

# Origins and Evolution of Language

## Week 5: Human evolution, social learning and cumulative culture

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Admin – for **my Thursday workshop people only**

Venue change for this week – I emailed you, if you didn't get it then come grab me / email me.

# Wrapping up last week

# Bonobos?

Multiple similar cases of compositional call combination?

Their correlational method seems highly prone to false positives (false positive rate as high as 80%!)

Berthet, M., Surbeck, M., & Townsend, S. W. (2025). Extensive compositionality in the vocal system of bonobos. *Science*, 388, 104-108.

Wartel, A. et al. (2026). Structure without semantics: no evidence for bonobo compositionality in Berthet et al. (2025). *PeerJ*, 14, e21651.

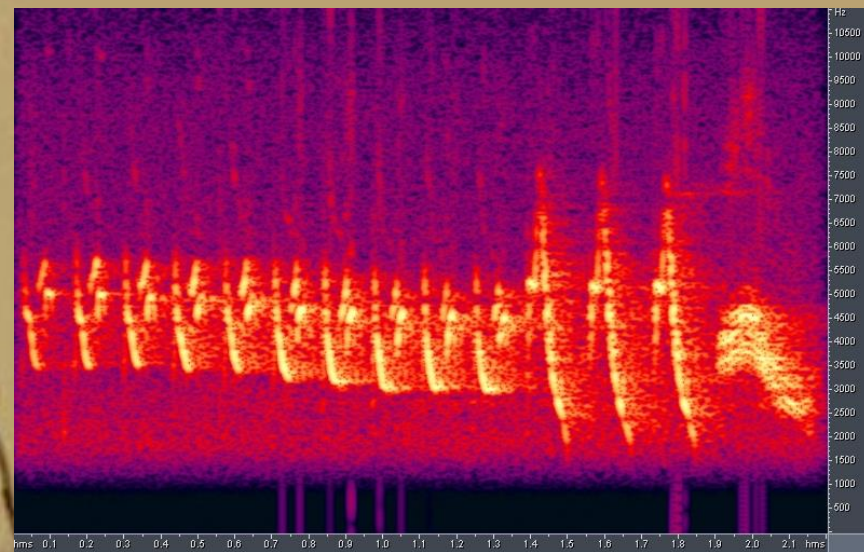


# Abundant evidence of structure in **bird song**

- Songs consist of sequences of notes
- Constraints on the order of combination
- Structure in the signal doesn't subserve meaning
- **Vocal learning**
  - Absent in primate vocal behaviour (?)
- Ultimate functions
  - Territorial defense
  - Courtship
  - Pair/group bonding (duetting)



# Chaffinch song



# Structure of chaffinch song (British)

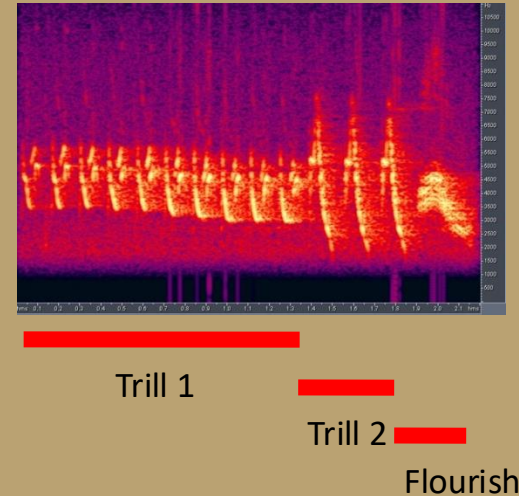
Each bird has 1-6 song types

- Mean 2-3

Order of notes in each song fixed

2-5 trill phrases, followed by a flourish

- Trill: sequence of 2 or more near-identical units
  - Number of repetitions can vary
- Flourish: no repetition
- Re-use of notes
  - Different songs may share, e.g., a flourish



# Willow warbler song

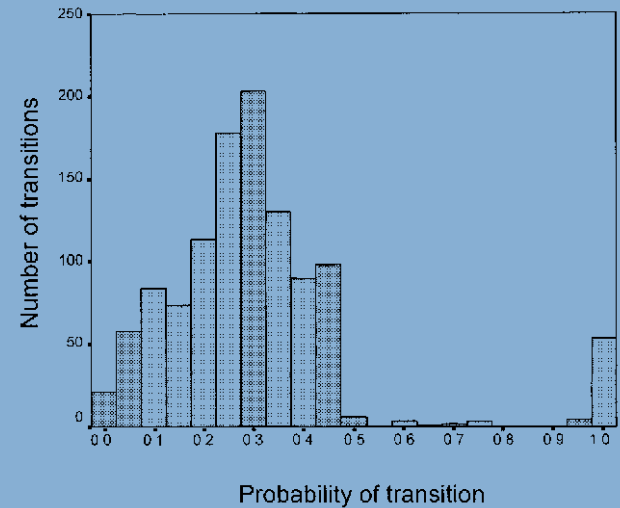


> 100 songs for some birds

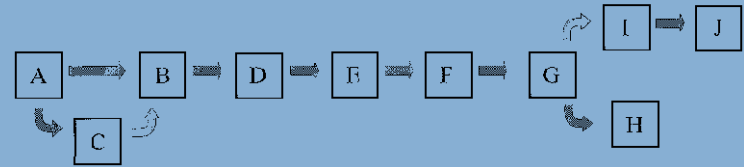
- Repertoire size varies

Mix of predictable and less predictable transitions

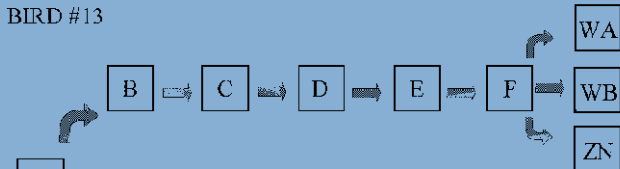
- A simple grammar



BIRD #117



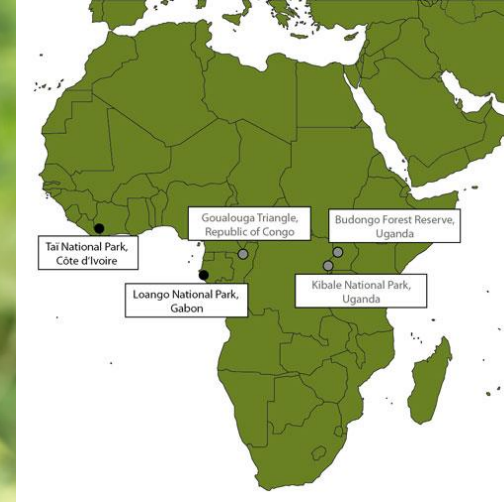
BIRD #13





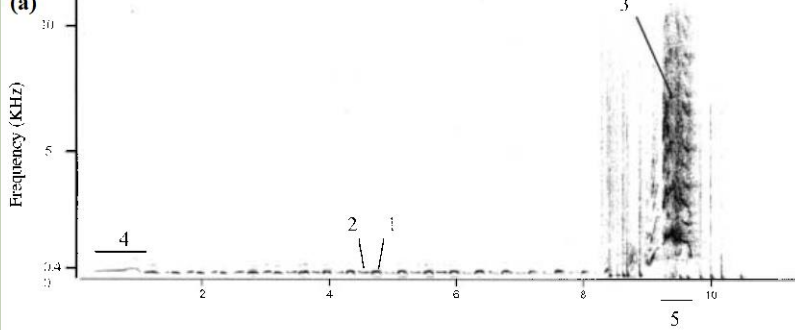
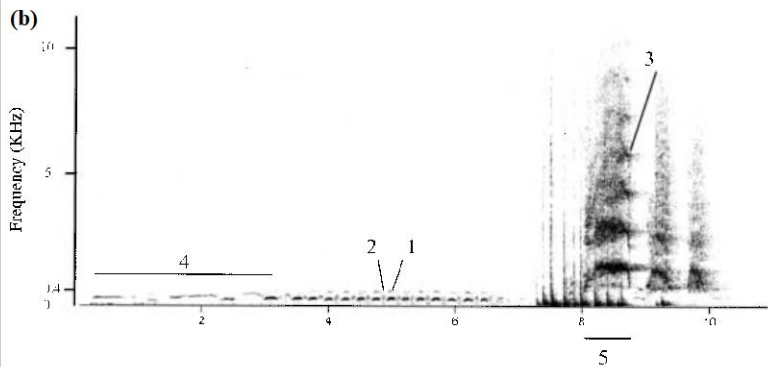
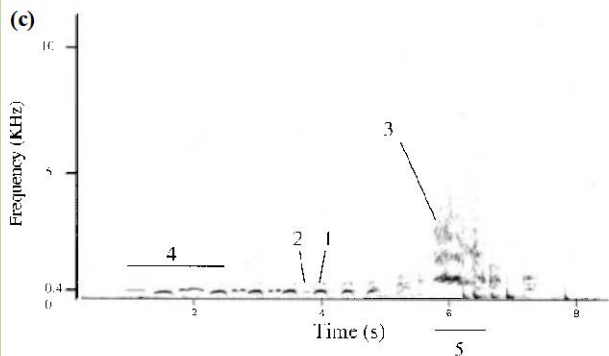
© Julie Goodall

# Suggestive evidence for learned vocalizations in chimpanzees?



Pant hoots of chimpanzees vary between neighbouring groups

Crockford, C., Herbinger, I., Vigilant, L. & Boesch, C. (2004). Wild Chimpanzees Produce Group-Specific Calls: a Case for Vocal Learning? *Ethology*, 110, 221—243.



Crockford et al. (2004): pant hoots of neighbouring groups differ in (e.g.):

- Length of intro (4)
- Peak frequency of screams (3)
- Duration of climax (5)

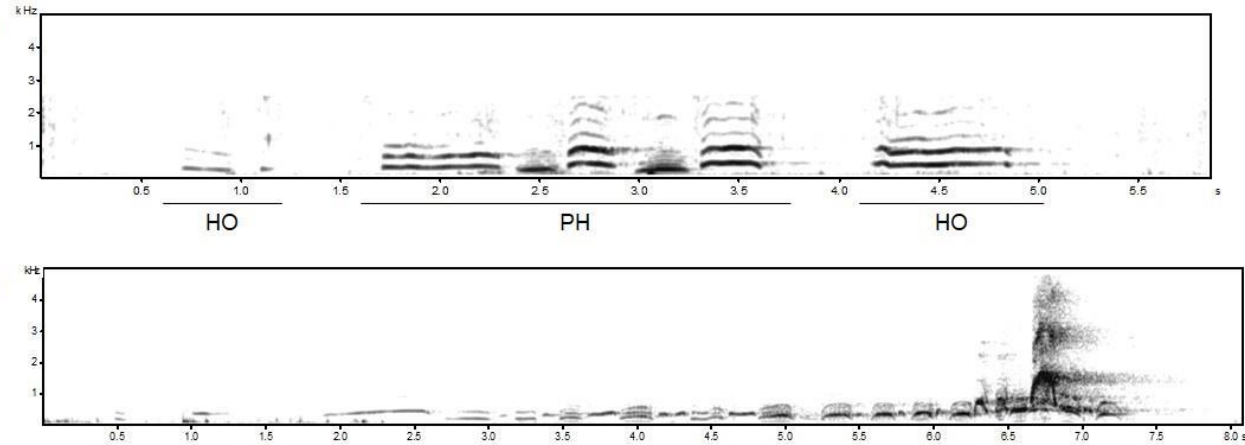
But Desai et al. (2022) fail to replicate in Gombe National Park

- Substantial inter-individual differences, small sample sizes

Crockford, C., Herbinger, I., Vigilant, L. & Boesch, C. (2004). Wild Chimpanzees Produce Group-Specific Calls: a Case for Vocal Learning? *Ethology*, 110, 221–243.

Desai, N. P., Fedurek, P., Slocombe, K. E., & Wilson, M. L. (2022). Chimpanzee pant-hoots encode individual information more reliably than group differences. *American Journal of Primatology*, 84, e23430.

