

Origins and Evolution of Language

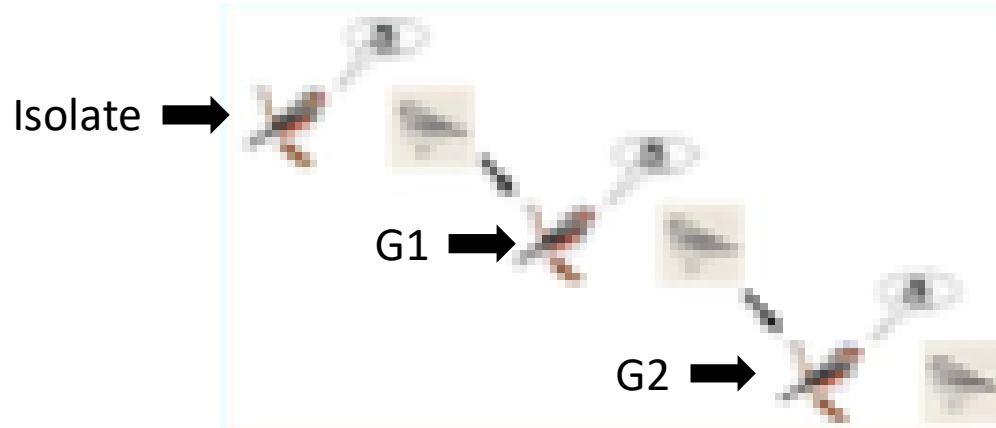
Week 7: (Grammar learning and then)

The evolution of social cognition

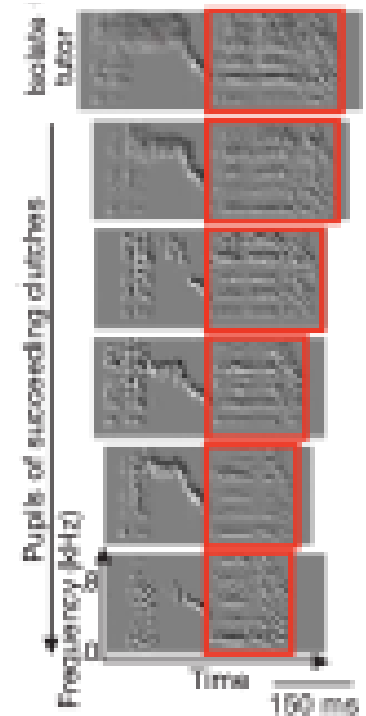
Kenny Smith

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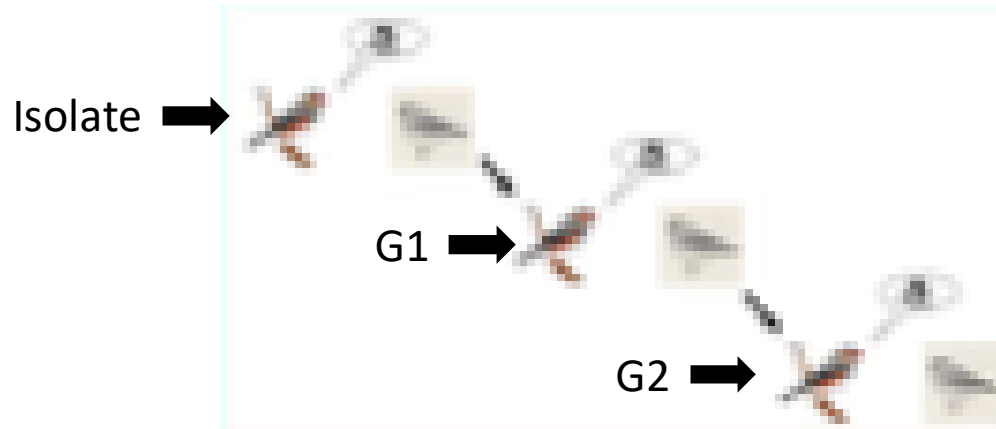
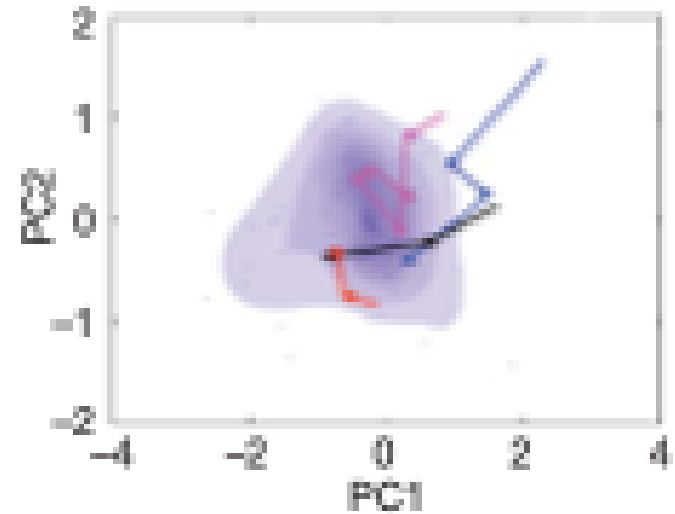
Follow-up from last week's tutorial: iterated learning in zebra finches



Fehér, O., Wang, H., Saar, S., Mitra, P. P., & Tchernichovski, O. (2009). De novo establishment of wild-type song culture in the zebra finch. *Nature*, 459, 564–568.



Follow-up from last week's tutorial: iterated learning in zebra finches



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Plan for today

- Grammar learning from last week
 - And a reminder of where we are and where we are going
- Mind-reading and language
 - Ostensive-inferential communication
 - Knowing what others know
 - Mind-reading in word learning
 - The evolution of mind-reading

