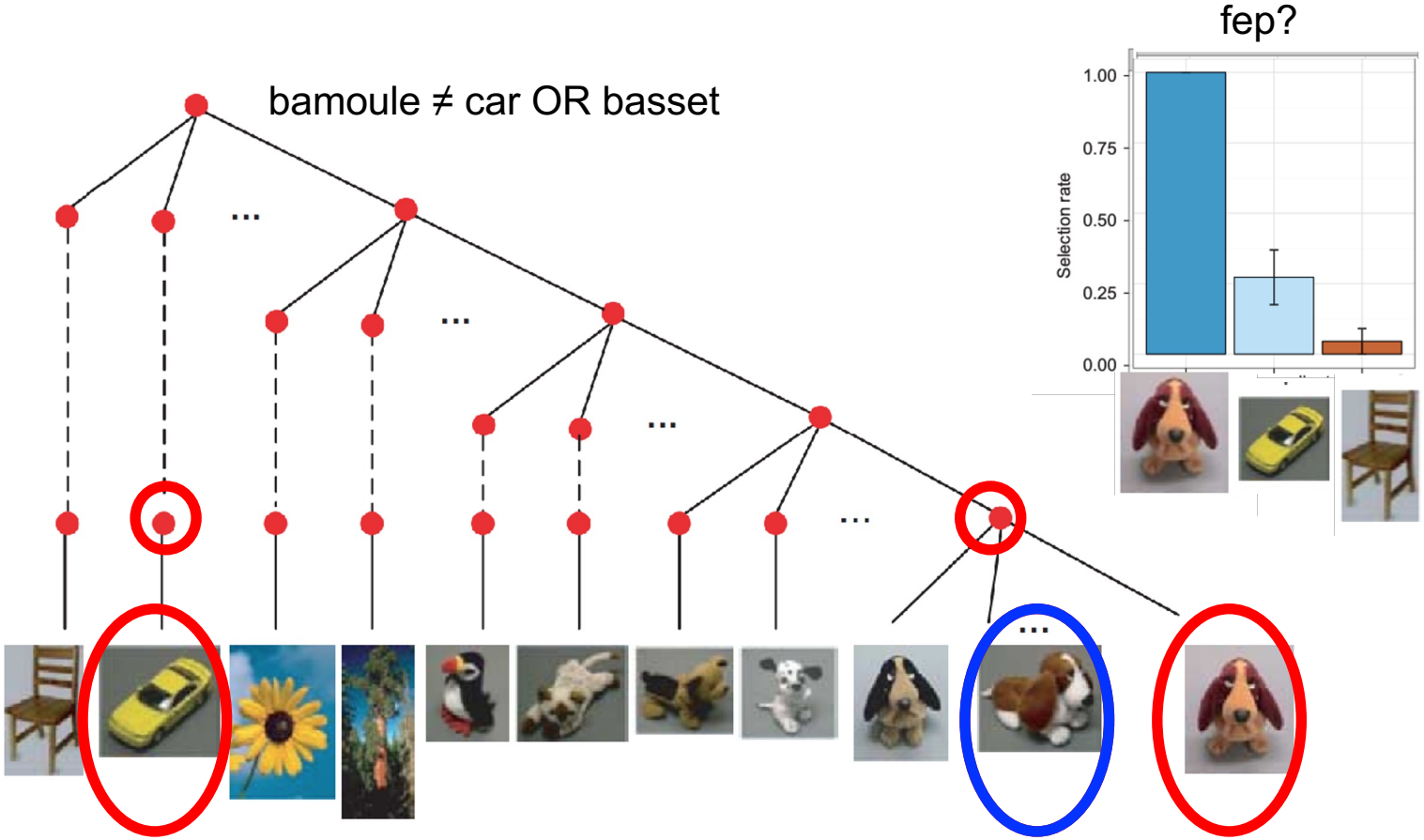
Xu & Tenenbaum, 2007

Connectedness: in children and adults



Dautriche & Chemla, 2016; Dautriche, Chemla & Christophe, 2016

Connectedness: in children and adults



Dautriche & Chemla, 2016; Dautriche, Chemla & Christophe, 2016

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Connectedness: A constraint on lexicons

Connectedness may be an active constraint during language acquisition:

→ learners would be biased to search for connected meanings

→ a bias that would translate at the level of the lexicon

Can the roots of humans' bias for connectedness be found independently of language ?

→ Focus on **non-human animals** and **logical words** (quantifiers)

Examples of connected quantifiers: more than 5, between 3 and 5

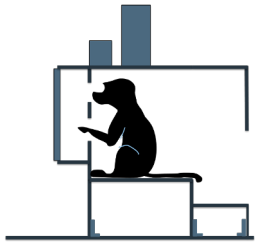
Examples of non-connected quantifiers: 3 or 7, outside of 3 and 5

Connectedness for logical words: Baboons

CNRS primate centre –Rousset

N = 25 Baboons *Papio papio*

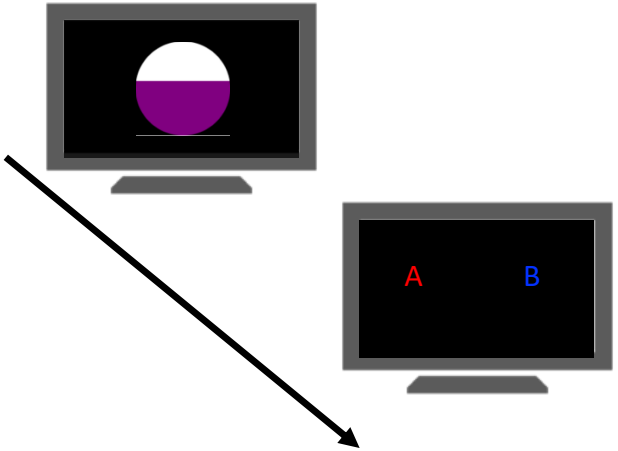
Connectedness for logical words: Baboons



Task: Learn a quantifier-like rule.

