

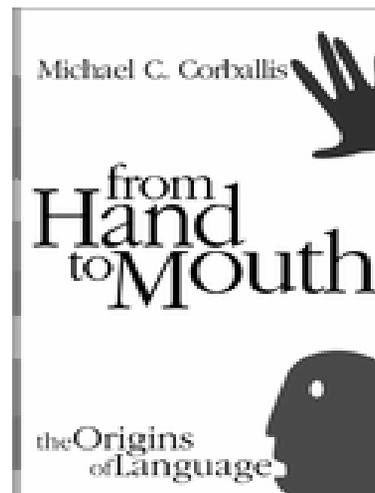
Language as gesture

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The Gestural Theory of Language Origins

- “I cannot doubt that language owes its origins to the imitation and modification of various natural sounds, and man’s own distinctive cries, *aided by signs and gestures*” (Darwin)
- Also Arbib, Armstrong, Condillac (1756), Critchley, Donald, Givon, Hewes (1973), Place, Ruben, Stokoe, Vico (1744), Wilcox, Wundt, and many others ...

... including myself!

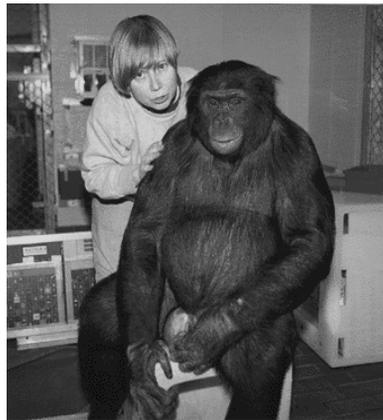


The argument

- Left hemisphere controls both speech and manual praxis
- Sign language is a fully syntactic language
- Chimps can learn a form of sign language, but can't learn to speak
- People gesture as they speak, in synchrony with speech



Kanzi, a bonobo, is the most famous and successful of the “linguistic apes”



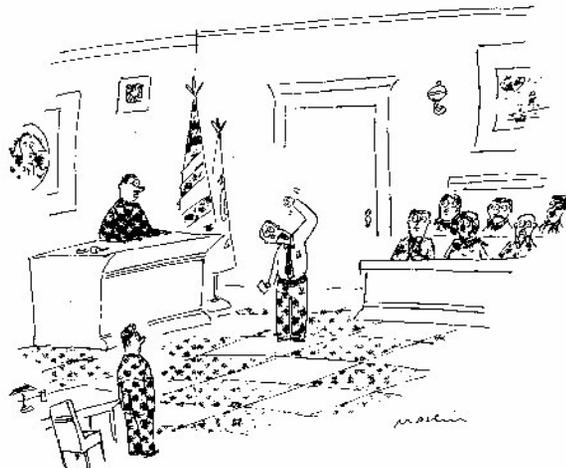
Kanzi and friend

Manual gesturing is part of regular speech ...



“And do you, Stephanie, promise to love, honor, and obey?”

And sometimes conveys the whole message



“The bailiff—minus the theatrics—will now read the verdict.”

The Problem

“... the gestural theory has one nearly fatal flaw. Its sticking point has always been the switch that would have been needed to move from a visual language to an audible one”

—Robbins Burling, *The Talking Ape* (2005, p. 123)

How to answer this?

The Answer

- Speech itself is a gestural system
- Language started as a largely manual system
- Facial gestures were gradually added
- Voicing was added to facial gestures
- ... and took over (though not completely)

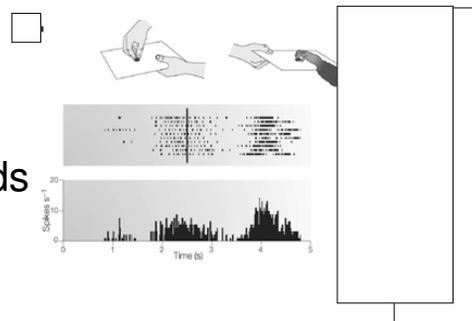
Gentilucci, M. & Corballis, M. C. 2006. From manual gesture to speech: A gradual transition. *Neuroscience & Biobehavioral Reviews*, 30, 949-960..

The motor theory of speech perception

- Arose from research of Alvin Liberman and colleagues at the Haskins Labs, leading to **articulatory phonology**
- Speech conceived as *gestures* of the lips, the velum, the larynx, and the blade, body, and root of the tongue
- Perception of speech involves recovery of gestures, not acoustic analysis
- These gestures are partly visible (lipreading, McGurk effect, ...)

Motor theory boosted by the discovery of **mirror neurons**

- First discovered in Area F5 in the monkey
- These fire when the animal makes a grasping movement, and also when it observes the same movement made by another
- Maps observation onto execution
- Area F5 corresponds to Broca's area



- V.S. Ramachandran: "I predict that mirror neurons will do for psychology what DNA did for biology. They will provide a unifying framework and help explain a host of mental abilities that have hitherto remained mysterious."

