Who has a more sophisticated communication system,

molluscs or monkeys?

frequency and length of communicative interactions?

role of communication in social life?

➔ number of distinct communicative displays?

information content (entropy) of communicative exchanges?

complexity of psychological states resulting from communication?

???

After 450 million years…

Cephelopods:
15-35 distinct displays

Non-human primates:
15-35 distinct displays

Primates **are** “more evolved” than molluscs

- More complex bodies and brains
- More complex social structures
- More complex and flexible behavior
- Longer lived
- Better at learning and problem solving

- BUT no real change in “vocabulary size”

Evolution in action? (it's not just squid and monkeys...)

For most relatively social adult fishes, birds and mammals, the range or repertoire size [of communicative displays] for different species varies from 15 to 35 displays.

-Encyclopedia Britannica, "Animal Communication"

3 unique things about human language

- Big, discrete vocabulary

  10,000-100,000 “words”… or more

- Recursive compositionality

  making bigger messages by combining smaller ones,

  more complex meanings by combining simpler ones

- Action to “change others’ minds”

  we know others may have different knowledge and beliefs

  we communicate to inform, persuade, etc.

Many other “little” things...

- Displaced reference
- “Doubly digital” vocabulary
  words are discrete and well individuated
  words are patterns of digital sound elements (“phonemes”)
- Variability in sound system and word meanings
  constant spontaneous social change -- new dialects
  adults have trouble adapting -- shibboleths
- Singing/chanting
  stylization of pitch and time in ratios of small integers
- Various specific formal properties
  - e.g. morphological “blocking”

Language is weird

- Quantitatively and qualitatively unique
  - like elephants' trunks
- No similar evolutionary trends in other species
  - other species don't "want" to pick up peanuts with their noses
    - all mammals have flexible noses, some use them as manipulators
    - no general trend to develop anything like trunks
  - other species don't "want" to exchange very complex messages
    - (nearly) all mammals make noises, some use them to communicate
    - no general trend to develop anything like human speech

Human linguistic progress?

- No “primitive” languages
  - in terms of sound structure
  - in terms of word structure
  - in terms of sentence structure (?)
- There is variation in linguistic complexity
  - but no clear correlation with social structure or “cultural stage”
  - e.g. simpler versus more complex syllable structures
    - but French & Japanese aren’t more “primitive” languages than English
  - maybe civilization leads to more syntax, less morphology?
    - I.e. more sentential embedding, less complex word structure
    - evidence is anecdotal at best
- Vocabulary tends to grow
  - in written languages
  - in languages with old “classic” literature
  - in languages with a large population in diverse occupations

… but vocabulary is easy to gain or lose -- for homo sapiens…

Spontaneous communication among non-human primates is:

- limited to a small repertoire of signals
- whose categories are built in
  - meanings change a bit according to the environment
- reference is immediate, not displaced
- “theory of mind” abilities are nonexistent
  - or at best very limited
- just like “lower” animals
  - including some invertebrates

With training…

many creatures can be taught to makes sounds or gestures
when they see a “referent” or when they want something.

It’s even easier for them to learn to associate particular sounds, gestures or icons with (types of) objects.

This can look a lot like human speech communication:
but such abilities make it all the stranger
that other speech-like communication systems haven’t evolved.

Relationship of this kind of operant conditioning to human linguistic behavior is controversial
(more on this later in the course…)

Communication: "*theory of mind*"

To attribute beliefs, knowledge and emotions to both oneself and others is to have what Premack and Woodruff (1978) term a *theory of mind*. A theory of mind is a theory because, unlike behavior, mental states are not directly observable
[. . .]
[E]ven without a theory of mind, monkeys are skilled social strategists. It is not essential to attribute thoughts to others to recognize that other animals have social relationships or to predict what other individuals will do and with whom they will do it. Moreover, it is clearly possible to deceive, inform, and convey information to others without attributing mental states to them.
[. . .]
However, the moment that an individual becomes capable of recognizing that her companions have beliefs, and that these beliefs may be different from her own, she becomes capable of immensely more flexible and adaptive behavior.

Cheney and Seyfarth, *How monkeys see the world*

Animals' theory of mind?