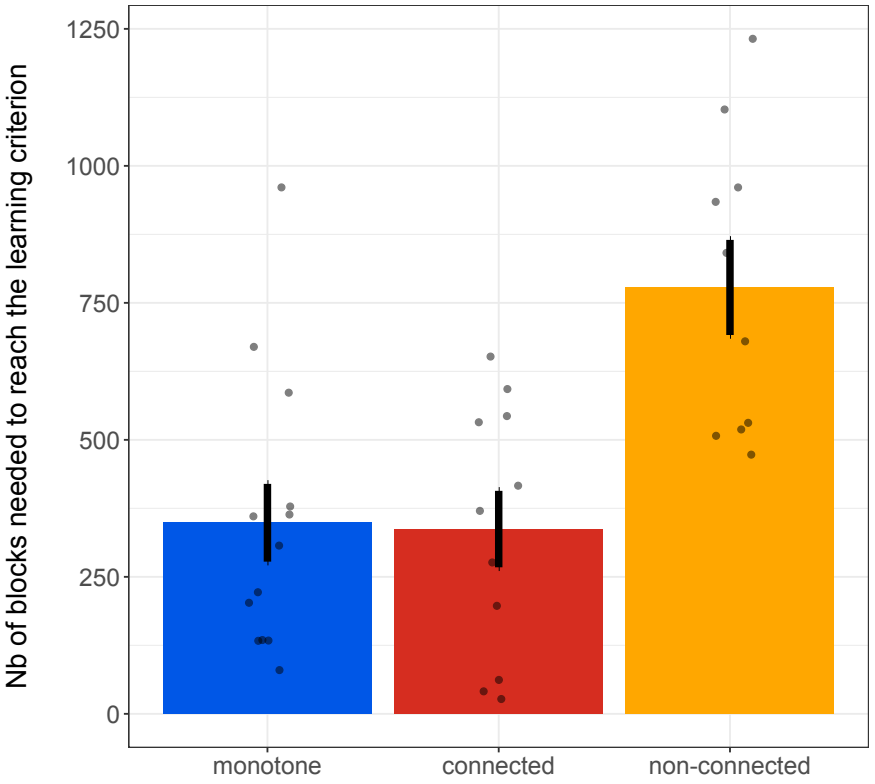
- Participants categorize each display and receive feedback
- Displays containing circles characterized by the proportion of color

	0%	20%	40%	60%	80%	100%
						
Monotone	A	A	A	B	B	B
Connected	B	B	A	A	A	B
Non-connected	B	A	A	B	B	A



Chemla, Dautriche, Buccola & Fagot, 2019

Connectedness for logical words: Baboons



N = 14

Within-subject design

Baboons find easier to learn connected patterns than nonconnected patterns

Chemla, Dautriche, Buccola & Fagot, 2019

Lexical meanings: summary

The bias for connectedness may have non-linguistic roots

Important consequences:
→ at the level of the lexicon: general constraint on meanings
→ For learning: connectedness reduces the number of hypotheses for a word
→ A (justified) prior in word learning models

Future: extend this approach to other lexical properties
→ conservativity (but see Spenader & de Villiers, 2019)

Roadmap

Evidence for the existence of cognitive foundations

1. Lexical meanings
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Evidence for the existence of cognitive foundations

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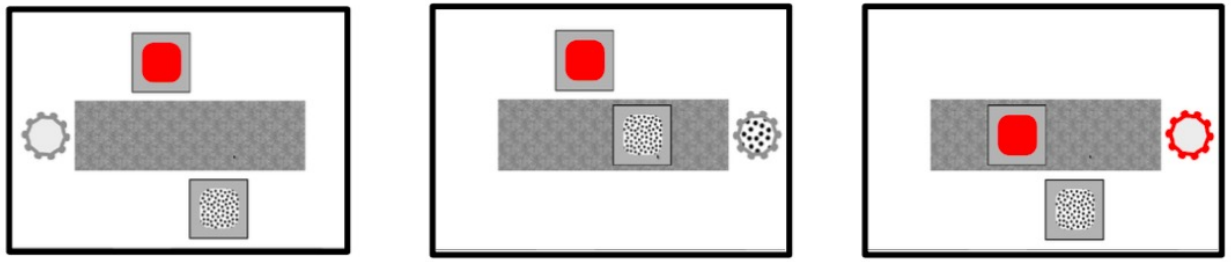
Compositionality in infancy

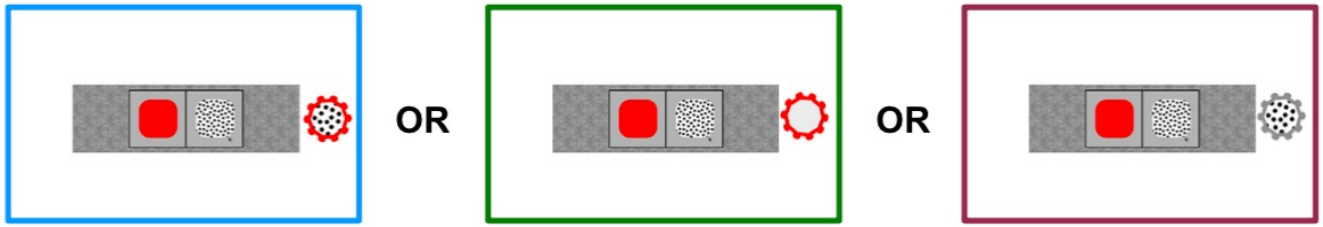
Can infants compose mental representations?