The mirror system

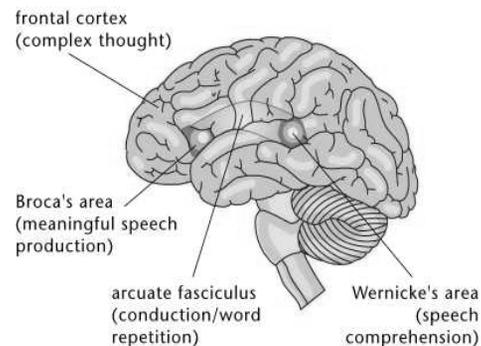
- Now known to include areas in STS and parietal lobes
- In monkey this system has to do with manual action
- In humans it overlaps with the language areas
- ***Speech belongs, at least partly, in the mirror system***

Direct-matching hypothesis (Rizzolatti)

- Mirror system is specialized for the perception of biological motion
- These include
 - Manual gestures
 - Environmental sounds
 - And, in humans, speech sounds

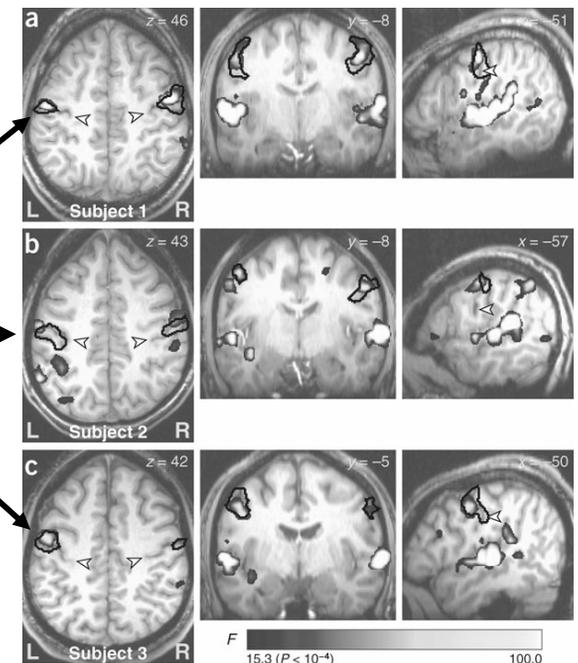
Speech is part of the mirror system in humans

- Probably introduced late in hominid evolution
- And into the left hemisphere
- No evidence that animal vocalization is part of the mirror system



Mirror neurons In Broca's area

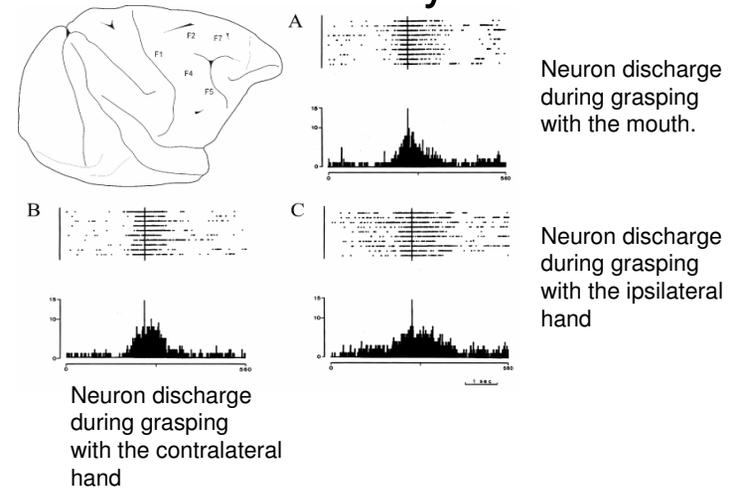
Areas activated by production (black outline) and perception (red outline) of meaningless syllable