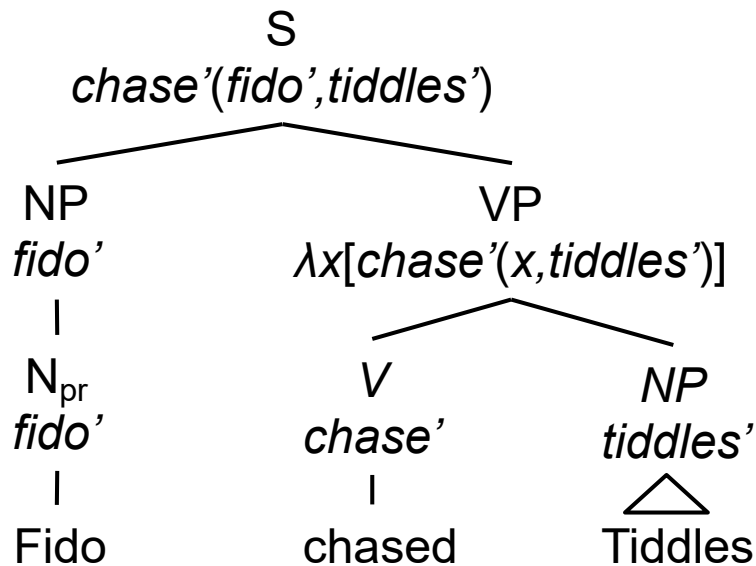
Grammar learning

See also this week's tutorial

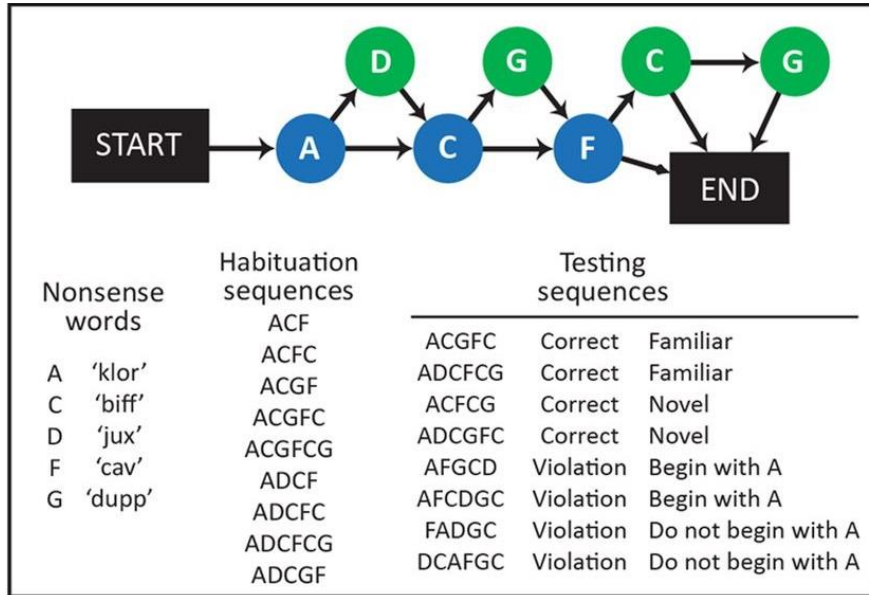
Reminder: Language's communicative power comes from its **structure**

Compositionality: the meaning of an expression is a function of the meaning of its parts and the way in which they are combined

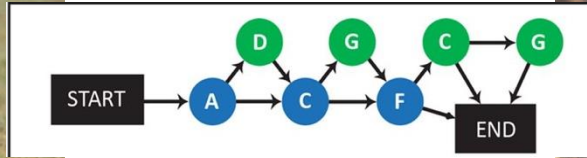
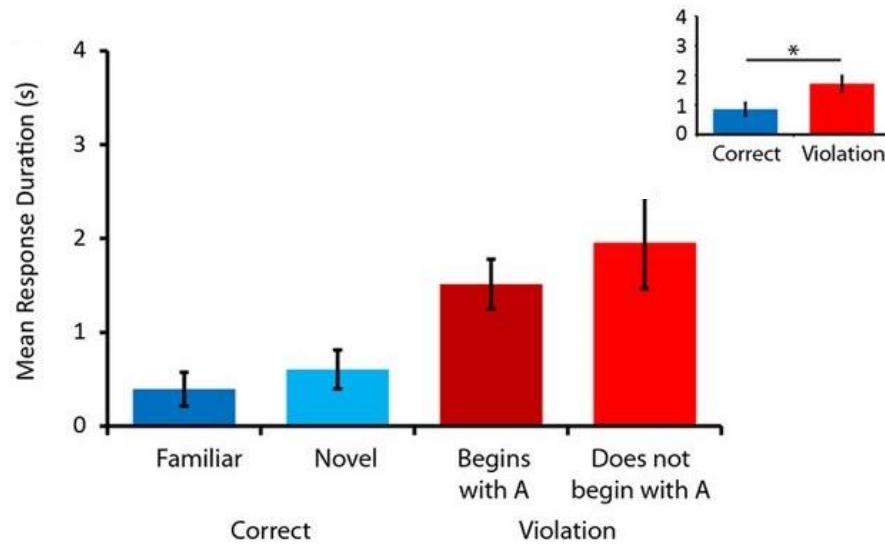
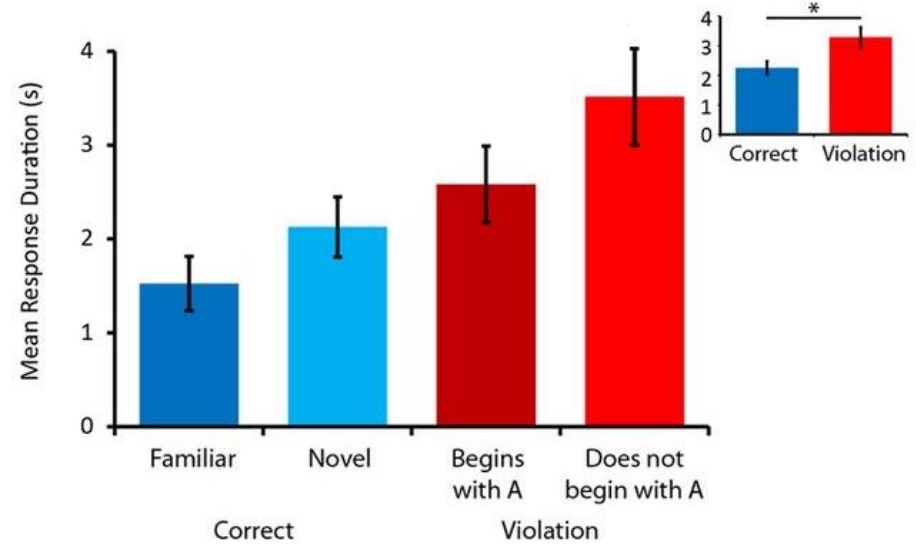
$S \rightarrow NP VP$	$VP'(NP')$
$NP \rightarrow N_{pr}$	N'_{pr}
$N_{pr} \rightarrow \text{Fido}$	$fido'$
$N_{pr} \rightarrow \text{Tiddles}$	$tiddles'$
$VP \rightarrow V NP$	$V'(NP')$
$V \rightarrow \text{chased}$	$\lambda x [\lambda y [(chase'(x,y))]]$



Artificial Grammar Learning in non-humans



Wilson, B., Slater, H., Kikuchi, Y., Milne, A., Marslen-Wilson, W., Smith, K., & Petkov, C. (2013). Auditory artificial grammar learning in macaque and marmoset monkeys. *Journal of Neuroscience*, 33, 18825-18835.
 For review see e.g. Petkov, C. I., & Ten Cate, C. (2020). Structured Sequence Learning: Animal Abilities, Cognitive Operations, and Language Evolution. *Topics in Cognitive Science*, 12, 828– 842.

