Origins and Evolution of Language
Week 7: vocal learning and grammar learning

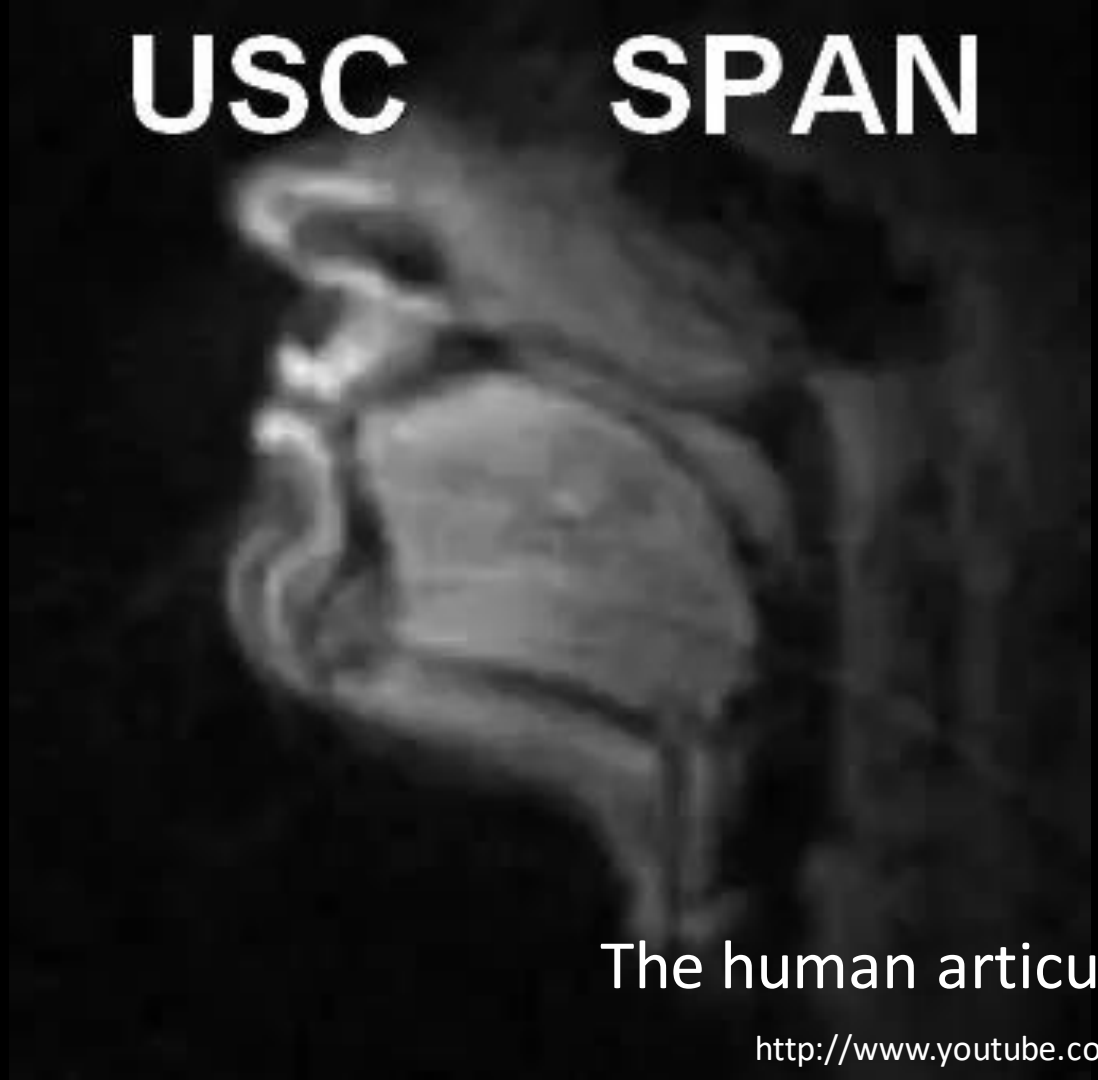
Kenny Smith

kenny.smith@ed.ac.uk

Plan for today

- Finishing off on technology and language
  - Technology, cumulative culture, and language
- Evolution of vocal apparatus for speech: quick summary of Fitch chapter 8
  - Descended larynx, thoracic vertebral canal, air sacs
- Comparative psychology of language learning
  - Complex vocal imitation
  - Grammar learning
  - Are humans special in our language learning abilities?

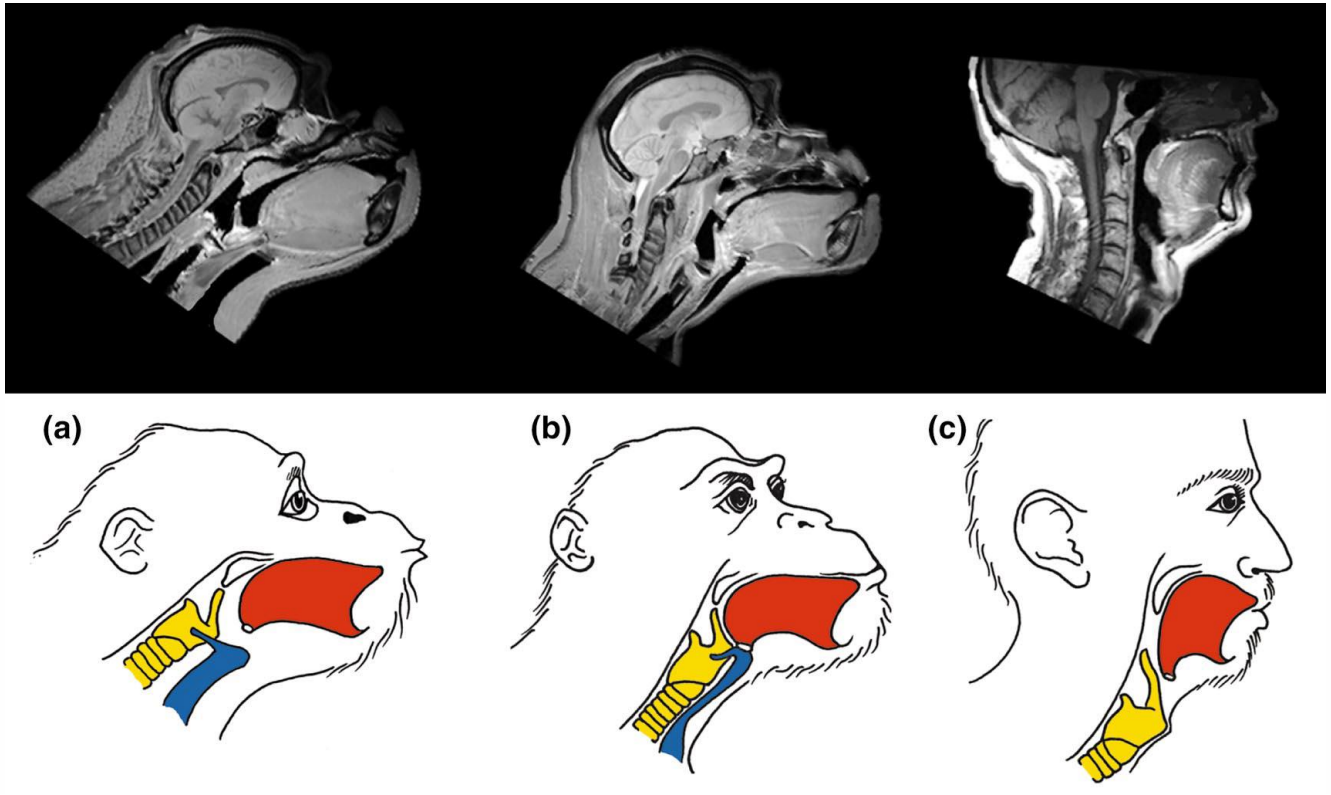
Evolution of speech: the vocal apparatus (Fitch chapter 8)