Wilson SM et al. (2004) *Nature Neuroscience*, 7, 701-702

Hand gestures and mouth gestures are intimately connected, even in monkeys

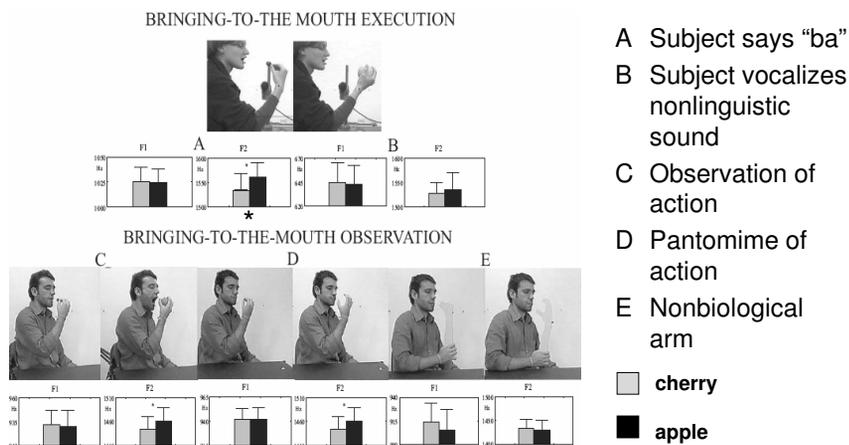
Recordings from area F5 in the monkey



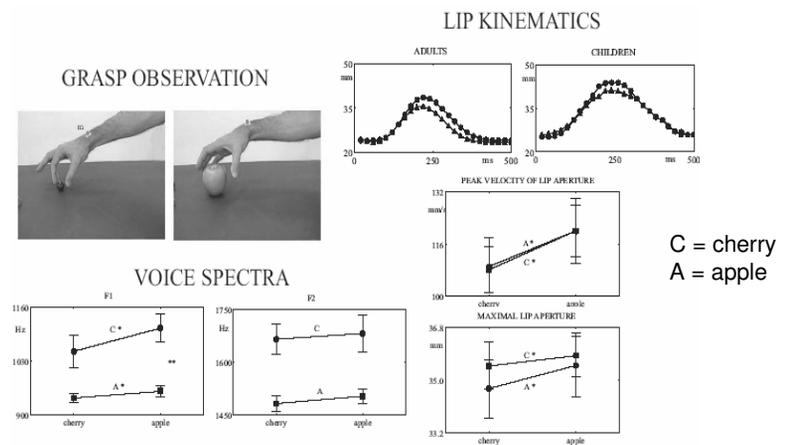
Rizzolatti, G., et al. (1988) *Exp. Brain Res.* **71**, 491-507.

Speech in humans is affected by action

Even if the action is simply a grasping movement



Gentilucci, M., et al. (2004). *European Journal of Neuroscience*, **19**, 190-202.



Gentilucci, M., et al. (2004). *Neuropsychologia* **42**, 1554-1567.

Why the link?

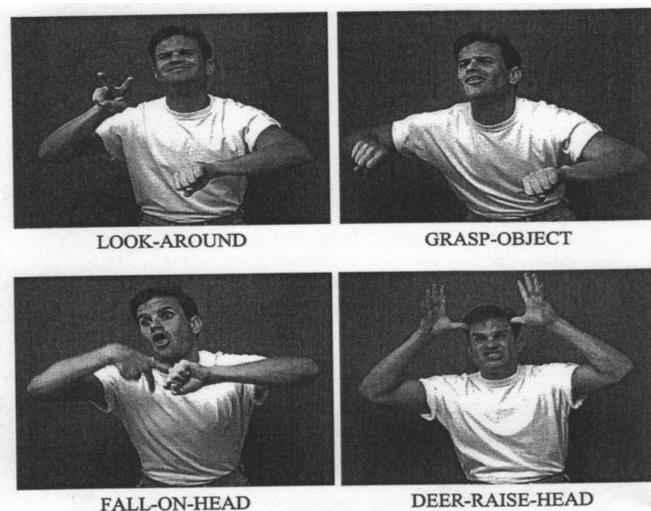
- The link between hand and mouth derives from eating!
- Double hand-mouth command system is present in monkeys, but does not involve vocalization
- Peter MacNeilage: Speech originated from repetitive ingestive movements of the mouth

MacNeilage, P.F. (1998). *Behav. Brain. Sci.* 21, 499-546.

Clues from sign language

- Mostly carried out with the hands
- Also overlaps with the mirror system
- But involves the face as well as the hands
- **Hence a continuity between speech and signing—both involve gestures of the face and hands**

The face in action

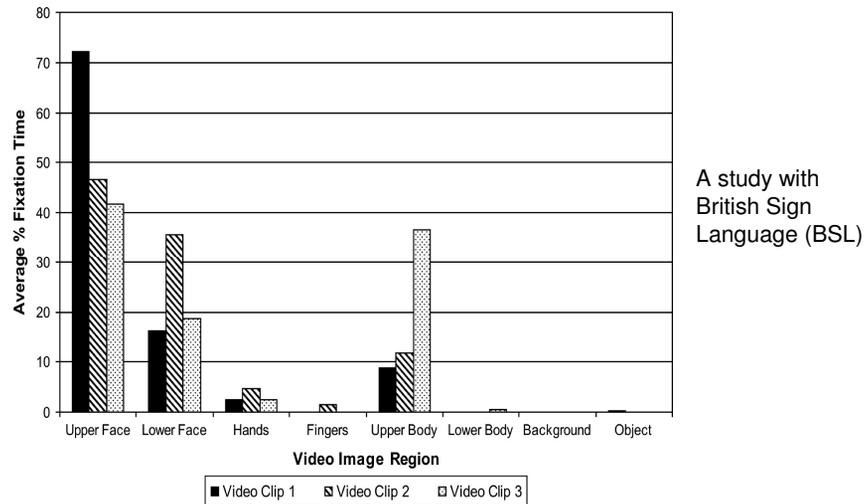


The face in action



Translation: "It's funny—you know that my cat is reserved and snooty, and my dog is boiling mad"

