Origins and Evolution of Language
Week 8: The evolution of social cognition

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Plan for today

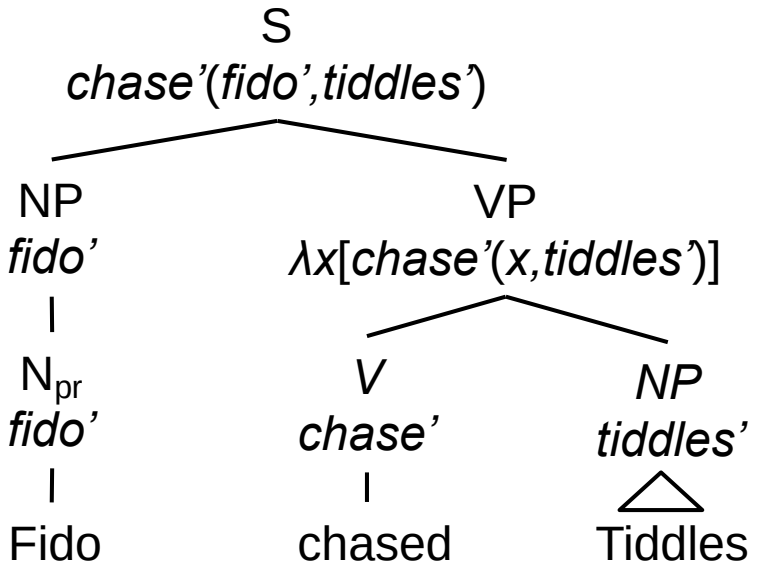
- Finish off grammar learning
  - And a reminder of where we are and where we are going for the final few weeks
- Mind-reading and language
  - Questions from the reading quiz
  - Ostensive-inferential communication
  - Knowing what others know
  - Mind-reading in word learning
  - The evolution of mind-reading

Grammar learning in non-humans

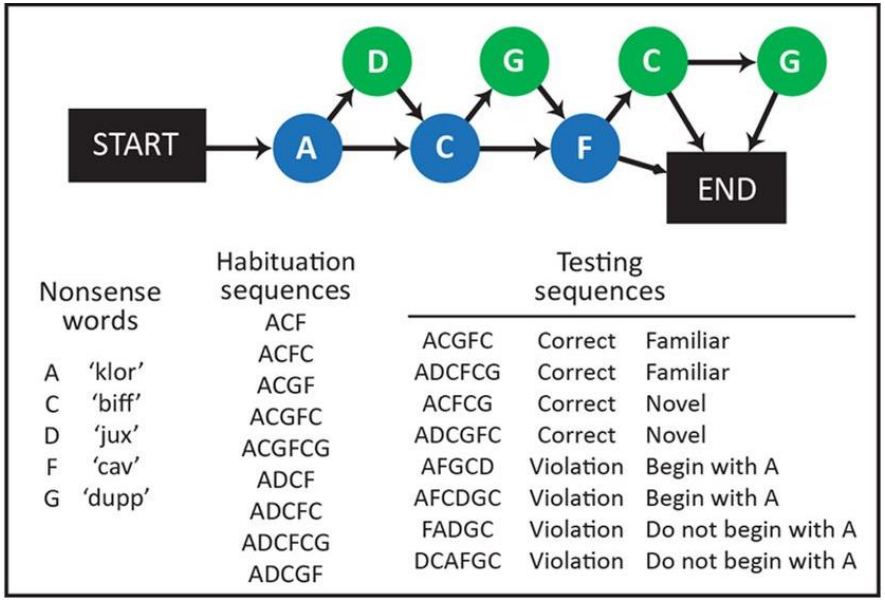
Reminder: Language's communicative power comes from its **structure**

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

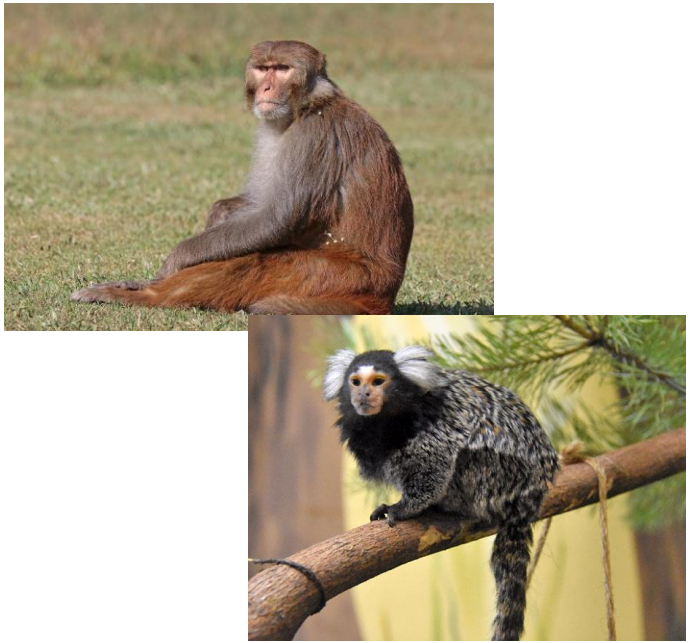
S → NP VP *VP'*(*NP'*)
NP → N_{pr} N'_{pr}
N_{pr} → Fido *fido'*
N_{pr} → Tiddles *tiddles'*
VP → V NP *V'*(*NP'*)
V → chased $\lambda x\,[\lambda y\,[(chase'(x,y)]]$



Artificial Grammar Learning in non-humans



Nonsense words		Habituation sequences	Testing sequences		
A	'klor'	ACF	ACGFC	Correct	Familiar
C	'biff'	ACFC	ADCFCG	Correct	Familiar
D	'jux'	ACGF	ACFCG	Correct	Novel
F	'cav'	ACGFC	ADCGFC	Correct	Novel
G	'dupp'	ACGFCG	AFGCD	Violation	Begin with A
		ADCF	AFCDGC	Violation	Begin with A
		ADCFC	FADGC	Violation	Do not begin with A
		ADCFCG	DCAFGC	Violation	Do not begin with A
		ADCGF			