The human articulators at work

http://www.youtube.com/watch?v=0-aEN2xHBCc

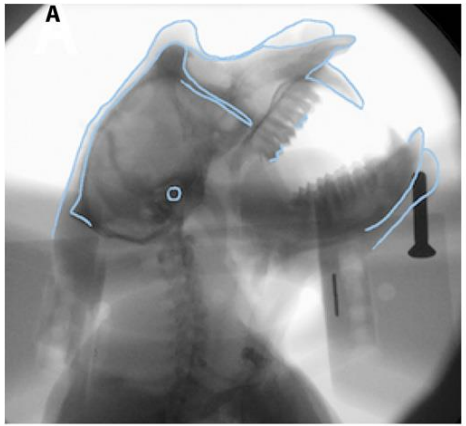
The descended larynx and the two-chamber vocal tract

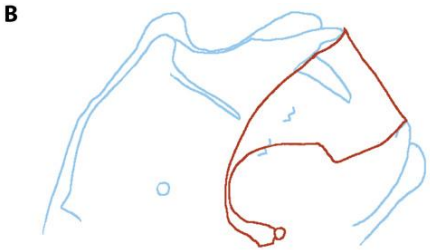


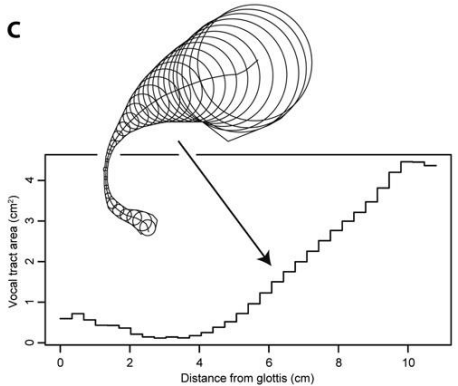
Fitch, W. T. (2000). The evolution of speech: a comparative review. *Trends in Cognitive Sciences, 4*, 258-267.

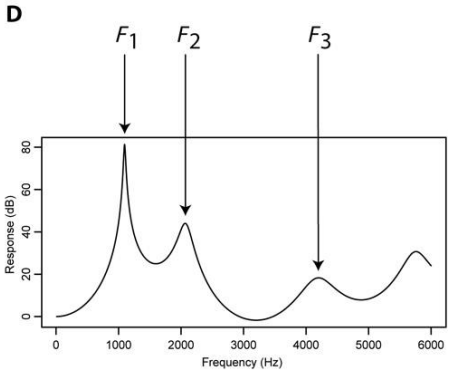
Fitch, W.T. and D. Reby, The descended larynx is not uniquely human. *Proceedings of the Royal Society B, 268,* 1669-1675

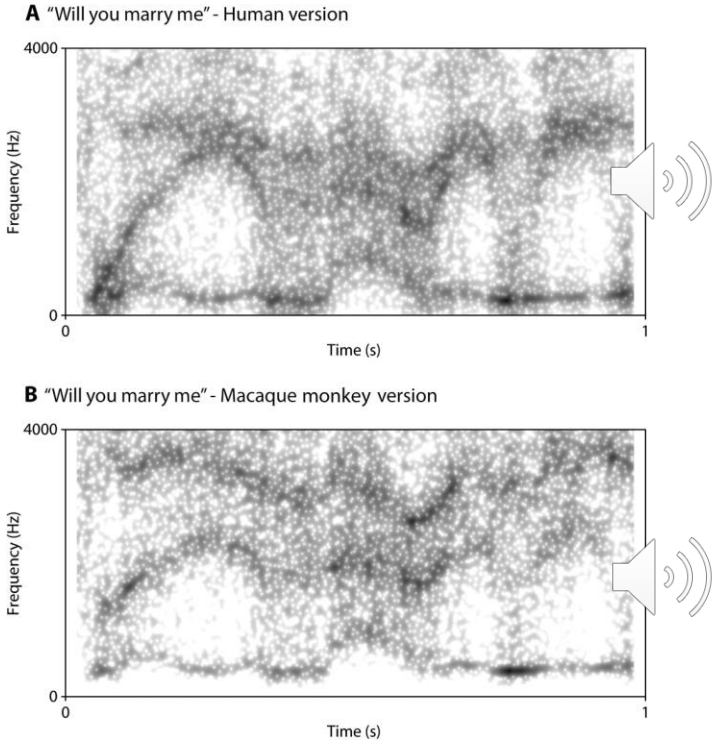
And a monkey vocal tract is probably good enough









