The evolution of human cognition.
Findings from comparative approaches in Psychology and Biological Anthropology

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Lecture 3

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- Language and Communication
- The Selection for Language
- Convergent evolution of cognitive abilities
- Human evolution on macro-evolutionary scale
- Methodological issues with animal cognition research

Language and Communication

Language

- Language and Communication
- Origins of Language

What is language?

- One of the hallmarks of the human species
- There are about 7,097 living languages in the world

- Language as a culturally transmitted mode of communication x mental faculty

Darwin (1871)

“The habitual use of articulate language is, however, peculiar to man; but he uses, in common with the lower animals, inarticulate cries to express his meaning, aided by gestures and the movements of the muscles of the face.”

Language x Communication

- “Traditionally, animal signals have been seen as 'affective’ or emotional, providing information only about the internal motivational state of the signaller and/or the probability that the signaller will engage in certain sorts of behaviour.” (Smith, 1977)

- Language includes many facets

What is communication?

- One animal agent influences the behaviour or mental state of another through signals.
- The modality varies: smell, colour, sound, gestures etc.
- Sender x Receiver

Evolution of language

- Apparent universality of language structure and acquisition among humans -> suggests that there is some sort of “innate language acquisition device” (Chomsky, 1957) or “a language instinct” (Pinker, 1994)

Defining features of language

- Limited number of words can be recombined to produce almost infinite number of sentences

-> semantics, syntax

- speech

Semantics

- Words in languages have meaning (referents)

Syntax

- Structure of sentences
- Can create almost indefinite number of meanings from a finite number of words

Speech

- Vocal imitation (in animals humans, some birds, cetaceans and bats)
- Reconfigured vocal tract (e.g. descended larynx, changes in hyoid bone positioning)

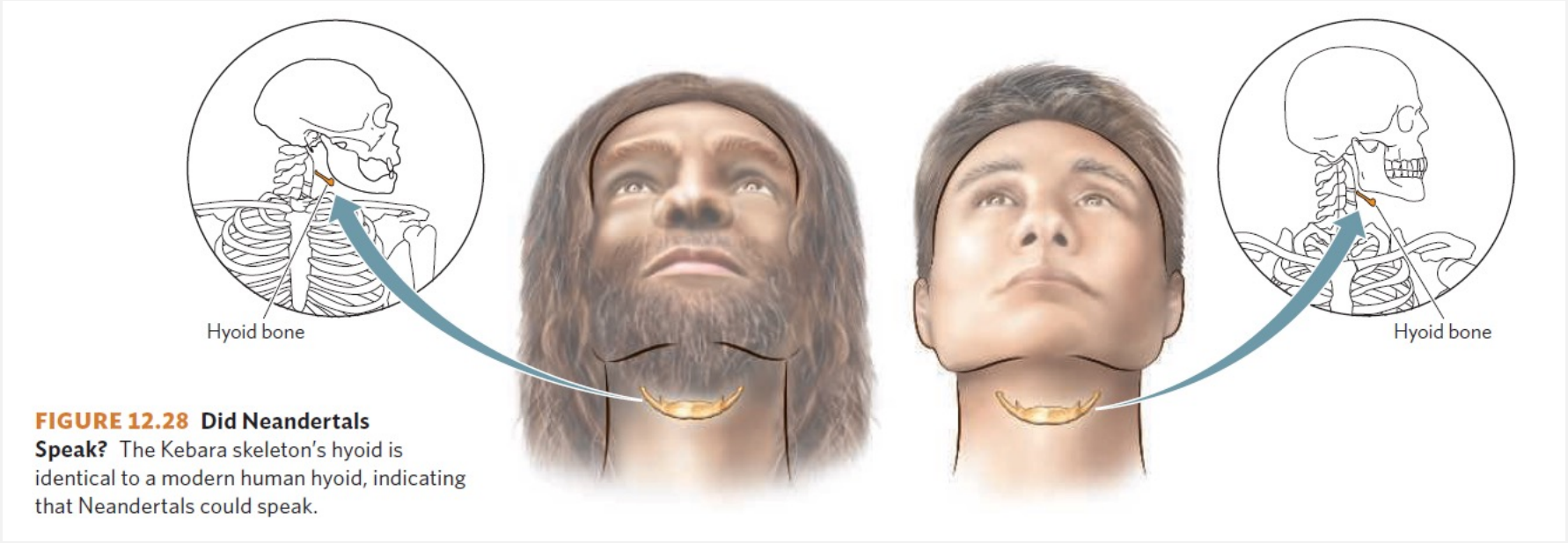


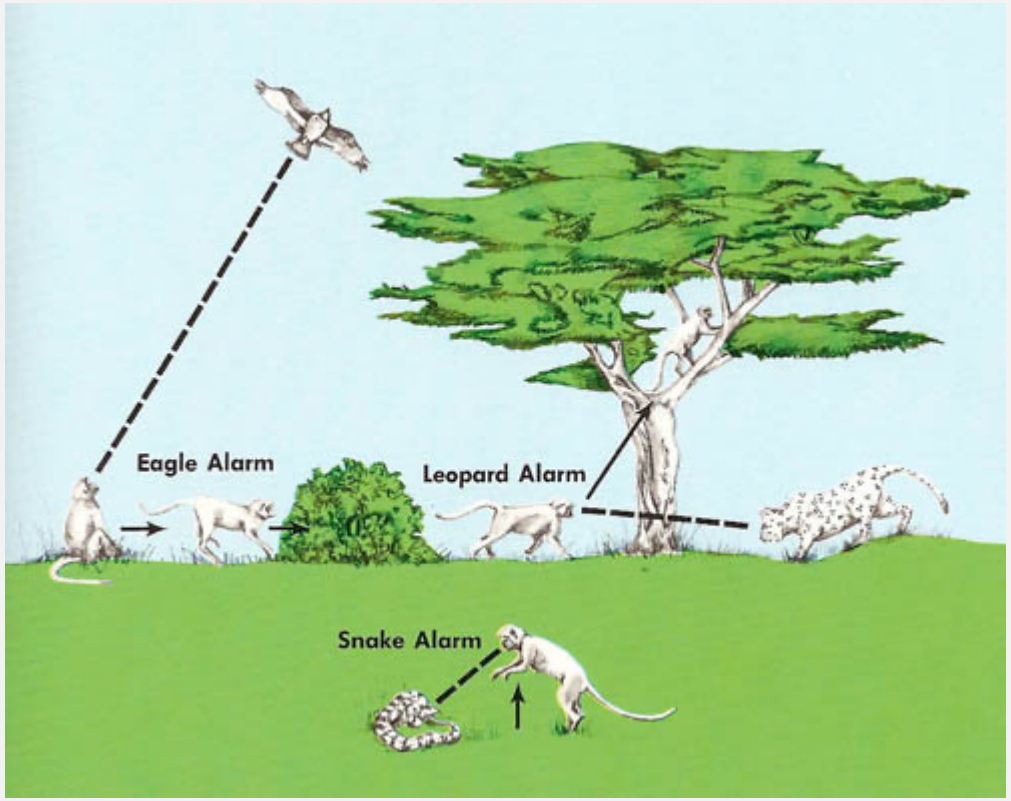
FIGURE 12.28 Did Neandertals Speak? The Kebara skeleton's hyoid is identical to a modern human hyoid, indicating that Neandertals could speak.

Research issues

- Shared x unique distinction
- Evolved gradually or by sudden change
- Evolved from pre-existing communication system or by exaptation

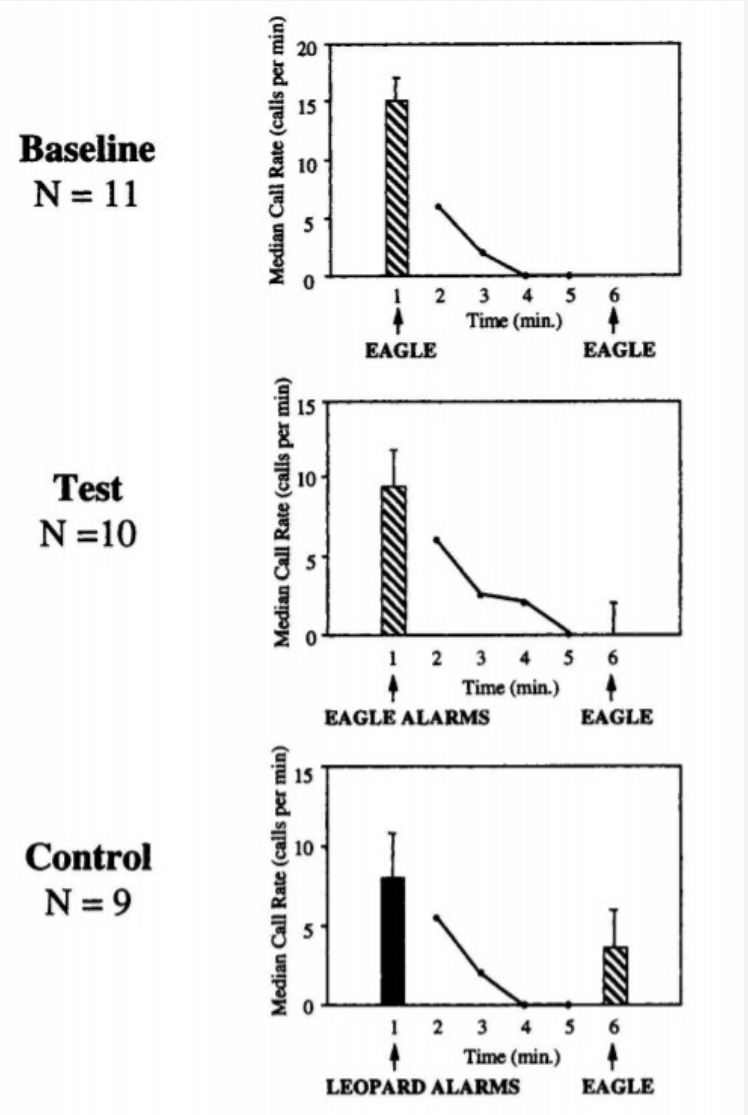
Referential communication

- Vervet monkeys in Africa produce three distinct alarm calls (Struhsaker, 1967)
- Play-back experiment showed that these calls contain information about the class of a predator (Sayfarth et al.,1980)