- Gaze following
- Attention-getting behavior
- Cooperative action
- Deception, empathy, grudging, reconciliation, etc. …
- Argument by analogy: "when we do X, we attribute knowledge and beliefs to others, so when animals do X, they make similar attributions"

However

If you design an experiment to test “other minds” reasoning in animal analogues, it always (more or less) fails (so far…)

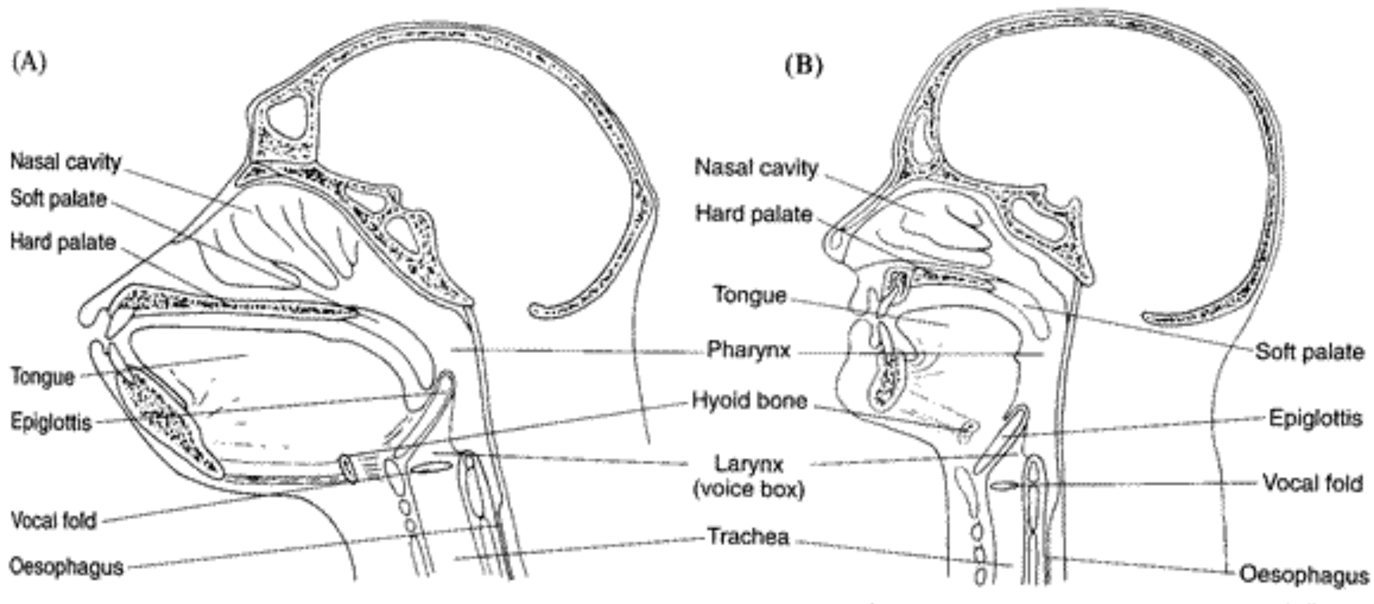
For details, see this article
and discussion later in the course.

Evolution of language

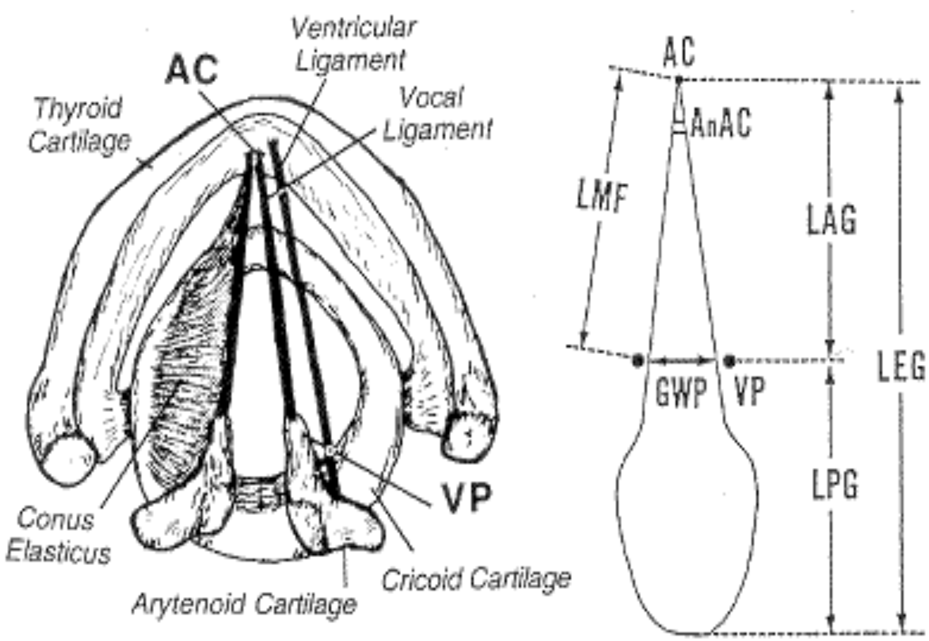
Possible evolutionary adaptations for (spoken) language:

- larynx lowering/pharynx expansion
- sexual dimorphism in larynx size and position
- pitch perception and speech perception more generally
- speech motor control
- general and specific brain expansion
- Functional localization in Broca's and Wernicke's areas

Development of the pharynx



Sexual dimorphism in larynx size and position

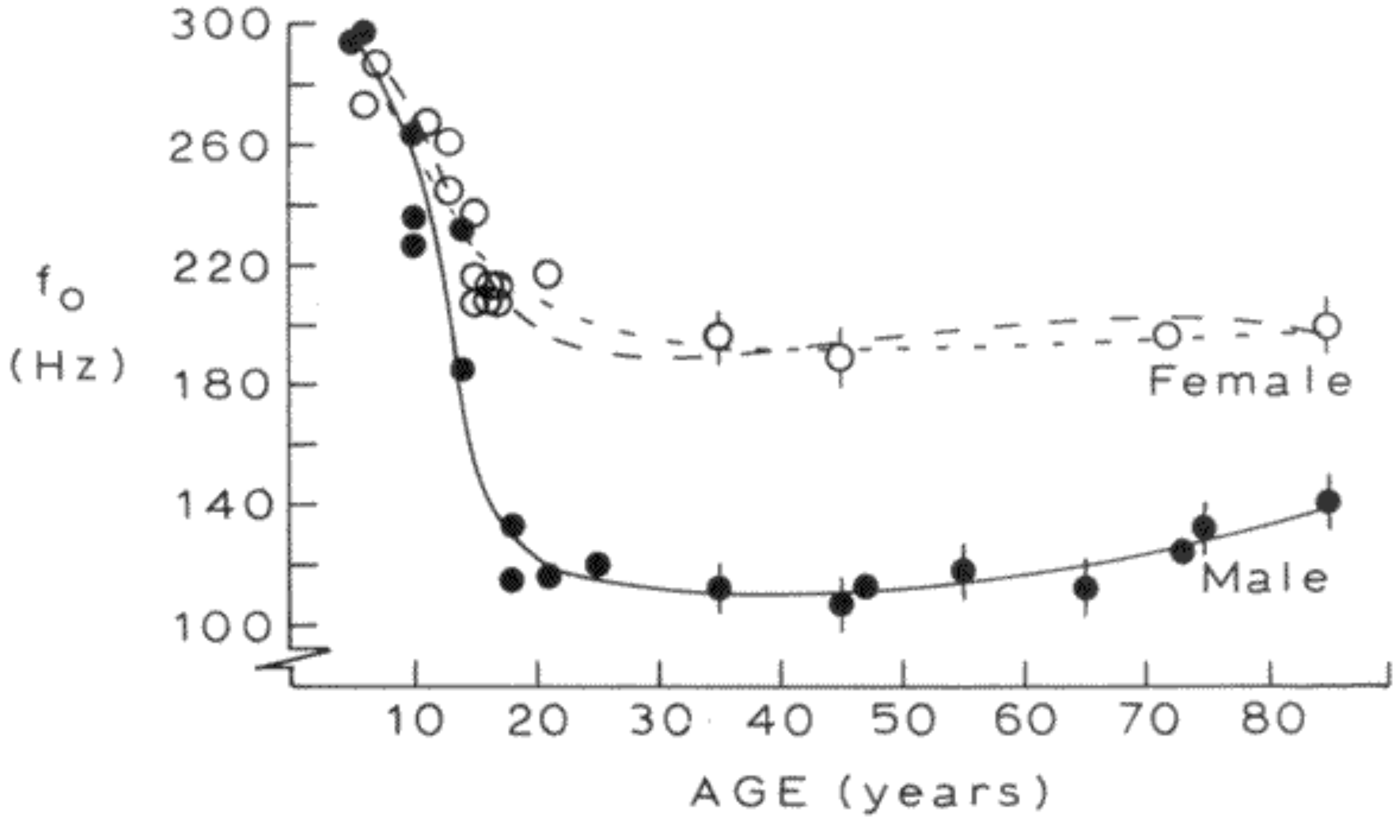


AC	anterior commissure
VP	tip of vocal process
AnAC	angle of bilateral vocal folds at AC
GWP	glottic width at vocal process level
LEG	length of entire glottis
LAG	length of anterior glottis
LPG	length of posterior glottis
LMF	length of membranous vocal fold

Sex differences in laryngeal measurements (Data from Hirano et al. 1997)

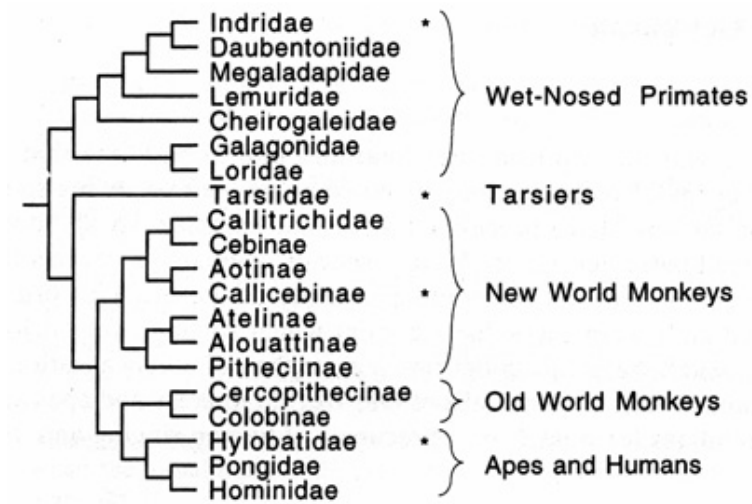
	Male	Female	Ratio M/F
AnAC in degrees	16	25	
LMF in mm	15.4	9.8	1.57
GWP in mm	4.3	4.2	1.02
LAG in mm	15.1	9.5	1.59
LPG in mm	9.5	6.8	1.40
LEG in mm	24.5	16.3	1.50

Sex and F0



300
260
220
180
140
100
f_o (Hz)
Female
Male
10 20 30 40 50 60 70 80
AGE (years)

Phylogeny of singing in primates



Singing is rare in mammals. It occurs in members of 26 species in four primate genera: Indri, Tarsius, Callicebus, Hylobates. These are 11% of primate species and 4% of primate genera. Since the four singing genera are widely separated, they are thought to have evolved singing independently.

In all singing primates, both males and females sing, and duetting usually if not always occurs. All singing primates are monogamous (with the possible exception of humans).

Most bird species sing; often bird song is mostly male; duetting bird species are also usually monogamous.

Are humans monogamous?

In most mammalian species, sexual access is either determined by rank… and results in polygyny; or else … two individuals become "attached" to one another and then isolate themselves from other members of their species…

[In humans] what is common is… cooperative, mixed-sex social groups, with significant male care and provisioning of offspring, and relatively stable patterns of reproductive exclusion, mostly in the form of monogamous relationships.

Reproductive pairing is not found in exactly this pattern in any other species.

--Terence Deacon, "The Symbolic Species"

Gular sac

Some gibbons have developed a large "gular sac" apparently involved with breath control and/or resonance. Gular sac size and song complexity seem to correlate across species.