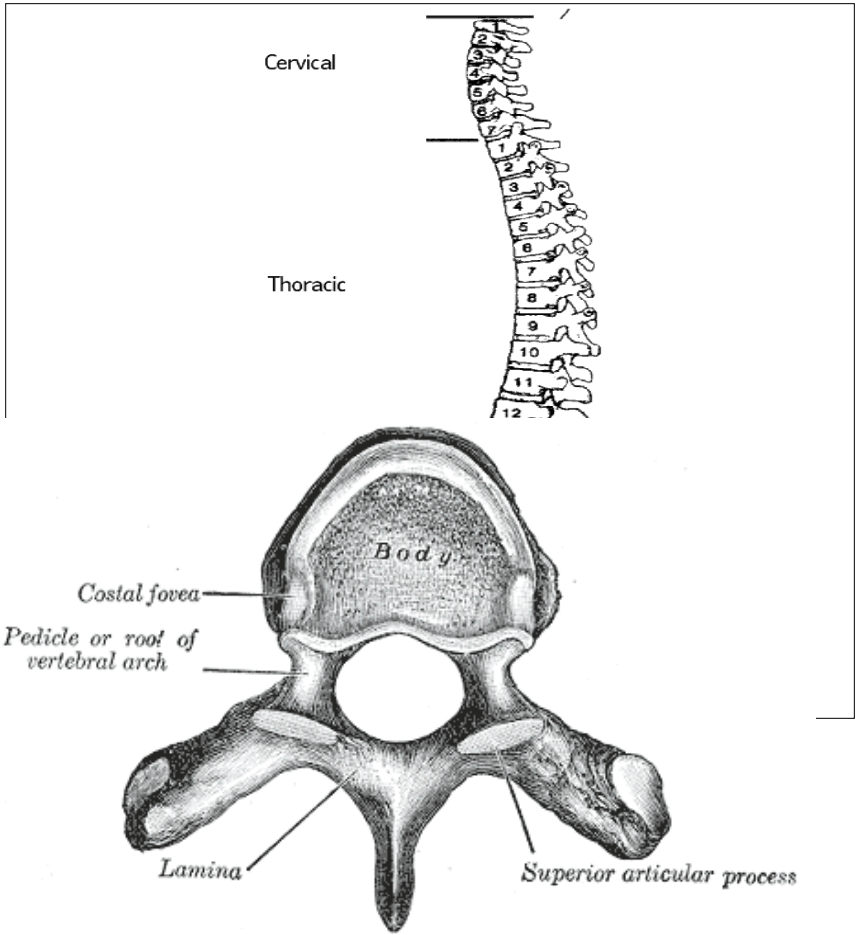


Fitch, W. T., De Boer, B., Mathur, N., & Ghazanfar, A. A. (2016). Monkey vocal tracts are speech-ready. *Science Advances, 2*, e1600723.

Breathing control

"[M]odern humans and Neanderthals have an expanded thoracic vertebral canal compared with australopithecines and *Homo ergaster,* who had canals of the same relative size as extant nonhuman primates. … [T]here was an increase in thoracic innervation during human evolution. Possible explanations for this increase include postural control for bipedalism, increased difficulty of parturition, respiration for endurance running, an aquatic phase, and choking avoidance. These can all be ruled out, either because of their evolutionary timing, or because they are insufficiently demanding neurologically. The remaining possible functional cause is increased control of breathing for speech."

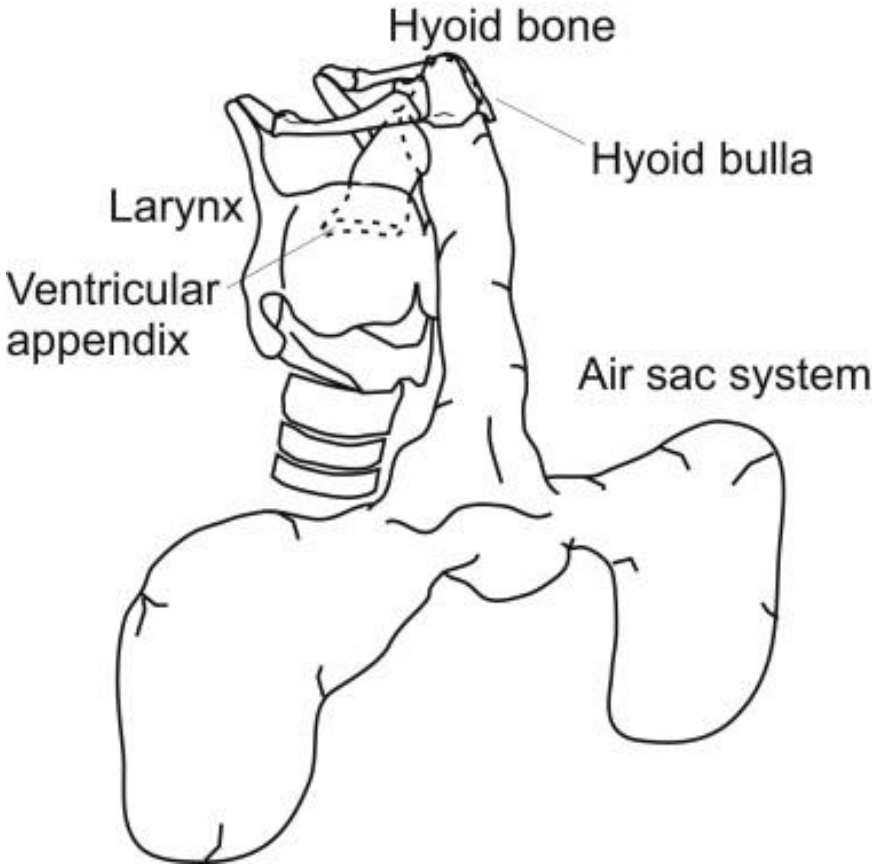
- Date: 1.6M to 100k years ago

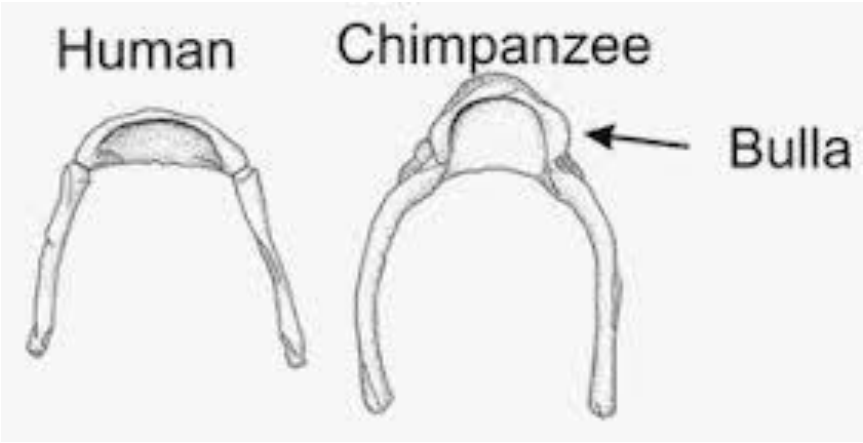


MacLarnon, A. & Hewitt, G. (1999). The evolution of human speech: the role of enhanced breathing control. *American Journal of Physical Anthropology*, *109,* 341–363.