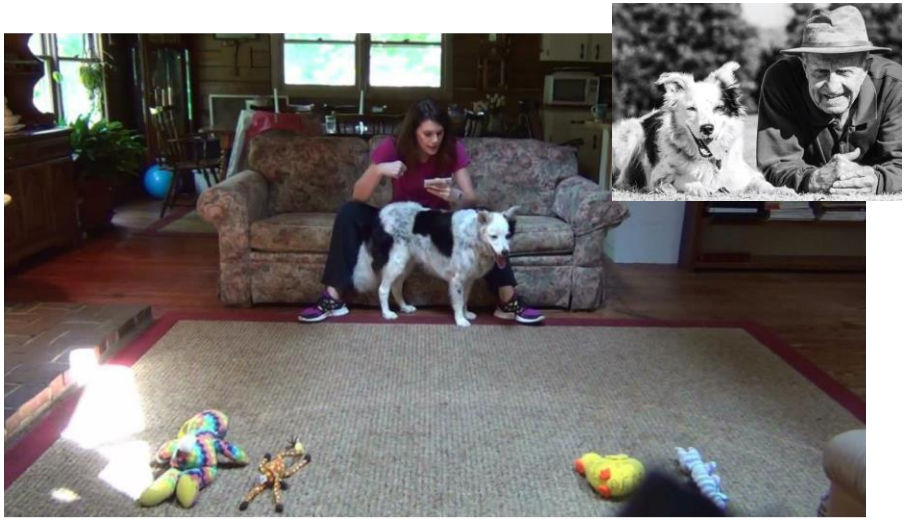


Wilson, B., Slater, H., Kikuchi, Y., Milne, A., Marslen-Wilson, W., Smith, K., & Petkov, C. (2013). Auditory artificial grammar learning in macaque and marmoset monkeys. *Journal of Neuroscience, 33,* 18825-18835.
For review see e.g. Petkov, C. I., & Ten Cate, C. (2020). Structured Sequence Learning: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

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.

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

Chase person1(g) per
Person1(g) pat(g) per
Person1(g) person2(g

le 3

nparison of Most Frequent Comb

Kanzi
2 items
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)

Savage-Rumbaugh, E. S.,. McDonald, K., Sevcik, R. A., Hopkins, W. D., & Rupert, E. (1986). Spontaneous Symbol Acquisition and Communicative Use By Pygmy Chimpanzees (Pan paniscus). *Journal of Experimental Psychology: General, 115*, 211–235.

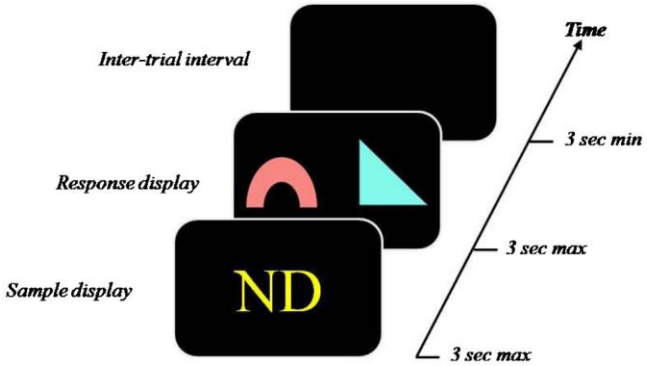
Savage-Rumbaugh, E. S., Murphy, J., Sevcik, R., Brakke, K., Williams, S., Rumbaugh, D., & Bates, E. (1993). Language comprehension in ape and child. *Monographs of the Society for Research in Child Development, 58*, 1–252.

Perhaps a deficit for **hierarchy**?

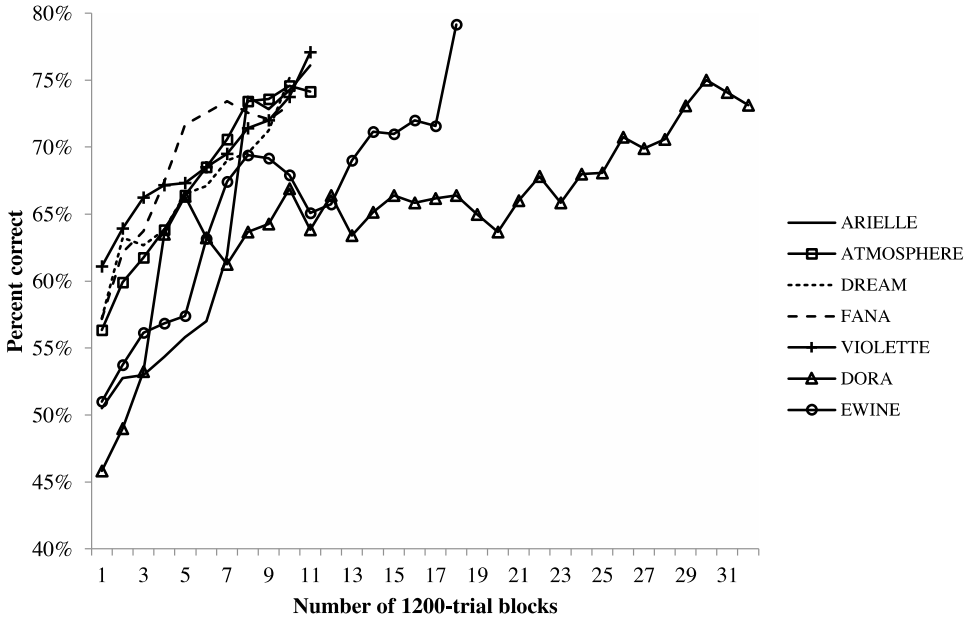
- Could just be ‘semantic soup’ plus smart interpretation?
  - *Cut the onions with your knife*
  - *Put the pine needles in the refrigerator*
- But he can handle reversible events (cf. also Chaser)
  - *Put the tomato in the oil*
  - *Put some oil in the tomato* [Kanzi pours oil in a bowl with the tomato]
- But no strong evidence for **hierarchy**
  - *Give the water and the doggie to Rose*. [Gives dog only]
  - *Give the lighter and the shoe to Rose*. [Gives lighter only]
  - *Give me the milk and the lighter* [Responds correctly]

Truswell, R. (2017). Dendrophobia in bonobo comprehension of spoken English. *Mind and Language, 32,* 395-415.

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.

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 expressions

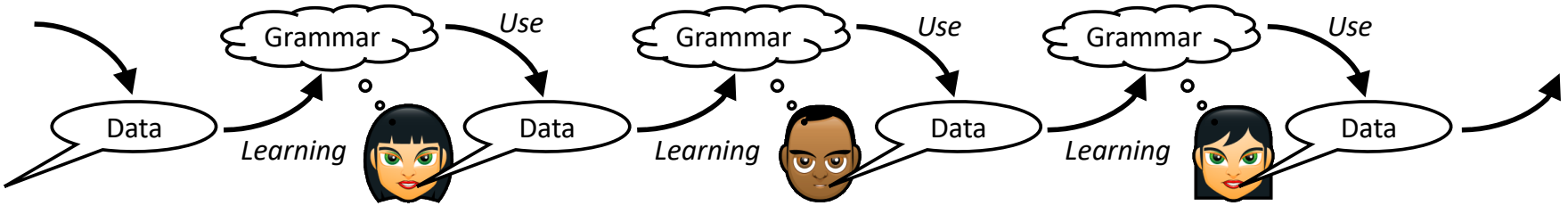
- But larger-N lab studies surprisingly scarce, and these tasks seem to be hard

Humans are not unique in our ability to process meaningful sequences

- **But we may be uniquely proficient**

Pausing to take stock

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
- Structure allows language to learnable yet communicatively powerful

The idea

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

What you've seen so far

Human linguistic communication does indeed have unusual properties (see week 4)

- Evidence for intentional communication rare in the animal world
- Lots of structured communication out there, but structure is simpler and typically not meaning-related

Human capacity to sustain complex non-linguistic cultures (e.g. tools) is also unusual (see week 6-7)

- Animal cultures exist but are simpler
- Language implicated in maintenance of stone tool technology?