Familiarization



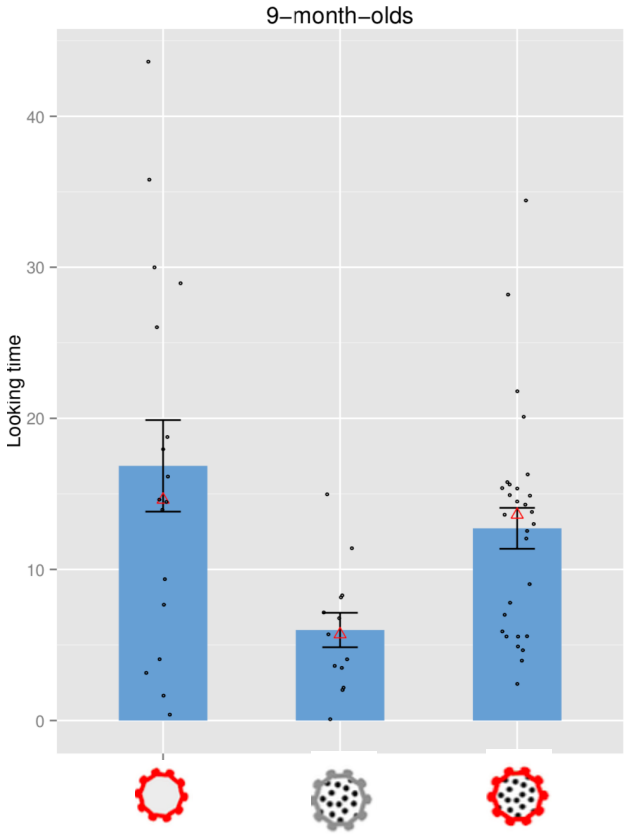
Test

Violation of expectation



Piantadosi, Palmeri & Aslin, 2019

Compositionality in infancy



Piantadosi, Palmeri & Aslin, 2019

As if 9-month-old infants expect only the second transformation to have applied

→ Computational limitations

1+1+1 fails 2+1 succeeds (Moher, Tuerk, & Feigenson, 2012, Baillargeon, Miller, & Constantino, 1994)

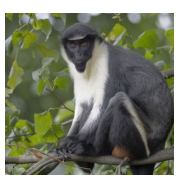
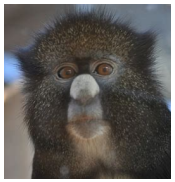
→ Computational limitation or task difficulty?

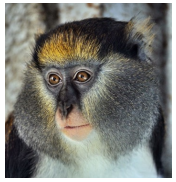
Compositionality: summary

12-month-old infants can compose mental representations

Compositionality in animals

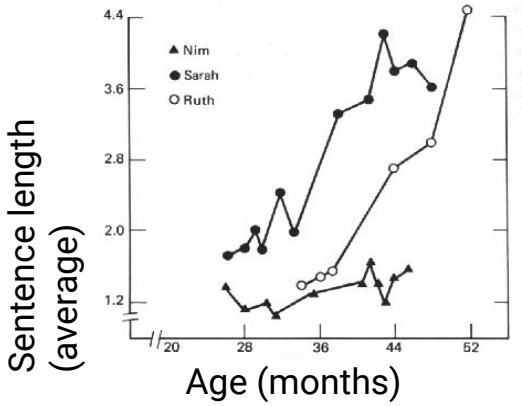
→ Compositionality in animal communication appears limited



Coye et al., 2016; Arnold and Zuberbuhler, 2008; Suzuki et al., 2016; Coye et al., 2015

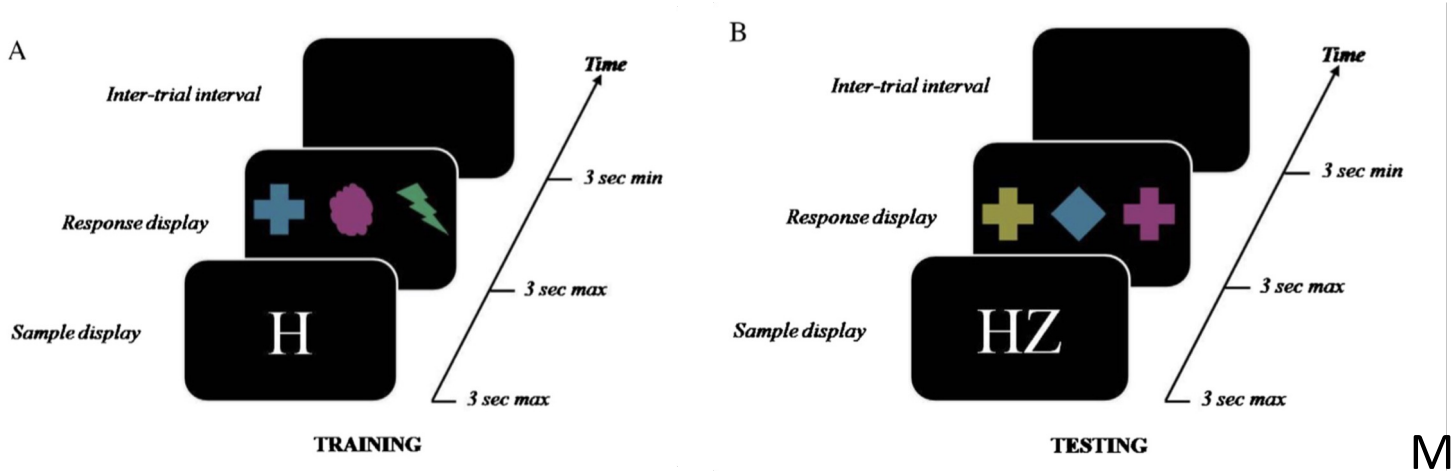
→ Compositionality in trained apes appears limited