Deaf people watching signing fixate mostly on the face



Muir, L. J. et al. J. Deaf Stud. Deaf Educ. 2005 10:390-401

Language from hand to face

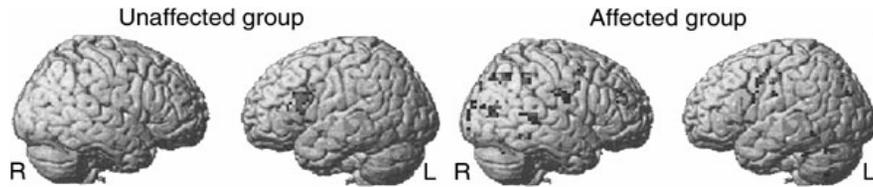
- Gestural language moved increasingly to the face as hands became more occupied with manufacture, tool use, and carrying
- The “face” includes tongue and, eventually, the larynx
- Sound was added to make hidden mouth gestures accessible
- ***Speech is facial gesture half swallowed***

The next step was to add vocalization, so that language could be heard as well as seen

FOXP2 and the rise of speech

- KE family: deficits in speech due to mutation on the FOXP2 gene on chromosome 7
- The primary deficit is oro-facial movement and articulation
- Affected members of the KE family don't show activation of Broca's area when generating verbs
- ***FOXP2 gene responsible for introducing vocal articulation to the mirror system?***

FOXP2 and the Mirror System



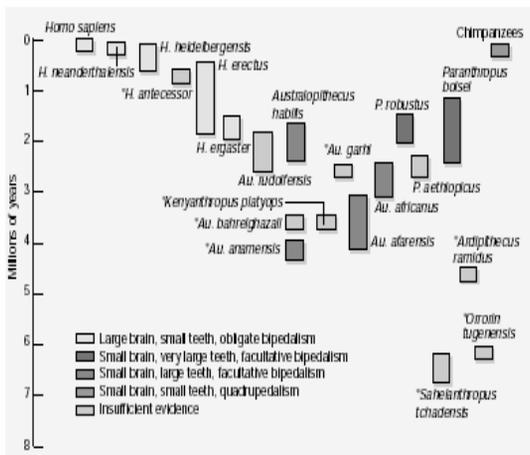
- Unaffected KE members show activation of Broca's area when generating verbs
- Affected members show bilateral activation *excluding* Broca's area
- Could FOXP2 have assimilated orofacial/vocal control into Broca's area, and the mirror system?

Liégeois *et al.*, *Nature Neuroscience*, 2002, **11**, 1230-1237

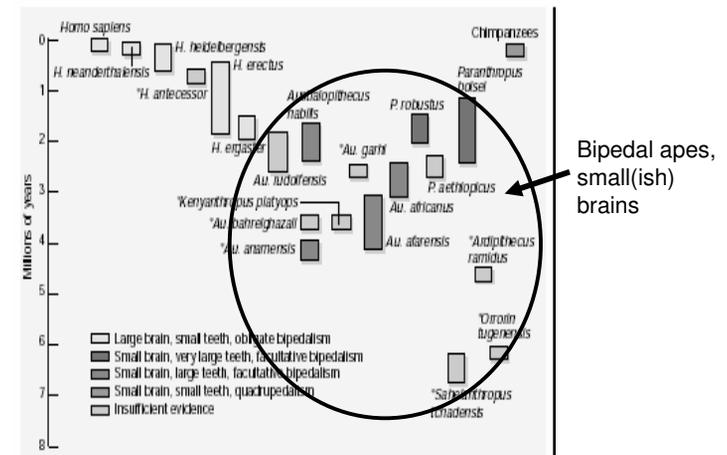
When did it all happen?