Human capacity for learning complex meaning-bearing communicative signals is unusual (see last week/today)

- Vocal learning seen in other animals, but limited in our closest relatives?
- Other animals can learn sequencing constraints, but maybe only simple ones?
- Other animals can learn rules of meaningful combination, but maybe limited?

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

Ostensive-inferential communication

The ability to express and recognize intentions

- Informative intentions: I want you to know X
- Communicative intentions: I want you to know that [I want you to know X]

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 based on these clues and context, with inferences guided by the knowledge that the speaker wants the hearer to be able to infer their informative intention

Using language involves inferring mental states of others

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?

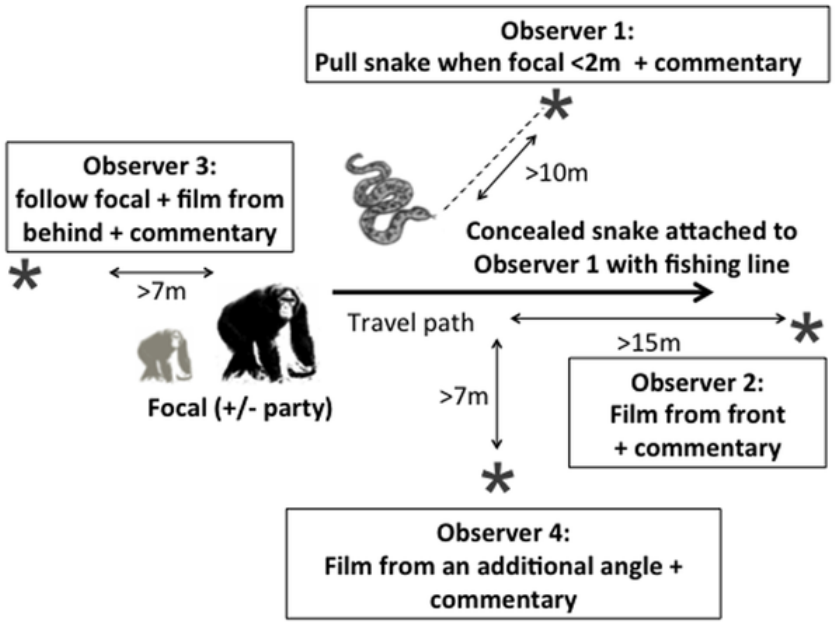
Reminder: Absence of intentional communication in macaques?

- 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**

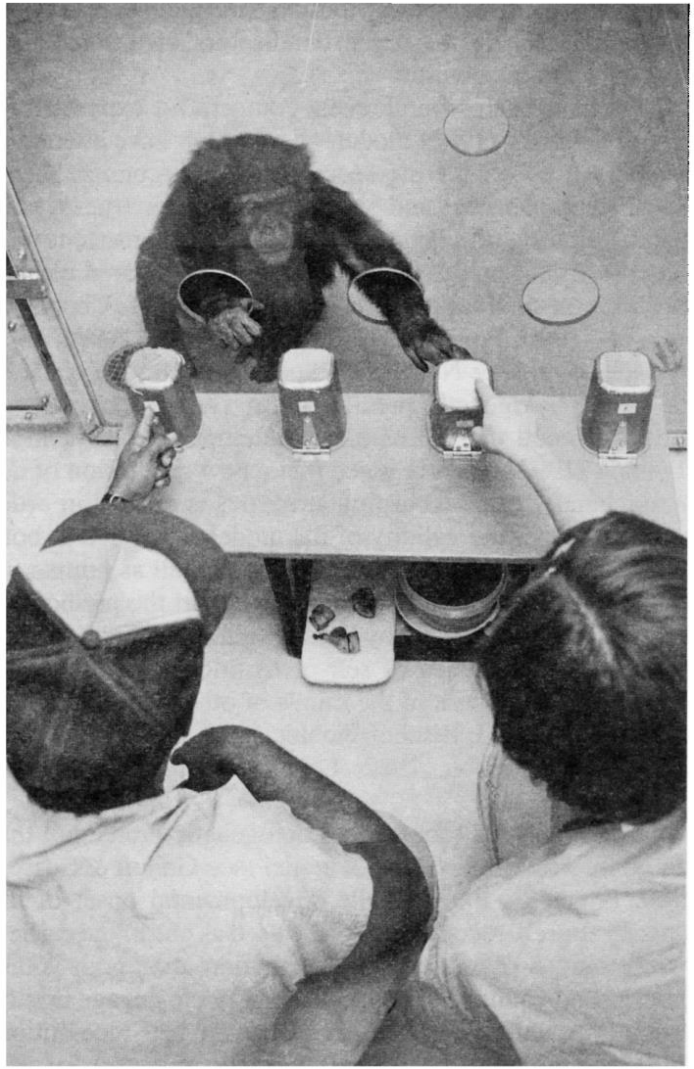
Cheney, D., & Seyfarth, R. (1990). Attending to behaviour versus attending to knowledge: examining monkeys' attribution of mental states. *Animal Behavior, 40,* 742-753.

Reminder: Intentional communication in chimpanzees?

- Wild chimps
- Surprised with snake model, either alone or in part of group
  - Presence of others matters?
  - Gaze-alternation?
  - Persist until others safe?