Air sacs

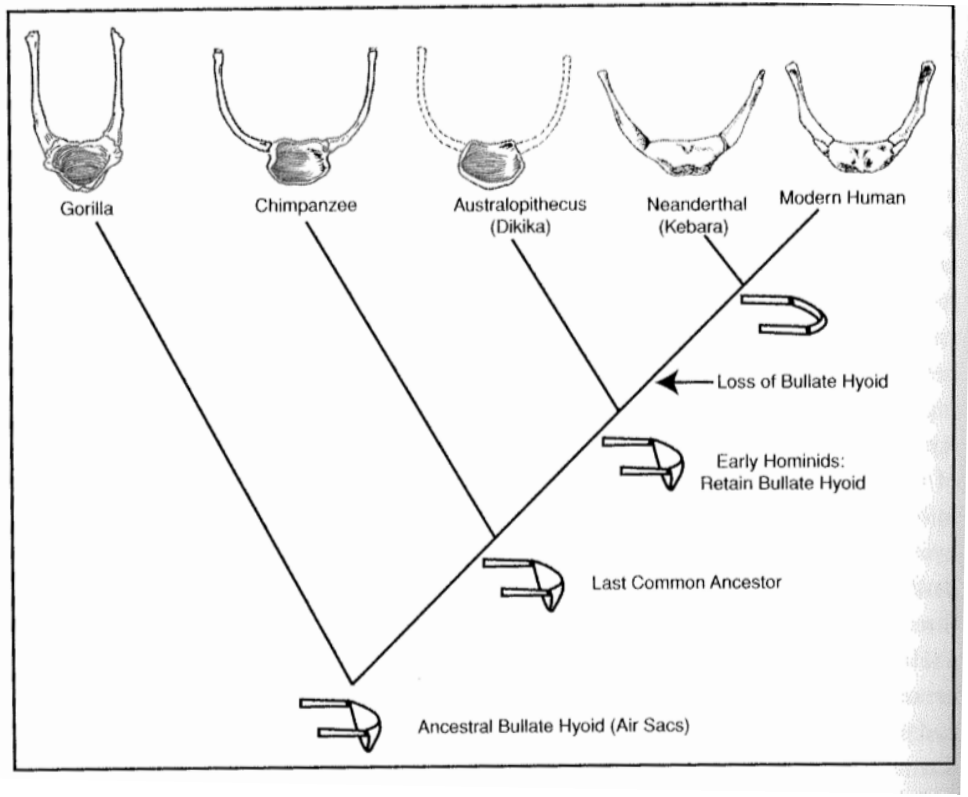
Air sacs



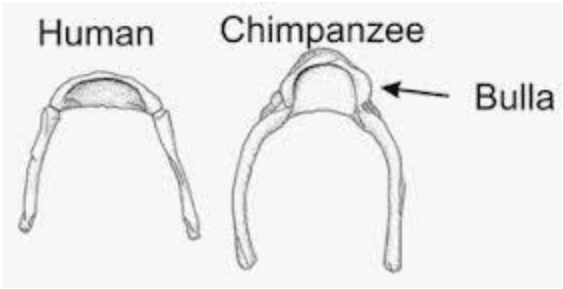


De Boer, B. (2012). Loss of air sacs improved hominin speech abilities. *Journal of Human Evolution*, *62,* 1–6.

Air sac evolution



Fitch 2010, p. 334



Cause of the loss of air sacs?

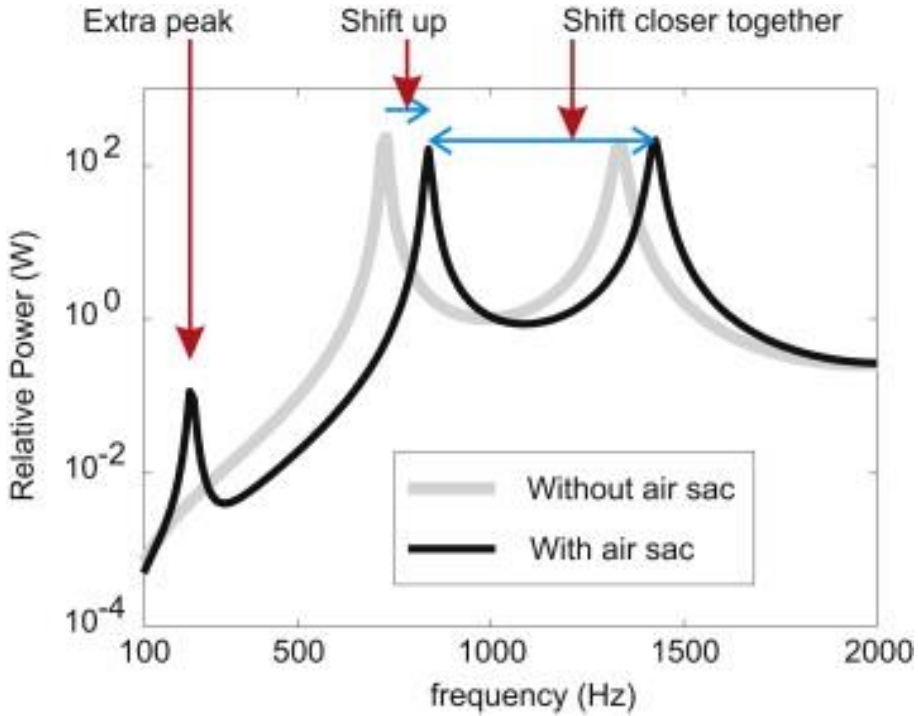
- Descended larynx as an alternative mechanism for size exageration?
- Pressure for reliable production of distinctive signals? See De Boer, B. (2012). Loss of air sacs improved hominin speech abilities. *Journal of Human Evolution, 62,* 1–6.