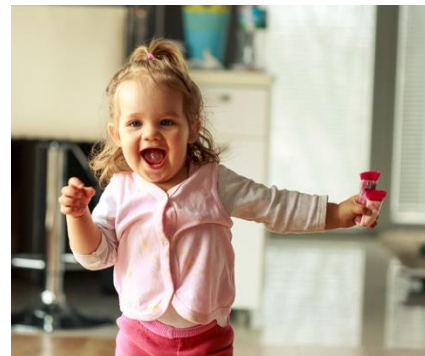


Wilson, B., Slater, H., Kikuchi, Y., Milne, A., Marslen-Wilson, W., Smith, K., & Petkov, C. (2013). Auditory artificial grammar learning in macaque and marmoset monkeys. *Journal of Neuroscience*, 33, 18825-18835.

Non-adjacent dependency learning

Training

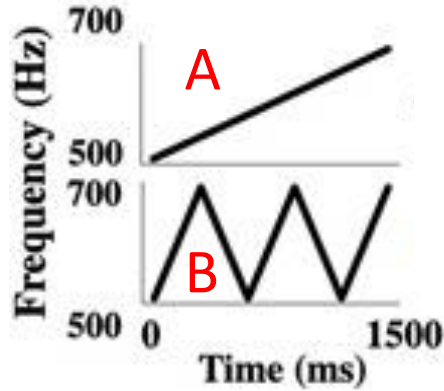
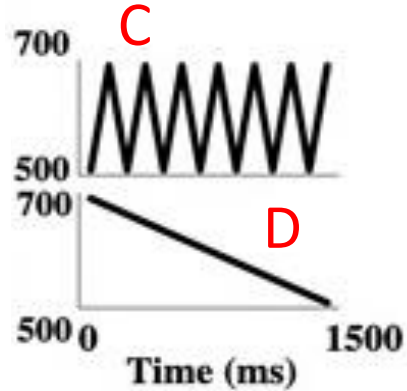
pel wadim rud... vot kicey jic... pel feenam rud...
vot wadim jic... vot puser jic... pel puser rud...
vot kicey jic... vot skiger jic... pel kicey rud ...



Test

pel wadim rud
pel wadim jic?
vot wadim jic
vot wadim rud?

Non-adjacent dependency learning



Non-adjacent dependency learning

Sequence type Example AD Example Non-AD

Familiarization

$A_1 - B_7$

$A_1 - X_{24} - B_7$

$C_5 - D_1$

$C_5 - X_{11} - D_1$

Generalization

$A_{13} - B_{11}$

$A_{13} - X_{115} - B_{11}$

$C_{10} - D_{16}$

$C_{10} - X_{214} - D_{16}$

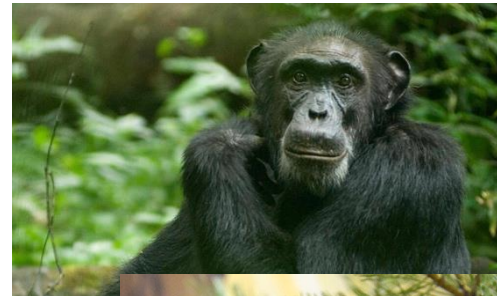
Violation

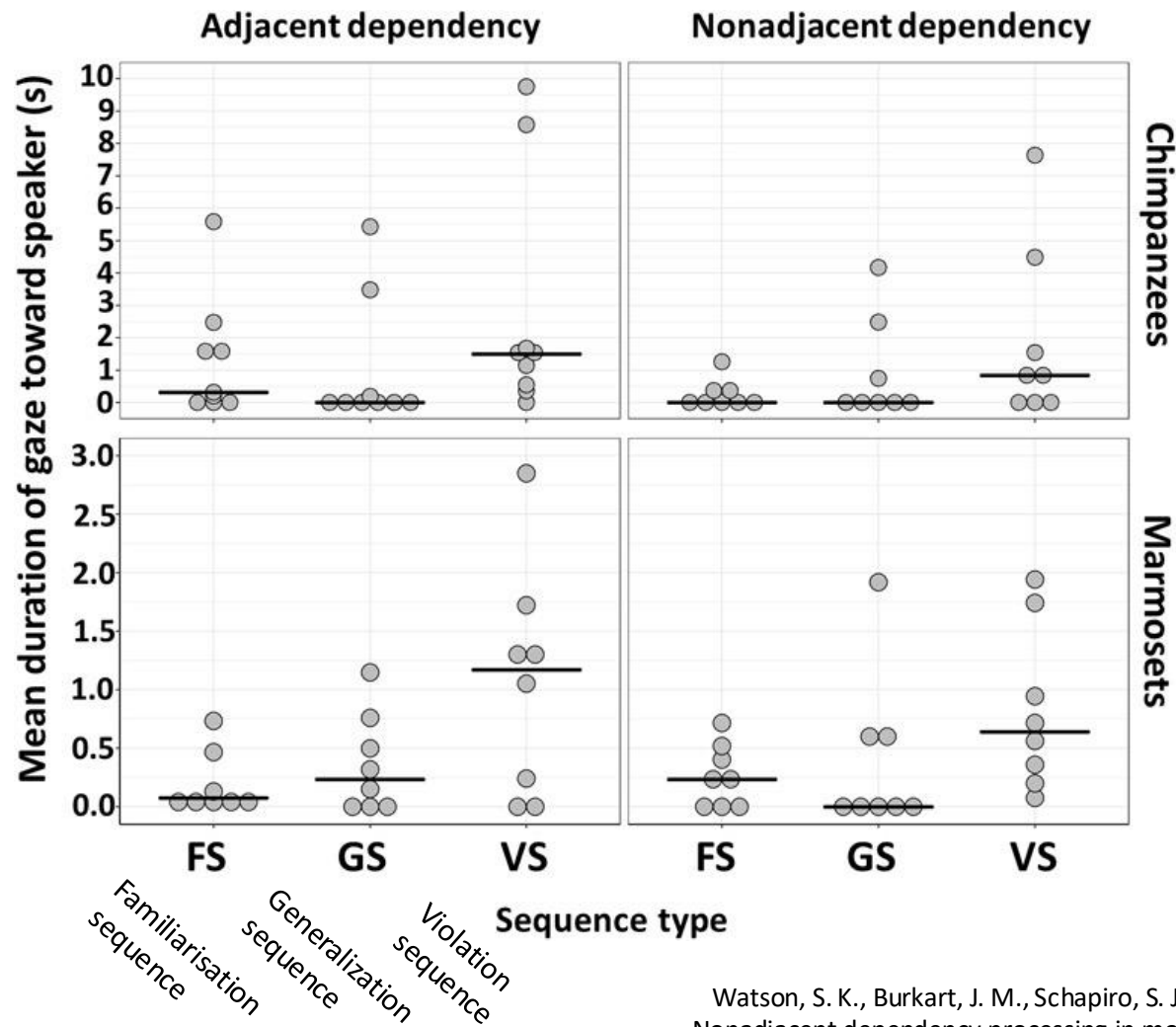
$A_{13} - D_{11}$

$A_{13} - X_{115} - D_{11}$

$C_{10} - B_{16}$

$C_{10} - X_{214} - B_{16}$





How about learning of **meaningful** sequences?