Schel, A. M., Townsend, S. W., Machanda, Z., Zuberbühler, K., & Slocombe, K. E. (2013) Chimpanzee Alarm Call Production Meets Key Criteria for Intentionality. *PLoS ONE, 8*, e76674



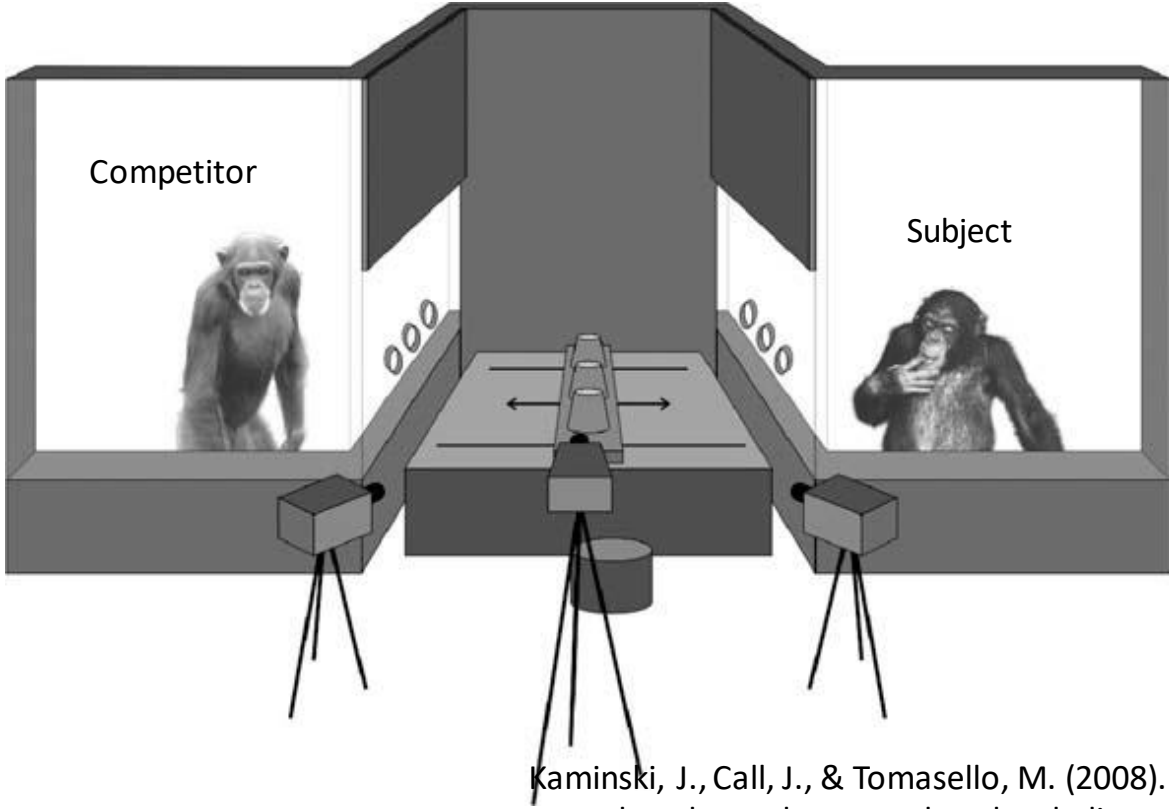
Knowing others' minds: knowing what others know

- 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**

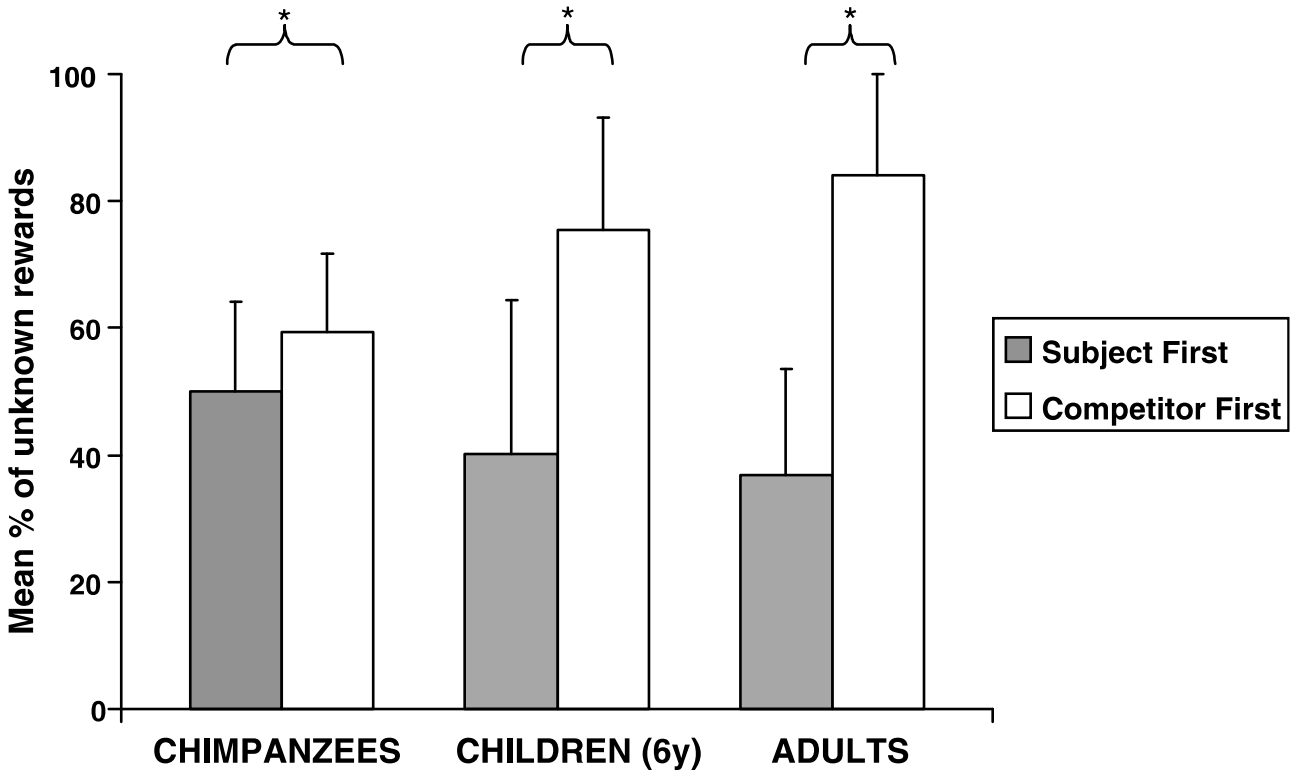
Povinelli, D. J., Rulf, A. B., & Bierschwale, D. T. (1994). Absence of knowledge attribution and self-recognition in young chimpanzees (*Pan troglodytes*). *Journal of Comparative Psychology, 108,* 74–80.