The acoustic effects of air sacs

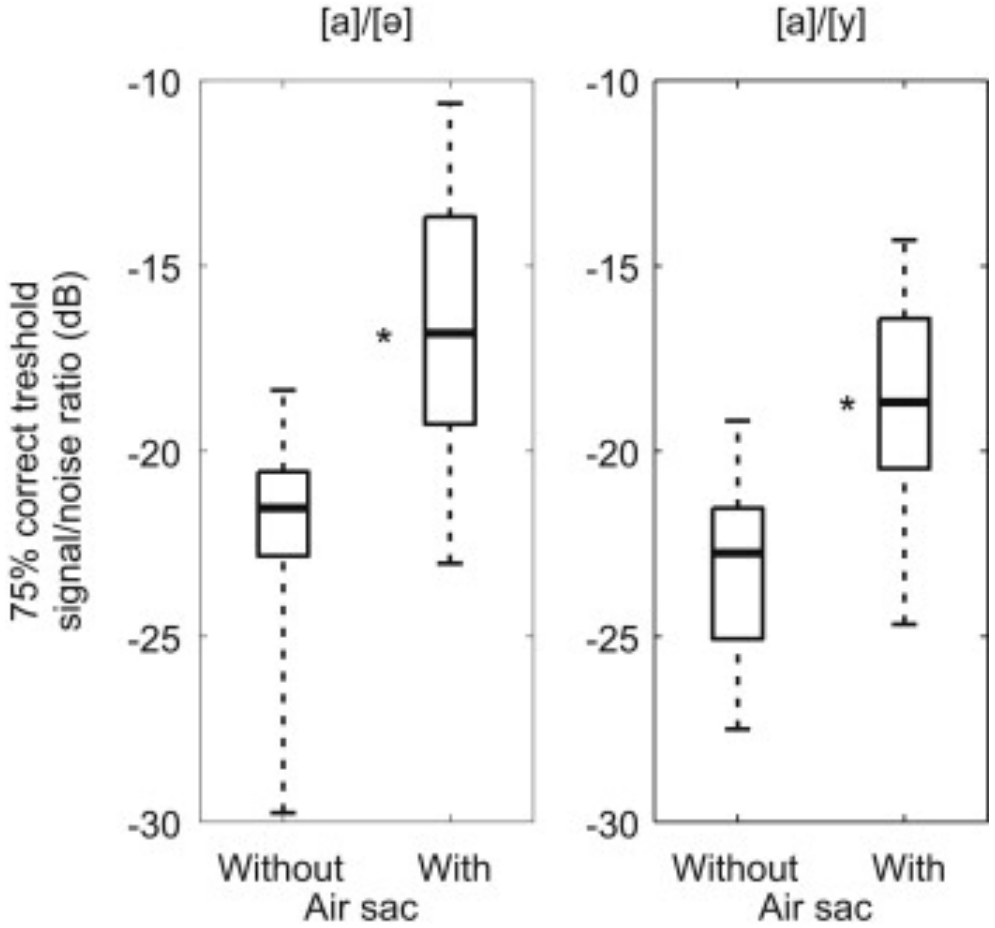
You sound bigger

Sound travels better in dense forests

But potential loss of distinctiveness?



De Boer, B. (2012). Loss of air sacs improved hominin speech abilities. *Journal of Human Evolution*, *62,* 1–6.



De Boer, B. (2012). Loss of air sacs improved hominin speech abilities. *Journal of Human Evolution*, *62,* 1–6.

Complex vocal imitation

Complex vocal imitation

http://www.youtube.com/watch?v=0-aEN2xHBCc

Complex vocal imitation in non-humans

https://www.youtube.com/watch?v=VjE0Kdfos4Y

Ridgwaye, S., Carder, D., Jeffries, M., & Todd, M. (2012). Spontaneous human speech mimicry by a cetacean. *Current Biology, 22,* R860-R861.

Rawls, K, Fiorelli, P, & Gish, S. (1985). Vocalizations and vocal mimicry in captive harbor seals, *Phoca vitulina. Canadian Journal of Zoology, 63,* 1050-1056.

Functions of vocal learning?

Complexity?

- Create elaborate repertoire: complexity as an end in itself

Index of group membership?

- *Password* hypothesis
- Dialects and accents, and early learning

Pair / group bonding?

- Duetting birds
- Functions of music?

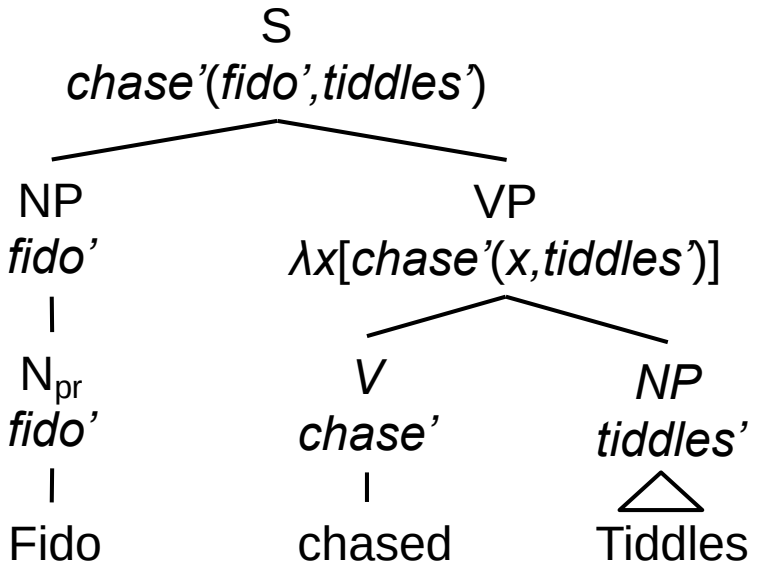
Fitch, W. T. (2000). The evolution of speech: a comparative review. *Trends in Cognitive Sciences, 4*, 258-267.