- Three giant steps for humankind
 1. **6-7 million years ago**: split from the great apes. Bipedalism → primitive manual language
 2. **2 million years ago**: emergence of *Homo*, increase in brain size, migrations from Africa. Language becomes more complex (syntactic), with addition of facial and some vocal elements (grunts)
 3. **170,000 years ago**: emergence of *Homo sapiens* in Africa, and the "human revolution." Mutation of FOXP2 and dominance of vocal language

Hominid evolution



Hominid evolution

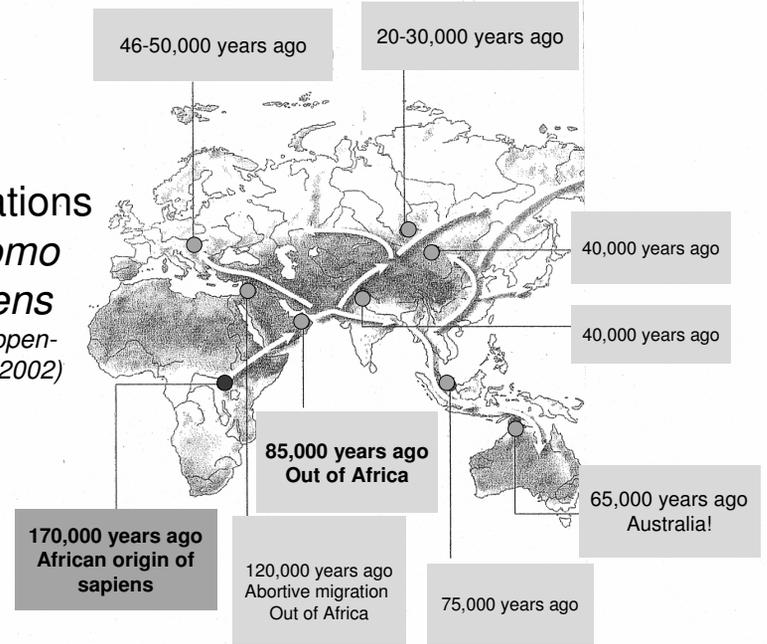


Then, out of Africa, came *Homo sapiens*



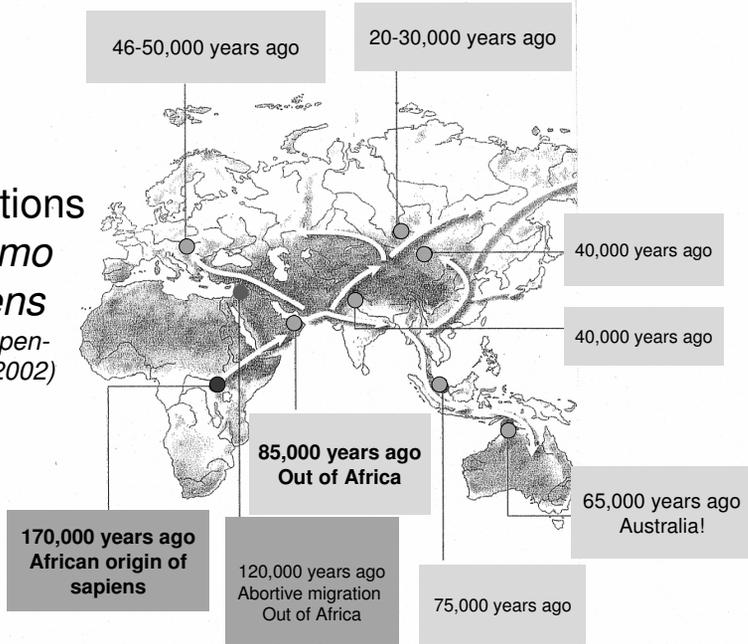
Early migrations of *Homo Sapiens*

(after Oppenheimer, 2002)