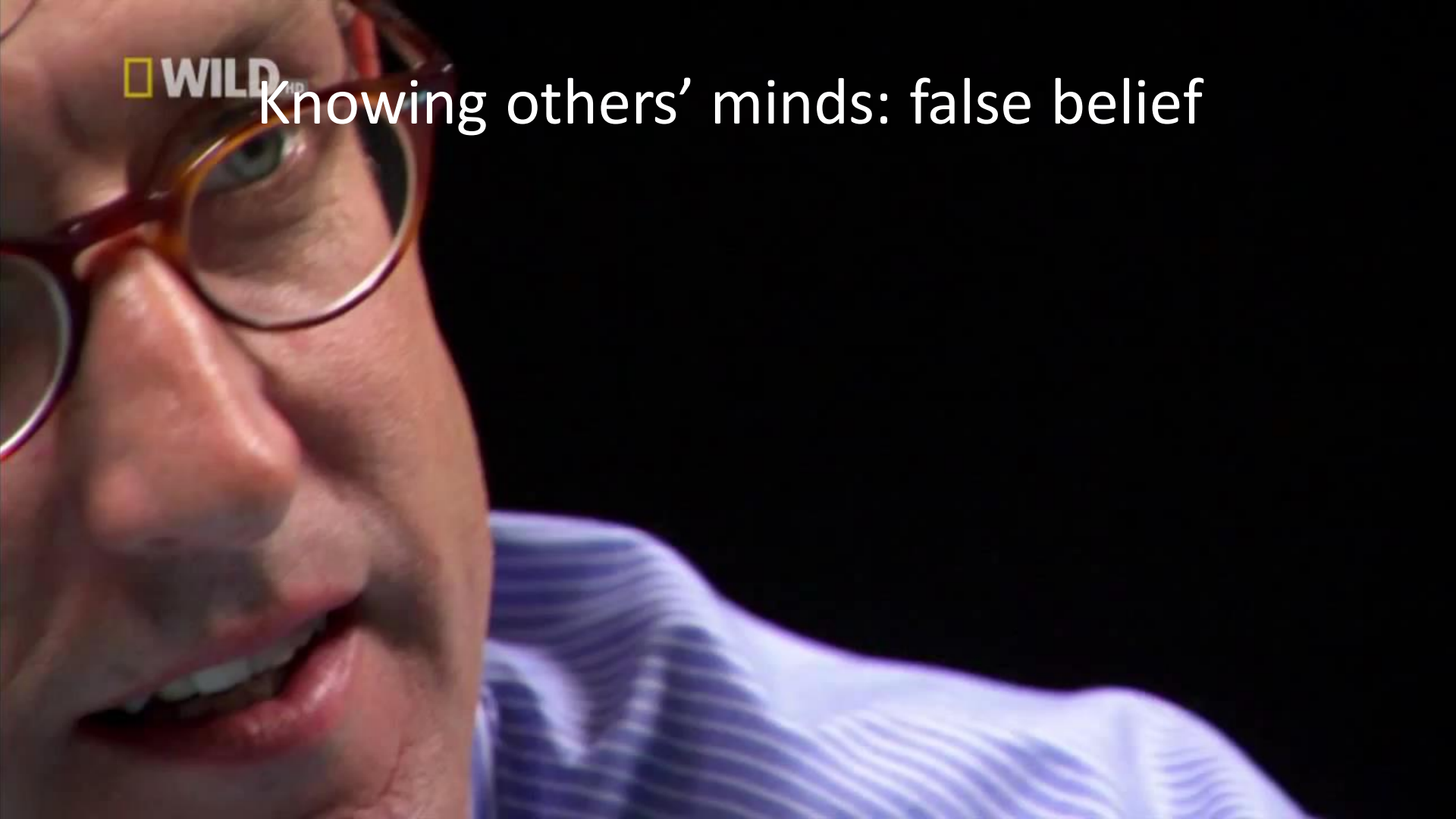
Knowing others' minds: knowing what others know



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

Knowing others' minds: knowing what others know





Knowing others' minds: false belief

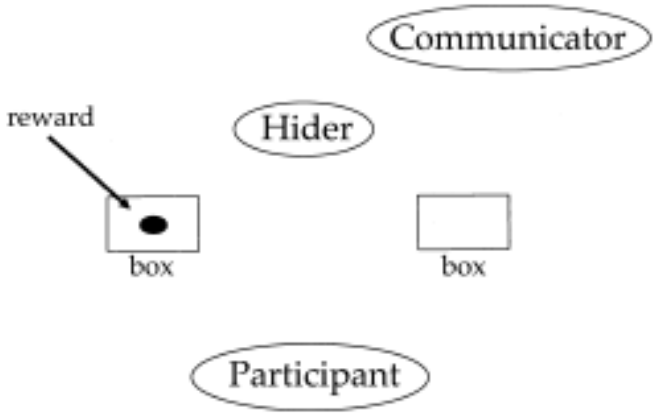
Knowing others' minds: false belief

Standard setup:

- Hider puts reward in box
- Communicator puts marker on box containing reward
- Subject chooses box

False belief version:

- Communicator leaves room
- Hider switches reward
- Communicator returns, places marker