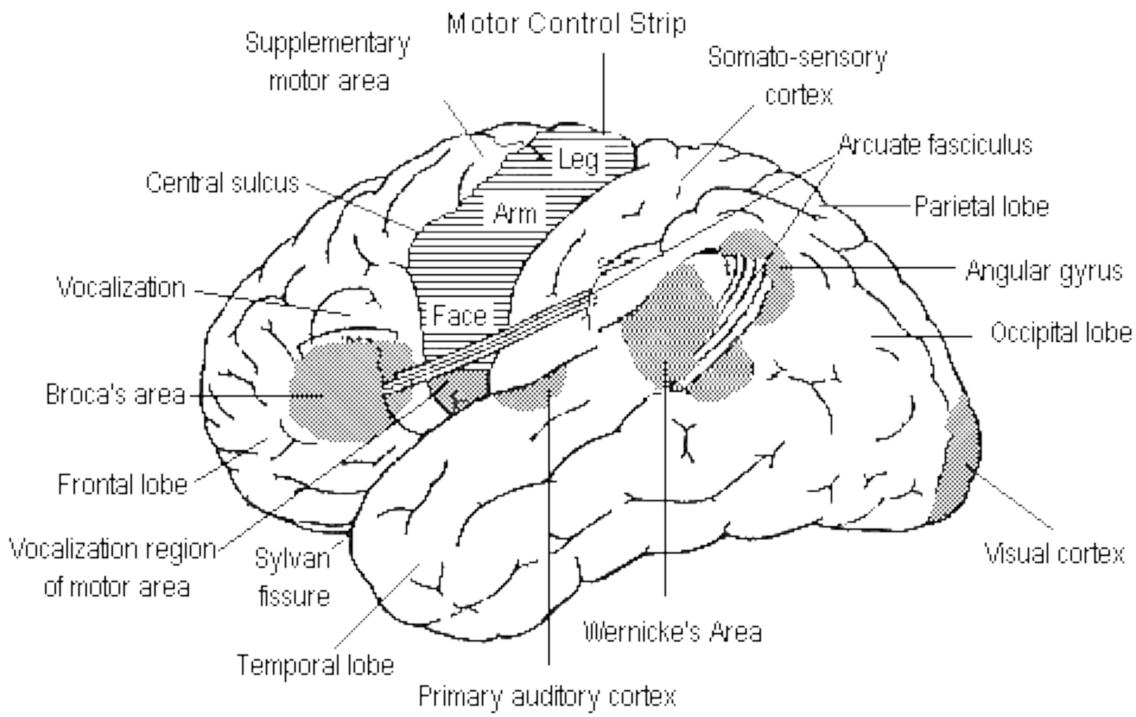
Symphalangus syndactylus

(siamang):

"the [siamang] duet is probably the most complicated opus sung by a land vertebrate other than man…"

--Marshall and Sugardjito (1986)

Localization of brain function



Broca’s aphasia

M.E. Cinderella...poor...um 'dopted her...scrubbed floor, um, tidy...poor, um... 'dopted...Si-sisters and mother...ball. Ball, prince um, shoe...

Examiner Keep going.

M.E. Scrubbed and uh washed and un...tidy, uh, sisters and mother, prince, no, prince, yes. Cinderella hooked prince. (Laughs.) Um, um, shoes, um, twelve o'clock ball, finished.

Examiner So what happened in the end?

M.E. Married.

Examiner How does he find her?

M.E. Um, Prince, um, happen to, um...Prince, and Cinderalla meet, um met um met.

Examiner What happened at the ball? They didn't get married at the ball.

M.E. No, um, no...I don't know. Shoe, um found shoe...

Wernicke's aphasia

Examiner Yeah, what's happening there?

C.B. I can't tell you what that is, but I know what it is, but I don't now where it is. But I don't know what's under. I know it's you couldn't say it's ... I couldn't say what it is. I couldn't say what that is. This shu-- that should be right in here. That's very bad in there. Anyway, this one here, and that, and that's it. This is the getting in here and that's the getting around here, and that, and that's it. This is getting in here and that's the getting around here, this one and one with this one. And this one, and that's it, isn't it? I don't know what else you'd want.

Why in these places?

- Broca's area is next to the motor strip in the orofacial area:
  control of speech articulation there makes sense.
- Wernicke's area is next to auditory cortex,
  towards the visual and somatosensory areas:
  grounding of spoken word meanings there makes sense

Deaf Aphasia

Taken together, studies of the neural basis of sign language processing highlight the presence of strong biases that left inferior frontal and posterior temporal parietal regions of the left hemisphere are well suited to process a natural language independent of the form of the language…

-David P. Corina (MIT Encyclopedia of Cognitive Sciences)

("Left inferior frontal" == Broca's area;
"[left] posterior temporal parietal" == Wernicke's area)

For example, deaf signers with Broca's aphasia show 'telegraphic signing' with difficulties in sign morphology, though their ability to mime is unaffected.