“ball fetch”
“stick point”

Ramos, D., & Ades, C. (2012). Two-item sentence comprehension by a dog (*Canis familiaris*). *PLoS ONE*, 7, e29689.



“to sugar take decoy”
“to decoy take sugar”

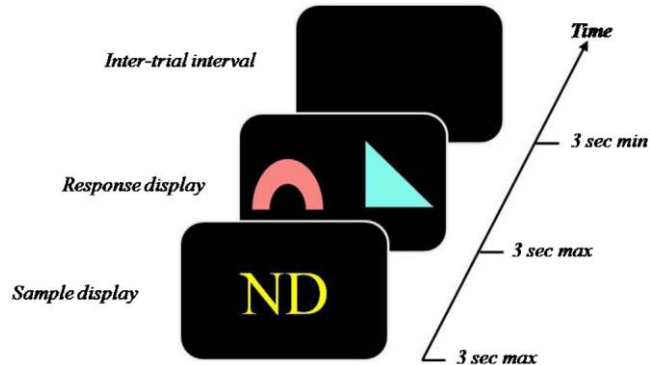
Pilley, J. W. (2013). Border collie comprehends sentences containing a prepositional object, verb, and direct object. *Learning and Motivation*, 44, 229-240.

[Chaser in action: <https://www.youtube.com/watch?v=omaHv5sxIFI>]

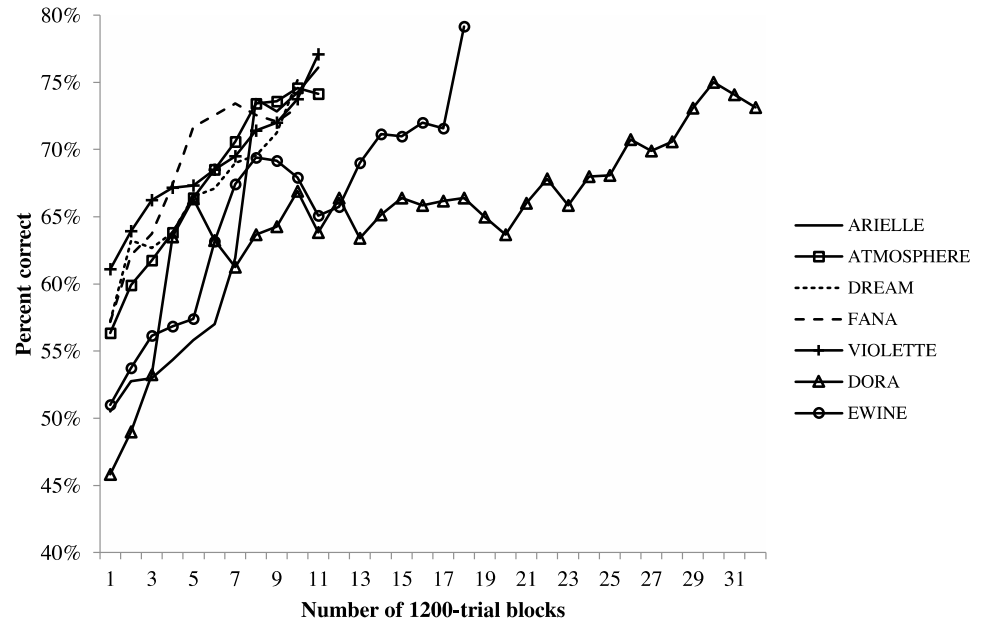
<https://youtu.be/2Dhc2zePJFE>

Savage-Rumbaugh, E. S., Murphy, J., Sevcik, R., Brakke, K., Williams, S., Rumbaugh, D., & Bates, E. (1993). Language comprehension in ape and child. *Monographs of the Society for Research in Child Development*, 58, 1–252.

Puzzling failures in (most) baboons



6 letters (3 for shapes, 3 for colours)
3 shapes, 3 colours



Medam, T., & Fagot, J. (2016). Behavioral assessment of combinatorial semantics in baboons (*Papio papio*). *Behavior Processes*, 123, 54-62.

How about **production** of meaningful sequences?

Chase bite
 Chase Kanzi
 Person(g) come(g)
 Tickle ball
 Bite person(g)
 Come(g) chase(g)
 Ball tickle
 Chase Sue
 Kanzi chase
 Surprise money
 Bite chase
 Pat(g) person(g)
 Kanzi grab
 Grab person(g)
 Chase bite
 Pat(g) this(g)
 Chase come(g)
 Person(g) go(g)
 Ball pat(g)
 Person(g) bite
 Chase tickle

le 3

Comparison of Most Frequent Comb

Kanzi

2 items

Chase person 1(g) per
 Person 1(g) pat(g) per
 Person 1(g) person 2(g)

Chase person(g)
 Person(g) chase(g)
 Chase(g) Person(g)
 Person(g) pat(g)
 Chase bite
 Chase Kanzi
 Person(g) come(g)
 Tickle ball
 Bite person(g)
 Come(g) chase(g)



A man with glasses and a dark shirt is looking down at a laptop screen. The background is a plain, light-colored wall. The text "She answers with gesture and vocalization" is overlaid on the image.