Zuberbuhler, Cheney & Seyfarth (1999)

- Habituation experiment with female Diana monkeys
- Monkeys showed habituation effect (rate of alarm calls produced) when prime and probe stimuli semantically similar but acoustically different



Zuberbuhler (2001)

- Campbell’s monkeys can use alarm calls of sympatric Diana monkeys

Primate language training

- Chimpanzees lack the appropriate vocal tract to form human speech sounds
- Studies focused on whether primates can learn forms of sign language

American Sign Language (ASL)

- Washoe, the chimpanzee (Gardner & Gardner, 1969) – was taught 132 signs
- Chantek, the orangutan (Miles, 1990)
- Koko, the gorilla (Patterson & Linden, 1981)
- https://www.youtube.com/watch?v=FqJf1mB5PjQ

(Terrace et al., 1979)

- Nim Chimpsky – infant chimpanzee
- Acquired vocabulary of cca 125 words over a period of 3,5 years (2 year old child acquires a vocabulary of about 10 words a day)
- Not able to produce long strings of signs

Token language

- Sarah, a chimpanzee (Premack, 1971) – trained to use plastic tokens to represent objects
- Lana, a chimpanzee (Rumbaugh, 1977) – learned that visual icons represent words in artificial language called “Yerkish”
- https://www.youtube.com/watch?v=pD9sgWuI_D4

Kanzi, the bonobo

- Savage-Rumbaugh & Lewin (1994) – learned to use a form of Yerkish
- Could correctly respond to particular word combinations – some understanding of syntax

What we learned from teaching primates sign language?

- Can learn signs, but unclear whether they can combine them spontaneously into sentences with novel meanings
- More success with token language than ASL

Studies of non-primates

- Other than primates, other obvious candidates for language may be the large-brained aquatic mammals and corvids and parrots

Cetaceans

- Herman et al. (1984) – command comprehension in two bottle-nosed dolphins who were taught over 50 signs
- Gisinger & Schusterman (1992) – trained Californian Sea lion to comprehend 190 signs, using similar gestures as used by the dolphins

Birds

- Some bird species are known to be able to adopt new vocalisations
- Pepperberg (1999) – Alex, African grey parrot
- https://www.youtube.com/watch?v=ldYkFdu5FJk

Dogs

- Chaser, a border collie (Pilley, 2011) – able to learn and recognize 1022 words
- https://www.youtube.com/watch?v=Ip_uVTWfXyI

Pilley, J. W., & Reid, A. K. (2011). Border collie comprehends object names as verbal referents. *Behavioural Processes*, *86*(2), 184–195. https://doi.org/10.1016/j.beproc.2010.11.007

Kaminski, J., Call, J., & Fischer, J. (2004). Word learning in a domestic dog: Evidence for "fast mapping." *Science*, *304*(5677), 1682–1683. https://doi.org/10.1126/science.1097859

Cognitive enculturalisation

- Acquisition of natural language affects the way in which we, and therefore language trained animals, may think
- Majid et al. (2004) – Dutch and Tzeltal speaker on spatial task
- New direction in nonhuman animal communication studies: https://www.youtube.com/watch?v=WI6034x_lP0
- Database of Ape gestures: https://greatapedictionary.ac.uk/video-resources/gesture-videos/

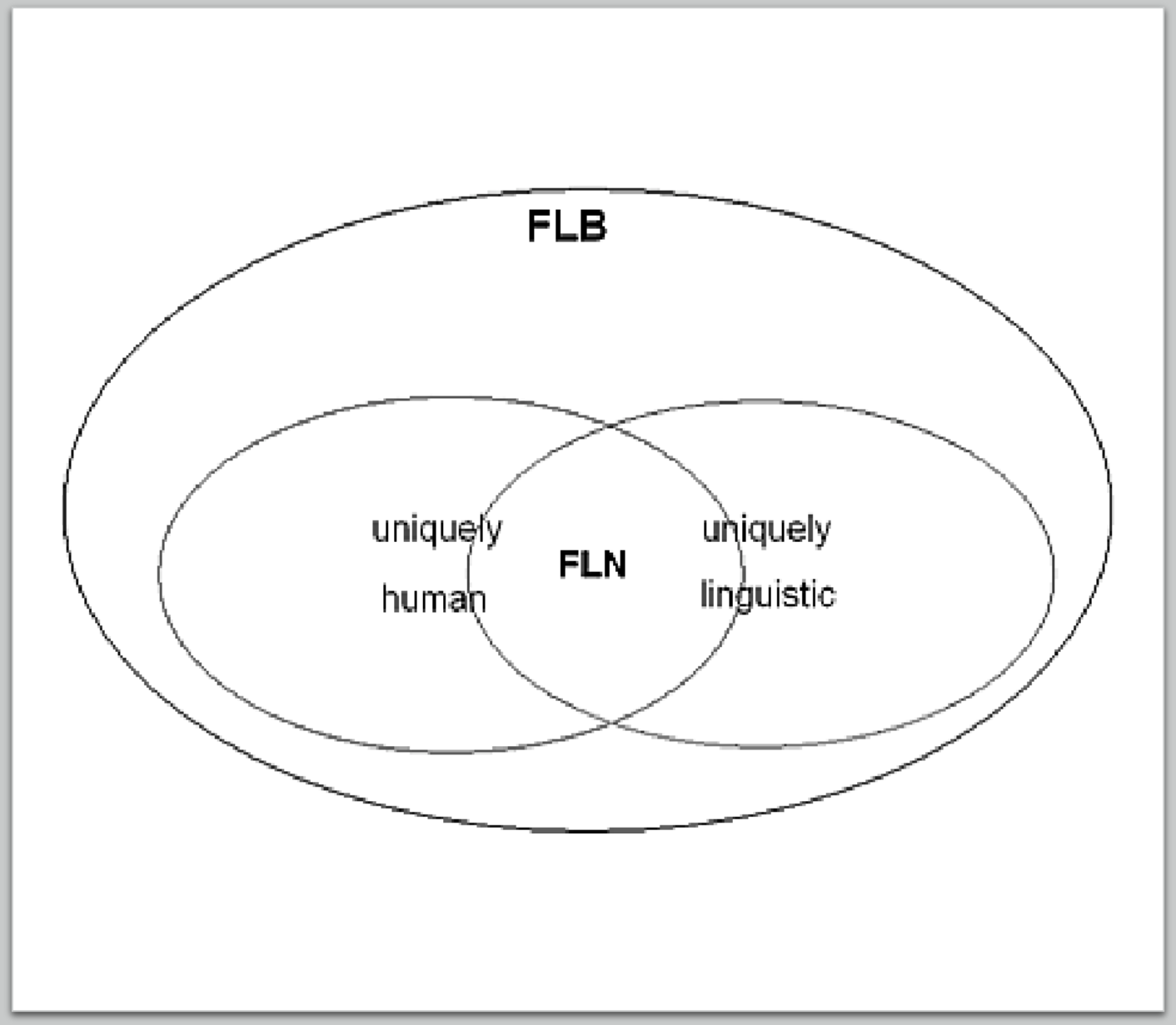
The Selection for Language

Components of language faculty

- Distinction proposed by Hauser, Chomsky, and Fitch (2002)
- Distinguishing between faculty of language in a broad sense (FLB) and faculty of language in narrow sense (FLN)
- Recursion – theorized to belong into FLN

Language traits

- Vocal imitation, reconfigured vocal tract, referential communication, semantics, grammatical structures etc.
- Memory, theory of mind, perception etc.



How did language mechanisms evolve

- Presumably individually focused selection for cognitive mechanisms underlying the FLB
- Old structures evolved for different reason could have been exapted for the purpose of language mechanisms

Pre-adaptations for langauge

- Prior to emergence of language, some pre-adaptations would have appeared in the hominid lineage
- Controversy over which pre-adaptations those would have been – candidates are e.g. use of symbolic meanings, joint attention, theory of mind, sophisticated imitation etc.

Christiansen, M. H., & Kirby, S. (2003). Language evolution: Consensus and controversies. *Trends in Cognitive Sciences*, *7*(7), 300–307. https://doi.org/10.1016/S1364-6613(03)00136-0

Language evolution

- Functional question – what is the benefit of the trait to the bearer (why did it evolve?)
- Phylogenetic question – how did the trait arise over the evolutionary time (how did it evolve?)

Why did it evolve?