# A lot is not known about call combinations in chimpanzees!



Girard-Buttoz, C., Zaccarella, E., Bortolato, T., Friederici, A. D., Wittig, R. M., & Crockford, C. (2022). Chimpanzees produce diverse vocal sequences with ordered and recombinatorial properties. *Communications Biology*, 5, 410.

# Summary of last week

- Intentional communication
  - Rare in primates, perhaps present in chimpanzees?
- Structured communication
  - Rare and limited in most primates, common in songbirds
  - Generally structure not subserving meaning, but there are hints in call combinations in chimpanzees
- Learned communication
  - Rare in primates (but perhaps present in chimpanzees?), common in songbirds
  - Relationship between vocal learning and structure?

# Communication in the Last Common Ancestor of chimpanzees, bonobos, and humans?

- Not 2<sup>nd</sup> 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!



# A question from the pre-lecture quiz

“When looking for evidence of language in non-human animals or early human ancestors, what exactly are we looking for? What criteria would allow us to distinguish genuine linguistic abilities from isolated, unsystematic associations between symbols and meanings that merely serve immediate practical purposes?”

- Semanticity and second-order intentionality
- Social learning
- Structure subserving meaning

# Plan for rest of today

- Human evolution: quick summary
  - Visual illustration of timeline of human evolution
  - Visual illustration of brain size evolution
- Technology, art, cumulative culture, and language
  - A look at the early evolution of tools
  - Symbolic behaviour 70kya?
  - Tool use and social learning in other species

# Exam-based angst from the pre-lecture quiz

“Do we need to know the orders of all the species mentioned in the article?”

“Human evolution involves too many biological and paleoanthropological terms, which made me dizzy after reading three hours. I hope the following lecture may help me conceptualize the trees of ancient human and different epochs clearly.”

# Fine-grained exam-based angst from the pre-lecture quiz

“How much detail are we expected to remember/know regarding the following?

- Technologies used by hominins and when they were used
- Different lineages of hominins and when they walked the earth
- The four models/hypotheses for how *Homo sapiens* came to populate the globe
- Specific anatomical adaptations of *Homo sapiens* (hand structure, feet structure, leg structure, etc.)”

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# An example exam question from previous years

“The Upper Palaeolithic Revolution, also known as the Great Leap Forwards, occurred approximately 40,000 years ago and saw a massive expansion in the complexity and variety of tools and art produced by our ancestors. What, if anything, does the timing of the Upper Palaeolithic Revolution tell us about the timing of the origins of human language?”

# A question from the pre-lecture quiz

“How do tool kit simplicity and human speech [language!] affect each other?”

That's the topic of Thursday's workshop.

# A question from the pre-lecture quiz

“I struggle with the idea of "multiple intelligences" - Is this still an idea that is supported by science?”

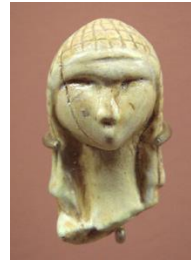
“[if] different abilities are governed by distinct and separate forms of intelligence ... much of tool-using behaviour and artistic ability would have to be based upon neurological structures fundamentally different from those that support verbal ability [sic].” (Tuttle, 2026, in *Encyclopedia Britannica*)

# A question from the pre-lecture quiz

“What does "symbolically-structured modern human culture" (mentioned in the 3rd paragraph) refer to?”

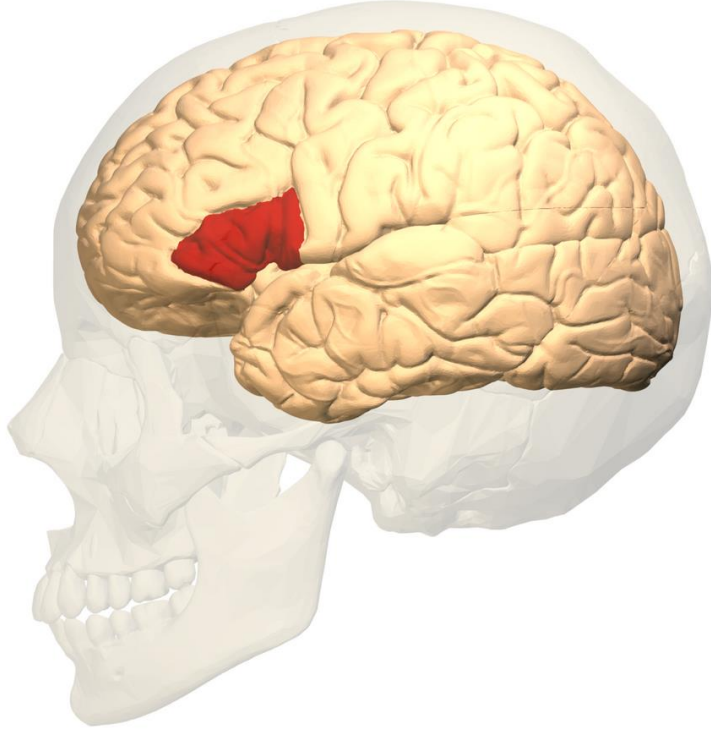
“This article is a discussion of the broad career of the human tribe from its probable beginnings millions of years ago in the Miocene Epoch (23 million to 5.3 million years ago) to the development of **tool-based and symbolically structured modern human culture only tens of thousands of years ago**” (Tuttle, 2026, in *Encyclopedia Britannica*)

## Upper Paleolithic Revolution “Great Leap Forward”, 100-40KYA (?)



# A comment from the pre-lecture quiz

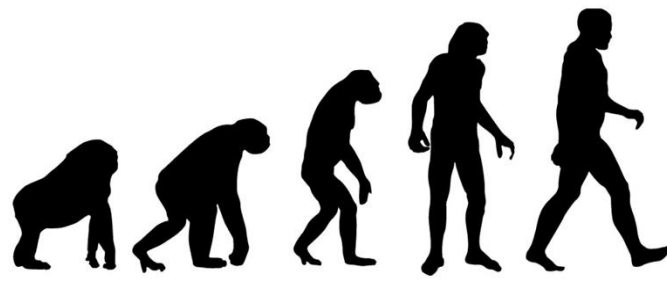
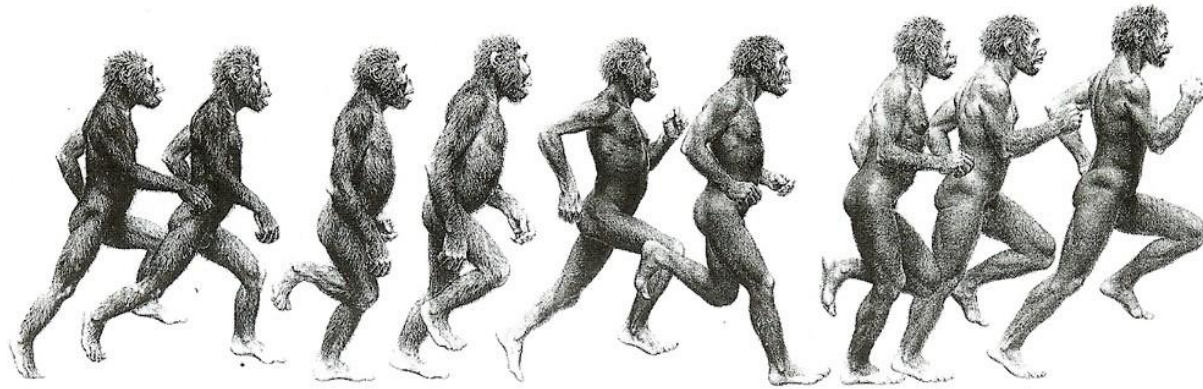
“Tuttle argues that you cannot judge speech ability from fossil brains, because the brains did not fit snugly against the skull and the braincases are incomplete and distorted, so features like a "Broca cap" are unreliable. His sharpest evidence is that some chimpanzees have prominent Broca caps yet no ape has ever produced speech despite extensive training attempts. I agree, and the strongest support comes from a study regarding how great ape gestures show flexible, intentional communication outside language, which shows that language-like capacities can exist without speech, so a brain region implicated in speech cannot be a sufficient marker of it. The chimpanzee evidence Tuttle cites is decisive because it is a direct falsification: if the same anatomy exists in a species that definitively lacks speech, that anatomy cannot entail speech, and the same caution must apply to fossil hominins.”



[https://commons.wikimedia.org/wiki/File:Broca%27s\\_area\\_-\\_lateral\\_view.png](https://commons.wikimedia.org/wiki/File:Broca%27s_area_-_lateral_view.png)



[https://en.wikipedia.org/wiki/Endocast#/media/File:Australopithecus\\_africanus\\_-\\_Cast\\_of\\_taung\\_child.jpg](https://en.wikipedia.org/wiki/Endocast#/media/File:Australopithecus_africanus_-_Cast_of_taung_child.jpg)