She answers with gesture and
vocalization

Copyright 2006 Dr. Sue Savage-Rumbaugh

<https://www.youtube.com/watch?v=UfHWTFlqEUE>





Summary on grammar learning

Artificial Grammar Learning suggests abilities to learn sequence constraints are present in other animals (including other primates)

- Grammars tested to date are quite simple
- Interpretation can be contentious

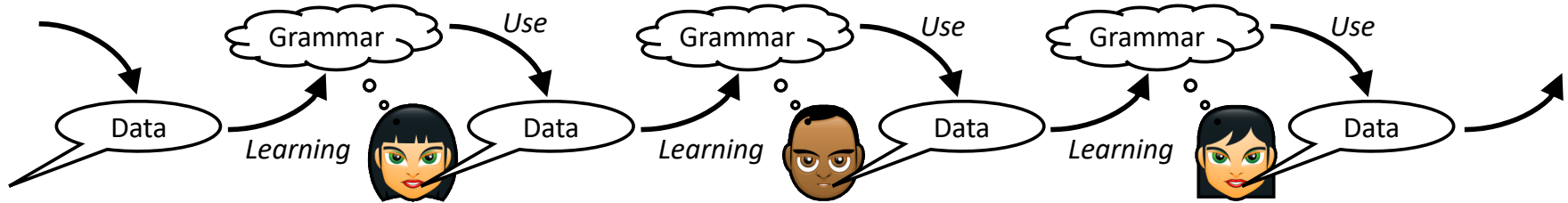
Language-trained animals can interpret complex (i.e. multi-part) expressions

- But larger-N lab studies surprisingly scarce, and these tasks seem to be hard

Humans are not unique in our ability to process meaningful sequences

- **But we may be uniquely proficient**

Reminder: Learning, use, and language design



- Language is passed from person to person by **learning**
- People learn from language as it is **used in communication**
- Language **evolves** in response to its learning and use

Reminder: the working hypothesis

- Humans ended up with an unusual combination of traits: ubiquitous social learning (including capacity for vocal learning and grammar learning) and **deep mental interpenetration**
- This set in place a cultural evolutionary process that shaped how language works

The Evolution of Social Cognition

Social cognition and language

Humans are unusual

- in our drive to share our mental states
- in our aptitude for reasoning about mental states in others



Mitteilungsbedürfnis: A need
to share thoughts or feelings

Mitteilungsbedürfnis in non-human animals: the only recorded example

Wild chimpanzee 'holdout'/'show' gesture

Wilke, C., Lahiff, N.J., Sabbi, K.H., Watts, D.P., Townsend, S.W., & Slocombe, K.E. (2022). Declarative referential gesturing in a wild chimpanzee (*Pan troglodytes*), *PNAS*, *119*, e2206486119. <https://doi.org/10.1073/pnas.2206486119>.

Learning language involves inferring mental states of others

“Doggy” = ?

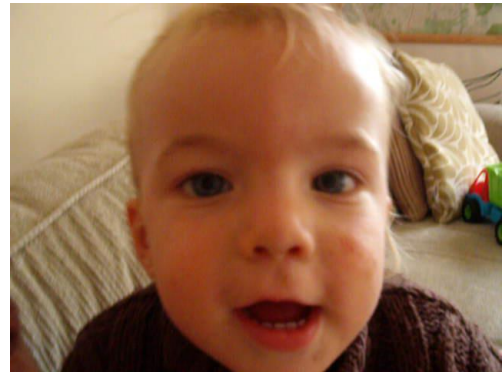
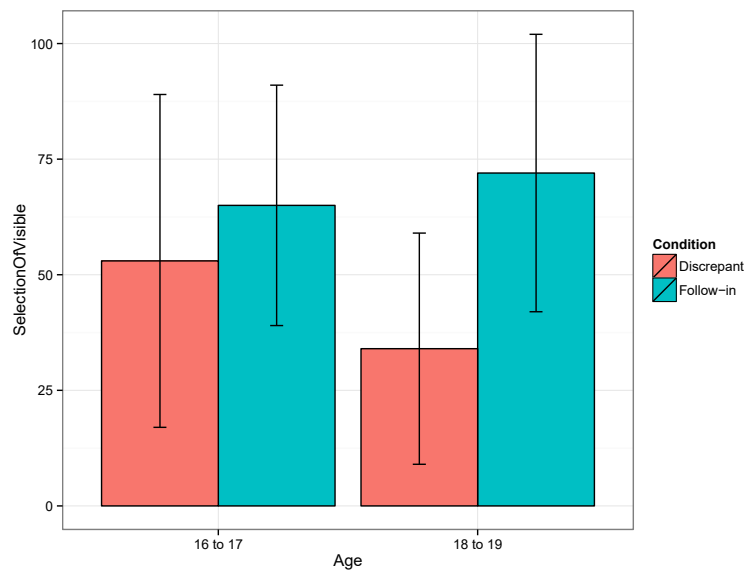
Look at the **doggy**!



Exploiting attentional focus

Word learning, 16-19 month olds

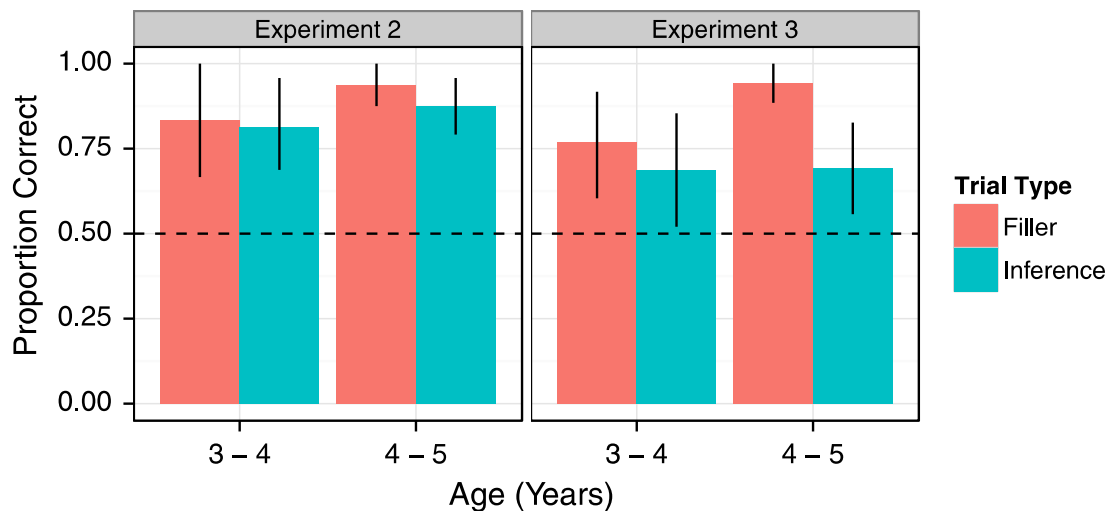
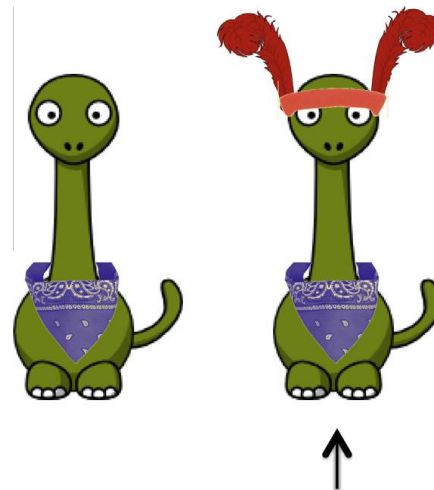
- Kid, experimenter, bucket, two novel objects
- Kid sees both toys, plays with one, other one goes back in the bucket
- Follow-in labelling: experimenter looks at toy kid is looking at and labels it (“it’s a toma!”)
- **Discrepant** labelling: experimenter looks at toy in bucket and labels it (“it’s a toma!”)