- Natural selection
- Sexual selection
- Kin selection

Individually focused natural selection

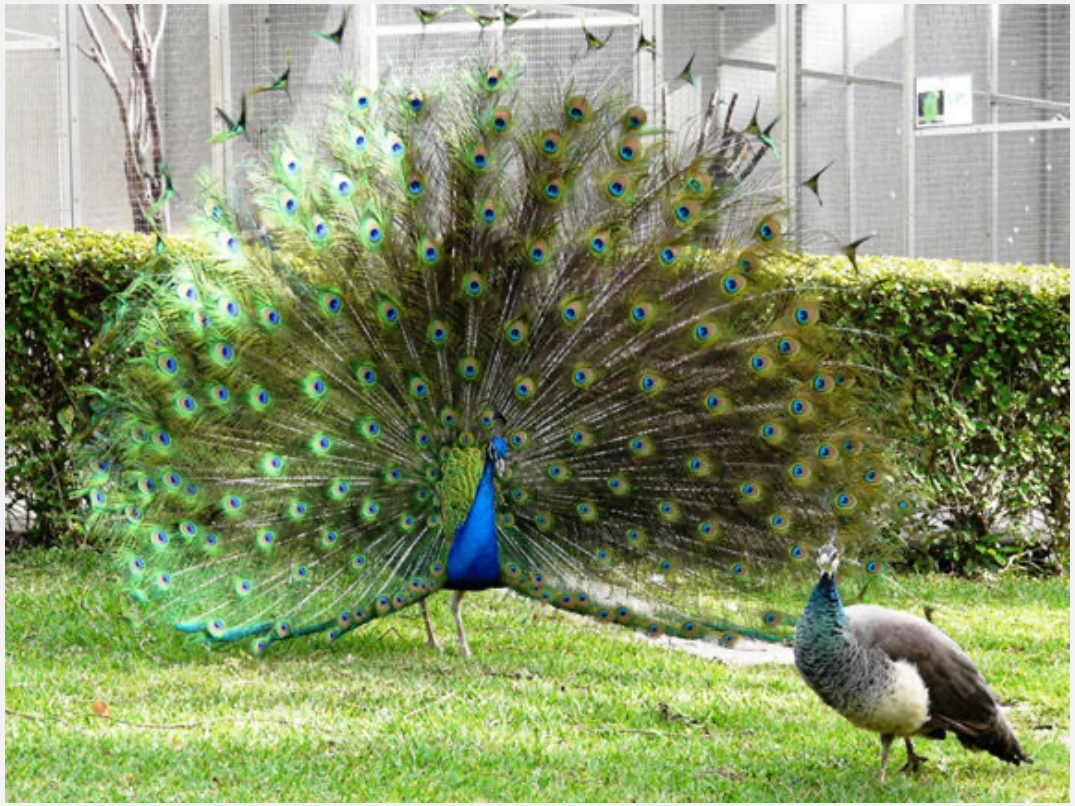
- Acted on the individual behaviour
- Language as primarily cognitive adaptation

- Lone mutant problem

Sexual selection

- Results from mating competition and female choice
- Complex language could increase mating success

- Sexually selected traits usually more pronounced in males, should appear close to reproductive age, “honest” traits are difficult to evolve



Kin selection (Hamilton, 1964)

- Evolutionary strategy which favors reproductive success of individuals with whom one shares the same alleles
- Advantage in sharing knowledge (foraging, predators) with relatives
- Especially advantageous in long-lived animals

Protolanguage (Bickerton,1981+)

- Composed of simple utterances of one or few words
- A lexicon without syntactical structure

Biological x Cultural Evolution

- Is grammar innate or culturally transmitted

Origins of language

- Controversy over whether language originated in manual gestures or evolved exclusively in the vocal domain

Gestural origins

- Apes considerably better at gestures
- Mirror neurons

Vocal origins

- Darwin (1871) – earliest stage of language evolution was musical
- Vocal control arising from mouth movements during eating
- Vocal control originating in brain networks that have evolved to enable either bipedality or tool-making

Discussion questions

1) Is Language uniquely human ability?
2) What may be the issues with researching cognitive abilities in enculturated animals such as Washoe, Koko, Nim, Sarah, Alex etc.?
3) Do you think language more likely had gestural or vocal origins?

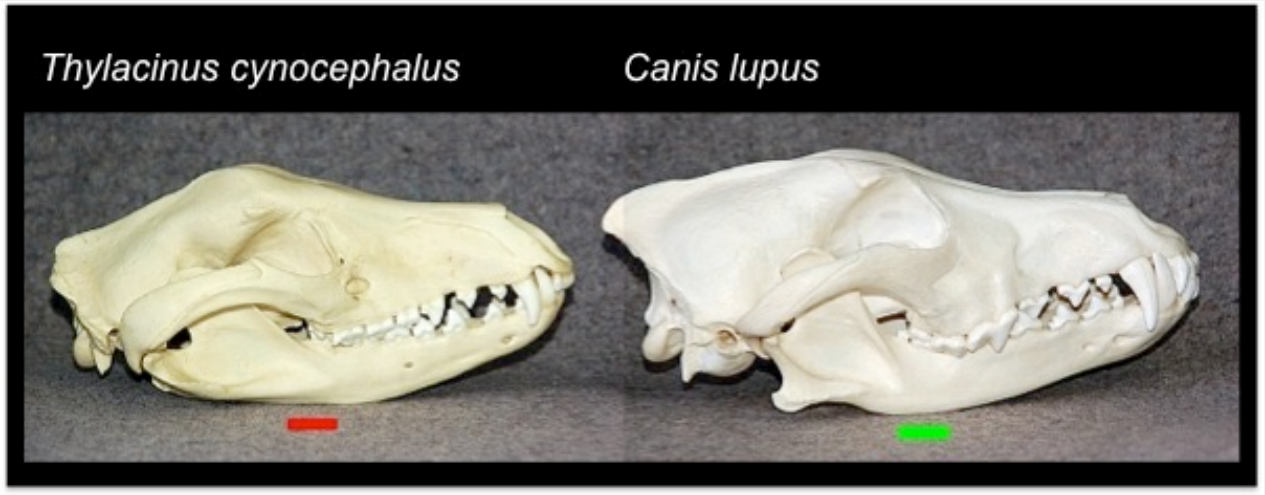
Recap

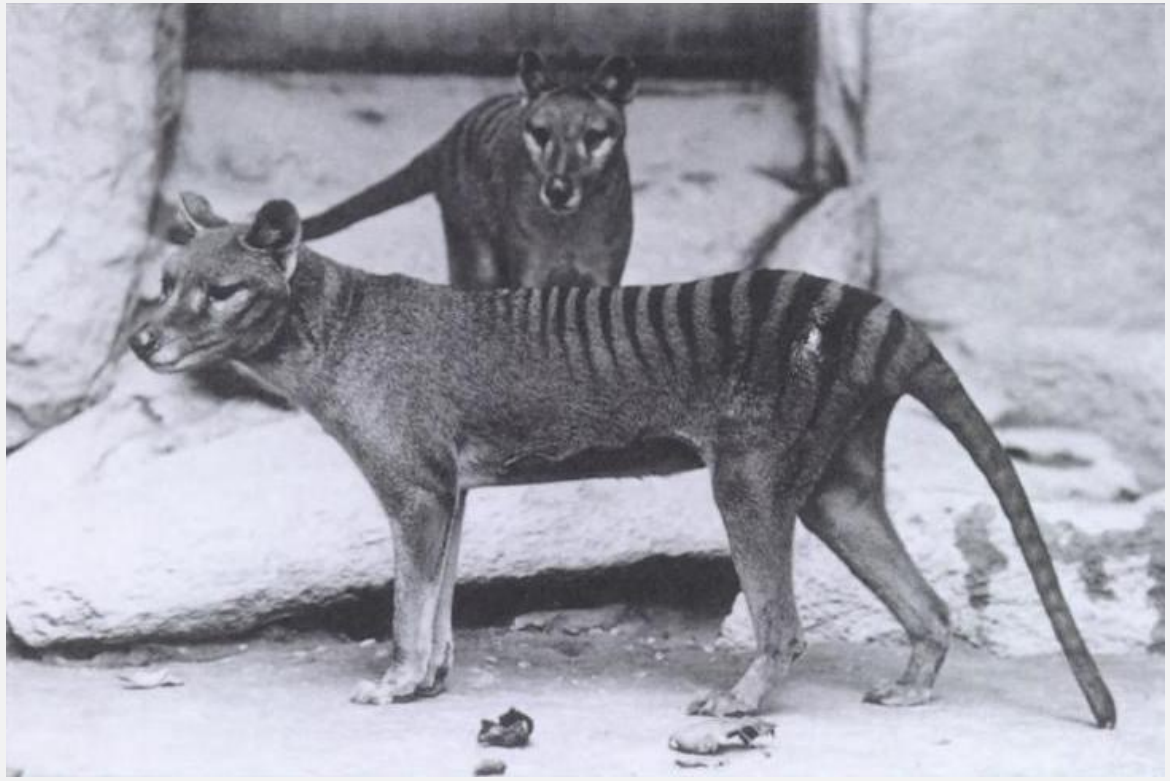
- Language has many facets – proposed division into FLB and FLN
- Two distinct question concerning the selection for language ability: Why did it evolve and how did it evolve?
- Largely contentious question, language does not fossilize
- Gestural x vocal protolanguage

Convergent evolution of cognitive abilities

Convergent evolution

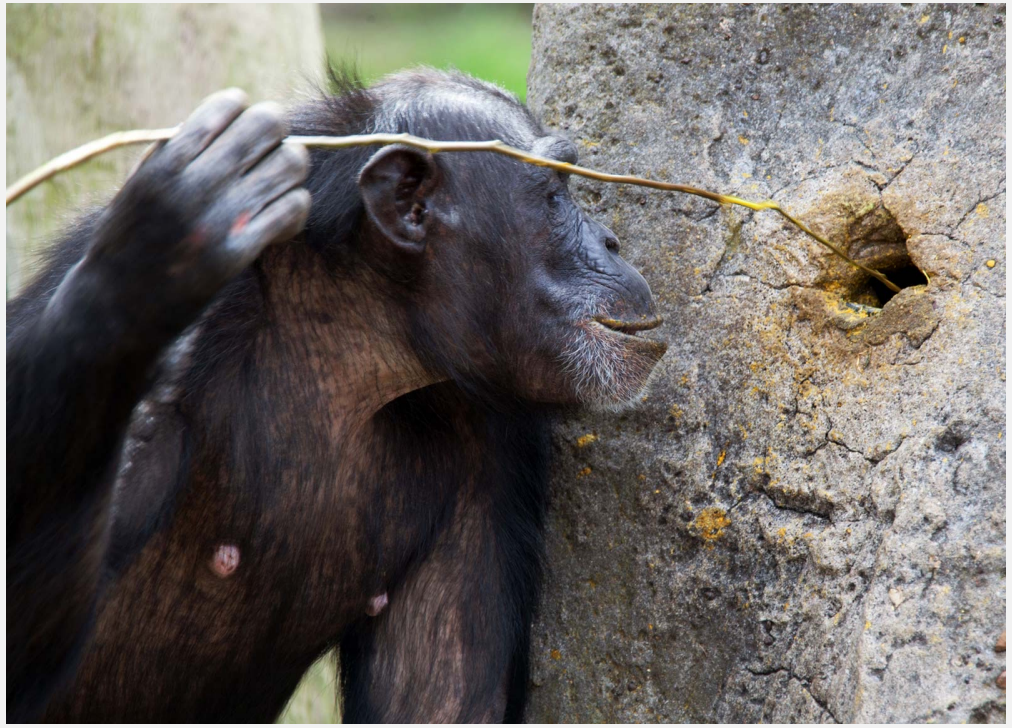
= Similar traits arising in distantly related species