*A. afarensis*

*A. africanus*

*A. robustus*

*A. boisei*

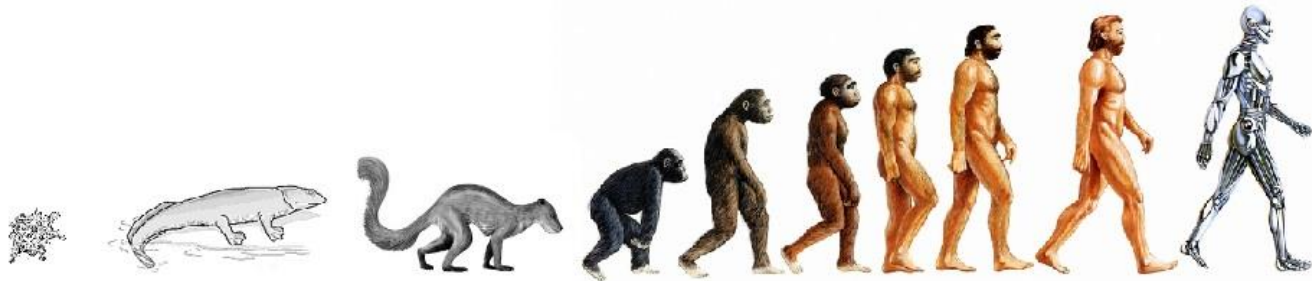
*H. habilis*

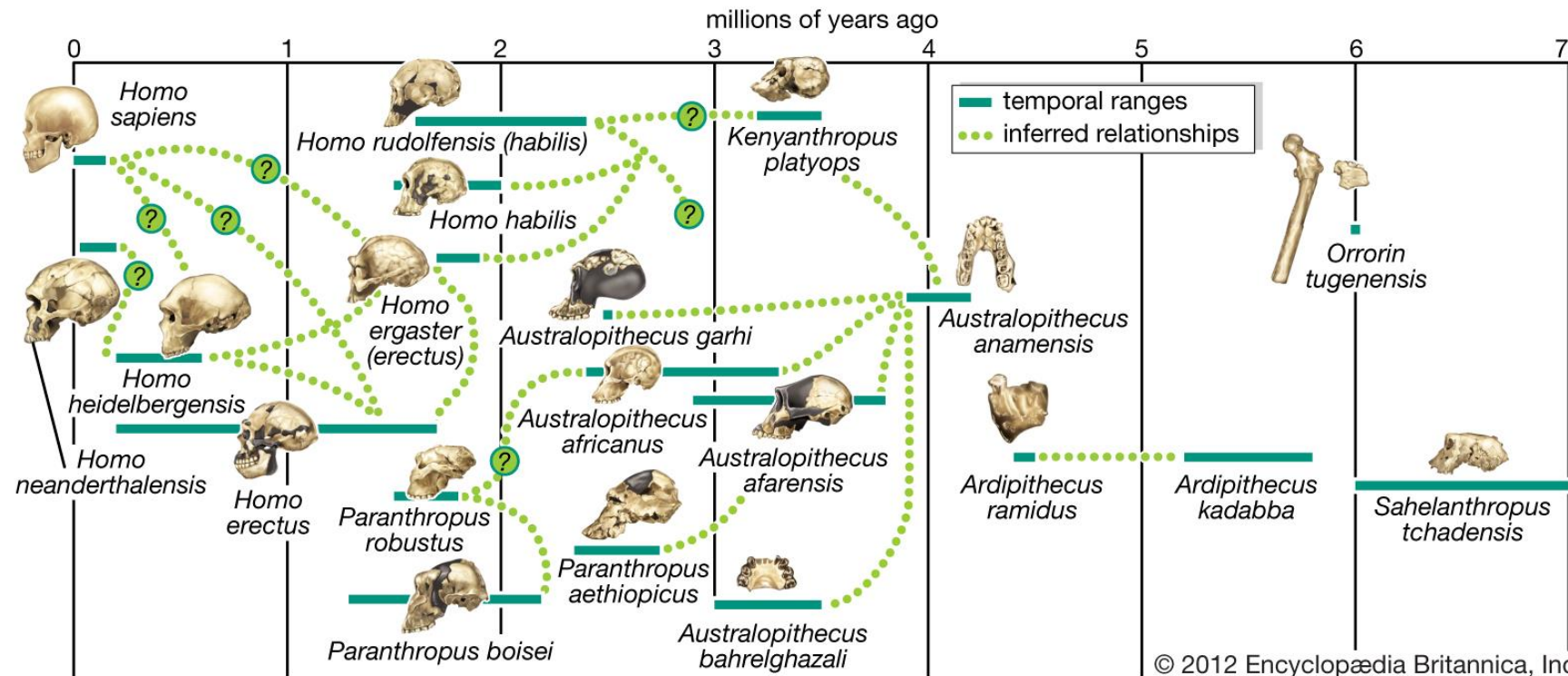
*H. erectus*

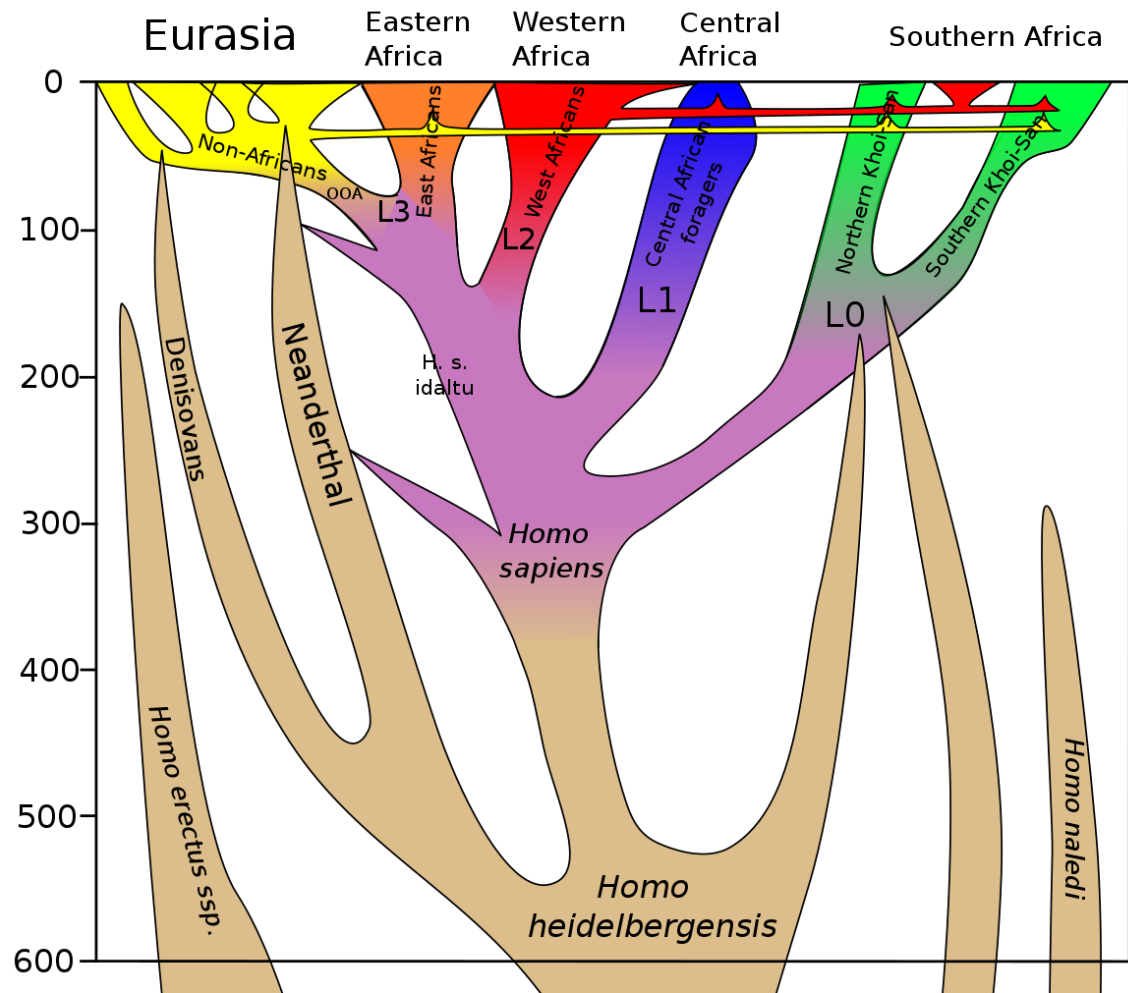
*H. sapiens*  
(archaic)

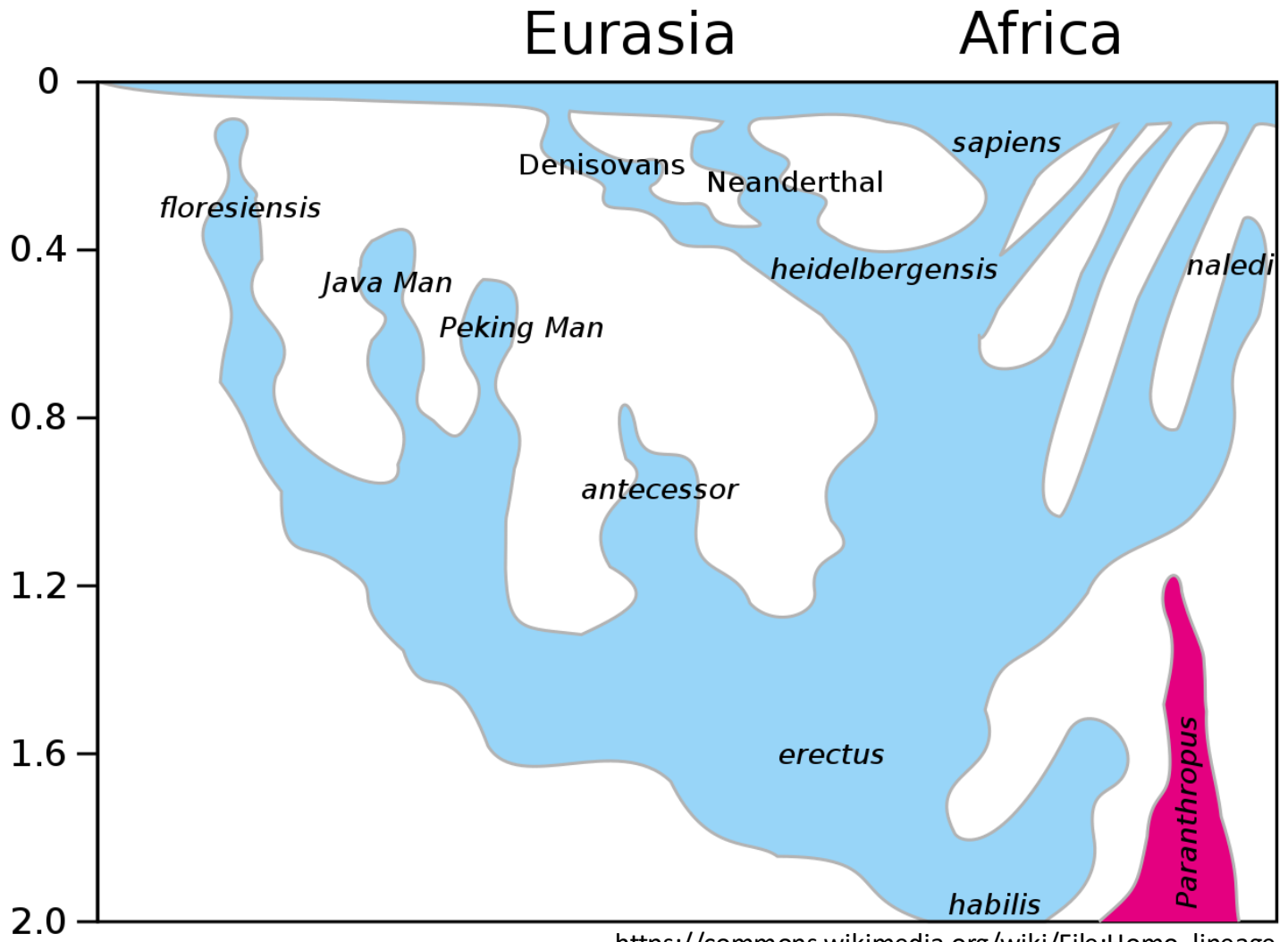
*H. sapiens*  
(Neandertal)

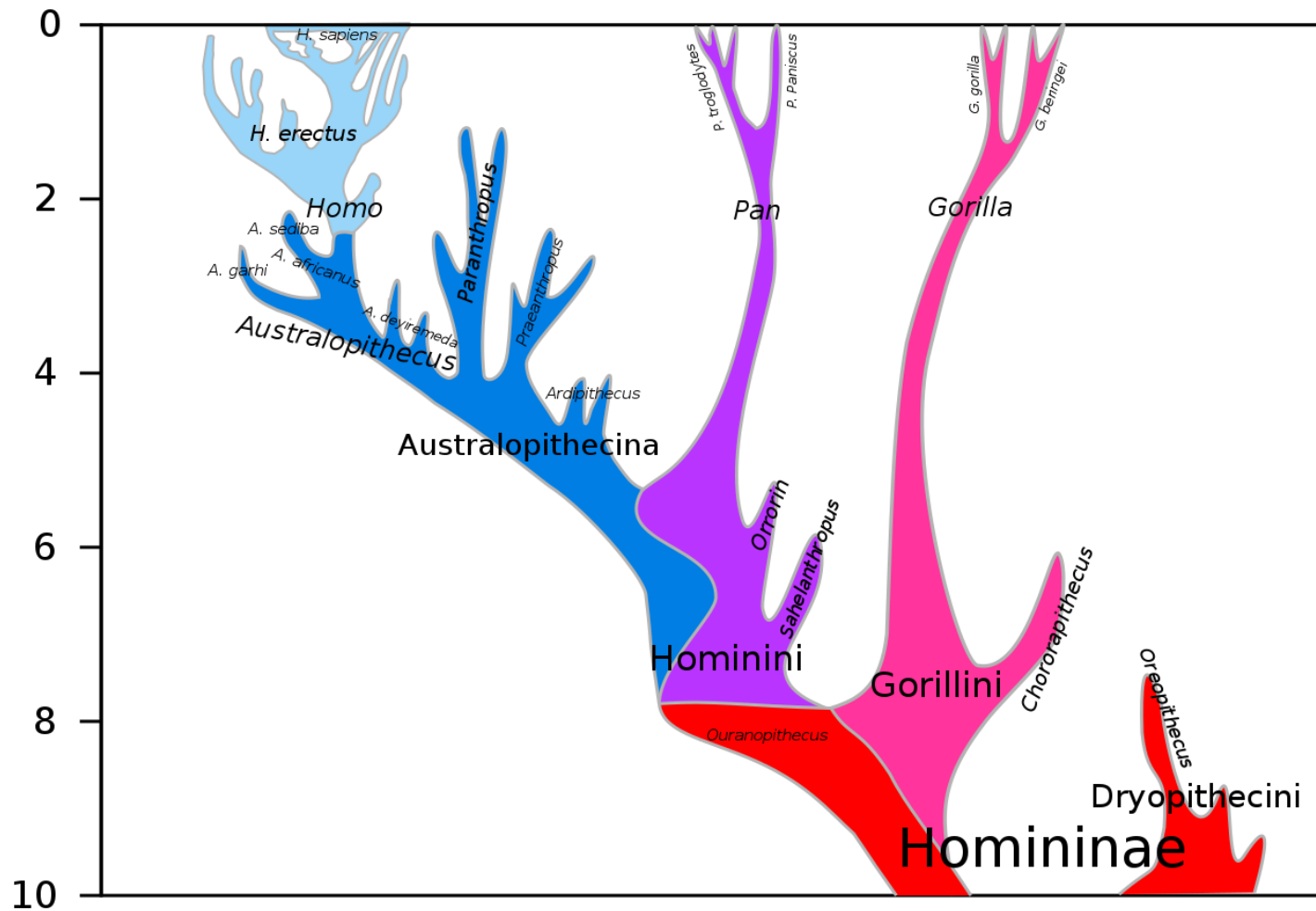
*H. sapiens*  
(modern)