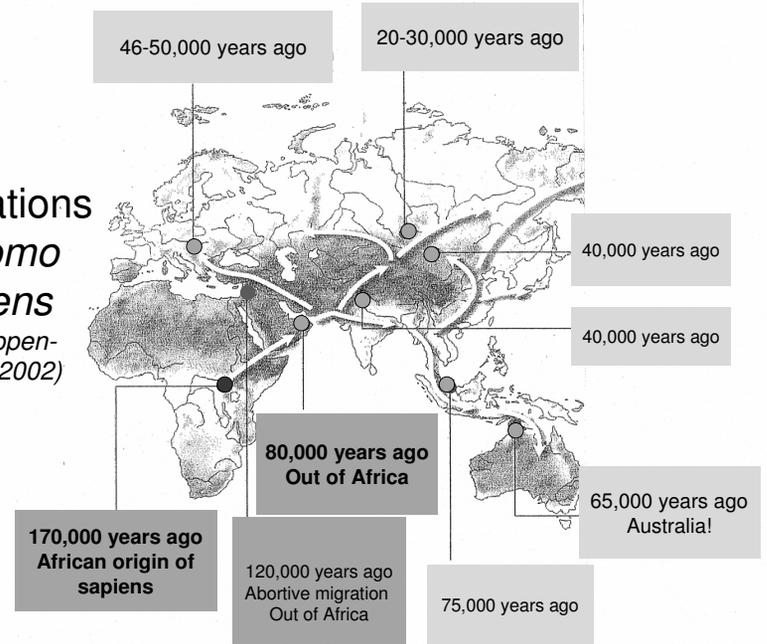
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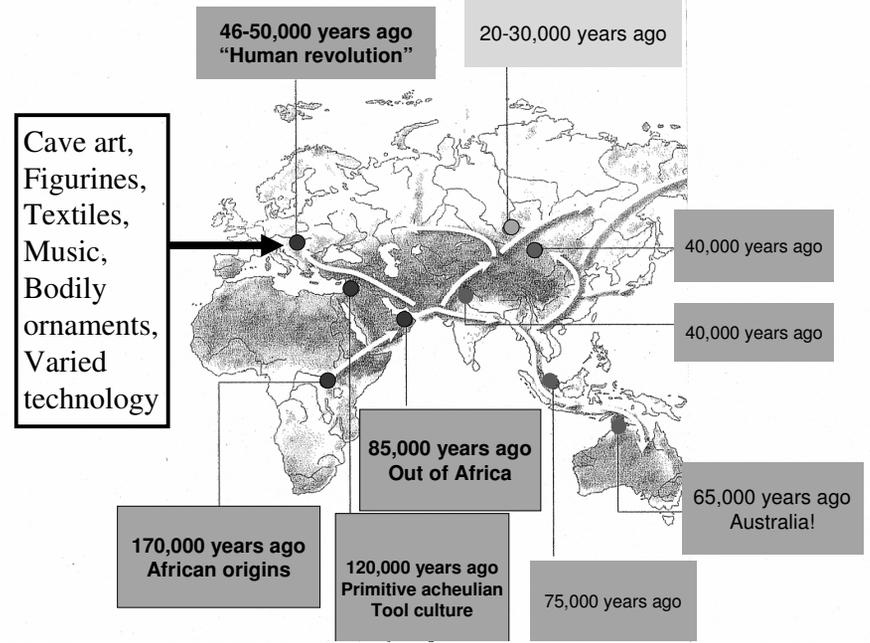
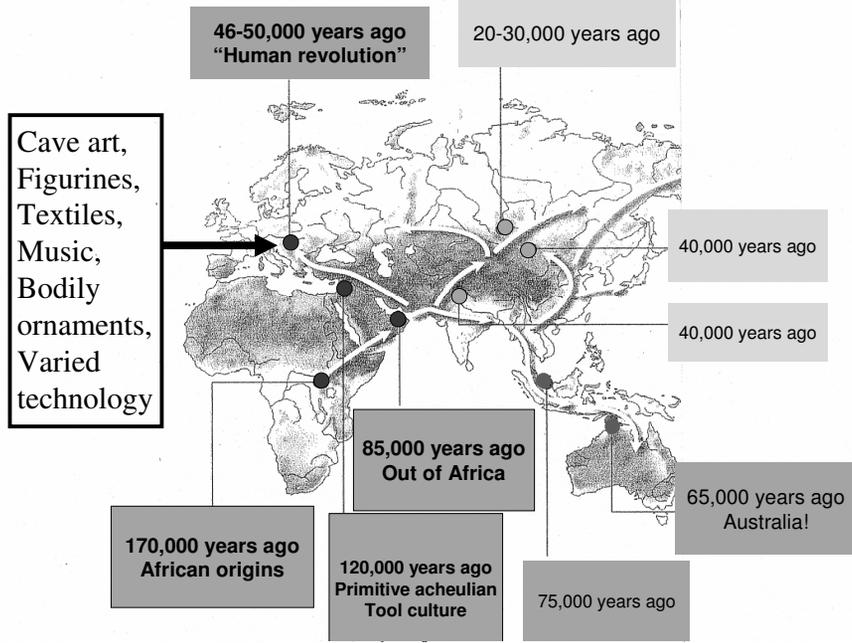
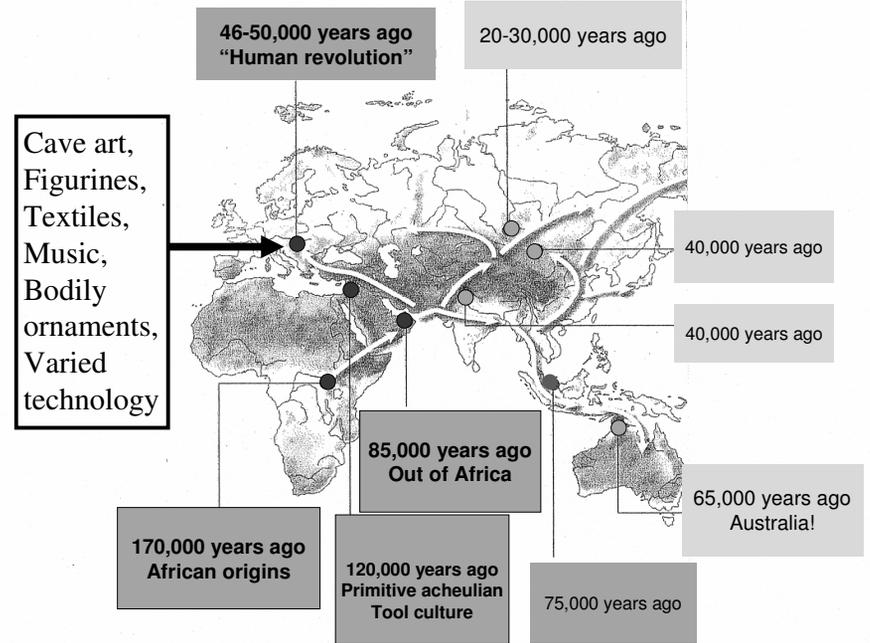
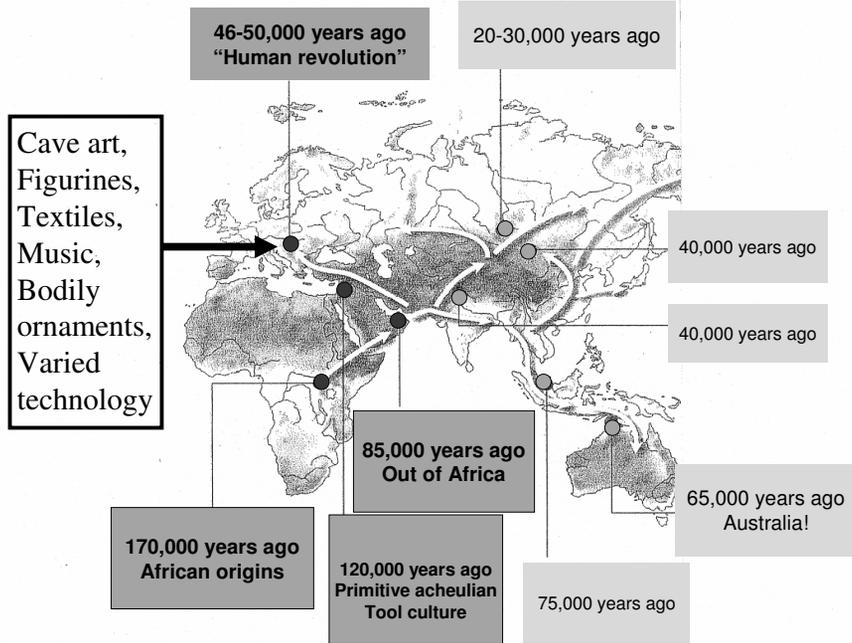
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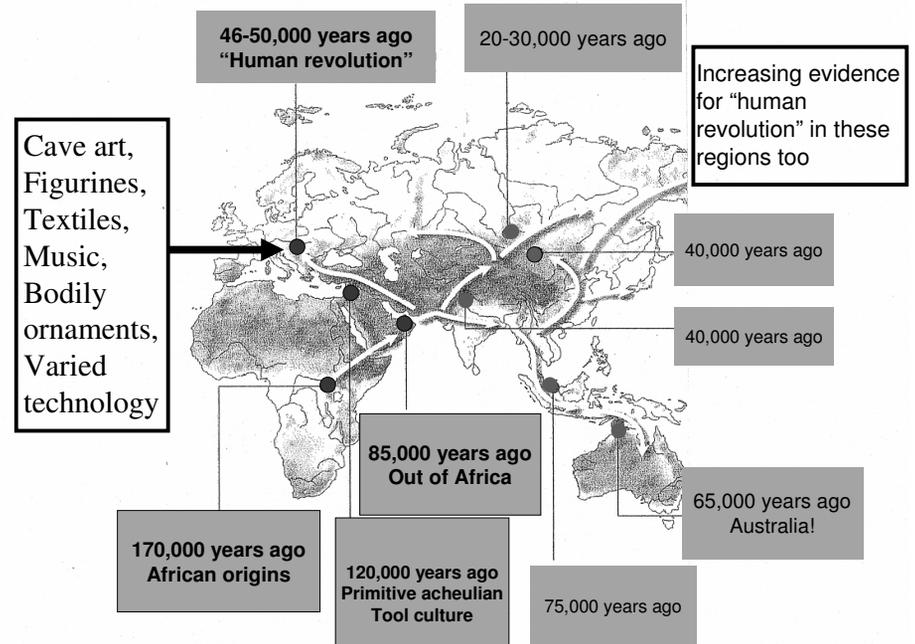
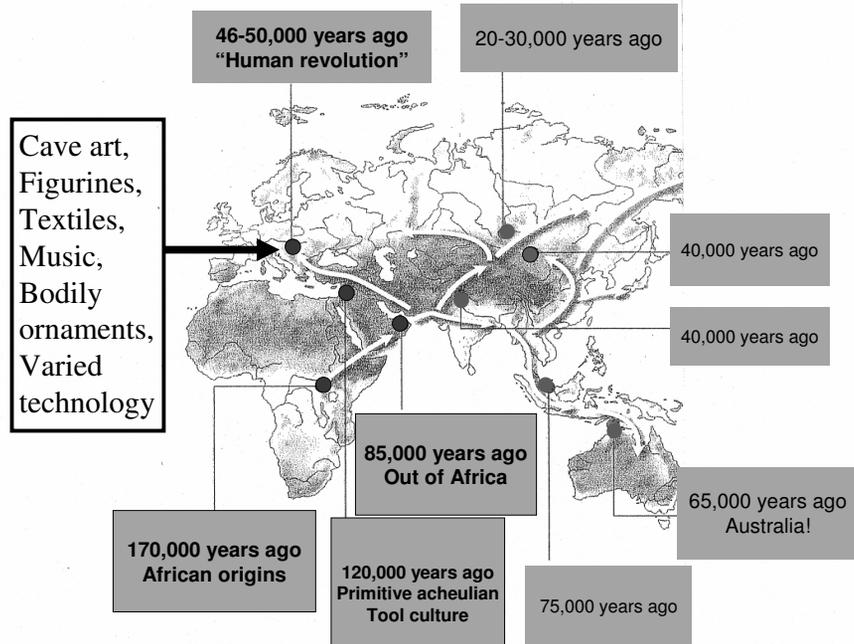