Grammar learning

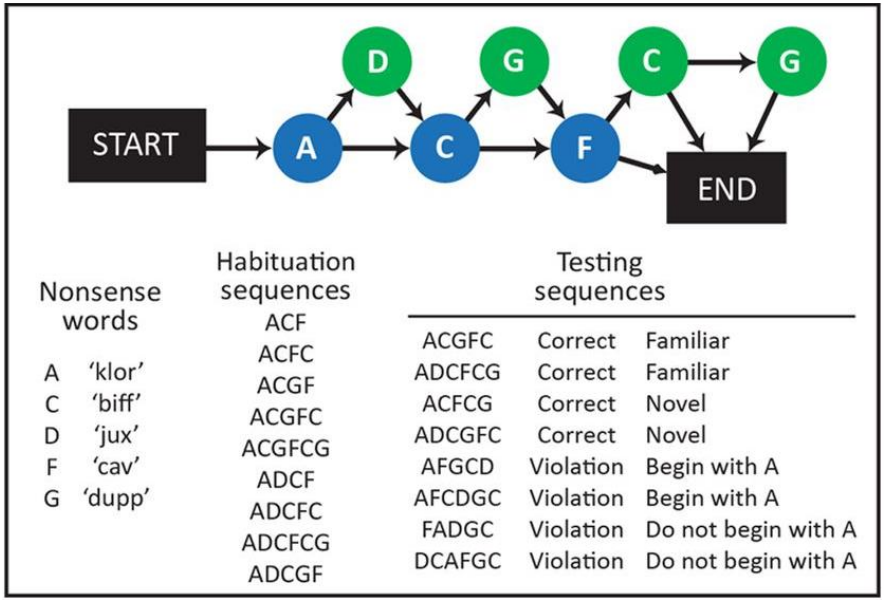
Reminder: Language's communicative power comes from its **structure**

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 $\lambda x\,[\lambda y\,[(chase'(x,y)]]$



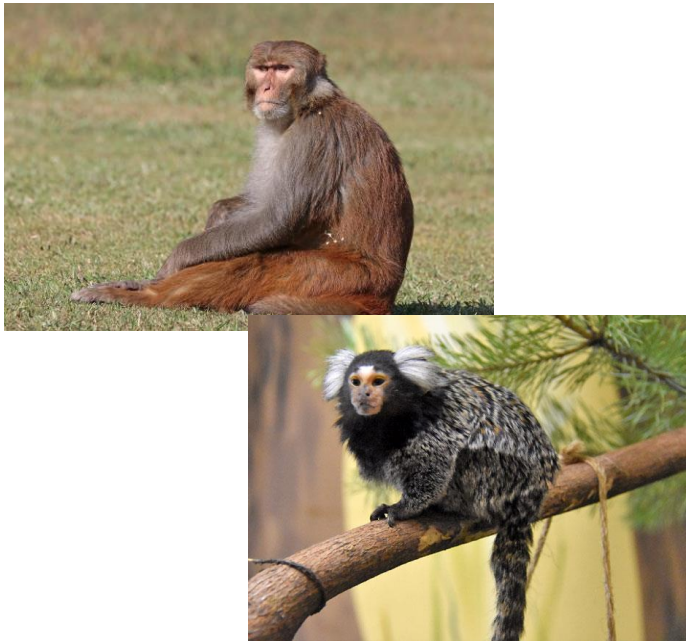
Artificial Grammar Learning in non-humans



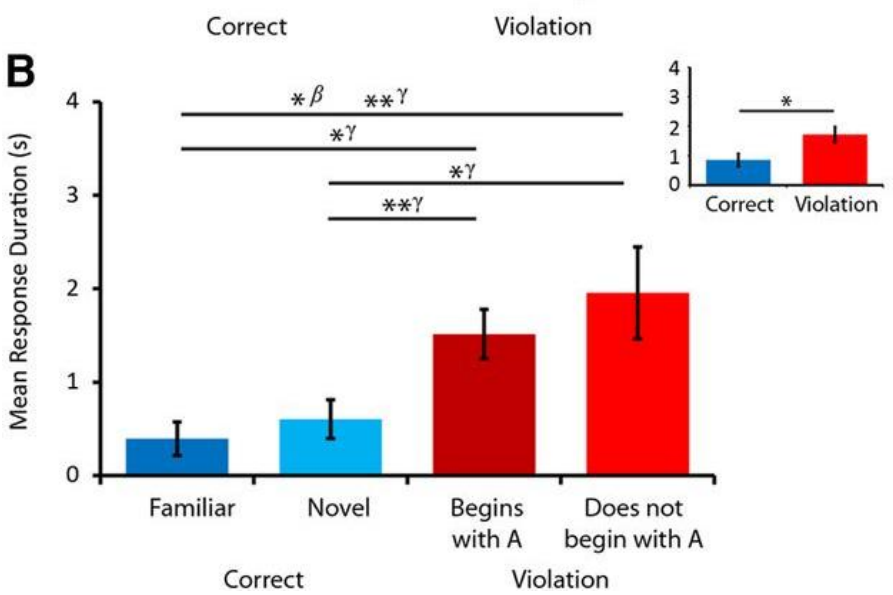
Nonsense words	
A	'klor'
C	'biff'
D	'jux'
F	'cav'
G	'dupp'

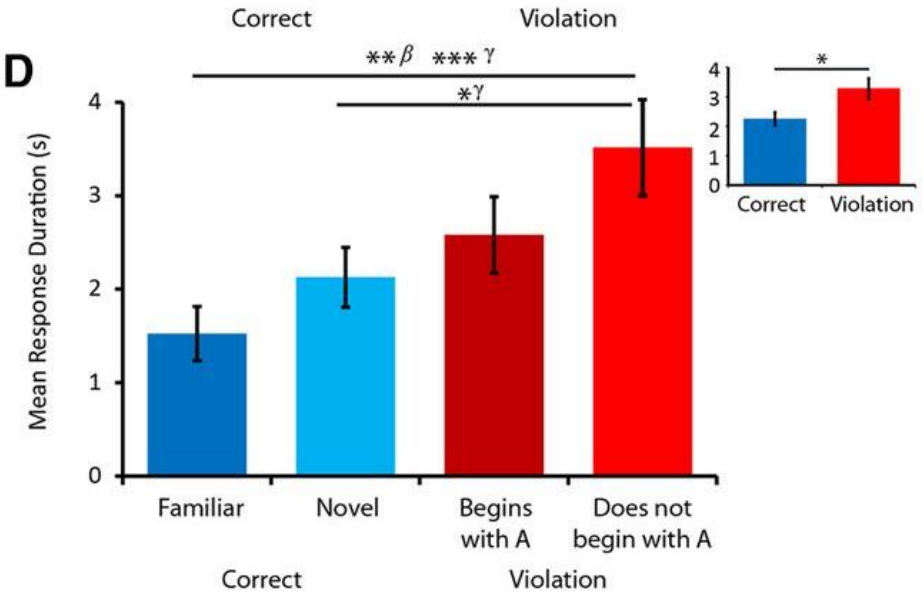
Habituation sequences
ACF
ACFC
ACGF
ACGFC
ACGFCG
ADCF
ADCFC
ADCFCG
ADCGF

Testing sequences		
ACGFC	Correct	Familiar
ADCFCG	Correct	Familiar
ACFCG	Correct	Novel
ADCGFC	Correct	Novel
AFGCD	Violation	Begin with A
AFCDGC	Violation	Begin with A
FADGC	Violation	Do not begin with A
DCAFGC	Violation	Do not begin with A



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.