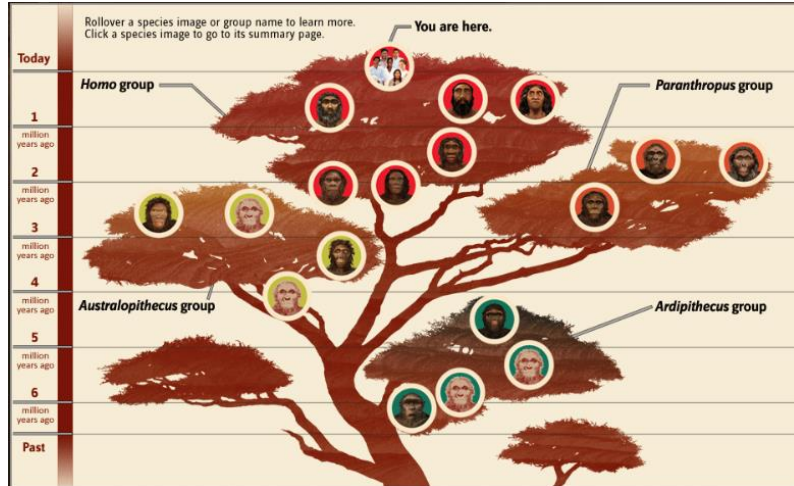
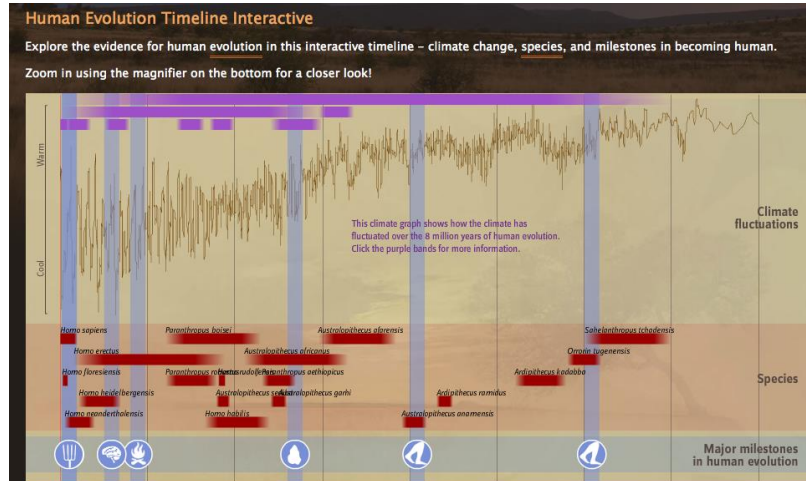




# A useful resource: Smithsonian Human Evolution Timeline

<http://humanorigins.si.edu/evidence/human-family-tree>

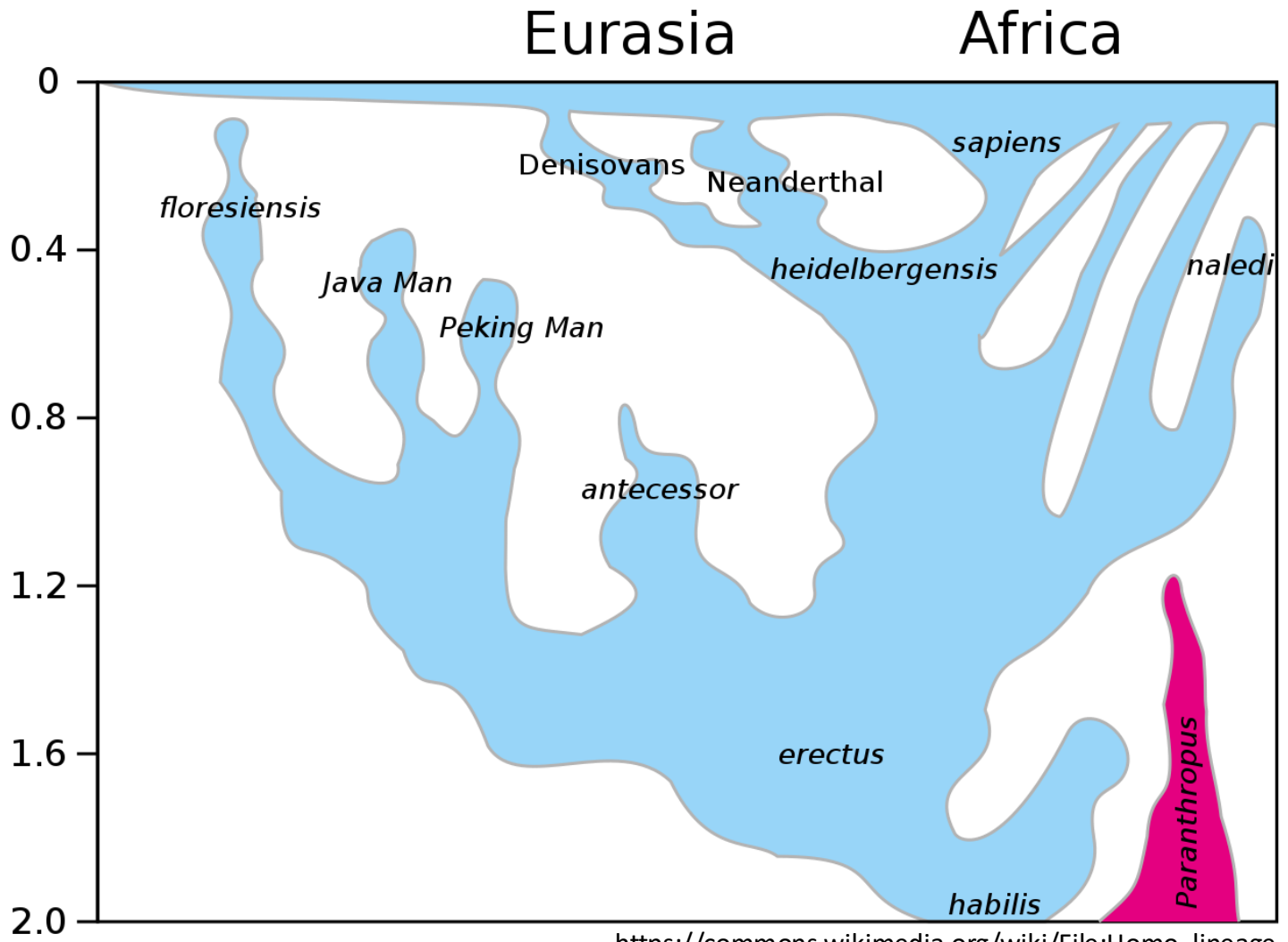
<http://humanorigins.si.edu/evidence/human-evolution-timeline-interactive>

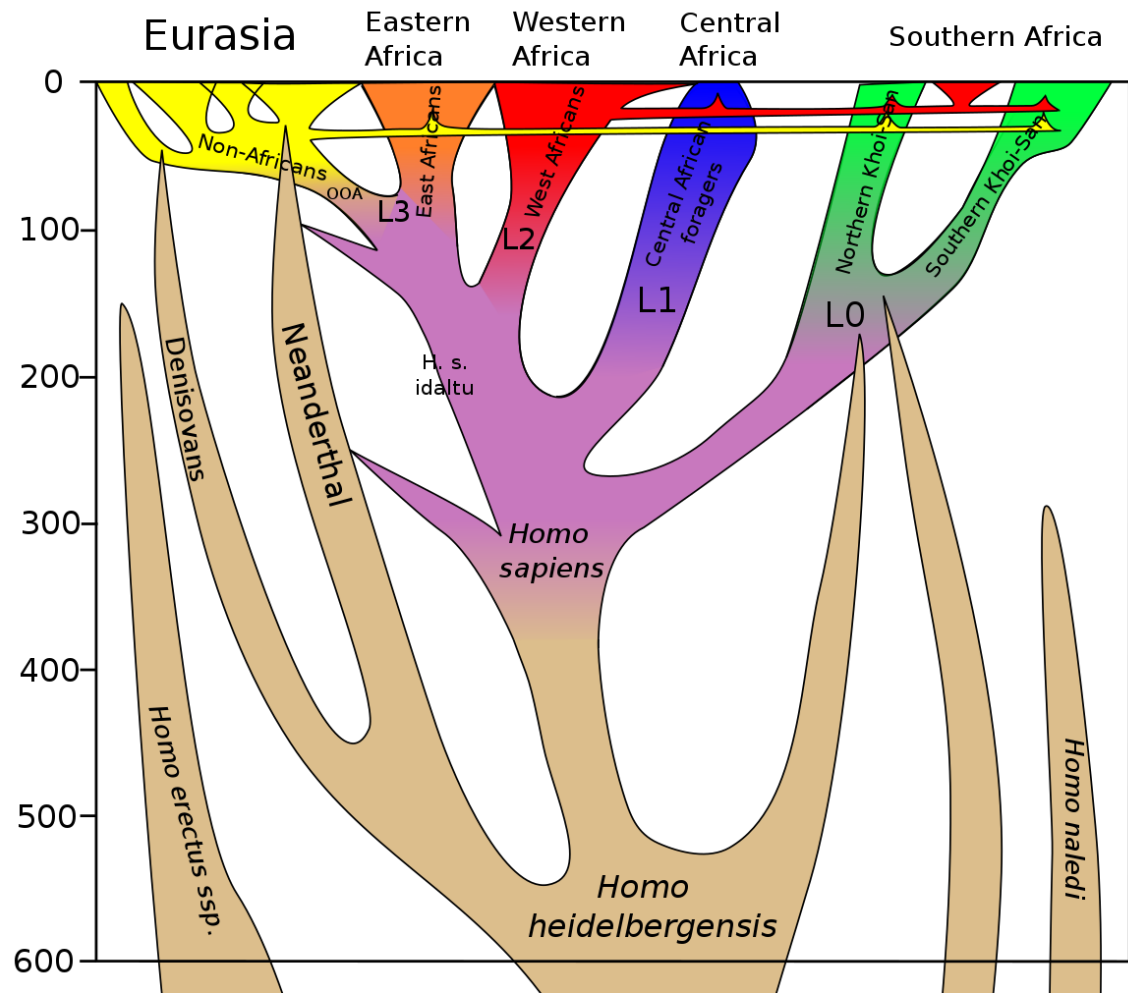


# Fine-grained exam-based angst from the pre-lecture quiz

“How much detail are we expected to remember/know regarding the following?