Terrace, 1979

Compositionality in animals

→ Compositionality elsewhere appears limited



H = cross
Z = purple

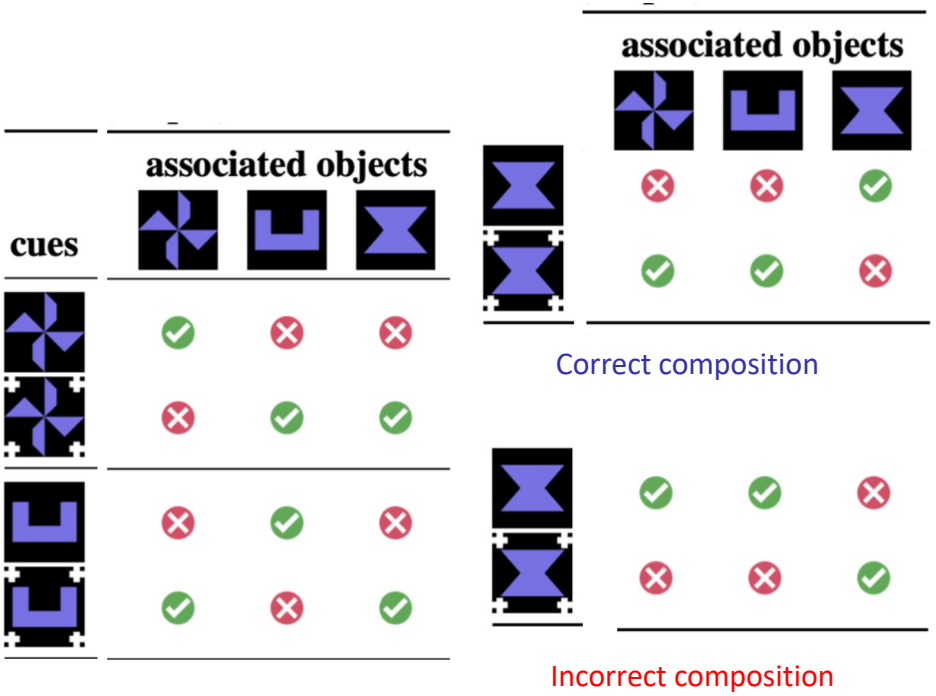
HZ = purple cross

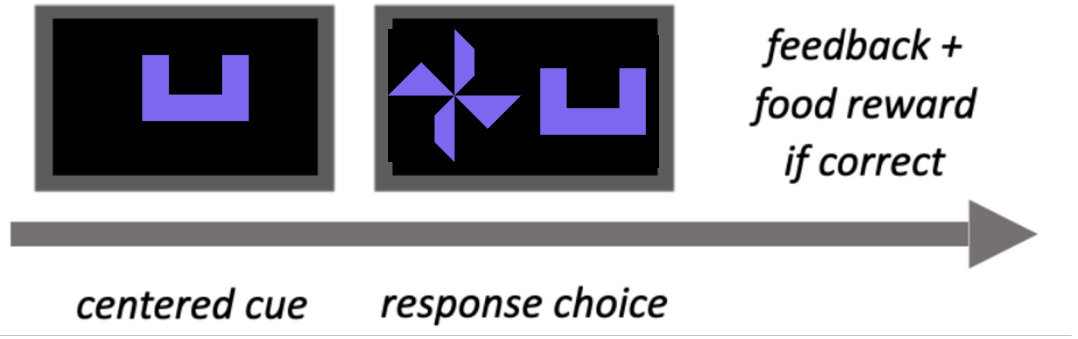
Medam & Fagot, 2016

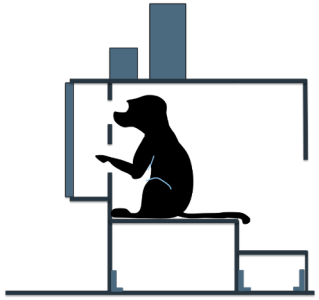
→ Task complexity or computational limitation?

Compositionality in baboons

Task: Learn cue-object associations





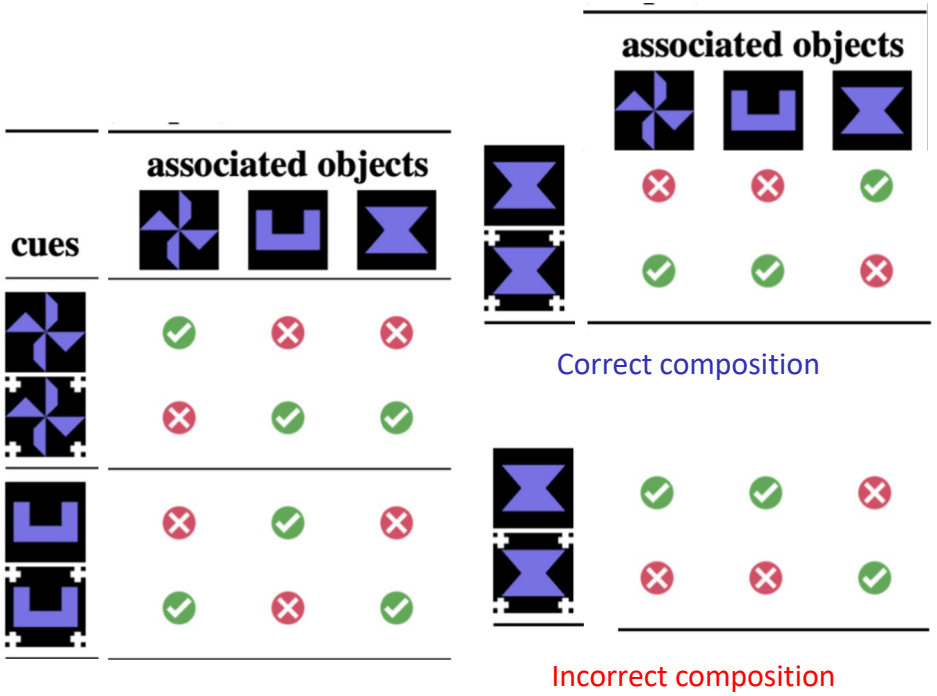


- Atomic cues
  → identity
- Compositional cues
  (atomic cue + visual “negative morpheme”)
  → complement set