Convergent evolution of mental characteristics

- A case can be made for convergent evolution of mental characteristics in primates, corvids, parrots and cetaceans



Recap: Theories of the Evolution of Intelligence

Food:

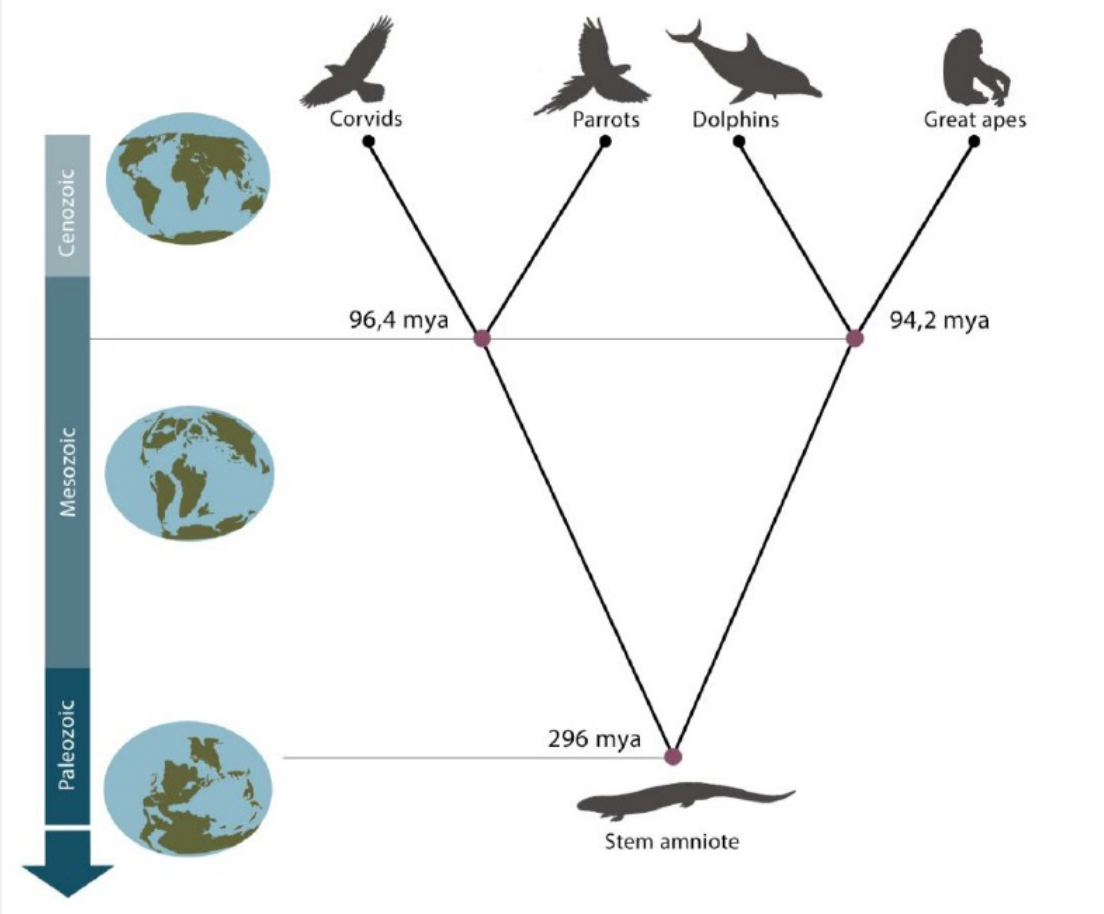
- Milton (1981) – primates have to monitor to distribution of widely spread food resources
- Additional physical challenge may be connected to extractive foraging

Sociality:

- Jolly (1966), Humphrey (1976) – challenges connected to surviving in complex social world
- Dunbar (1992,1998) – Social Brain Hypothesis

Apes, Corvids and Parrots

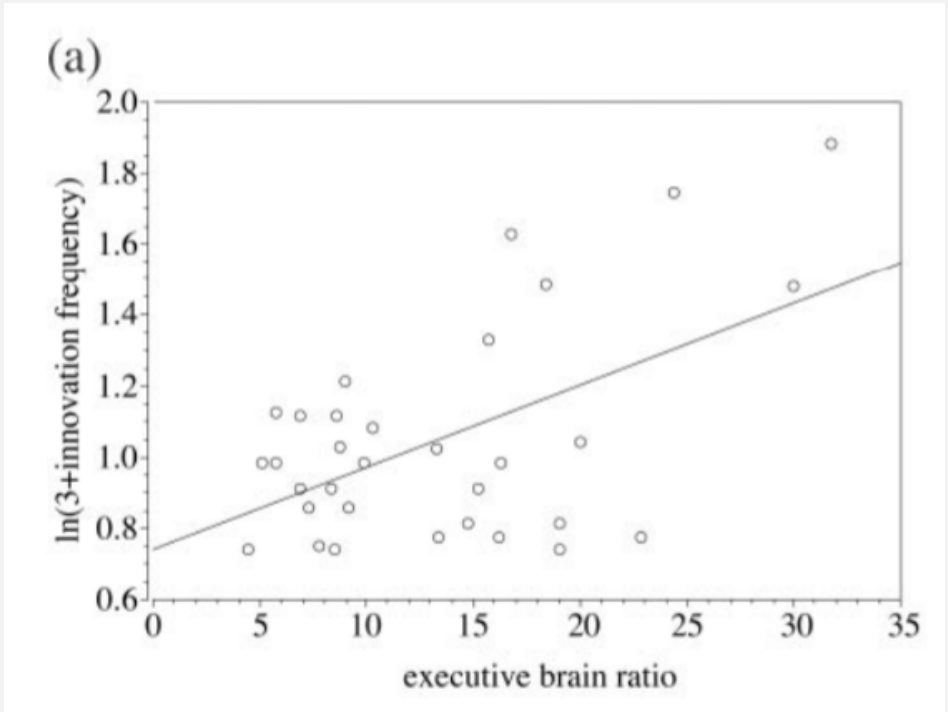
- LCA of Apes and Crows – cca 280 MYA
- All three groups long-lived
- Many live in complex social worlds
- Omnivorous generalists

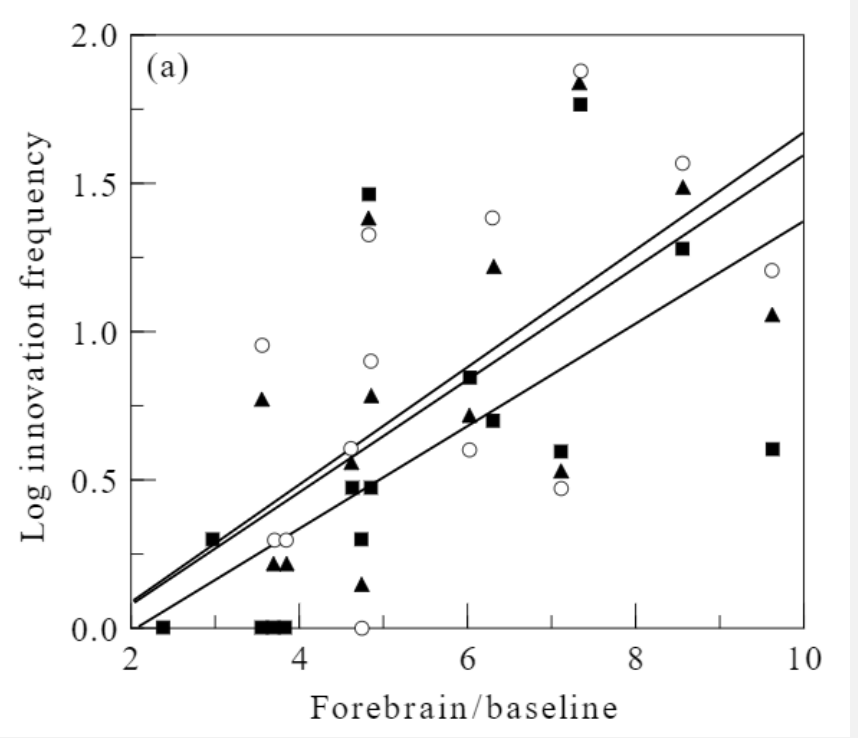


Osvath, M., Kabadayi, C., & Jacobs, I. (2014). Independent Evolution of Similar Complex Cognitive Skills : The Importance of Embodied Degrees of Freedom. *Animal Behavior and Cognition*, *August*. https://doi.org/10.12966/abc.08.03.2014

Innovative foraging and brain size

- Forebrain size associated with innovative behaviour in both birds and primates





Lefebvre, L., Whittle, P., & Lascaris, E. (1997). Feeding innovations and forebrain size in birds. *Animal Behaviour*, *53*, 549–560.