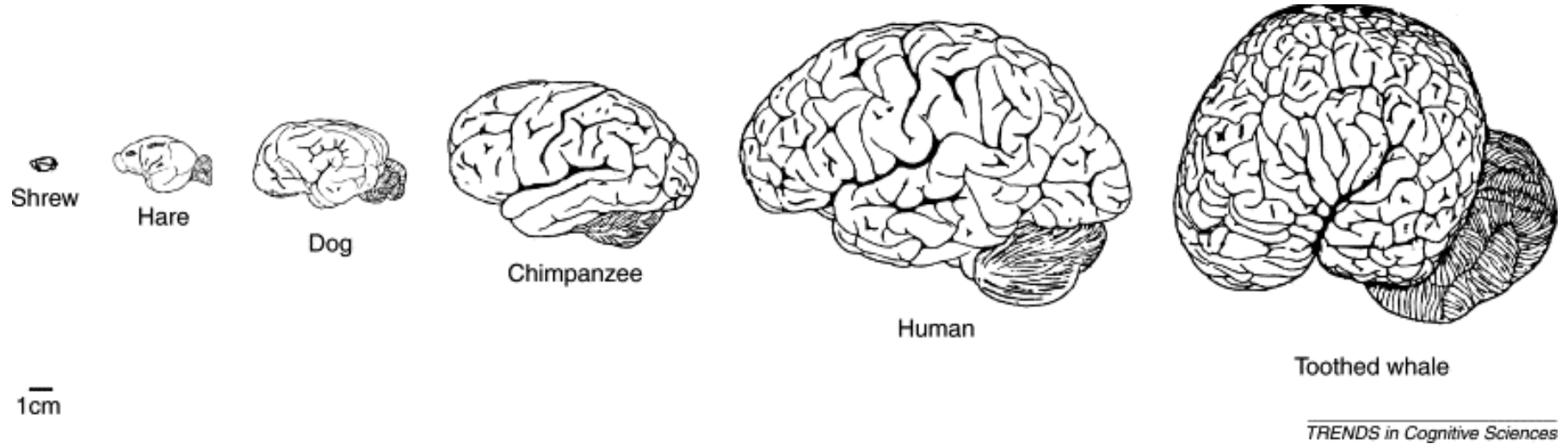
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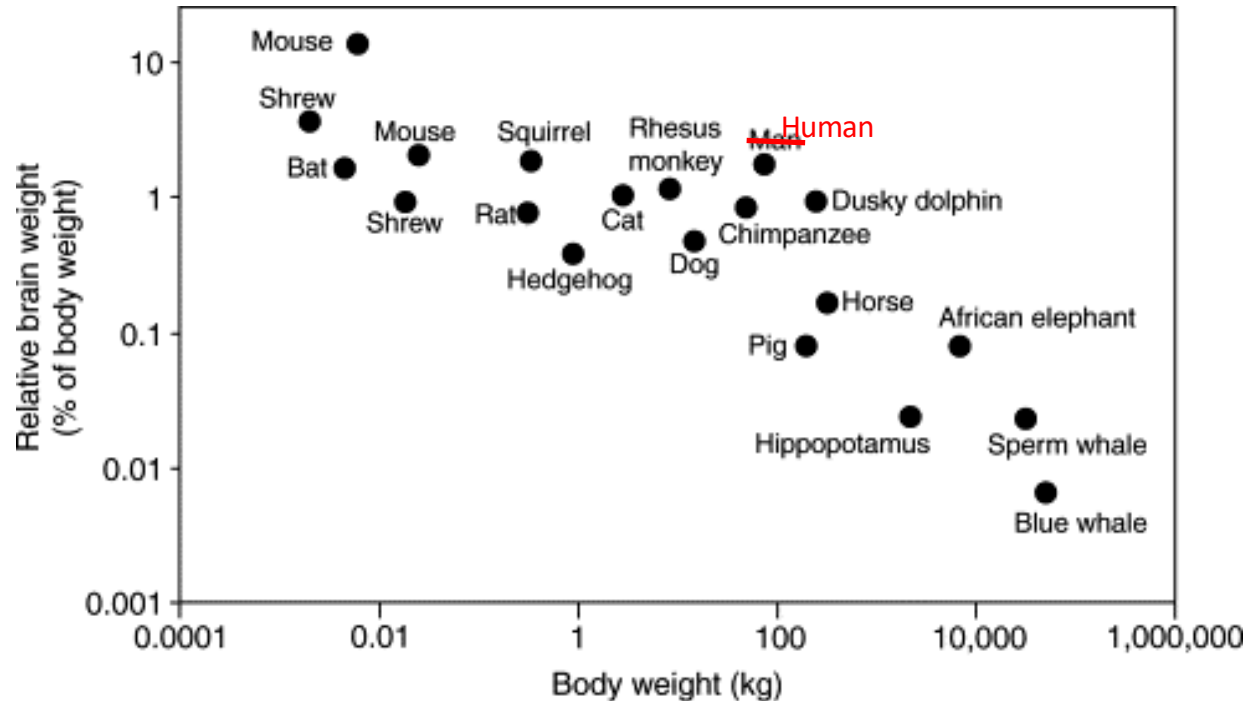
# Evolution of brain size

# Brain size: absolute size



Humans don't have the biggest brains, or the most folded cortex

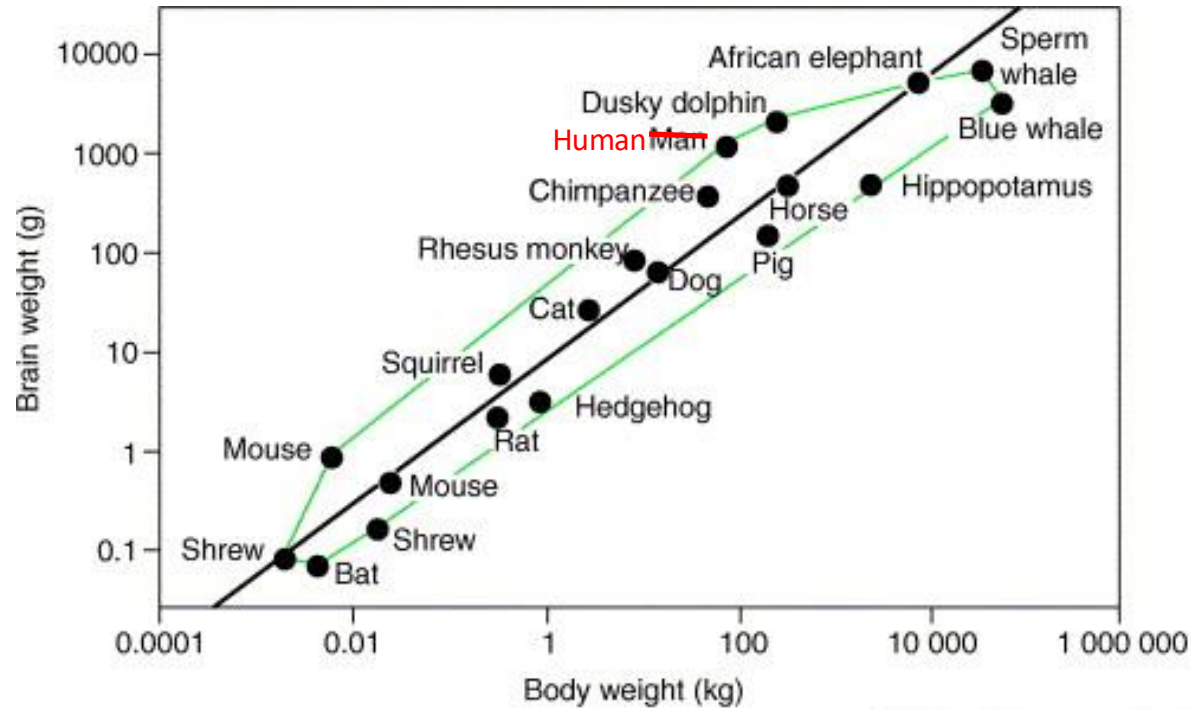
# Brain size as a % of body size



*TRENDS in Cognitive Sciences*

Humans don't have the biggest brains as a % of body weight

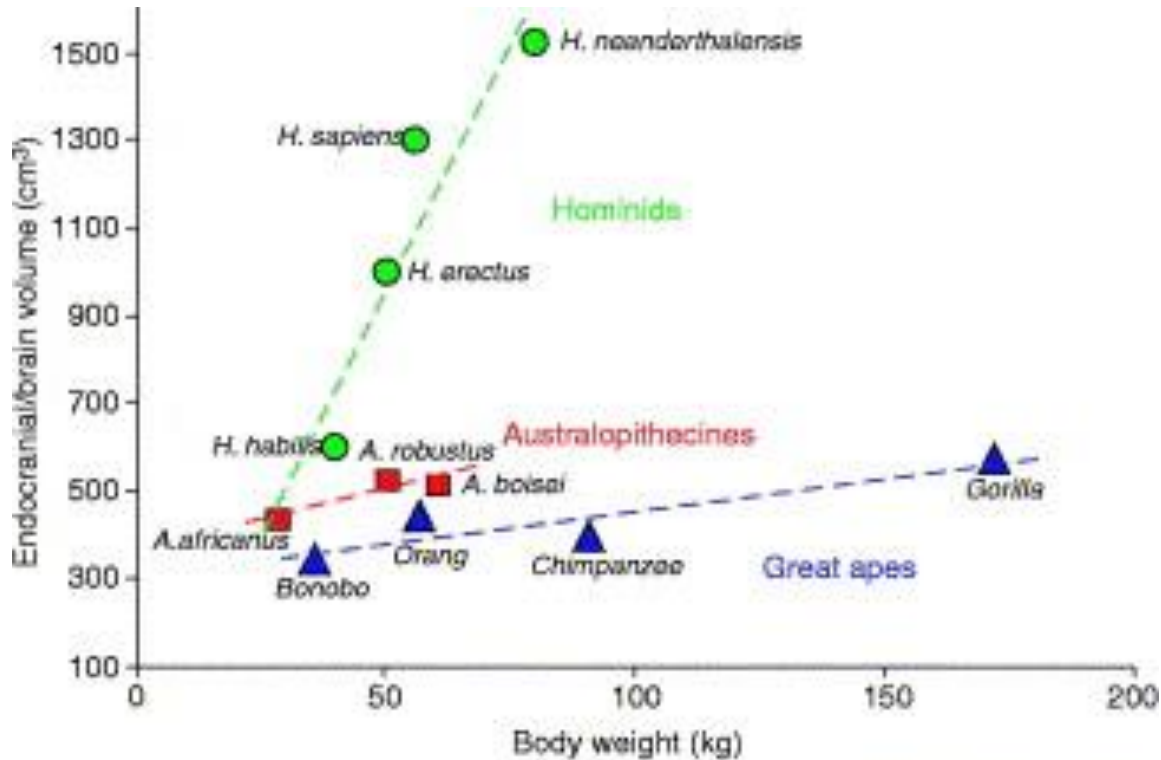
# Relative size and encephalization quotient