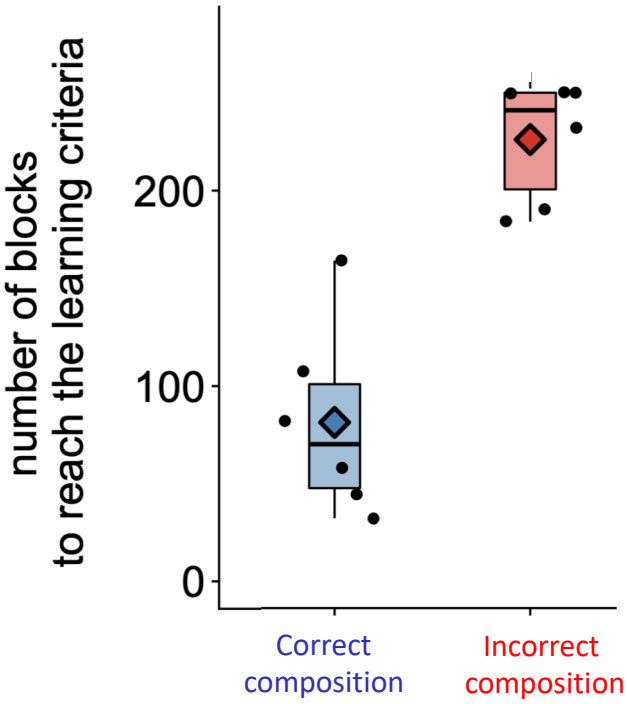
Dautriche, Buccola, Berthet, Fagot & Chemla (2022)

Compositionality in baboons

Task: Learn cue-object associations



N = 6 (within participant)



Dautriche, Buccola, Berthet, Fagot & Chemla (2022)

Compositonality: summary

9-month-old infants can compose mental representations

Baboons can respond to negation-like* operators <t, t>

Important consequences:

→ evidence that mental representations can compose in the absence of language

→ evidence is limited to a single logical connective* and to a single domain (physics)

Roadmap

Evidence for the existence of cognitive foundations

1. Lexical meanings
2. Compositionality
3. Word order

Roadmap

Evidence for the existence of conceptual preconditions

1. Lexical meanings
2. Compositionality
3. Word order

Word order

Recurrent word order patterns across languages

example: noun phrase ordering (N, Adj, Num, Dem)

English: these two purple horses

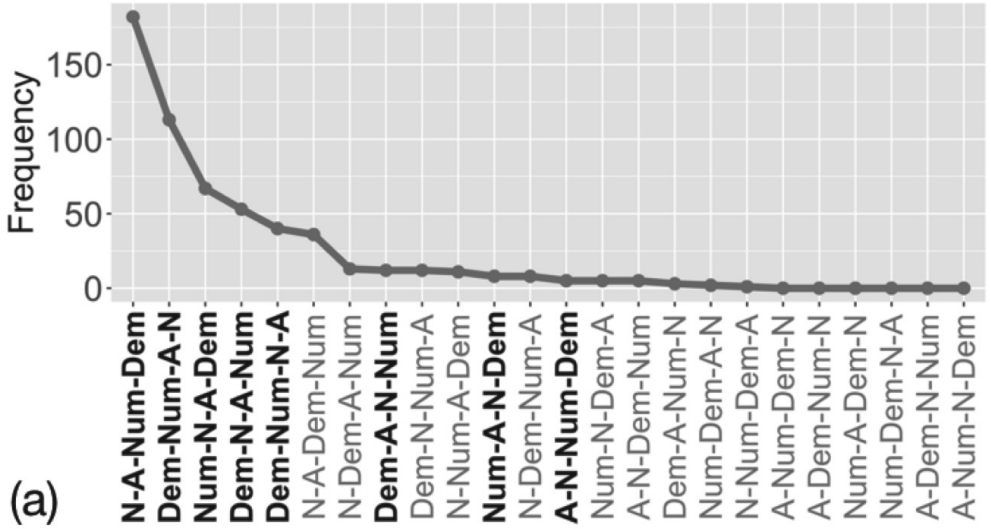
Thai: horses purple two these

Greenberg, 1963; Dryer, 2018; Culbertson et al, 2020

Word order

Recurrent word order patterns across languages

example: noun phrase ordering (N, Adj, Num, Dem)



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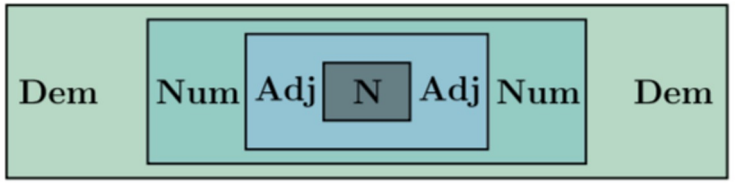


From Culbertson et al., 2020

Greenberg, 1963; Dryer, 2018; Culbertson et al,

Word order

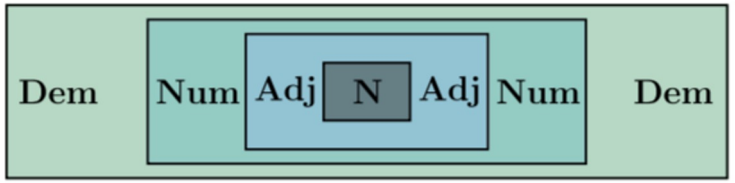
Recurrent word order patterns across languages

example: noun phrase ordering (N, Adj, Num, Dem)

Theory: a common underlying structure reflecting the order of compositional operations

Corroborating evidence

in linguistic humans



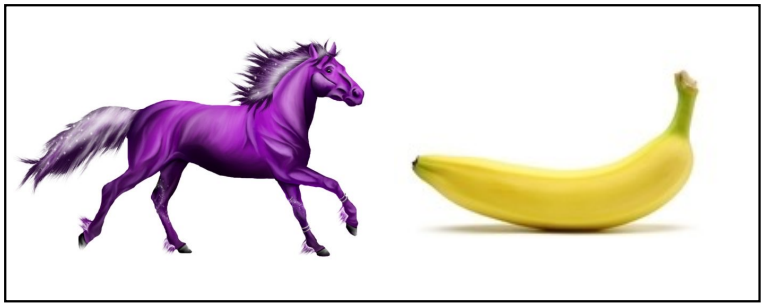
(Culbertson & Adger, 2014; Martin et al., 2019, 2020)

Word order

What is the origin of that underlying structure?