Kids can do this from age 5

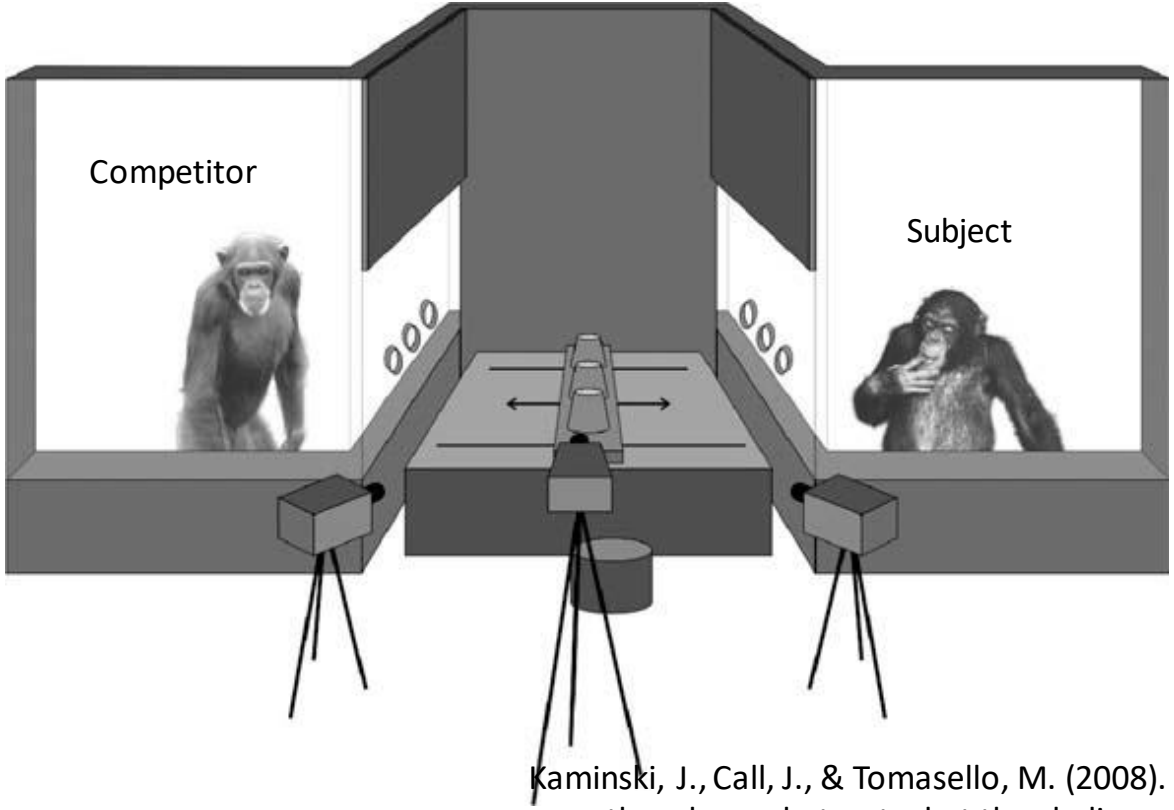
2 orangutans, 5 chimps

False belief task: 11%

5/7 get it right 0/4

Call, J., & Tomasello, M. (1999). A nonverbal false belief task: The performance of children and great apes. *Child Development, 70*, 381–395.

Knowing others' minds: false belief



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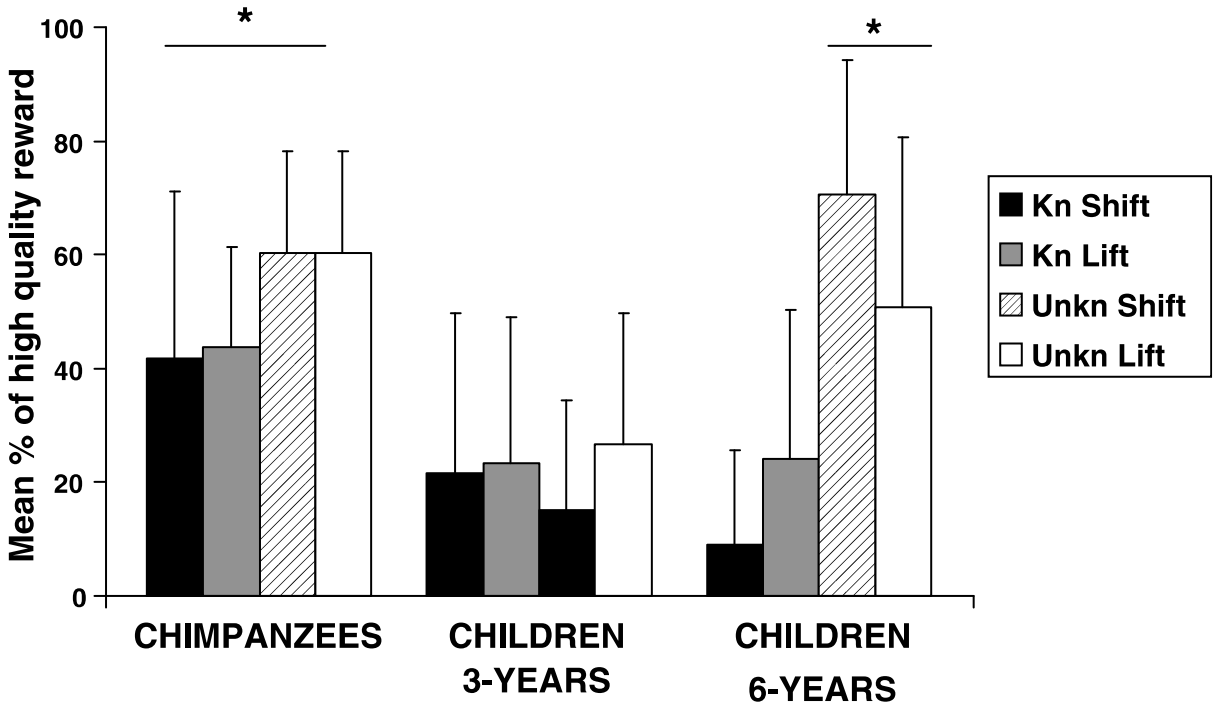
Knowing others' minds: false belief



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.

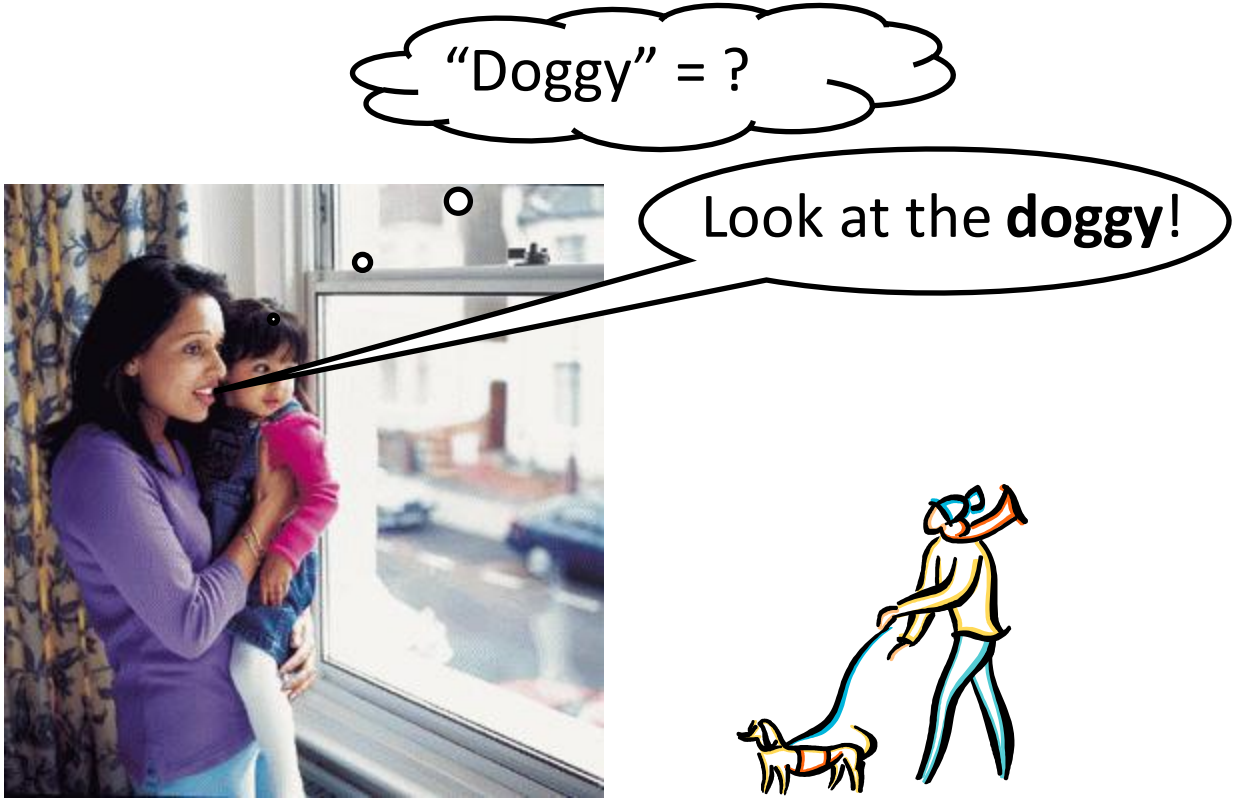
Knowing others' minds: false belief

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.