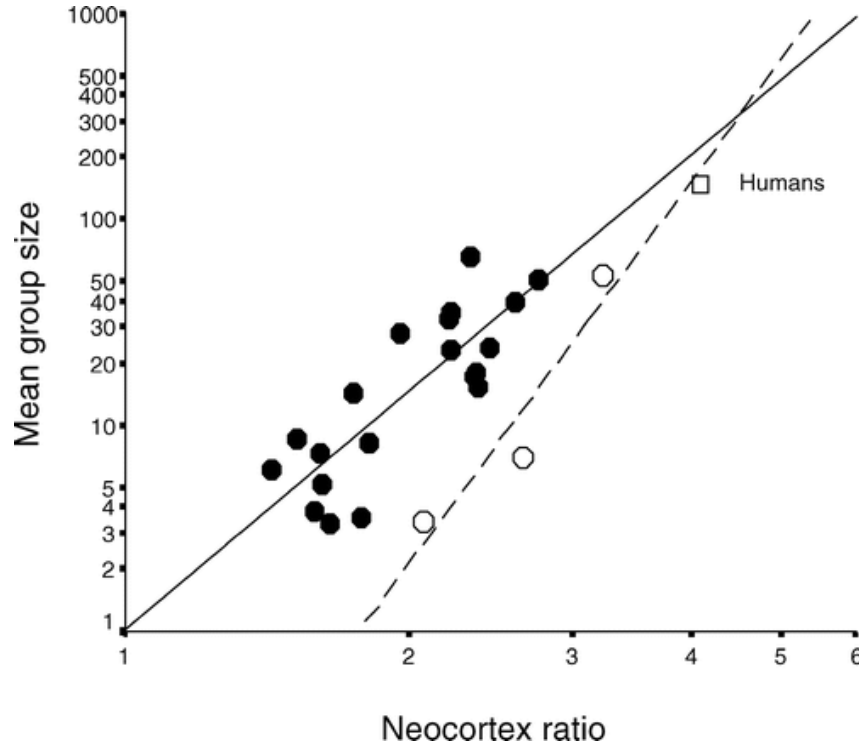
TRENDS in Cognitive Sciences

Human brains are big **relative to the brain a mammal of our size should have**

# The evolution of brain size



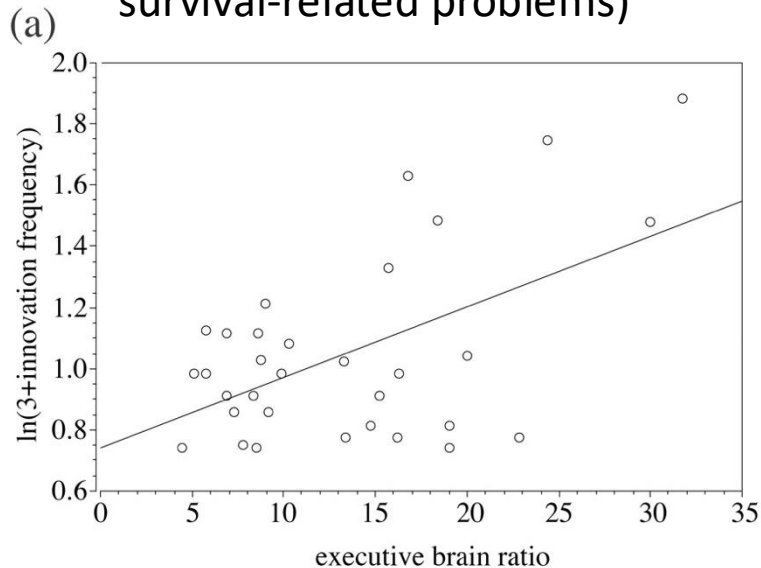
# Neocortex size and group size



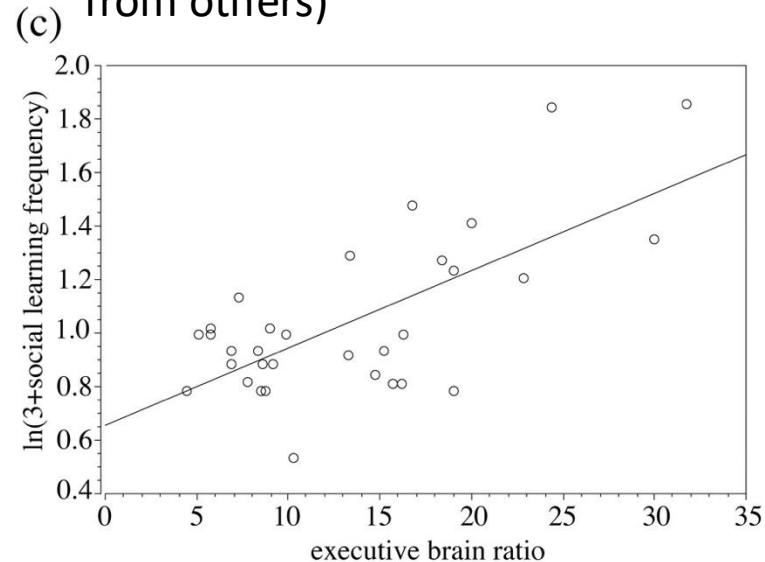
Dunbar, R. I. M. (2003). The Social Brain: Mind, Language, and Society in Evolutionary Perspective. *Annual Review of Anthropology*, 32, 163-181.

# Brain size and social learning, innovation and tool use in primates

Innovation (new solutions to survival-related problems)



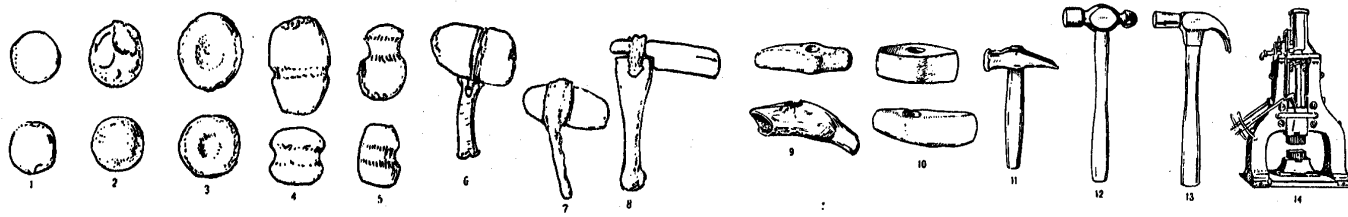
Social learning (acquiring skills/info from others)



Technology, art, cumulative culture, and language

# Cumulative cultural evolution

Behaviour and artefacts become increasingly complex, such that each generation uses techniques and objects they could never have invented by themselves (“the cultural ratchet”)



Products of CCE: technology, complex societies, **language**, ...

# DEVELOPMENT OF STONE TOOL TECHNOLOGY IN EASTERN AFRICA

Location of  
Lomekwi 3 site



## ACHEULEAN

Hand axes begin to  
appear 1.76 MYA.



## OLDOWAN

"Pebble cores"  
begin to appear  
~2.6 MYA.



**LOMEKWIAN**  
Earliest knapped  
tools discovered.  
Date: 3.3 MYA.



Millions  
of Years  
Ago

0.5

1.0

1.5

2.0

2.5

3.0

3.5



Indicates periods of large (>100K  
years) gaps in stone tool evidence

## MAJOR EVENTS



Climate shift to  
100K-year glacial cycles



*Homo erectus* appears  
in fossil record



Cooler, dryer climate  
in Eastern Africa

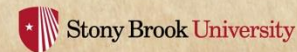


Oldest known  
*Homo* fossils

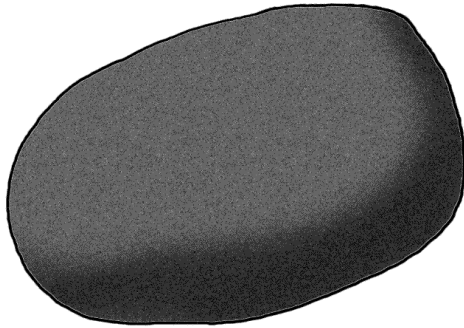


Oldest known  
stone tools

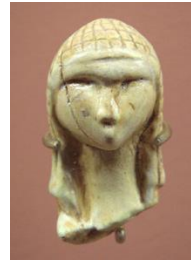
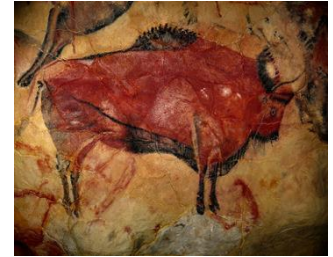
Image Copyrights: Acheulean, Lomekwian tools © MPK-WTAP;  
Oldowan tool © Turkana Basin Institute.



Mousterian  
0.3 MYA – 40KYA



Upper Paleolithic Revolution  
“Great Leap Forward”, 100-40KYA (?)



# DEVELOPMENT OF STONE TOOL TECHNOLOGY IN EASTERN AFRICA

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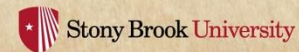


Oldest known  
*Homo* fossils



Oldest known  
stone tools

Image Copyrights: Acheulean, Lomekwian tools © MPK-WTAP;  
Oldowan tool © Turkana Basin Institute.





<https://www.youtube.com/watch?v=SrvPOkMs4U4>

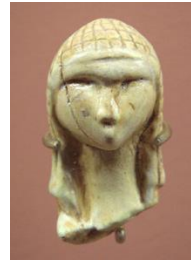
# This week's tutorial: tools and language

How did individuals acquire these skills?

- Individual trial-and-error learning?
- Emulation?
- Imitation?
- Teaching?
- **Teaching with language?**



## Upper Paleolithic Revolution “Great Leap Forward”, 100-40KYA (?)

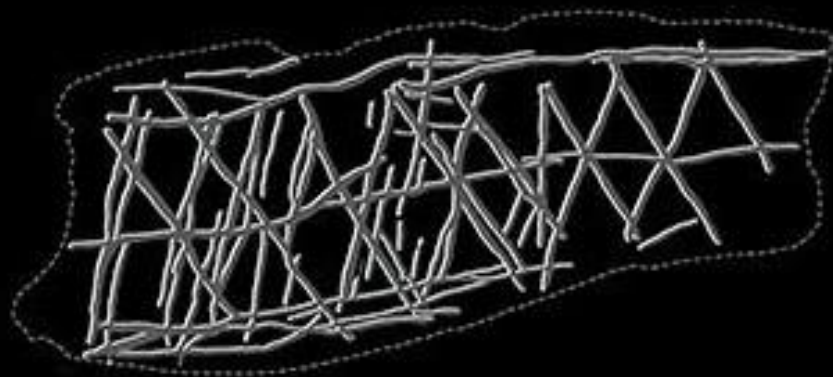




Blombos cave, South Africa

d







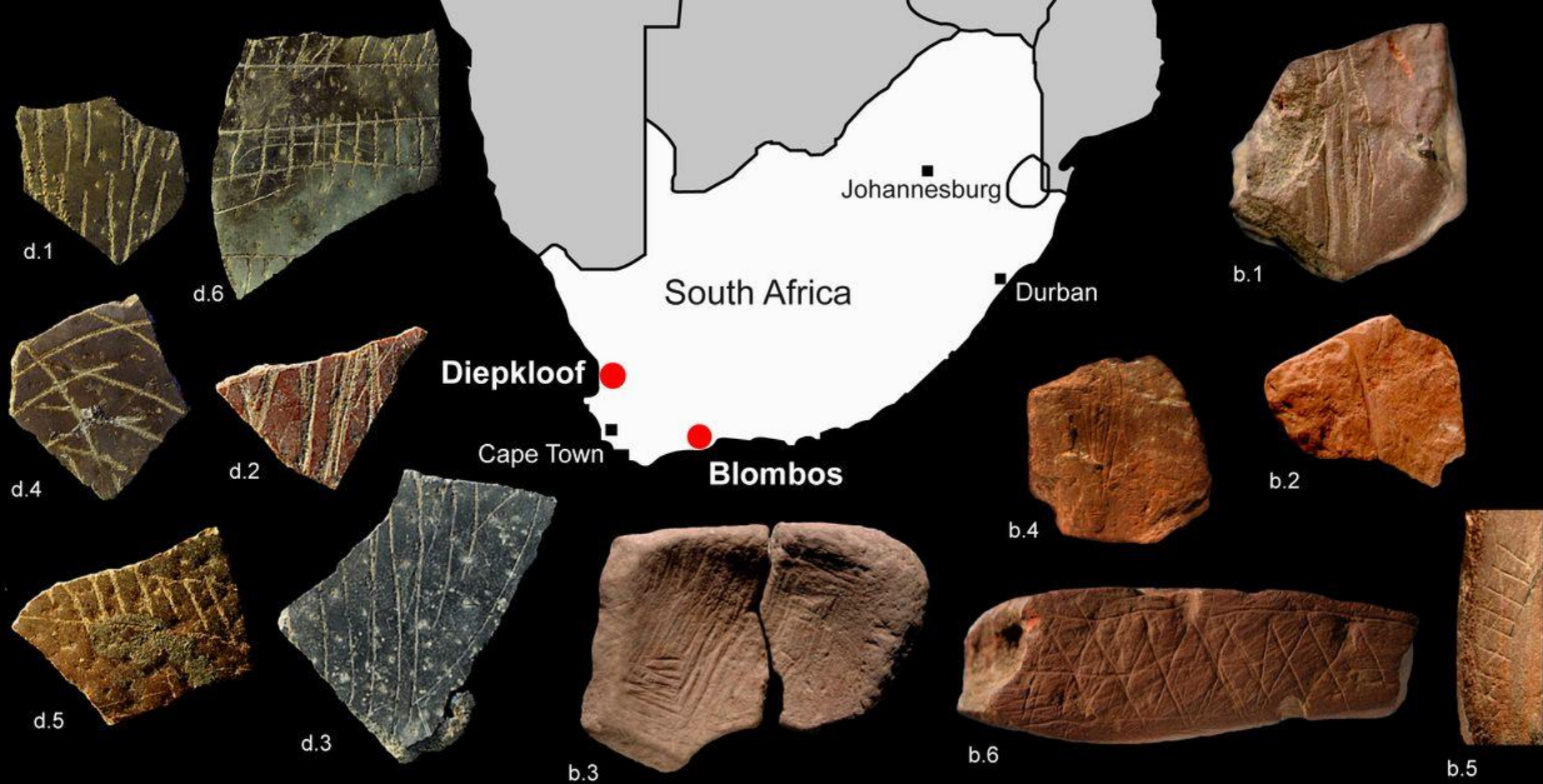
From Henshilwood, C.S. *et al.* (2018) An abstract drawing from the 73,000-year-old levels at Blombos Cave, South Africa. *Nature*, 562, 115–118.