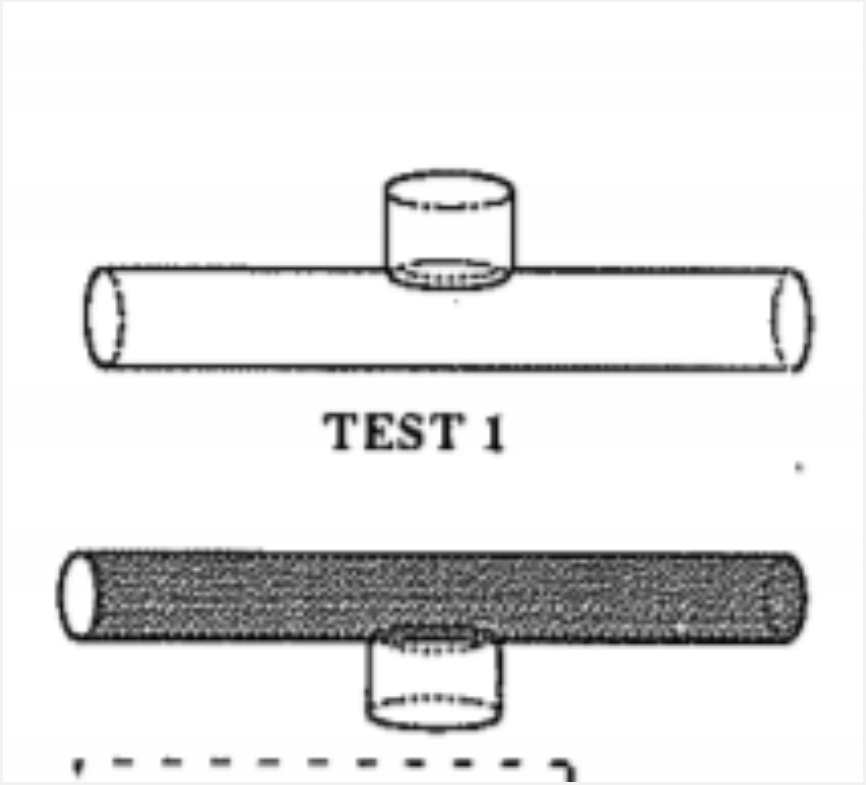
Reader, S. M., & Laland, K. N. (2002). Social intelligence , innovation , and enhanced brain size in primates. *PNAS*, *99*(7), 3–8.

Convergent evolution of tool use

- New Caledonian crows and chimpanzees

Trap tube task

- Visalberghi et al. (1994) – capuchin monkeys on functional and inverted trap tube task
- Limongelli et al. (1995) – 5 chimpanzees on functional trap tube task
- Chappel & Kachelnik (2004) – New Caledonian Crows can choose correct tool to push out a piece of food

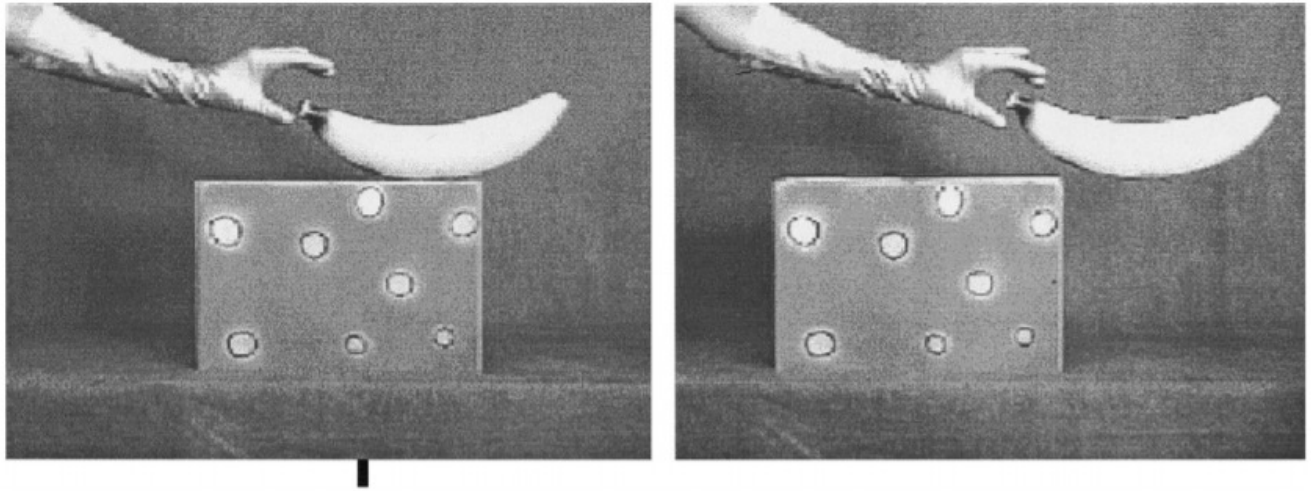


Cognitive Tool Kit (Emery & Clayton, 2004)

- Corvids and Apes face many of the same socio-ecological challenges
- Suggest 4 cognitive tools: causal reasoning, flexibility, imagination and prospection

Causal reasoning

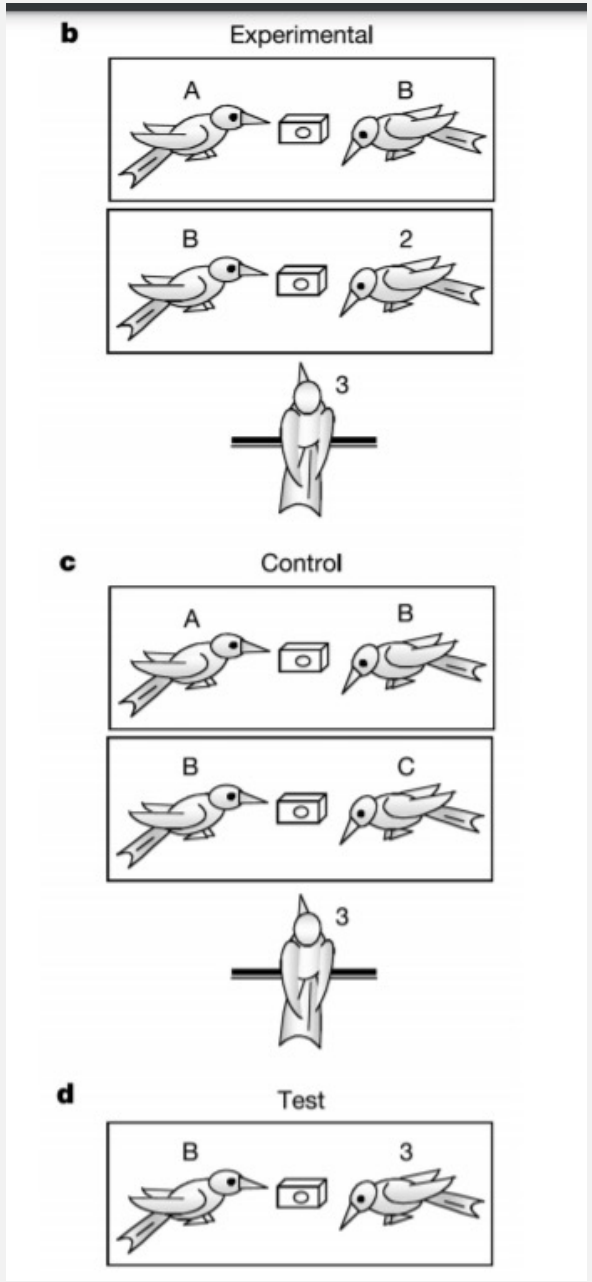
- Able to use innovative tools
- https://www.youtube.com/watch?v=ZerUbHmuY04
- Cacchione & Krist (2004) – chimpanzees look longer at physically impossible events
- Bird & Emery (2010) – adapted for rooks



Jelbert, S. A., Taylor, A. H., Cheke, L. G., Clayton, N. S., & Gray, R. D. (2014). Using the Aesop ' s Fable Paradigm to Investigate Causal Understanding of Water Displacement by New Caledonian Crows. *PLoS ONE*, *9*(3). https://doi.org/10.1371/journal.pone.0092895

Flexibility

- Able to solve transitive inference tests
- Treichler & Van Tilburg (1996) – rhesus monkeys can solve transitive inference tasks
- Paz-y-Miño et al. (2004) – pinyon jays can make transitive inferences about dominance status



Imagination

- Situations that are not currently available to perception can be planned out mentally
- Possibly key for Theory of Mind

Hare, B., Call, J., & Tomasello, M. (2001). Do chimpanzees know what conspecifics know? *Animal Behaviour*, *61*(1), 139–151. https://doi.org/10.1006/anbe.2000.1518

Emery, N. J., & Clayton, N. S. (2001). Effects of experience and social context on prospective caching strategies by scrub jays. *Nature*, *414*(6862), 443–446. https://doi.org/10.1038/35106560

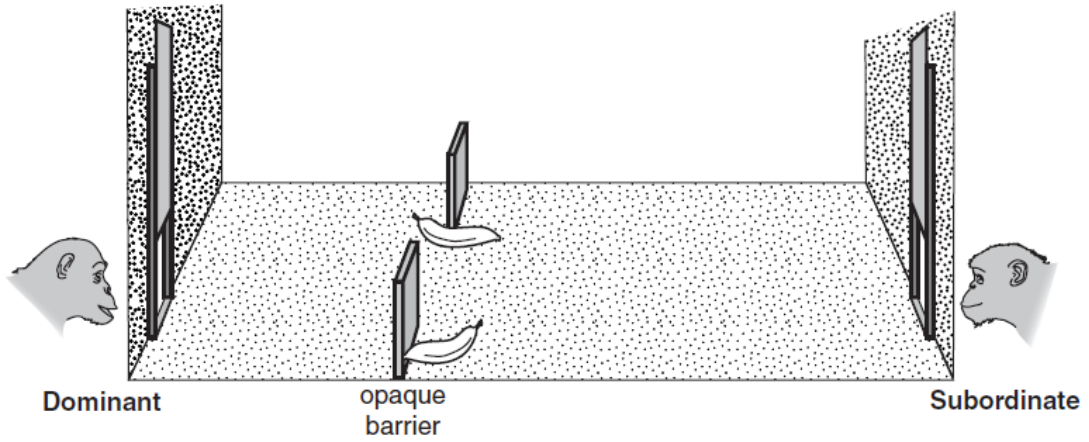


Figure 12.13. Test of whether chimpanzees behave as if knowing what another chimpanzee can see in a competition over food. The animals are shown just before being released into the central arena. The subordinate will get a slight head start; the food is closer to the dominant's end to enhance the competition. Adapted from Bräuer, Call, and Tomasello (2007) with permission.