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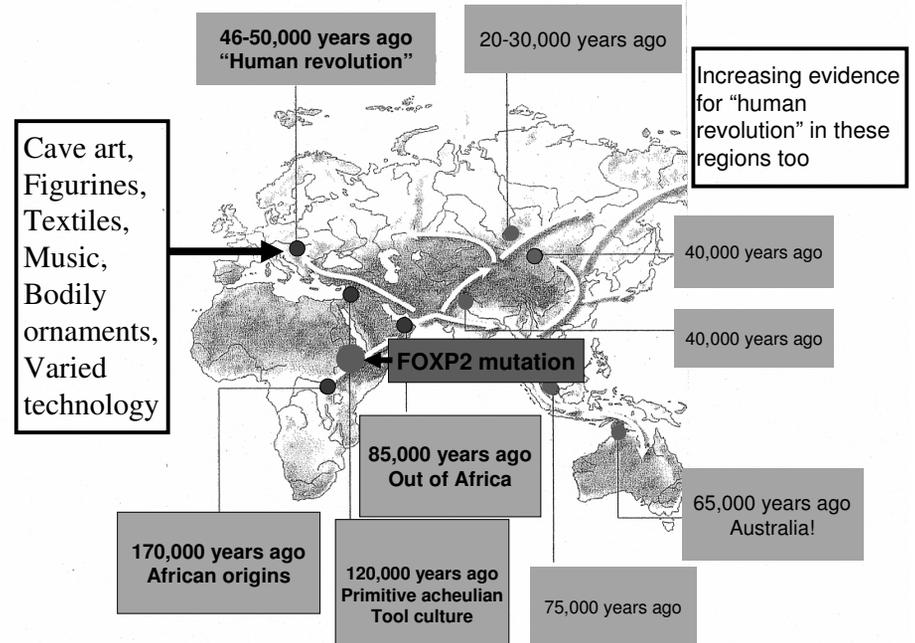