Baldwin, D. A. (1991). Infants' contribution to the achievement of joint reference. *Child Development*, 62, 875–890.

Expectations about how people use words

Do children assume that people use words in an informative way?



“This is a dinosaur with a dax” (Exp 2)
“Here is a dinosaur with a dax” (Exp 3)

Frank, M. C., & Goodman, N. D. (2014). Inferring word meanings by assuming that speakers are informative. *Cognitive Psychology*, 75, 80-96.

Using language involves inferring mental states of others (ostensive-inferential communication)

Speaker's utterances (or other communicative behaviours)

- provide evidence about their thoughts
- are designed to allow the hearer to infer those thoughts

Hearers infer meaning, guided by the knowledge that the speaker wants the hearer to be able to infer their meaning

Using language involves inferring mental states of others (ostensive-inferential communication)

The Cooperative Principle and Gricean Maxims

- **Quality:** Be truthful
- **Quantity:** Be as informative as required
- **Relation:** Be relevant
- **Manner:** Be clear

A: Where's Bill?

B: His dog died

The usual question: how did capacity to reason
about mental states in others evolve?

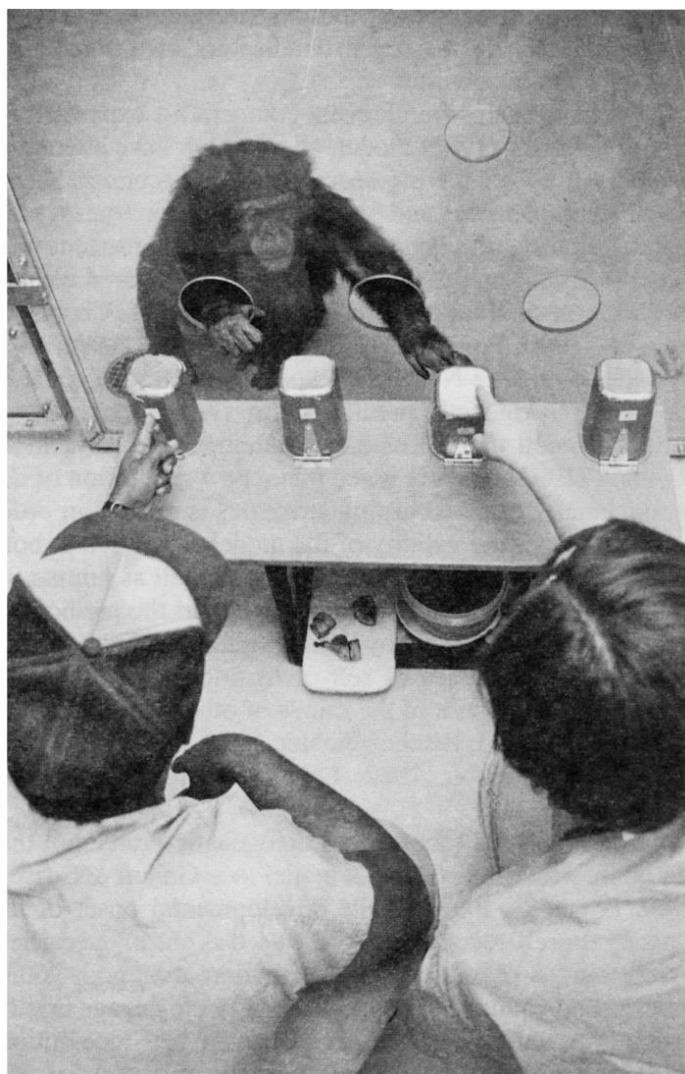
Is it a human-unique trait?

Or can we see similar abilities in our closest living relatives?

Reminder: Absence of 2nd order intentional communication in macaques?

- Mothers and infants
- **Ignorance condition:** Mother knows something, infant doesn't
 - Presence of food, predator
- **Knowledge condition:** They both know it
- **Mothers' vocalizations didn't differ between conditions**





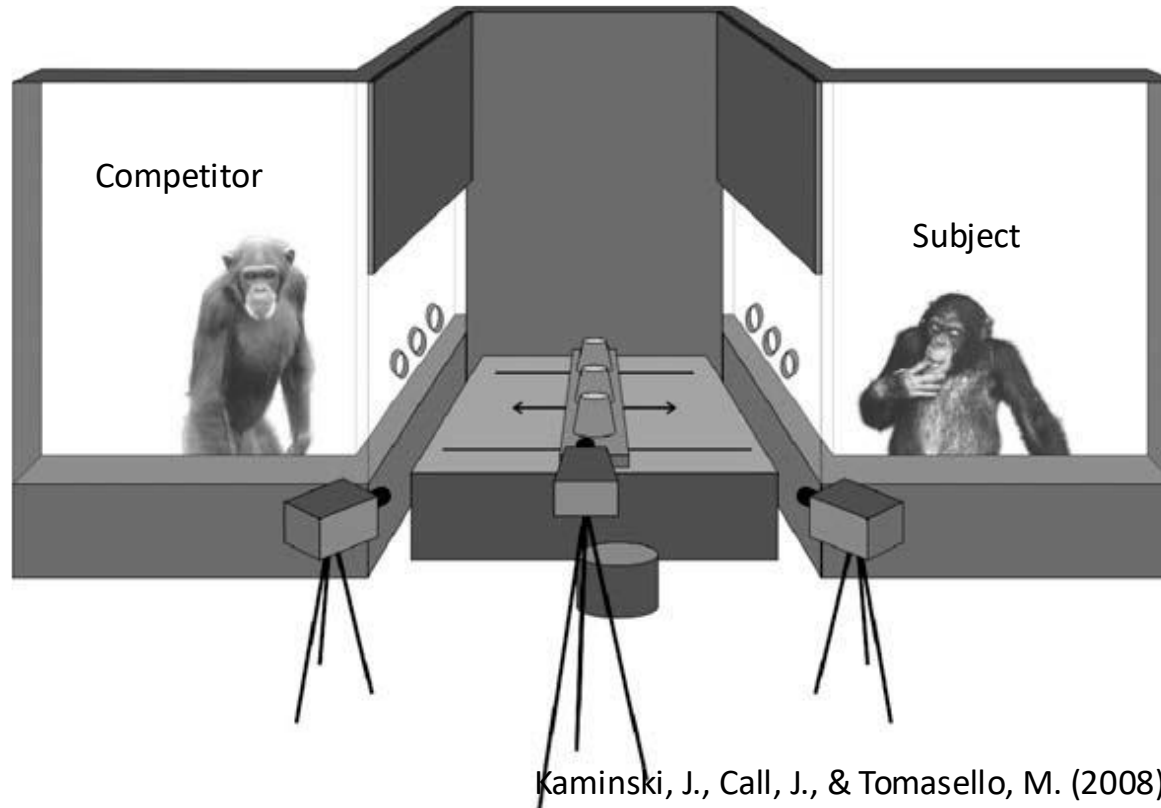
Knowing others' minds: knowing what others know