Prospection

- Imagining possible future events

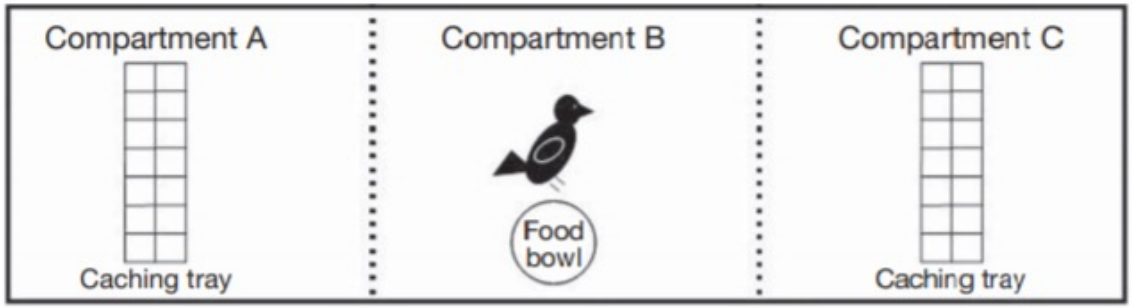


Figure 1 | Compartmental layout used for the 'planning for breakfast' experiment. The position of caching trays is shown in compartments A and C, and of the food bowl in compartment B. Dotted lines represent the compartmental divisions, although during caching no dividers were in place. In the second experiment, the compartmental layout was the same except that two food bowls, equidistant from compartments A and C, were used.

Raby, C. R., Alexis, D. M., Dickinson, A., & Clayton, N. S. (2007). Planning for the future by western scrub-jays. *Nature*, *445*, 919. https://doi.org/10.1038/nature05575

Brains

- Convergent evolution of cognitive abilities build on divergent neuroarchitecture

Dolphins

- Until H. erectus dolphins had the largest brain relative to body size of all species on the planet
- Complex societies
- Vocal imitation
- Ability to learn artificial language

Recap

- Corvids, parrots and apes have similar ecologies and face similar socio-ecological challenges
- Evolved similar “Cognitive Tool Kit”
- Filling similar niches

Cephalopods

- Short-lived
- Completely different brain architecture
- Solitary

But:

- Habitual tool-user
- Camera eye

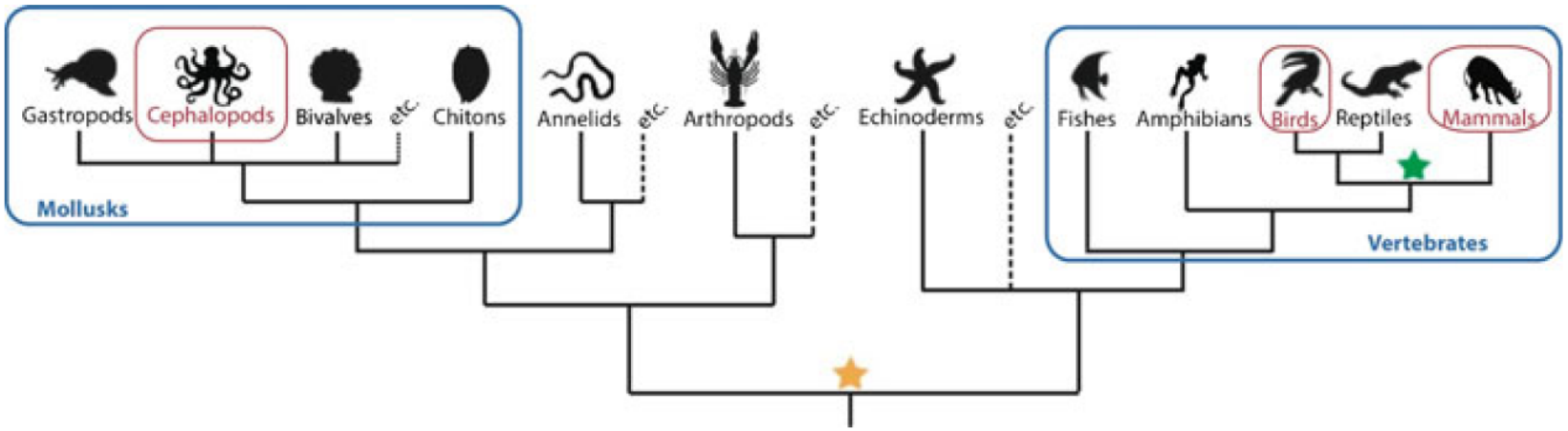


Fig. 2 Phylogenetic tree indicating the evolutionary relationship between cephalopods, birds and mammals. *Stars* indicate the location of the most recent common ancestor (MRCA) between cephalopods and vertebrates (*yellow*, ~600 million years ago) and between birds and mammals (*green*, ~300 million years ago)

Vitti, J. J. (2013). Cephalopod Cognition in an Evolutionary Context : Implications for Ethology. *Biosemiotics*. https://doi.org/10.1007/s12304-013-9175-7

Implications

- Important implications for animal welfare
- Challenges the assumption that intelligence has evolved only once
- Mammalian cortex is not the only platform on which intelligence may evolve

Looking at human evolution on macro-evolutionary scale

Macro-evolution

- Looking at evolution above the species level
- Patterns resulting from evolution and extinction of species over a long period of time

What shapes evolutionary patterns?

- Intrinsic factors: ecological and social challenges

- “Red Queen” hypothesis (Leigh Van Valen, 1973)

- Extrinsic factors: climate, tectonics etc.

- “Court Jester” hypothesis (Anthony Barnosky, 1999)

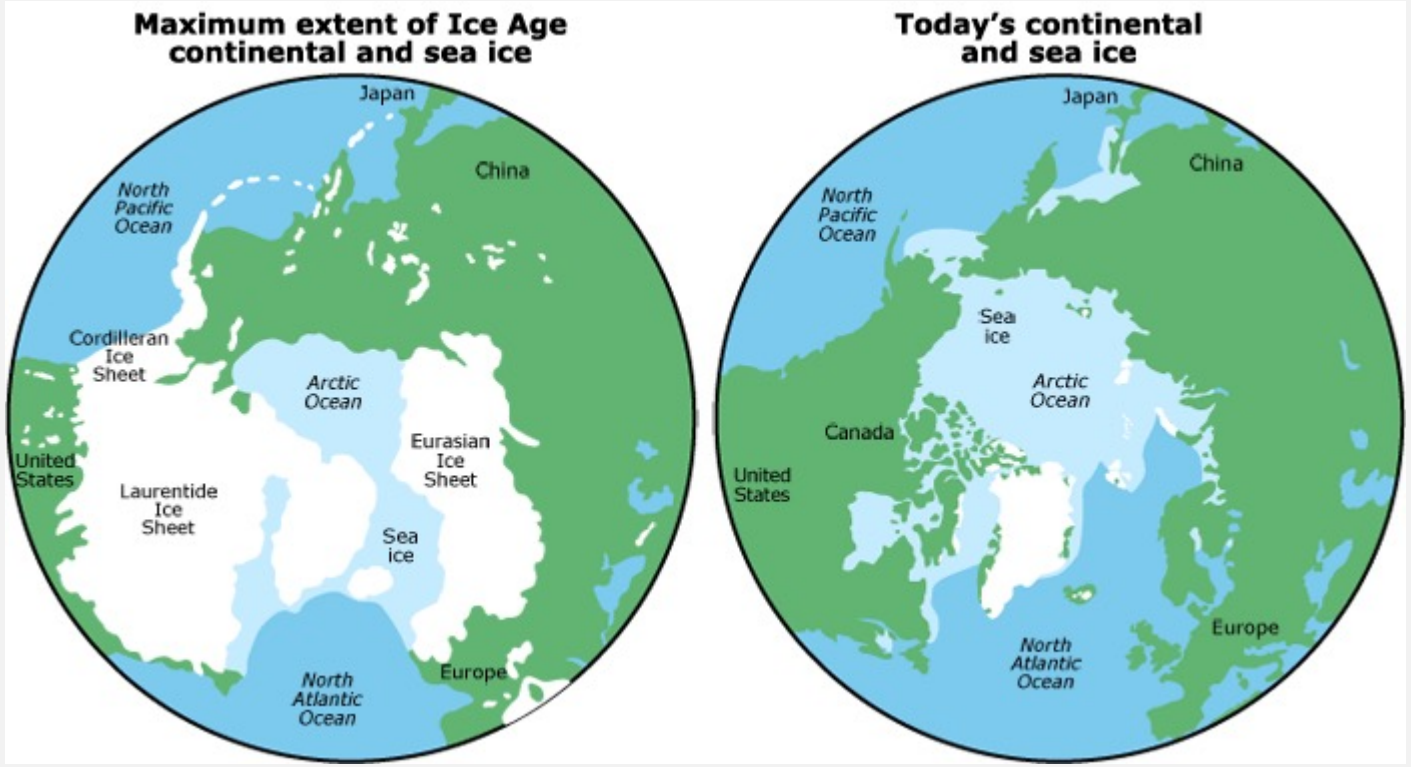
Red Queen Hypothesis (Leigh Van Valen, 1973)

- Arms races between species

"...it takes all the running you can do, to keep in the same place."
Lewis Caroll