Interpretation

- Speech is vocal output, auditory input
- Sign is manual output, visual input
- But deaf-from-birth signers
  show functional localization in the brain
  similar to speakers
- Suggests that Broca's and Wernicke's areas
  began as convenient processing regions
  for speaking and listening
- then became adapted for more general language
  functions

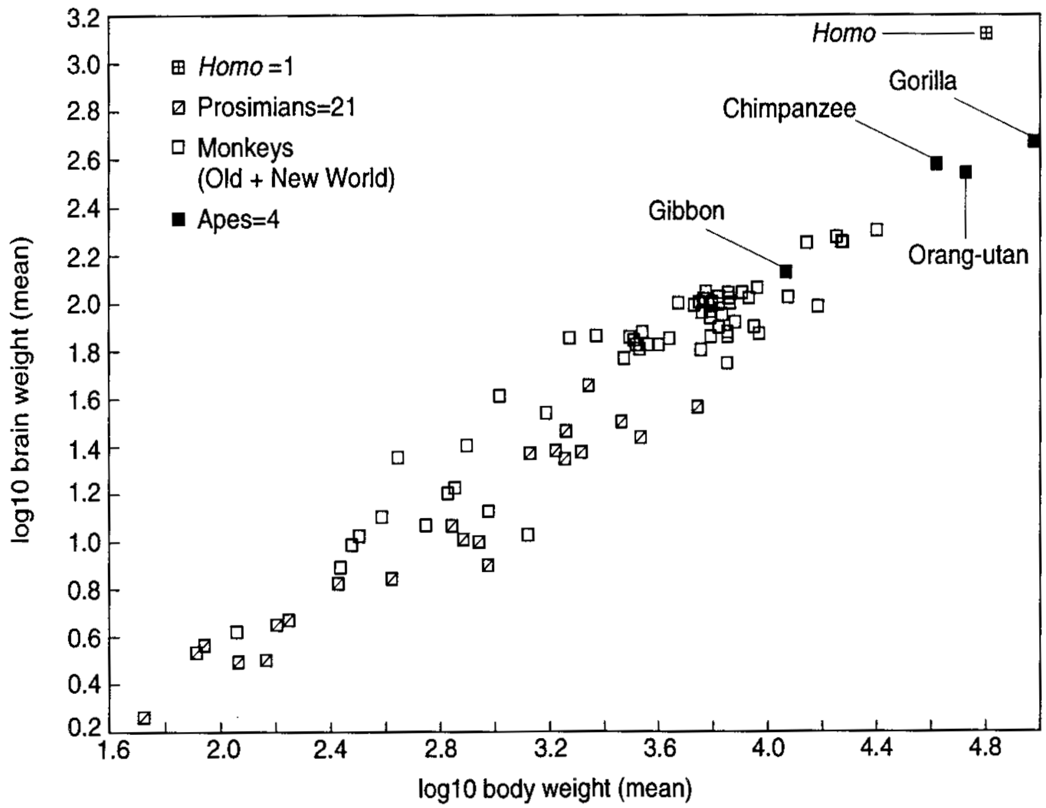
Brain changes in hominid evolution

There are four major reorganizational changes that have occurred during hominid brain evolution, viz.: (1) reduction of the relative volume of primary visual striate cortex area, with a concomitant relative increase in the volume of posterior parietal cortex, which in humans contains Wernicke's area; (2) reorganization of the frontal lobe, mainly involving the third inferior frontal convolution, which in humans contains Broca's area; (3) the development of strong cerebral asymmetries of a torsional pattern consistent with human right-handedness (left-occipital and right-frontal in conjunction); and (4) refinements in cortical organization to a modern human pattern, most probably involving tertiary convolutions. (this last 'reorganiziation' is inferred; in fact, there is no direct palaeoneurological evidence for it.)