- 6 juvenile chimps (approx. 4 y. o.)
- Two experimenters
- “Guesser” leaves room
- “Knower” hides food under cup
 - Chimp can’t see which one
- Both humans point to a cup
- Chimp indicates which cup he wants to look under

Kids can do this age 4, **chimps at chance**

Povinelli, D. J., Rulf, A. B., & Bierschwale, D. T. (1994). Absence of knowledge attribution and self-recognition in young chimpanzees (*Pan troglodytes*). *Journal of Comparative Psychology*, 108, 74–80.

Knowing others' minds: knowing what others know



Kaminski, J., Call, J., & Tomasello, M. (2008). Chimpanzees know what others know, but not what they believe. *Cognition*, 109, 224–234.

wooclap.com, code INMRBS

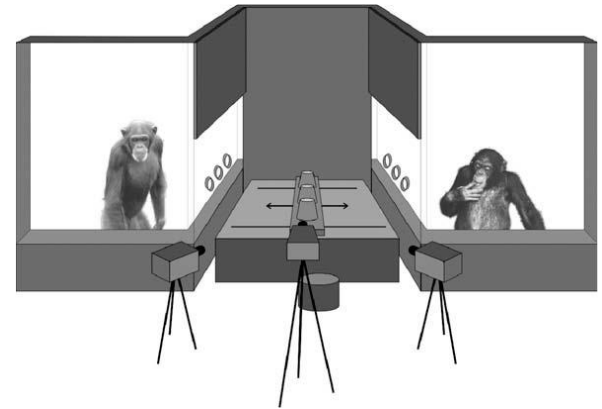
Reward A that you both saw hidden

Reward B that **only you** saw hidden

Competitor selects first, you don't see what they did

When it's your turn, which do you go for?

1. Reward A
2. Reward B



wooclap.com, code INMRBS

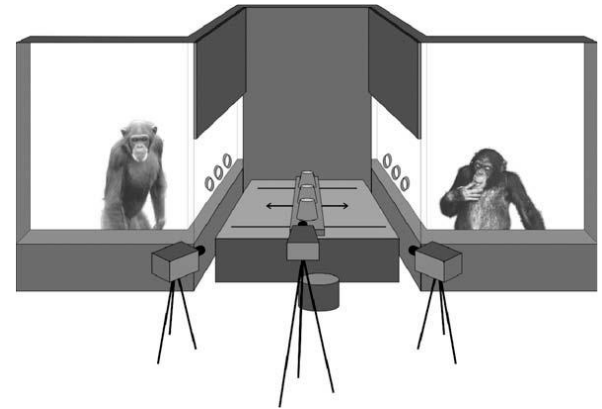
Reward A that you both saw hidden

Reward B that only you saw hidden

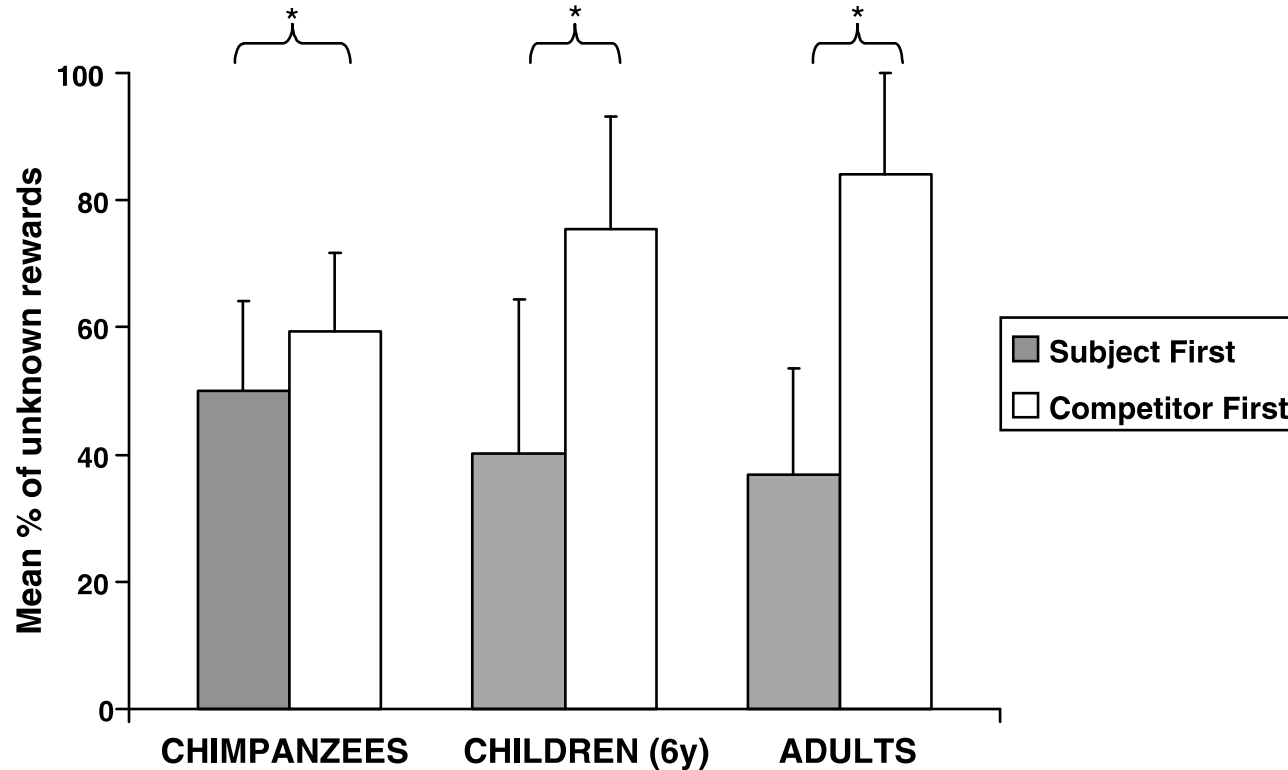
You select first, competitor won't see what you did

Which do you go for?