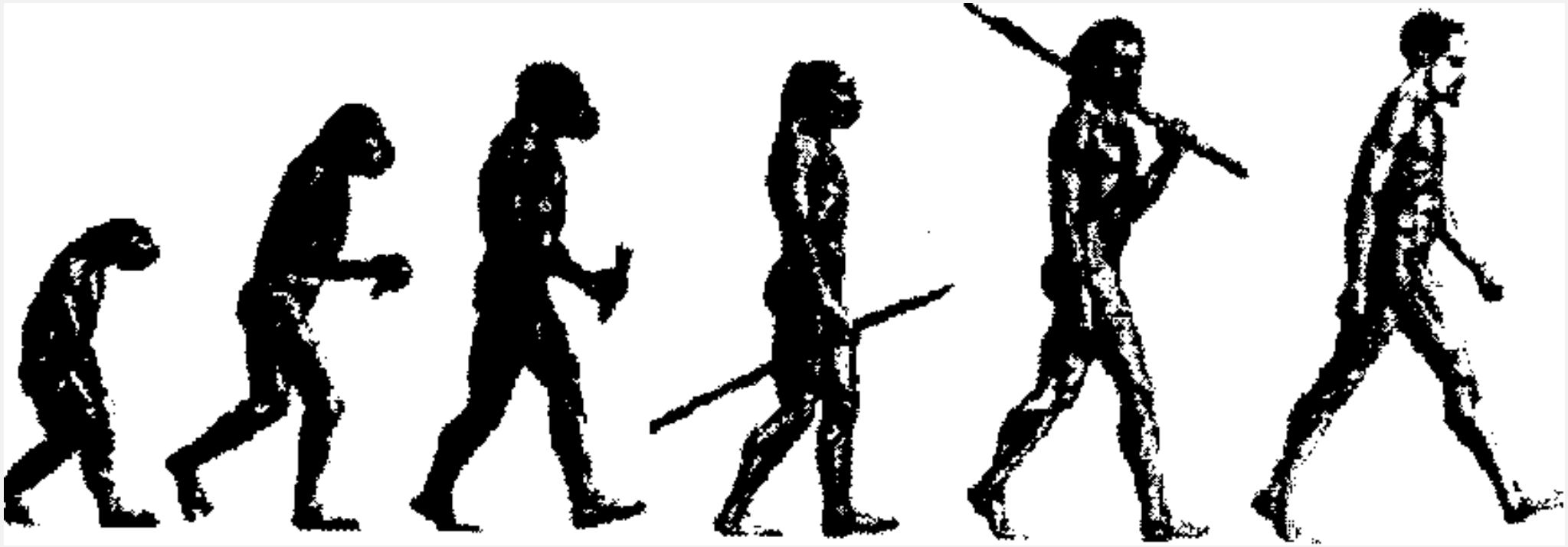
Court Jester Hypothesis (Anthony Barnosky, 1999)

- Abiotic factors – tectonic shifts, climate changes etc.

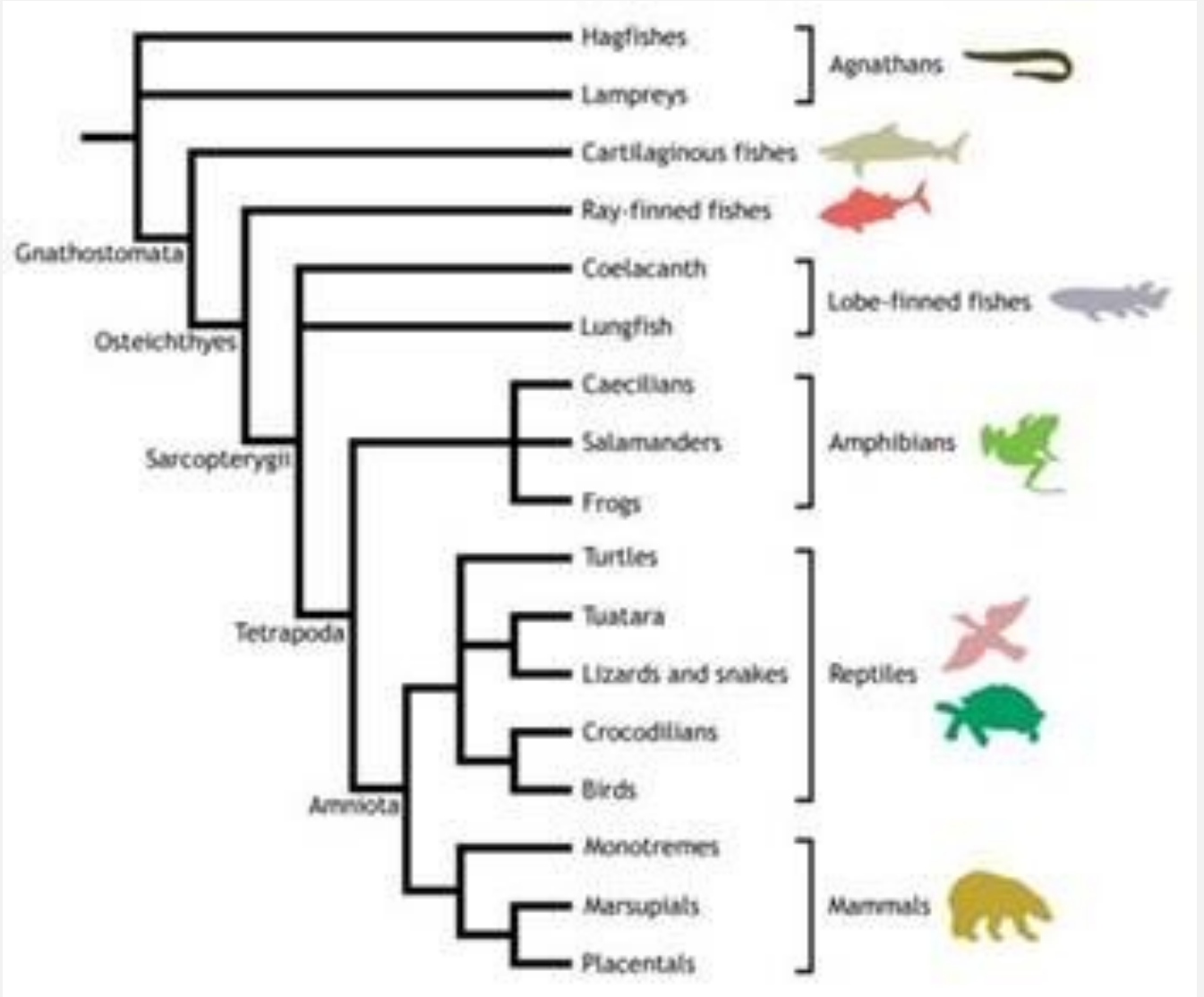


The march of progress

- Human evolution often viewed as a evolution towards progressively more complex versions