Hypothesis: ordering preferences might be detected in non-linguistic populations

A simpler (true) universal test case:



”a purple horse and a banana” -> purple-horse-banana

“un cheval violet et une banane” -> horse-purple-banana

But in *no* language: horse-banana-purple

Word order: summary

Baboons decompose objects into their features
& report their responses in a compositional order

Important consequences:
→ This suggests a natural syntax of concepts rooted in non-linguistic mental representations
→ More evidence for compositionality

Future work: Getting closer to NP ordering

Word order: agent-patient

Word order	English equivalent	Proportion of languages
SOV	"She him loves."	45%
SVO	"She loves him."	42%
VSO	"Loves she him."	9%
VOS	"Loves him she."	3%
OVS	"Him loves she."	1%
OSV	"Him she loves."	0%

Wikipedia from Russel, 2009

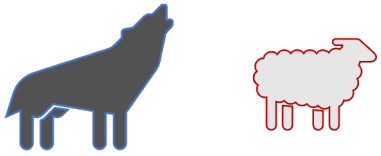
Languages tend to describe who is doing what to whom by placing agents before patients (99% of languages are SO)

A natural semantic organization of events?

Human adults tend to place agents before patients in non-verbal descriptions

Goldin-Meadow *et al.*, 2008

…that may come from attentional preferences



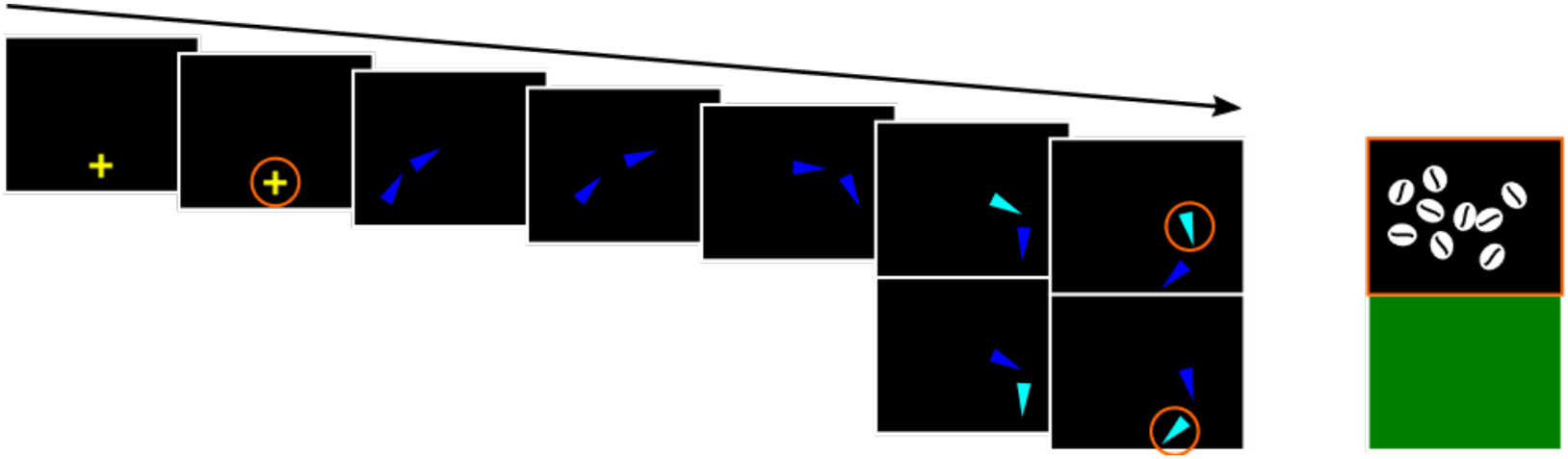
Rochat et al., 2004; Meyerhoff et al., 2014, Yin & Csibra, 2015; Galazka & Nyström, 2016; Galazka et al., 2016