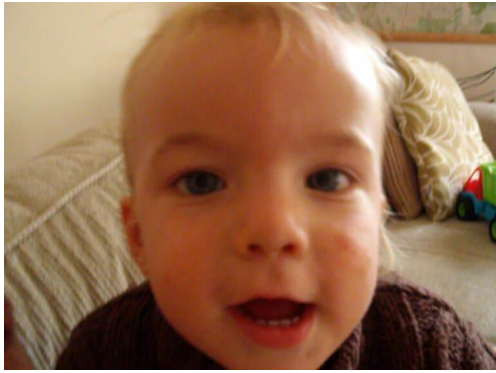
Condition	Target	Distractor	Total
	Experiment one		
FB1	10	4	14 (6)
FB2	10	6	16 (4)
Total	20	10	30 (10)
	Experiment two		
FB1	8	2	10 (6)
FB2	9	3	12 (2)
Total	17	5	22 (8)

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

Mind reading in language learning

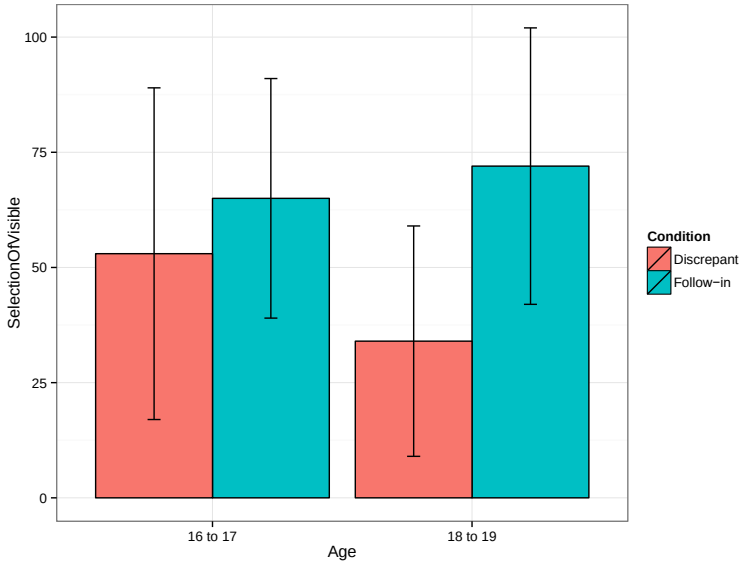


Exploiting attentional focus



Word learning, 16-19 month olds

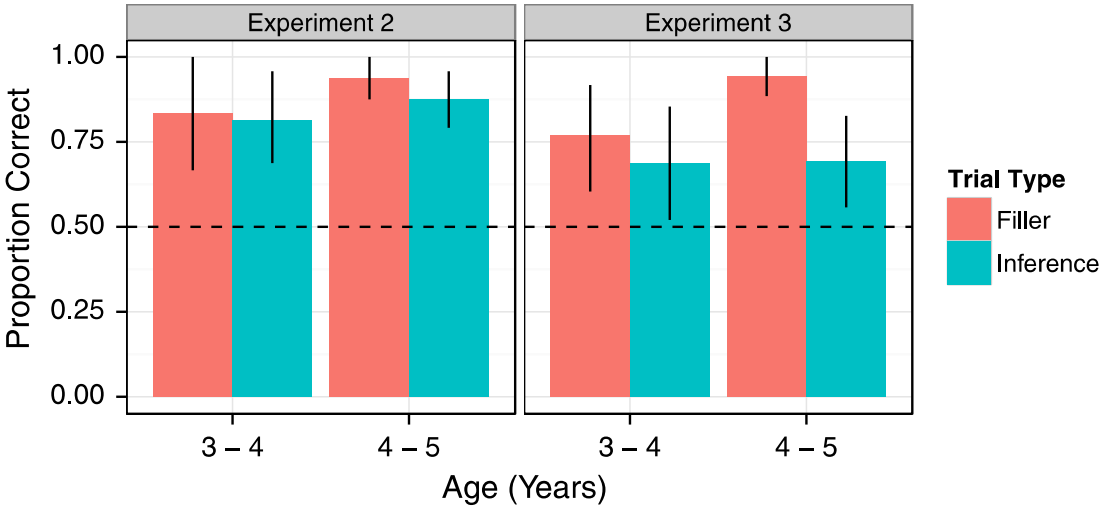
- Kid, experimenter, bucket, two novel objects
- Kid sees both toys, plays with one, other one goes back in the bucket
- Follow-in labelling: experimenter looks at toy kid is looking at and labels it (“it’s a toma!”)
- Discrepant labelling: experimenter looks at toy in bucket and labels it (“it’s a toma!”)

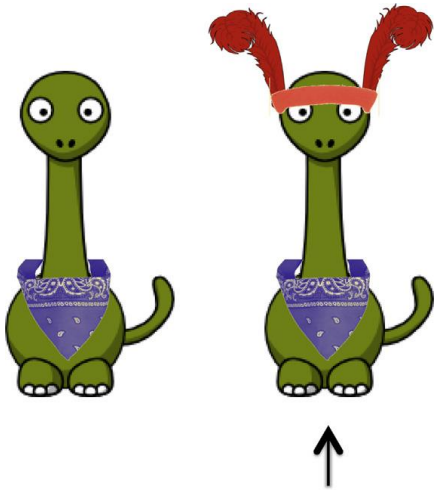


Baldwin, D. A. (1991). Infants’ contribution to the achievement of joint reference. *Child Development, 62,* 875–890.

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.


WILD
Other apes just don’t seem to understand how communication works

So why do we?