“evidence for modern cognition at c. 77–55 ky. In particular, we highlight the shell beads and engraved ochres from Blombos Cave as being examples of artifacts with clear symbolic meaning. A number of authors have previously suggested that the Blombos ochre pieces and the marine shell beads equate with information being stored outside of the human brain ... and that the transmission and sharing of the symbolic meaning of these items must have depended on “syntactical” language” (Henshilwood & Dubreuil, 2009, p. 60-61)

Henshilwood, C.S. & Dubreuil, B. (2009). Reading the artefacts: Gleaning language skills from the Middle Stone Age in southern Africa. In R. Botha & C. Knight (Eds.), *The Cradle of Language* (pp. 41-60). Oxford: Oxford University Press.

“We argue that the capacity to represent how an object appears to another person ... enables the invention of symbolic artifacts like beads and engraved ochres, but also of other artifacts whose symbolic component remains contentious, such as bone tools, bifacial points, and engraved ostrich egg shell. Because recursion is essential to articulate in language [this] kind of meta-representations ..., we predict that the presence of syntactic language can now confidently be “read” from some of the Blombos artifacts. ” (Henshilwood & Dubreuil, 2009, p. 61)

Henshilwood, C.S. & Dubreuil, B. (2009). Reading the artefacts: Gleaning language skills from the Middle Stone Age in southern Africa. In R. Botha & C. Knight (Eds.), *The Cradle of Language* (pp. 41-60). Oxford: Oxford University Press.



Tylén, K., Fusaroli, R., Rojo, S., Heimann, K., Fay, N., Johannsen, N. N., Riede, F., & Lombard, M. (2020). The evolution of early symbolic behavior in *Homo sapiens*. *Proceedings of the National Academy of Sciences*, 117, 4578-4584.

Engravings



Original  
Outlines



Experimental  
Stimuli



Early

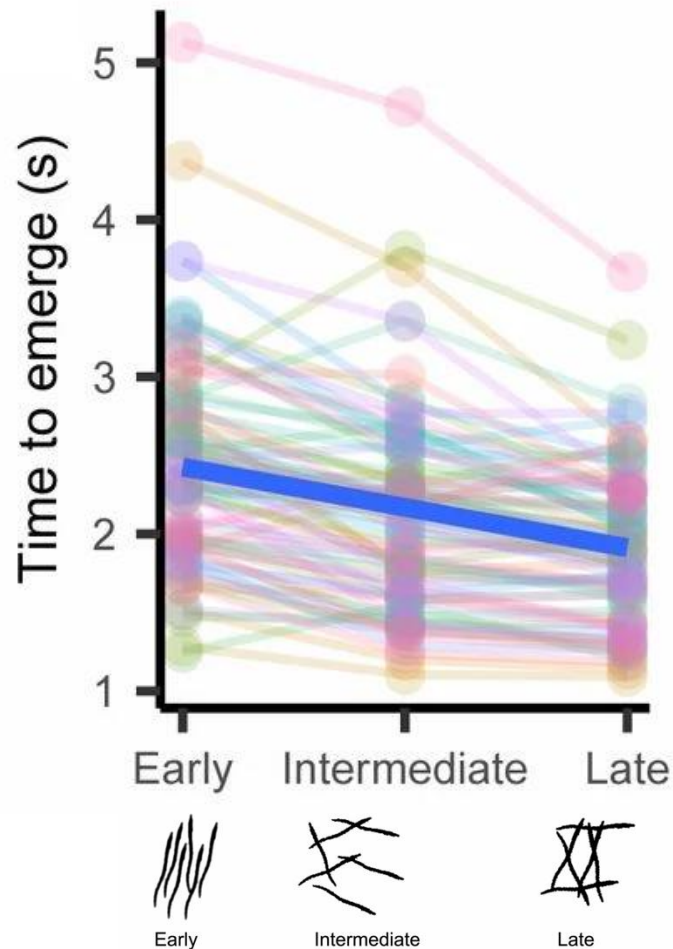
Intermediate

Late

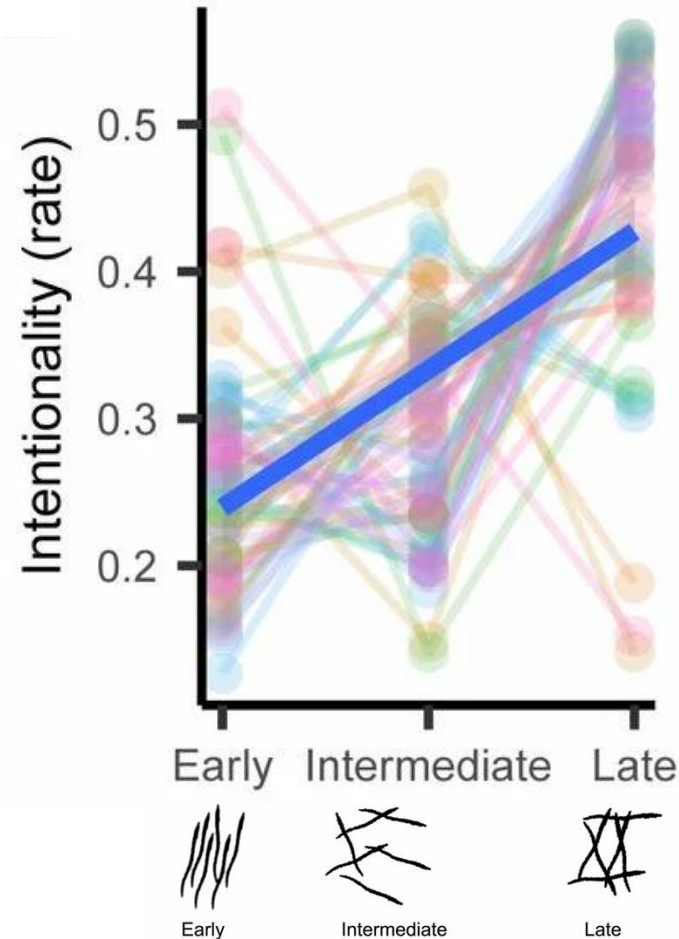
Tylén, K., Fusaroli, R., Rojo, S., Heimann, K., Fay, N., Johannsen, N. N., Riede, F., & Lombard, M. (2020). The evolution of early symbolic behavior in Homo sapiens. *Proceedings of the National Academy of Sciences*, 117, 4578-4584.

## Experiment 1: time to emerge under continuous flash suppression

- Measure of salience to human visual system



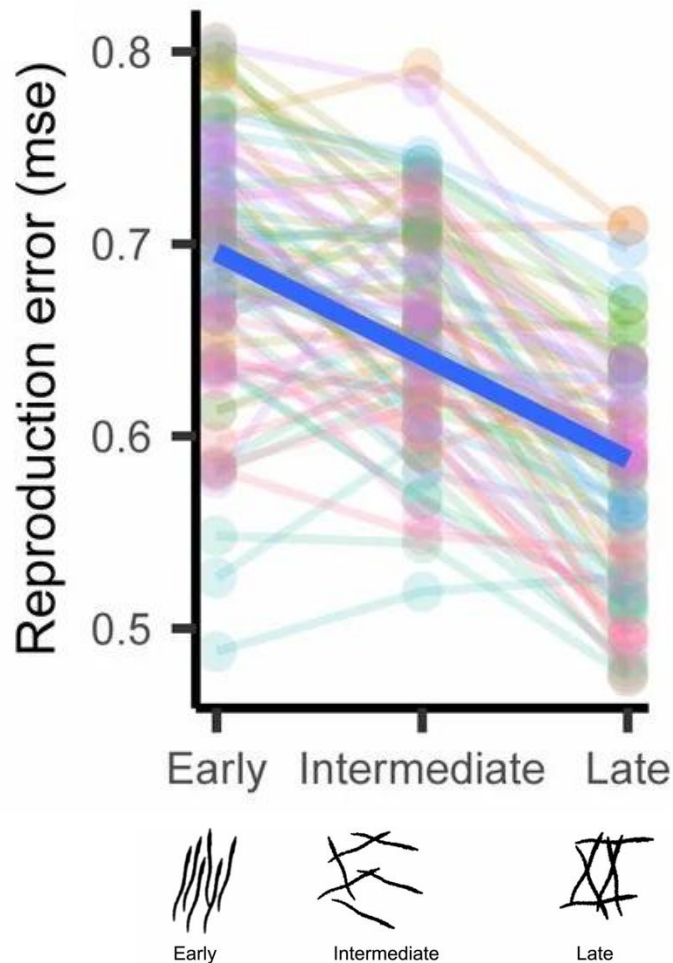
**Experiment 2:** “which is more likely to have been purposefully made by a human”



## Experiment 3:

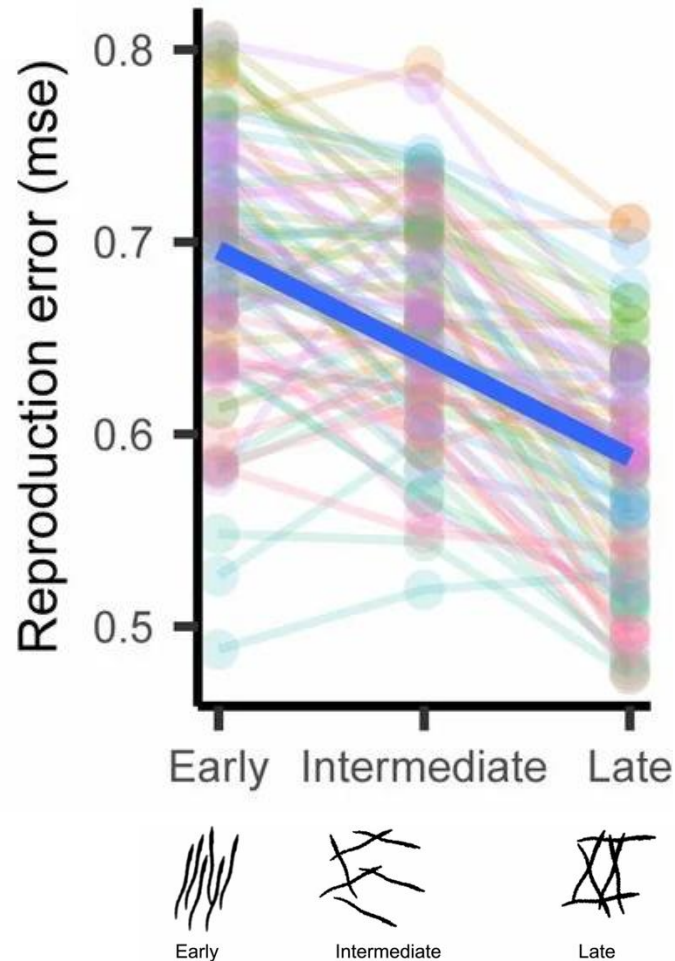
delayed reproduction

- Measures salience / learnability / structure?