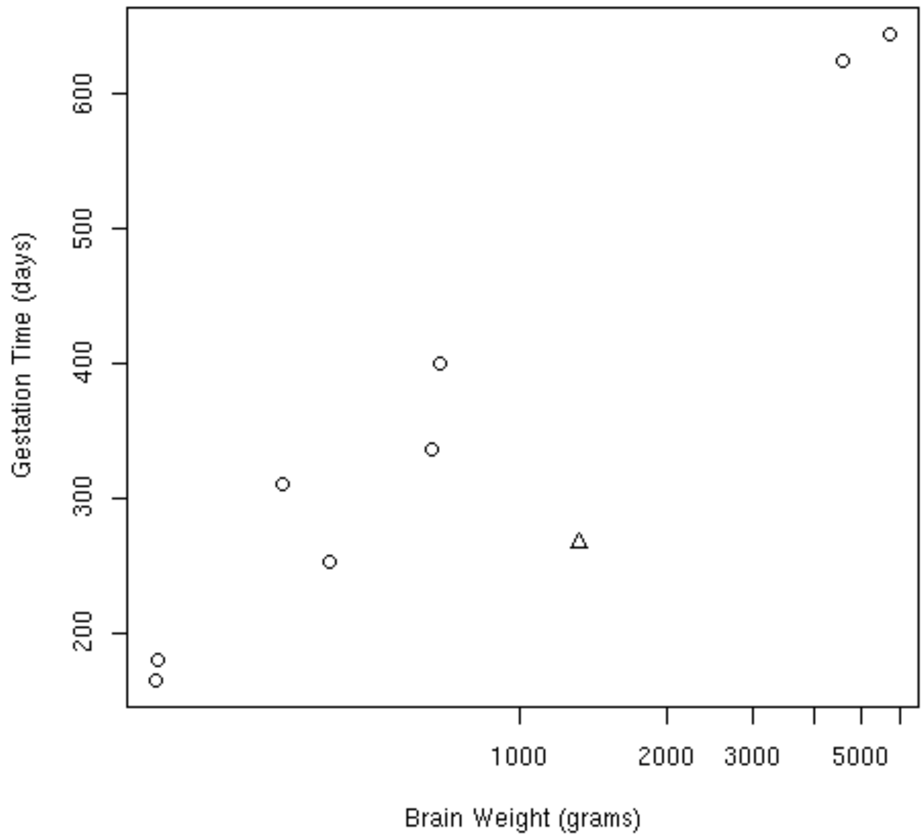
-Holloway, R. 1996. "Evolution of the human brain".

Note that of the four brain reorganizations cited by Holloway, three have to do with speech and language, while the forth is a somewhat vague catch-all category (“refinements in cortical organization to a modern human pattern”)

The hominid brain also got bigger



Brain weight vs. gestation time



Why the connection between brain size and body size?

Aren't bigger brains always better?
No, because neural tissue is expensive:
  human brain is 2% of weight, uses 20% of energy
  this imposes an economic cost/benefit trade-off
Bigger animals both need and can afford bigger brains,
just as bigger countries need/can afford bigger governments

Bigger body needs more sensory & motor nerves,
  and a fixed % "energy tax" supports a bigger CNS
Human "central government" is enormous relative to our size
  if we predict brain size from body size across species,
  human brain is about 7 times larger than expected (EQ)

Paying the price

Each adaptation makes language work better

… but at a cost!

* choking danger
* energy requirements of a bigger brain
* problems of neoteny

So why'd we do it?

From the perspective of hindsight, almost everything looks as though it might be relevant for explaining the language adaptation. Looking for the adaptive benefits of language is like picking only one dessert in your favorite bakery: there are too many compelling options to choose from. What aspect of human social organization and adaptation wouldn't benefit from the evolution of language? From this vantage point, symbolic communication appears "overdetermined." It is as though everything points to it. A plausible story could be woven from almost any of the myriad of advantages that better communication could offer: organizing hunts, sharing food, communicating about distributed food sources, planning warfare and defense, passing on toolmaking skills, sharing important past experiences, establishing social bonds between individuals, manipulating potential sexual competitors or mates, caring for and training young, and on and on.

-Terence Deacon, "The Symbolic Species"

If language is so great, why doesn't every species get one?

Possible answers:

- It's too expensive, relative to the benefits
  - e.g. in terms of brain tissue requirements
- It's hard to get started
  - e.g. requires an unlikely evolutionary "invention"
    - not just an extension of animal communication systems
  - or, "early releases" are not very useful
    - "theory of mind" lacking
    - displaced reference can be confusing