Word order: agent-patient

Floor Meewis

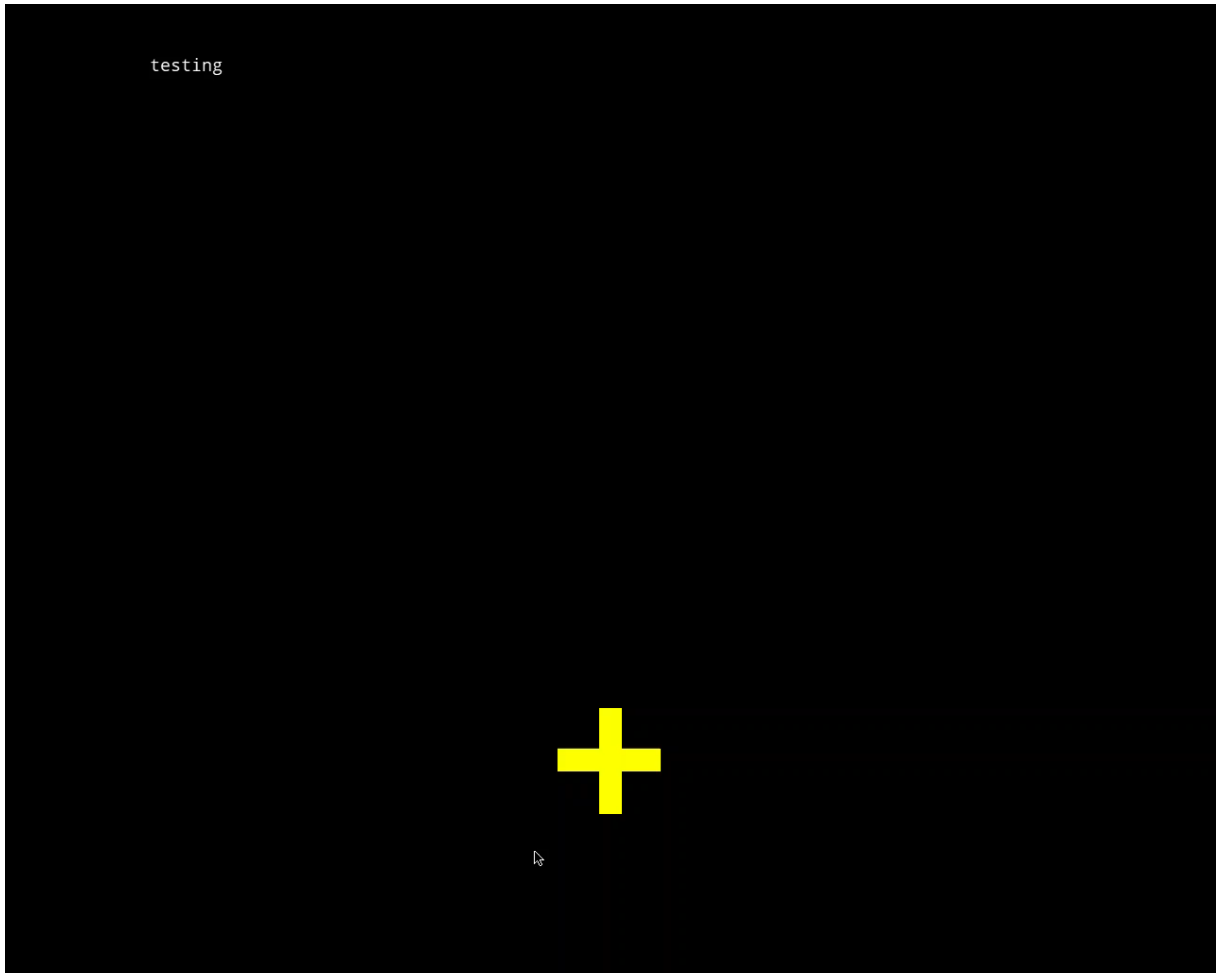
Task: change detection paradigm

Detect and tap the object that changed colour, measure the response time



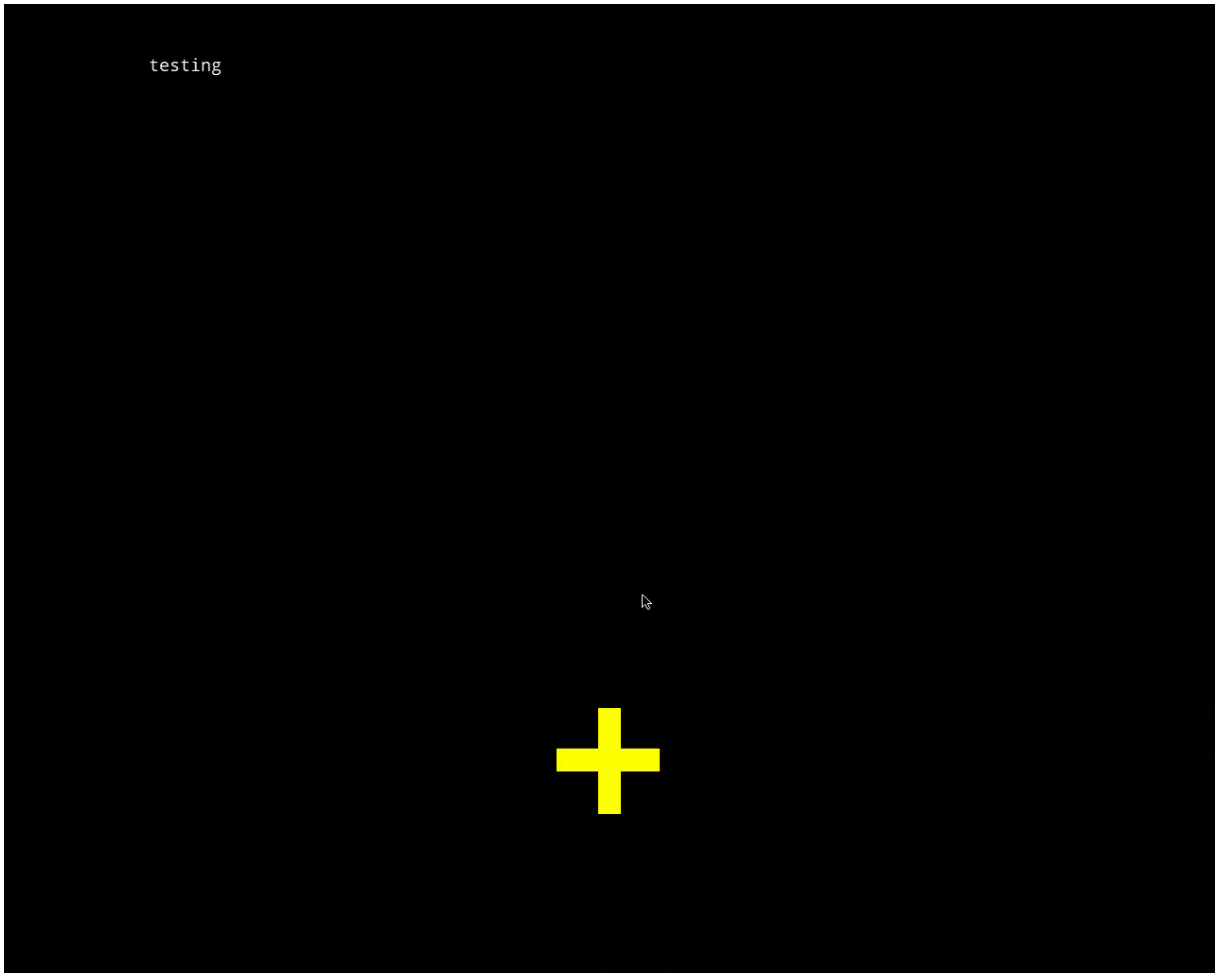
Chasing

Object 1 = chasee = patient
Object 2 = chaser = agent



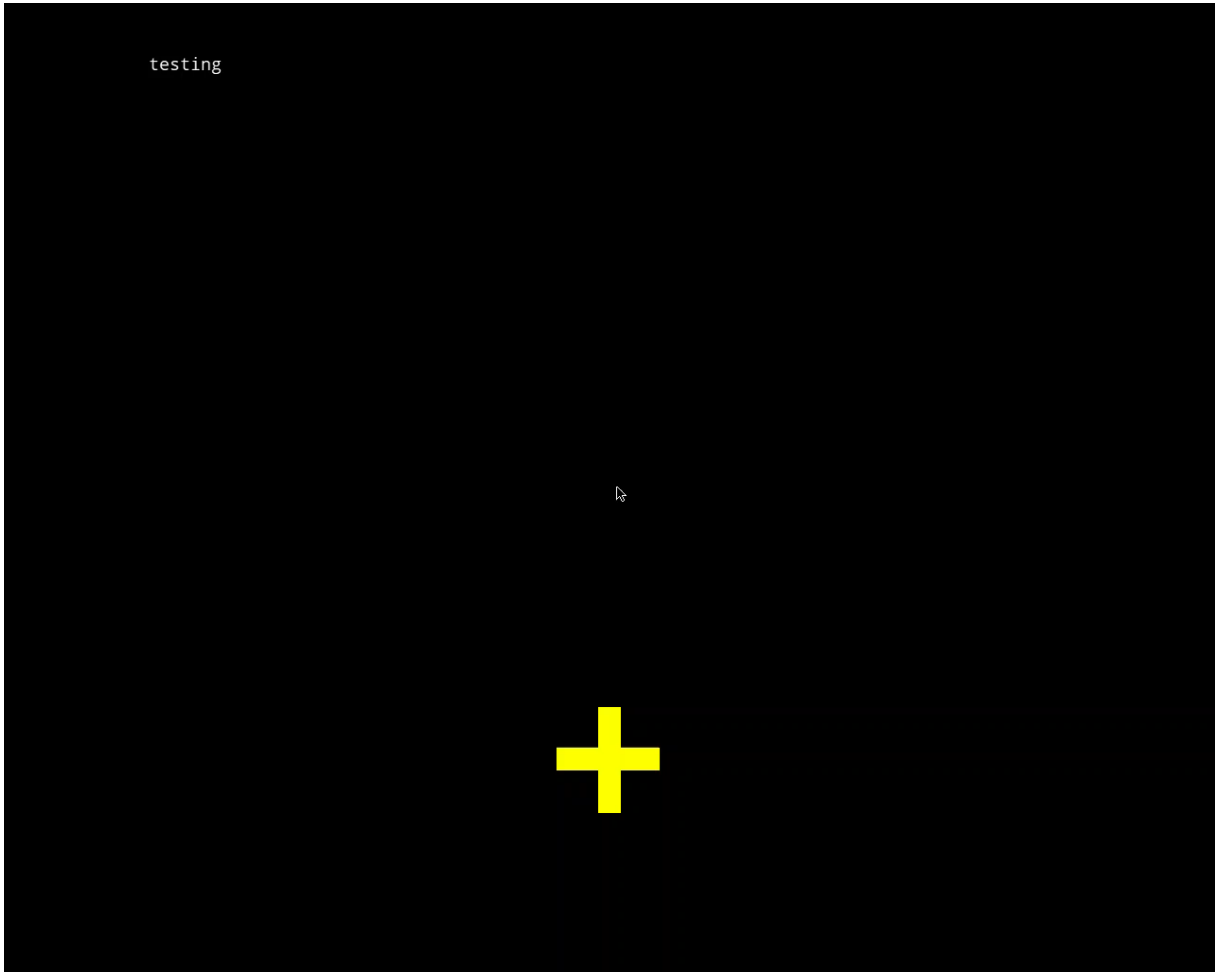
Control: No interaction

Object 1 = “chasee-like”
Object 2 = “chaser-like”



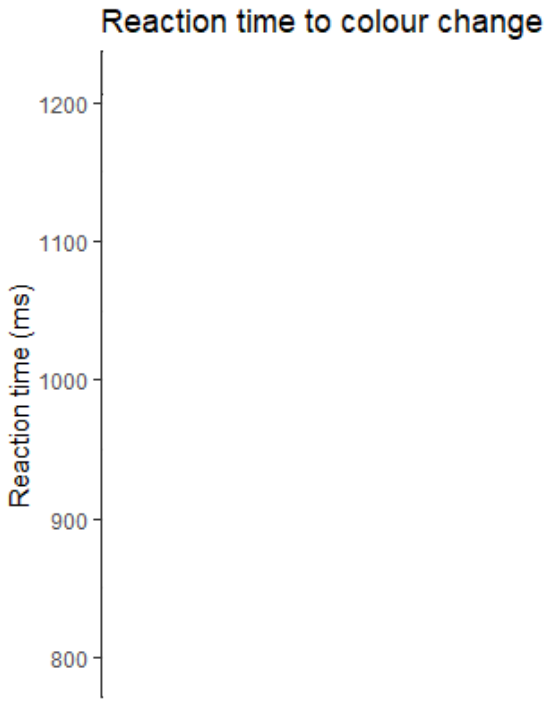
Control: Following

Object 1 = leader = agent
Object 2 = follower = patient



Word order: agent-patient

N = 13



Agent-patient: summary

Baboons show an agent preference in chasing interactions

Important consequences:

→ similar attentional preferences in humans and baboons

→ beyond chasing?

→ from attention to representation?

Future work:

→ How much of language/word order patterns could come from non-linguistic event representation?

Gleitman, 1990
Slobin 1973
Wilson, Zuberbuhler & Bickel, 2022

General summary

Why do languages look the way they are?

1. **Lexical meanings**

Baboons manipulate 'concepts' of the same shape as ours (i.e., connected)

2. **Compositionality**

Infants can compose mental representations

Baboons can respond to negation-like operators <t, t>

3. **Word order**

Baboons report responses in a "compositional" manner (adj-N)

Baboons shows an agent bias consistent with the prevalent SO order

General summary

Why do languages look the way they are?

→ Some properties of language may stem from attentional and perceptual processes and the mental representations that result from them (connectedness, compositionality, word order)

→ Sure, not *all* of language may be found in other species but the question is ***how much*** of language

→ Comparative approach: a necessary step in order to understand the evolution of the language capacity

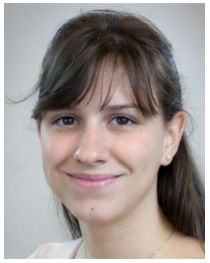
Thank you!

Joint work with:

Emmanuel Chemla

Joel Fagot

Nicolas Claidière



Melissa Berthet

Brian Buccola

Jennifer Culbertson

Floor Meewis