## Experiment 4: stylistic similarity between sites

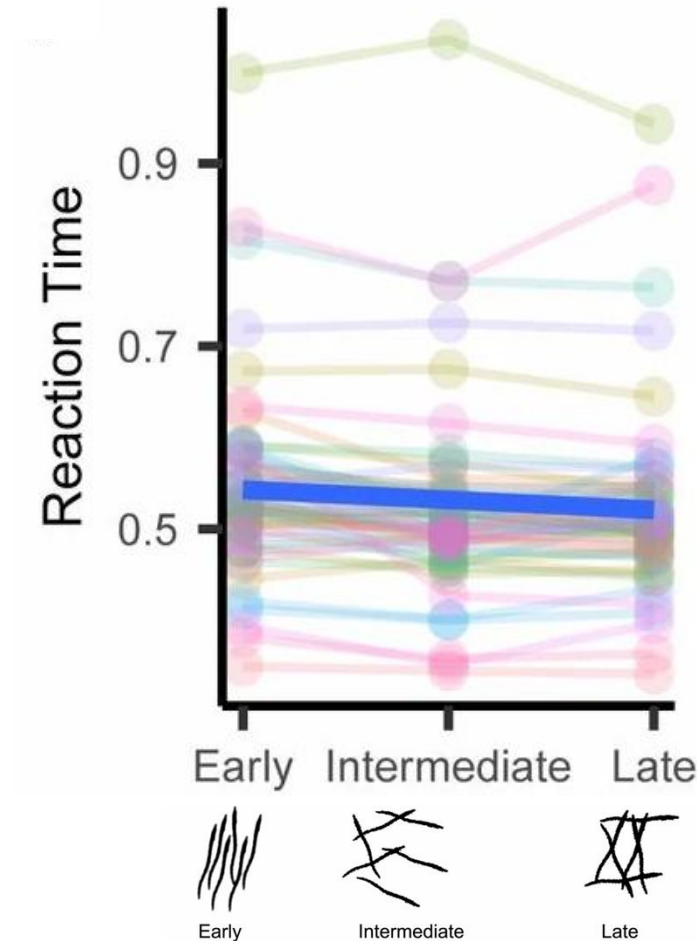
- Measures emergence of distinctive styles at different sites?



## Experiment 5:

differentiation of  
different carvings  
within sites

- Measures potential **communicative** function?



“Our findings [Experiments 1-4] support a view of the engravings as products of a cumulative cultural development toward more complex patterns with increasingly structured and symmetric line crossings, which make them more salient to the human eye, more recognizable as intentionally made, easier to reproduce from memory, and easier to recognize as belonging to a specific group. These properties have been shown to make symbolic forms easier for the visual system to process ... In other words, they track Middle Stone Age H. sapiens becoming increasingly skilled in producing engravings that resonate with the human cognitive system in effective ways.” (Tylén et al., 2020, p. 4582)

Tylén, K., Fusaroli, R., Rojo, S., Heimann, K., Fay, N., Johannsen, N. N., Riede, F., & Lombard, M. (2020). The evolution of early symbolic behavior in Homo sapiens. *Proceedings of the National Academy of Sciences*, 117, 4578-4584.

“there was also evidence that they evolved to become easier to remember and reproduce (Experiment 3), suggesting they have been subject to adaptive pressures for learnability. Similarly, the later patterns were easier to recognize as belonging to the same archeological site compared to the earlier patterns (Experiment 4). This suggests that the engravings were part of a cultural practice—a style—in which they were reproduced, transmitted, and learned within a social group” (Tylén et al., 2020, p. 4582)

Tylén, K., Fusaroli, R., Rojo, S., Heimann, K., Fay, N., Johannsen, N. N., Riede, F., & Lombard, M. (2020). The evolution of early symbolic behavior in *Homo sapiens*. *Proceedings of the National Academy of Sciences*, 117, 4578-4584.

“We found no evidence that the engraved patterns became increasingly discriminable within the two archeological sites. This suggests that the patterns were not under adaptive pressure to evolve affordances for a referential function linked to semantic contents.” (Tylén et al., 2020, p. 4582)

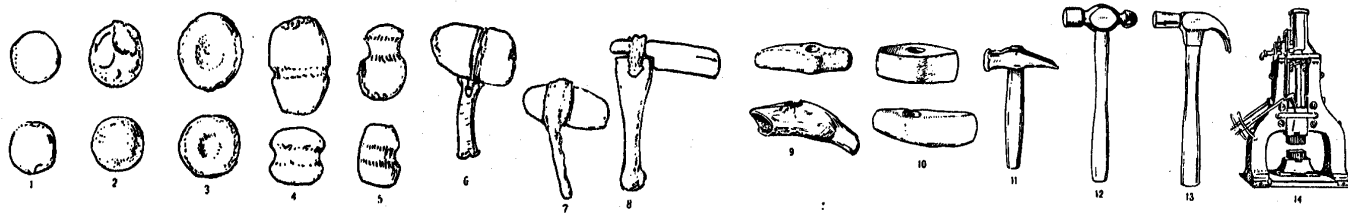
Tylén, K., Fusaroli, R., Rojo, S., Heimann, K., Fay, N., Johannsen, N. N., Riede, F., & Lombard, M. (2020). The evolution of early symbolic behavior in Homo sapiens. *Proceedings of the National Academy of Sciences*, 117, 4578-4584.

# Take-home message from Tylén et al (2020) (for me)

- You can do better than looking at artefacts and speculating
- But the kinds of conclusions you can support with evidence might be quite different in character from those of Henshilwood & Dubreuil (2009)

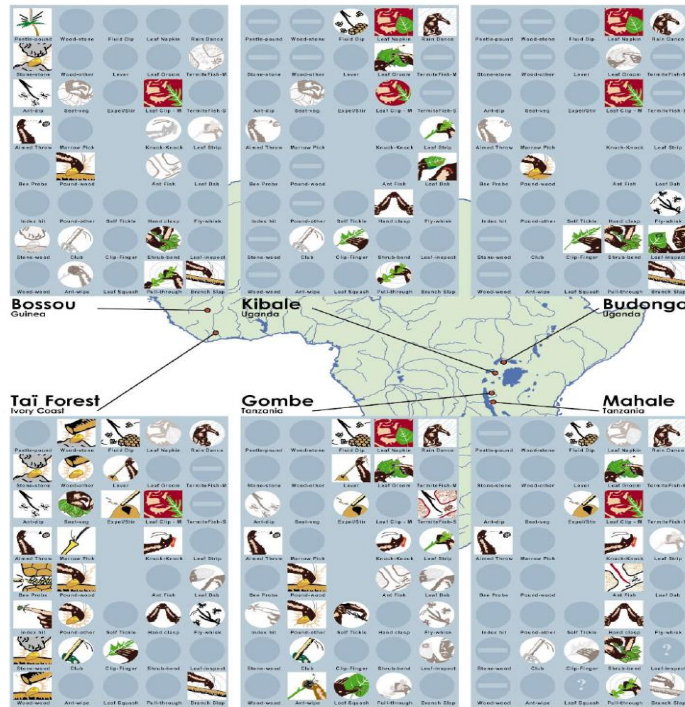
# Cumulative cultural evolution in non-humans?

Behaviour and artefacts become increasingly complex, such that each generation uses techniques and objects they could never have invented by themselves (“the cultural ratchet”)



Products of CCE: technology, complex societies, **language**, ...

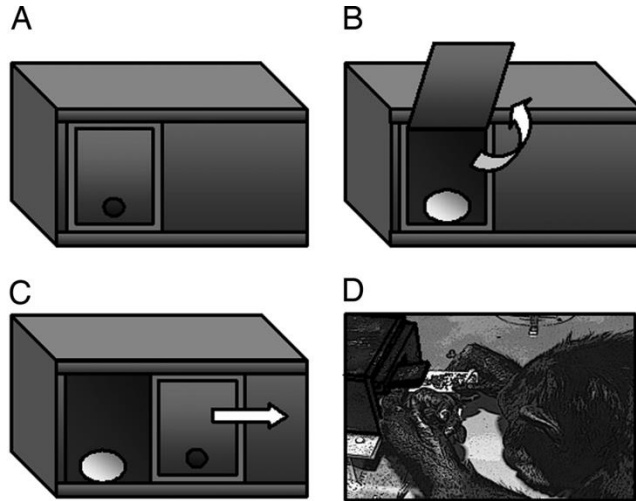
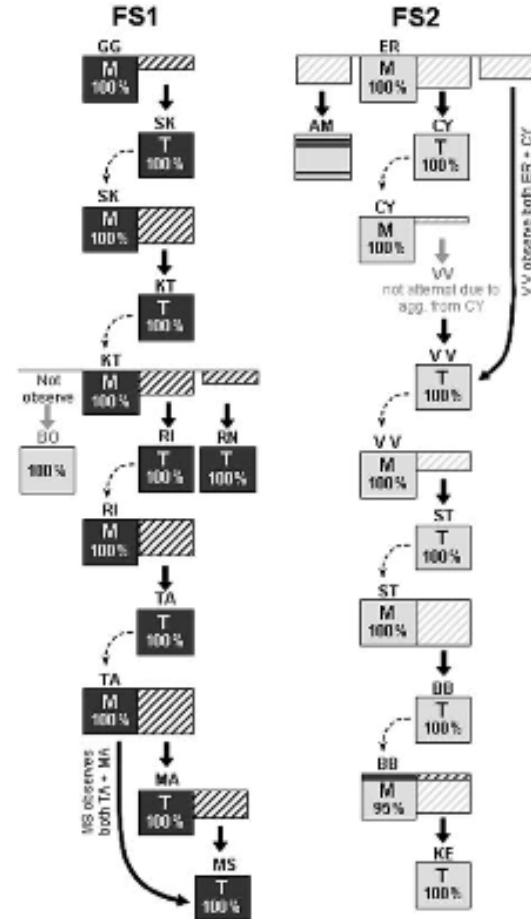
# Social learning and culture in chimpanzees



Behavioural variation in chimpanzee populations

- E.g. some groups crack nuts, some don't
- Some variation hard to explain due to differences in environment
- Probably (?) cultural

# Social learning and culture in chimpanzees



# Social learning and culture in bumblebees (!)



Alem, S. et al, (2016) Associative Mechanisms Allow for Social Learning and Cultural Transmission of String Pulling in an Insect. *PLoS Biology*, 14, e1002564.

# Social learning and culture in bumblebees (!)



Alem, S. et al, (2016) Associative Mechanisms Allow for Social Learning and Cultural Transmission of String Pulling in an Insect. *PLoS Biology*, 14, e1002564.

# Cumulative cultural evolution in non-humans?

“Undoubtedly, given the investigative and manipulative tendencies of the young chimpanzee and his ability to learn through trial and error, almost all of the feeding and tool using behaviours I have described could be invented anew by each individual” (Goodall, 1970)

Goodall, J. (1970). Tool using in primates and other vertebrates. *Advances in the Study of Behaviour*, 3, 195-250.



# Cumulative cultural evolution in non-humans?

“the human attributes that are described as ‘cultural’ in ordinary discourse, seem to be a good deal more complex than, for example, potato washing and termite-fishing...and it is plausible that their greater complexity derives from the accumulation of modifications”  
(Heyes, 1993)



# Culture in non-humans??

“stick pounding is a behavioral form that can be reinnovated by naive chimpanzees. Thus, this study adds to the growing body of evidence for the view that some chimpanzee tool-use behavioral forms can be reinnovated by naïve individuals” (Bandini & Tennie, 2019, p. 8)



Bandini, E., & Tennie, C. (2019). Individual acquisition of “stick pounding” behavior by naïve chimpanzees. *American Journal of Primatology*, 81, e22987.

# Summary of today

- Human evolution
  - Bushy, not linear
  - Rapid evolution of brain size
  - Evolution of technology and art, The Great Leap Forward
- Social learning, art and tool use, and language
  - What can be inferred from the archaeological record?
  - Are there better methods than just guessing?

# Next up

- Tutorial
  - Inferring language from tool use / material culture?
- Next lecture: vocal learning, comparative psychology of language learning