But actually evolution is to a large extent about diversity

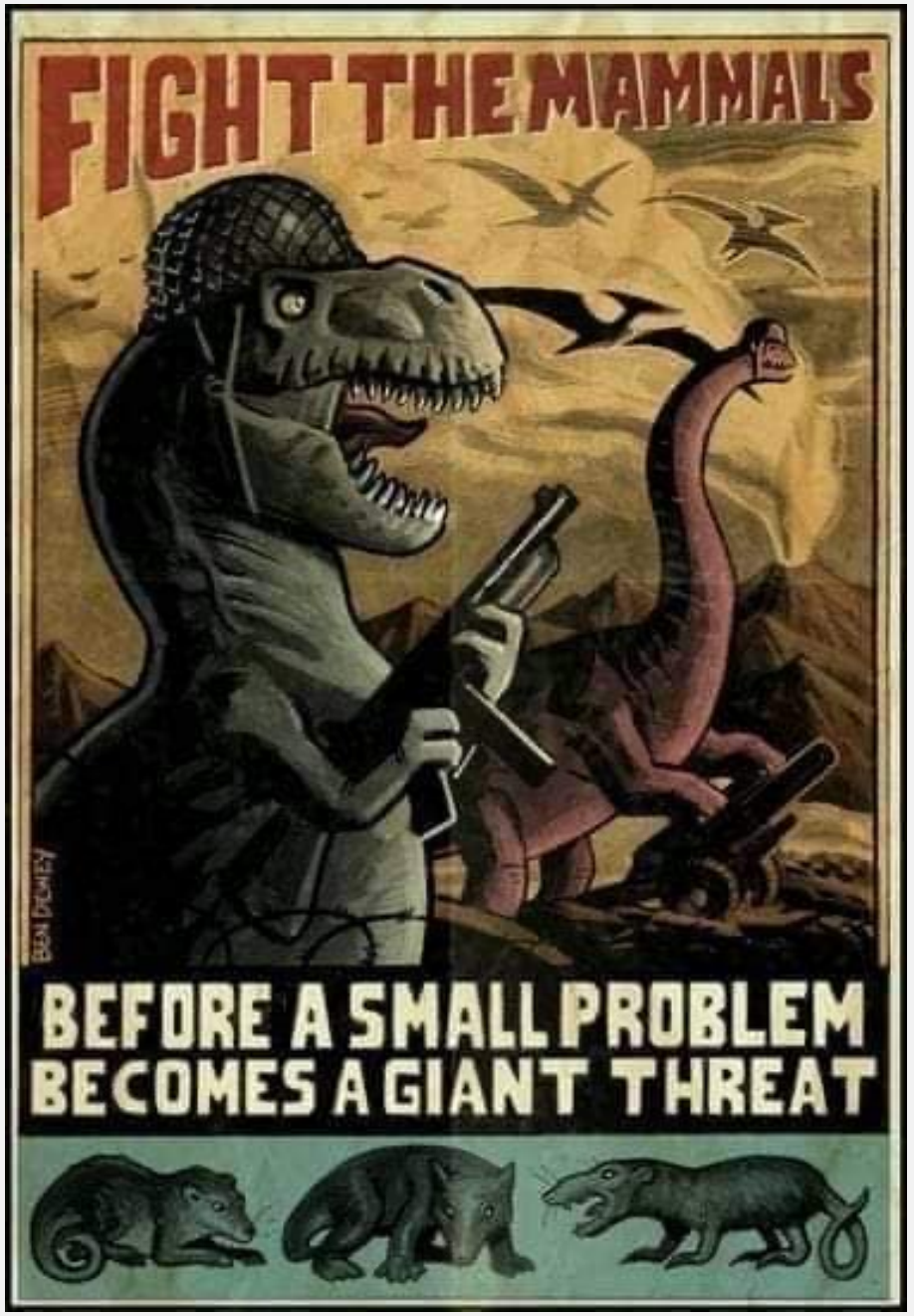


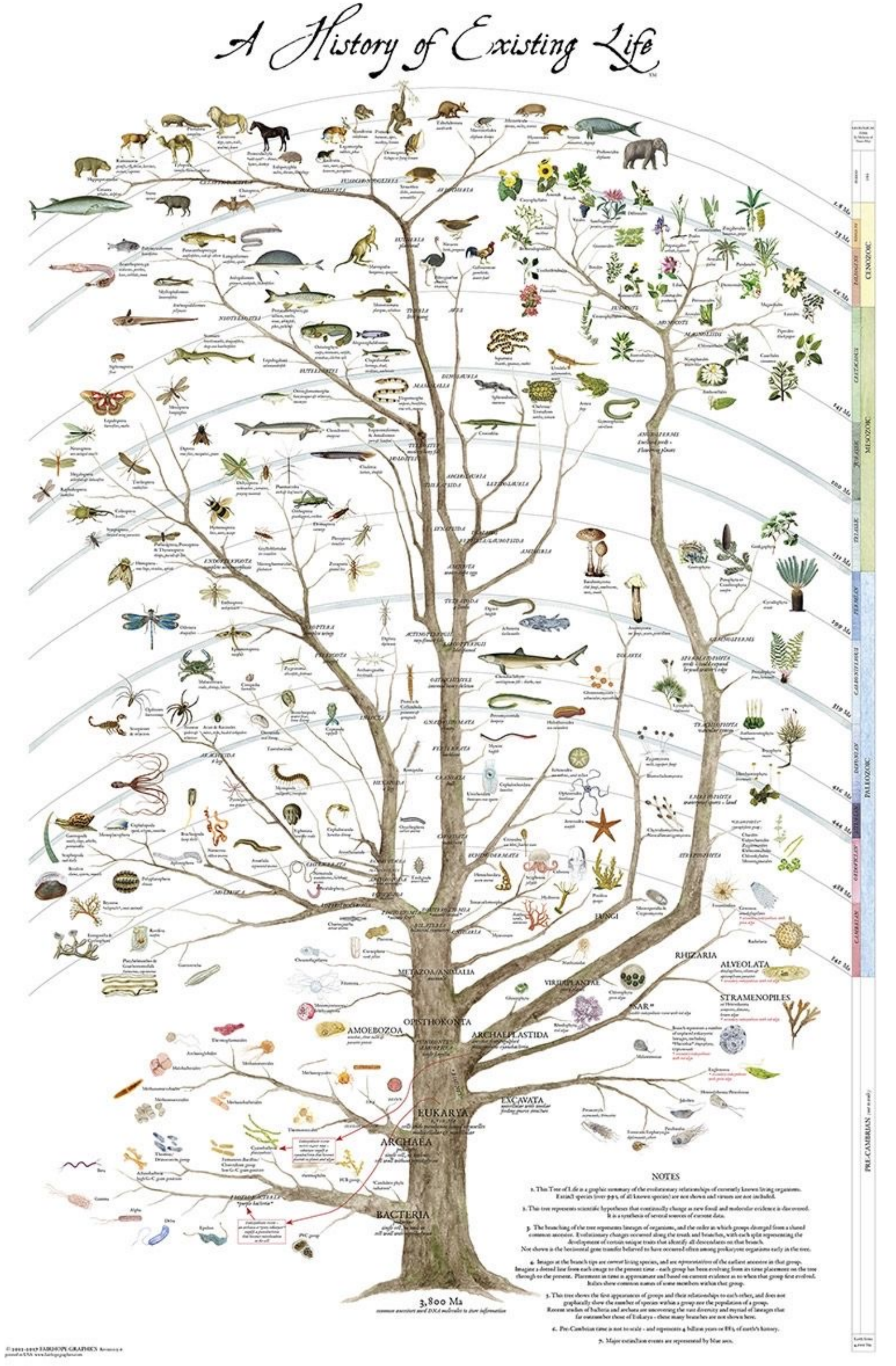
The tape of life

- Stephen Jay Gould (1989) – The Burgess Shale and the Nature of History
- Burgess Shale – fossil deposit
- Dating back to cca 530 MYA

The tape of life

- Rewinding the tape of life to different periods of evolutionary history
- Are mammals inevitable? Or life on land? Intelligence?




A History of Existing Life
CENOZOIC
MESOZOIC
PALEOZOIC
PRE-CAMBRIAN
METAZOA/ANIMALIA
FUNGI
VIRIDIPLANTAE
RHIZARIA
ALVEOLATA
STRAMENOPILES
SAR
AMOEBOZOA
OPISTHOKONTA
ARCHAEPLASTIDA
EXCAVATA
EUKARYA
ARCHAEA
BACTERIA
3,800 Ma
NOTES
6. Pre-Cambrian time is not to scale - and represents 4 billion years or 88% of earth's history.
7. Major extinction events are represented by blue arcs.

Discussion question

- Do you think that the evolution of human cognitive abilities was inevitable?

(i.e. if we replayed the tape of life to any point in the evolutionary history, would these abilities always evolve? Would humans be the ones with those abilities? Is there a point in history after which their evolution would no longer be inevitable?)

Recap

- Evolution is not a process towards increased organismal complexity
- Evolution will be influenced by both extrinsic and intrinsic factors affecting speciation and extinction events

Methodological issues in Animal Cognition research

Replication crisis

- Previously found effects are not replicated in subsequent studies or are much smaller than previously reported

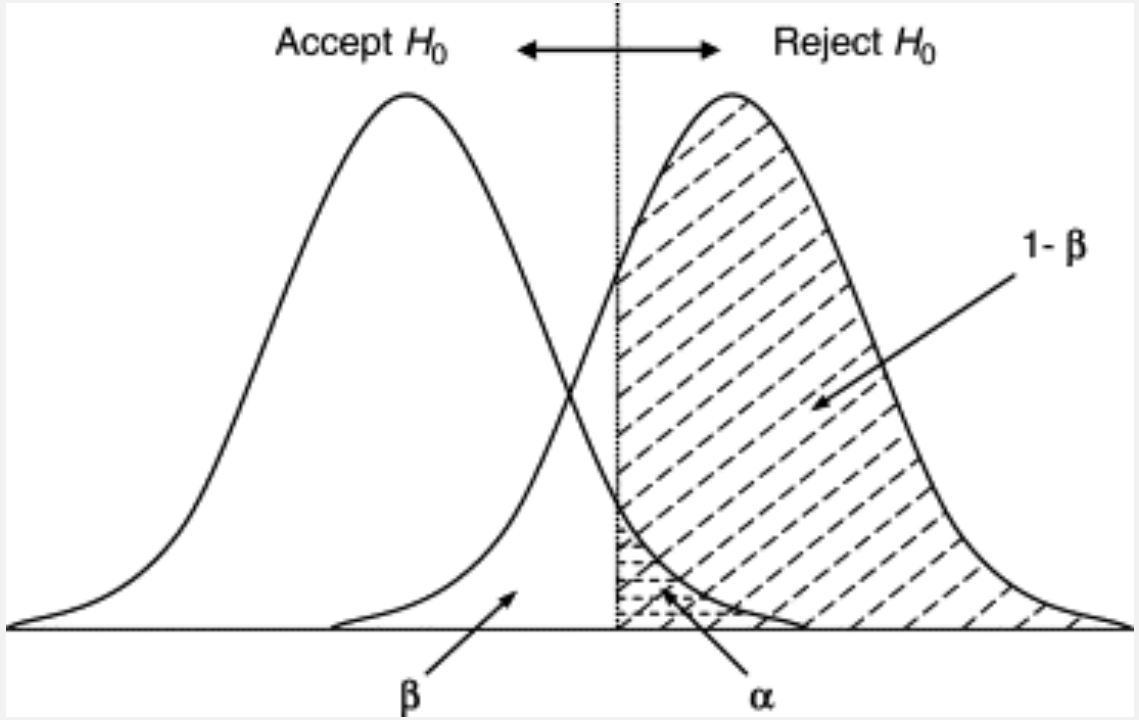
Comparative research

- Constraints on available number of individuals
- Research on specific species often comes from one or only few labs
- Individuals often tested in multiple experiments

The problem of representativeness

- Small samples
- Non-random sampling
- Often tested on only one apparatus or with one measurement

-> low statistical power



Farrar, B. G., Voudouris, K., & Clayton, N. S. (2021). Replications, Comparisons, Sampling and the Problem of Representativeness in Animal Cognition Research. *Animal Behavior and Cognition*, *8*(2), 273–295. https://doi.org/10.26451/abc.08.02.14.2021

Low replicability

- Studies on non-representative samples will be hard to replicate

Farrar, B. G., Voudouris, K., & Clayton, N. S. (2021). Replications, Comparisons, Sampling and the Problem of Representativeness in Animal Cognition Research. *Animal Behavior and Cognition*, *8*(2), 273–295. https://doi.org/10.26451/abc.08.02.14.2021

Low generalizability

- Researcher's claims will not often generalize to novel but related settings
- Lab studies often poorly positioned to generate representative data of the species in the wild

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Theory testing

- Lack of representative sampling produces weak tests of a theory or claim

Farrar, B. G., Voudouris, K., & Clayton, N. S. (2021). Replications, Comparisons, Sampling and the Problem of Representativeness in Animal Cognition Research. *Animal Behavior and Cognition*, *8*(2), 273–295. https://doi.org/10.26451/abc.08.02.14.2021

How to improve animal cognition research?

- Already many steps towards improving the quality of research
- Journal of Animal Behavior and Cognition: http://animalbehaviorandcognition.org/issue.php?id=33
- Manyprimates: https://manyprimates.github.io/

Increasing heterogeneity

- Sampling heterogeneity
- Measurement heterogeneity

Farrar, B. G., Voudouris, K., & Clayton, N. S. (2021). Replications, Comparisons, Sampling and the Problem of Representativeness in Animal Cognition Research. *Animal Behavior and Cognition*, *8*(2), 273–295. https://doi.org/10.26451/abc.08.02.14.2021

Increasing homogeneity and control

- E.g. performing experiments with blinded experimenters

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Cautious interpretation of findings

- Be wary of extremely good results

Recap

- Animal Cognition research faces problems with replication (as do other fields)
- May be especially vulnerable in some ways because of constraints on sample size and other characteristics of the field
- Ways to improve may be increasing the heterogeneity of the field as well as provide stricter controls and interpret the findings with caution

Please fill out the Course Feedback Form!

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