1. Reward A
2. Reward B



Knowing others' minds: knowing what others know

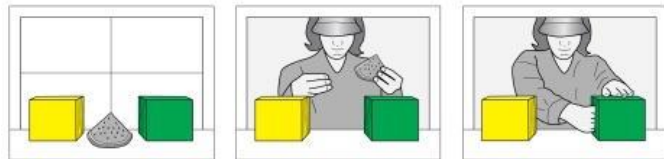




Knowing others' minds: false belief

Familiarization trials

Trial 1



Trials 2 and 3

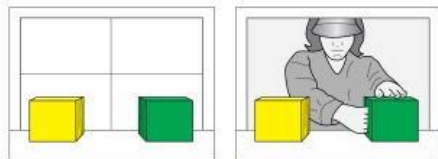
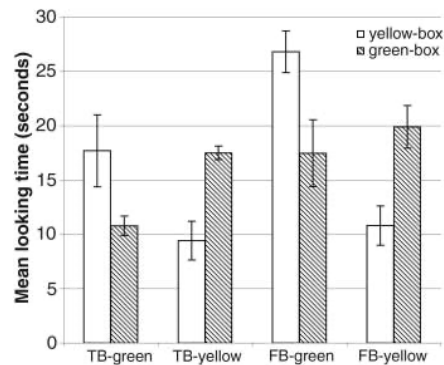
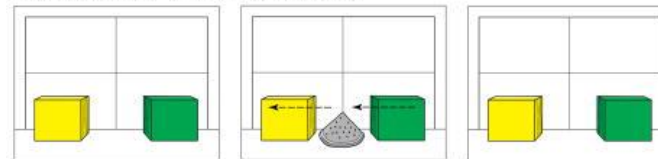


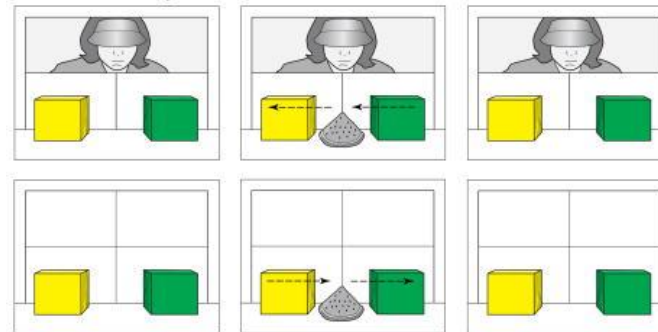
Fig. 4. Mean ($\pm$ SE) looking times during the test trial (after the actor reached into the green or yellow box) in the four belief conditions.

Belief-induction trial

False-belief-green condition

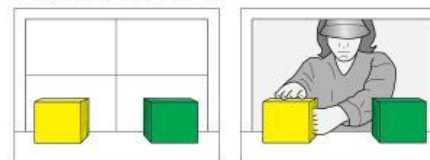


False-belief-yellow condition

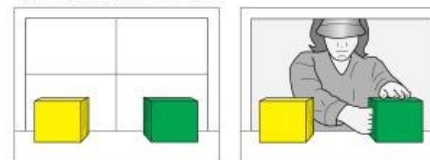


Test trial

Yellow-box event



Green-box event



False-belief 1

Chimpanzee Hatsuka

Krupenye, C., et al. (2016). Great apes anticipate that other individuals will act according to false beliefs. *Science*, 354, 110-114.

Familiarization

Bonobo Jasongo

Krupenye, C., et al. (2016). Great apes anticipate that other individuals will act according to false beliefs. *Science*, 354, 110-114.

Knowing others' minds: false belief

Table 1. Number of participants who made first looks to either the target or the distractor during the agent's approach in experiments one (N = 40) and two (N = 30). Values in parentheses indicate the number of participants who did not look at either.

Condition	Target	Distractor	Total
Experiment one			
FB1	10	4	14 (6)
FB2	10	6	16 (4)
Total	20	10	30 (10)
Experiment two			
FB1	8	2	10 (6)
FB2	9	3	12 (2)
Total	17	5	22 (8)

Krupenye, C., et al. (2016). Great apes anticipate that other individuals will act according to false beliefs. *Science*, 354, 110-114.

Other apes seem to struggle to understand
 how cooperative communication works



So why are we so good at it?

What selective pressures drive the evolution of mind sharing and mind reading?

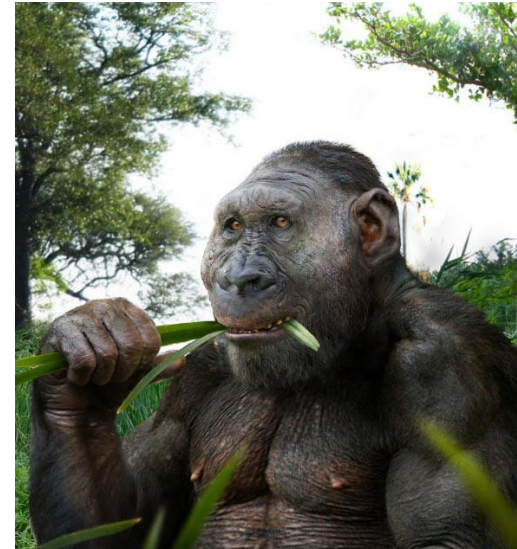
- We occupy a uniquely social niche?
- We occupy a uniquely technological niche?
- ...



Reminder: communication in the Last Common Ancestor of chimps and humans

- Not 2nd order intentional?
- No/minimal use of structure subserving meaning?
- Probably not learned?

But remember Fitch's point: their communication system may underrepresent their cognitive capacities!



How about these other capacities?

- The ability to learn complex grammars?
 - No/little capacity for complex vocal imitation
 - Some ability to learn complex sequencing constraints?
 - Some ability to learn compositional meaning-form mappings?
- Little motivation to mindshare??
- Some ability to mindread



The human package

Somehow, we ended up with

- The ability to learn complex grammars
 - capacity for complex vocal imitation
 - ability to learn complex sequencing constraints
 - ability to learn compositional meaning-form mappings
- The ability and motivation to mindshare and mindread

This sets up the preconditions for the **cultural transmission of learned, meaning-bearing communication**

- Once that's in place, exciting stuff happens

Next up

- Workshop
 - Animal grammar learning, a linguist takes a look
- Next lecture: the cultural evolution of grammar