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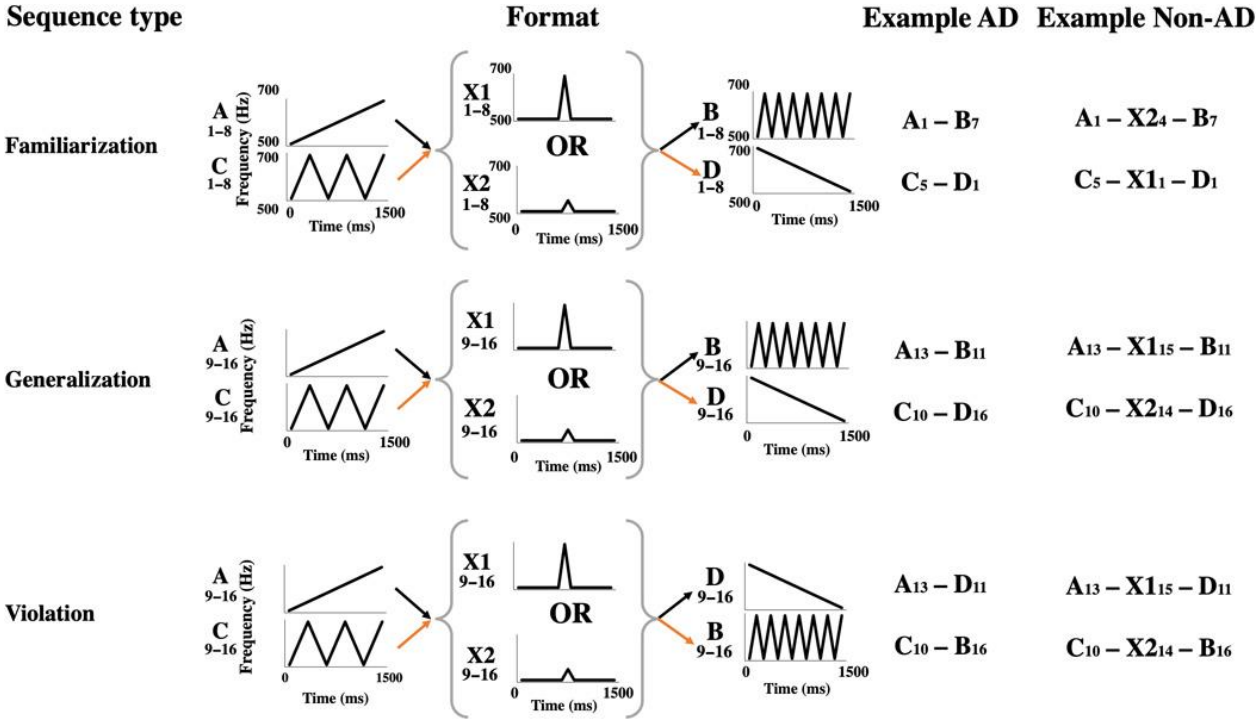
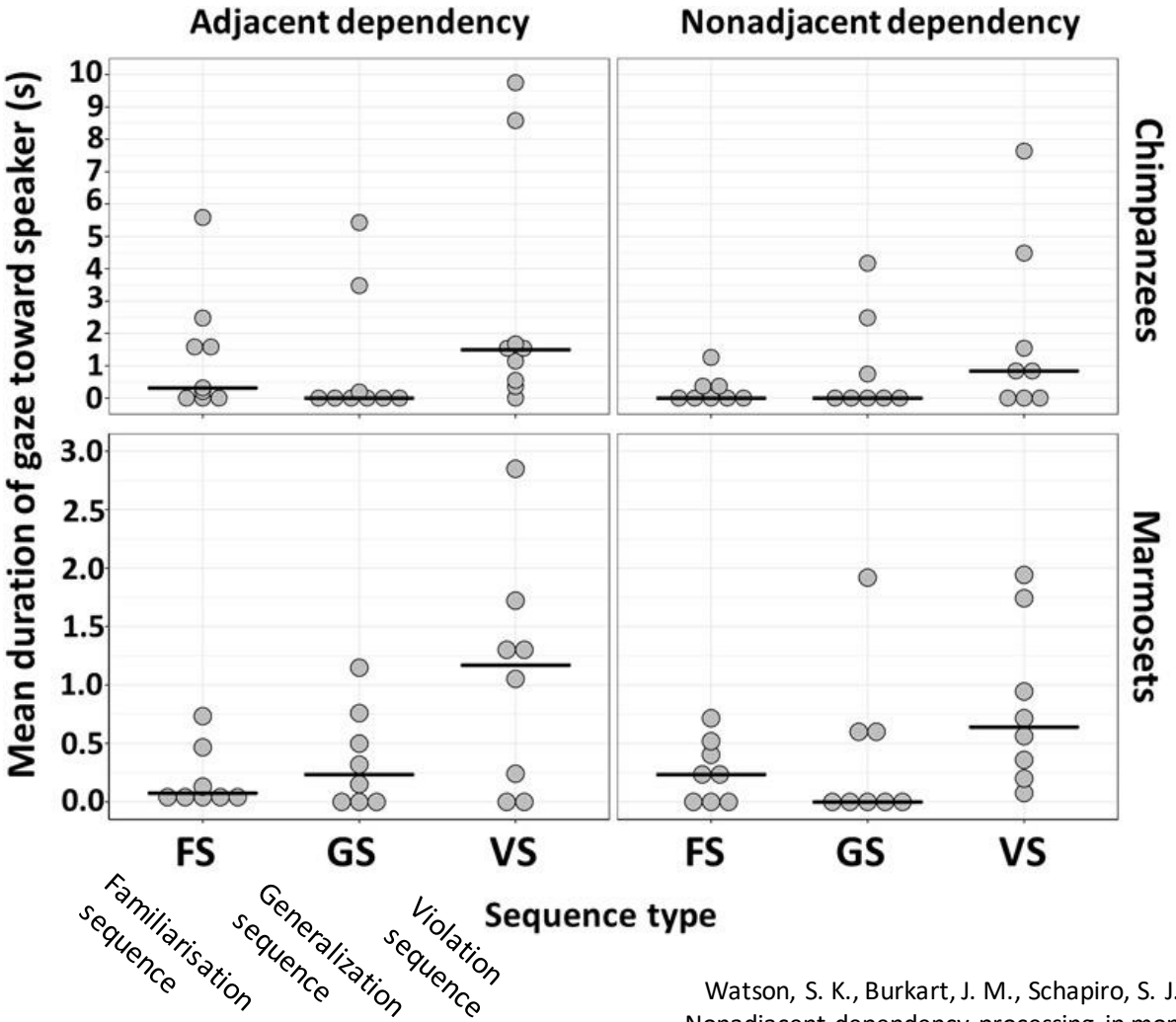
Non-adjacent dependency learning