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

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

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 mindread and mindshare

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

- Once that's in place, exciting stuff happens

Optional extra: recursive mindreading

Recursive mindreading

Ostensive-inferential communication might inherently require recursive representations of mental states

- I want you to know that [I want you to know X]

What are the limits of the human capacity to represent and reason about mental states in others?

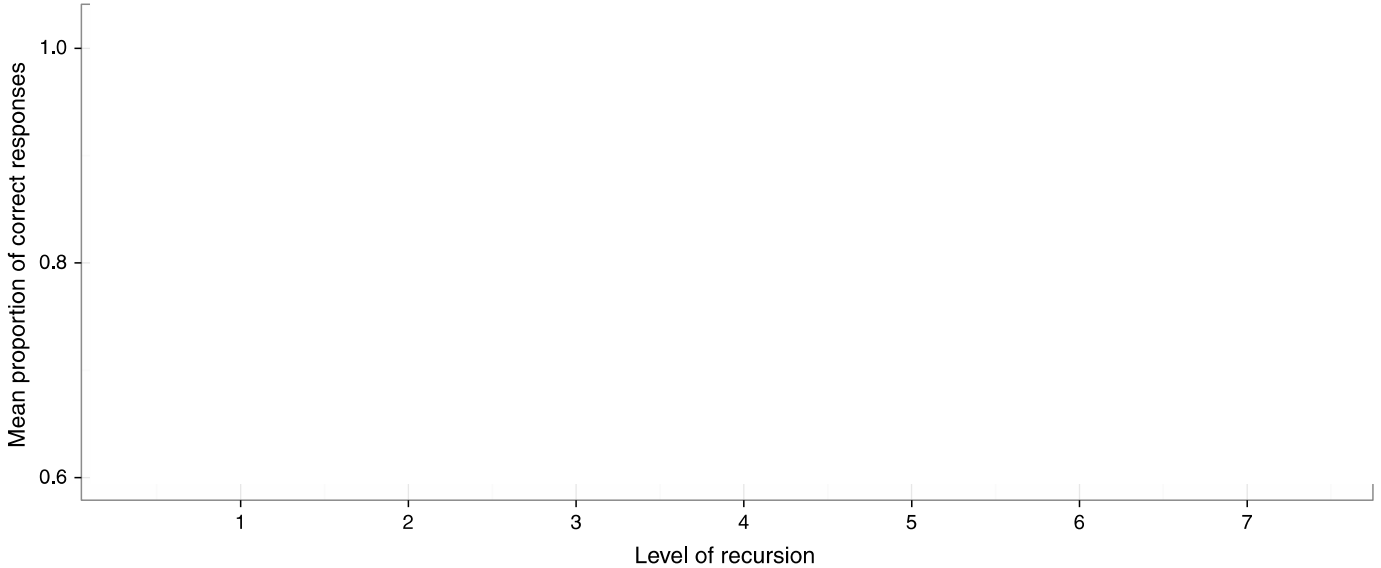
Sperber vs Moore

Sperber
You intend that
I believe that
you intend that
I know that my breath smells

Moore
You intend that
I know that my breath smells
+
You intend that
I know that you are telling me something

Recursive meta-representation: an experiment

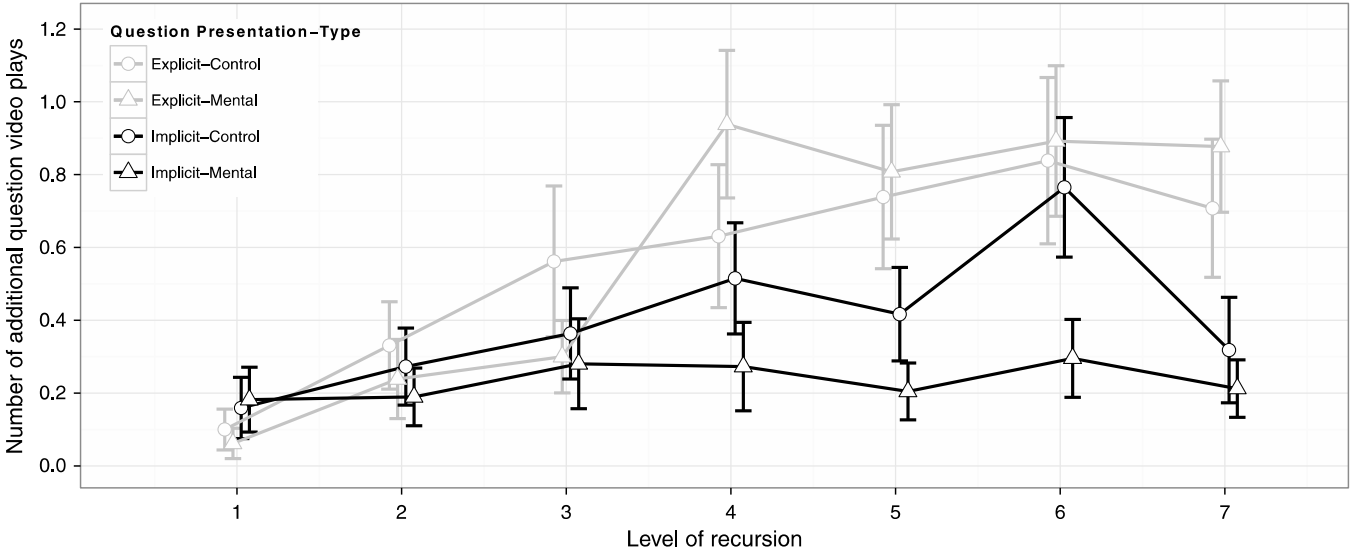
Watch a short video, answer some questions



O'Grady, C., Kliesch, C., Smith, K., & Scott-Phillips, T. (2015). The ease and extent of recursive mindreading, across implicit and explicit tasks. *Evolution and Human Behavior, 36,* 313-322.

Recursive meta-representation: an experiment

Watch a short video, answer some questions



O'Grady, C., Kliesch, C., Smith, K., & Scott-Phillips, T. (2015). The ease and extent of recursive mindreading, across implicit and explicit tasks. *Evolution and Human Behavior, 36,* 313-322.

People are awesome at representing other people's representations

- Basically at ceiling performance up to 7 levels
- Particularly for naturalistically-presented mental meta-representation
- No equivalent data for non-humans

People are awesome at representing other people's representations

In those Friends videos, why do you think it's so funny when they **say** what they are thinking?

A. Language isn't well-designed for talking about meta-representations, so it's tricky when it's used for that
B. Language is well-designed for talking about meta-representations, but once the embedding gets too deep, processing is too hard
C. Language is **actively unhelpful** in dealing with meta-representations

Next up

- Tutorial
  - Human social cognition: biological adaptation or culturally-transmitted trait?
- Next lecture: cultural evolution of structure