Watson, S. K., Burkart, J. M., Schapiro, S. J., Lambeth, S. P., Mueller, J. L., & Townsend, S. W. (2020). Nonadjacent dependency processing in monkeys, apes, and humans. *Science Advances, 6,* eabb0725.



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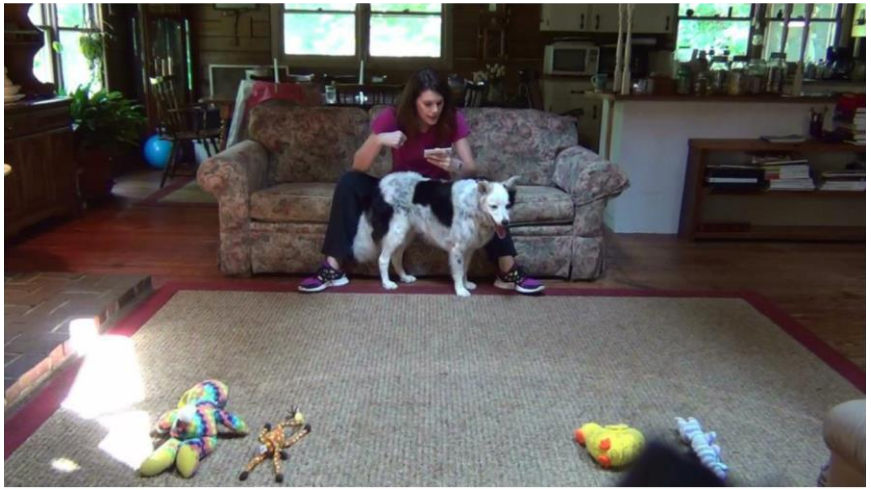
How about learning of **meaningful** sequences?

"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.

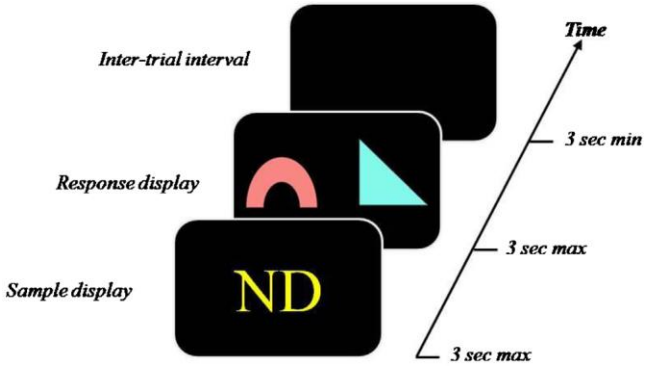
Savage-Rumbaugh, E. S., Murphy, J., Sevcik, R., Brakke, K., Williams, S., Rumbaugh, D., & Bates, E. (1993). Language comprehension in ape and child. *Monographs of the Society for Research in Child Development, 58*, 1–252.

Perhaps a deficit for **hierarchy**?

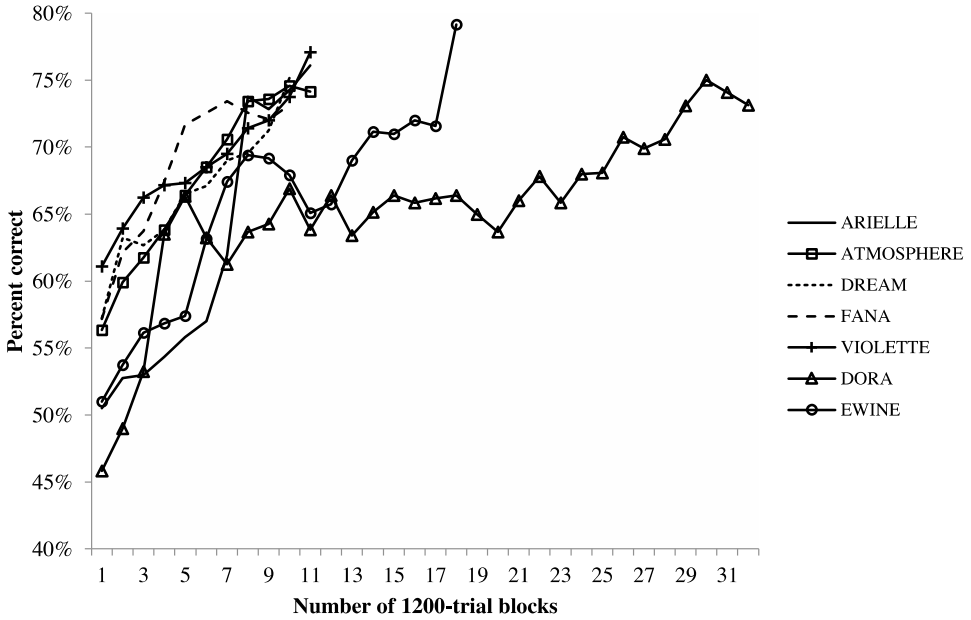
- Could just be ‘semantic soup’ plus smart interpretation?
  - *Cut the onions with your knife*
  - *Put the pine needles in the refrigerator*
- But he can handle reversible events (cf. also Chaser)
  - *Put the tomato in the oil*
  - *Put some oil in the tomato* [Kanzi pours oil in a bowl with the tomato]
- 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**

Next up

- Tutorial: language-trained animals
  - How is it done?
  - What can we learn?
- Next lecture: the evolution of social cognition
  - Sharing, theory of mind, intentionality