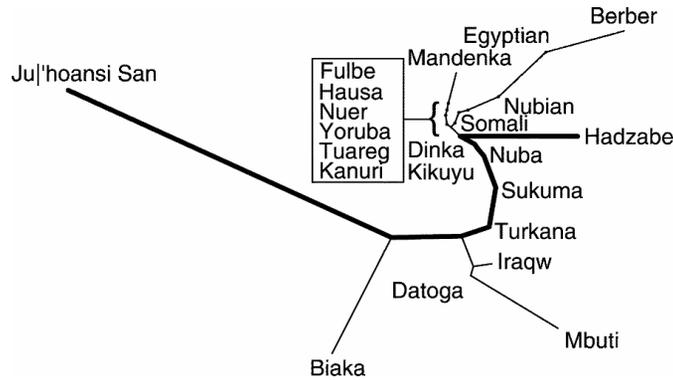
Evolution of the FOXP2 gene

- FOXP2 underwent 2 mutations in hominids after the split from the apes
- The more recent occurred *not earlier* than "the time since the onset of human population growth, some 10,000 to 100,000 years ago. ... This is compatible with a model in which the expansion of modern humans was driven by the appearance of a more-proficient spoken language"*
- This could fit into the gap between the two migrations out of Africa (120,000 and 85,000 yrs ago)

*Enard et al., *Nature*, 2002, 418, 871



African click languages



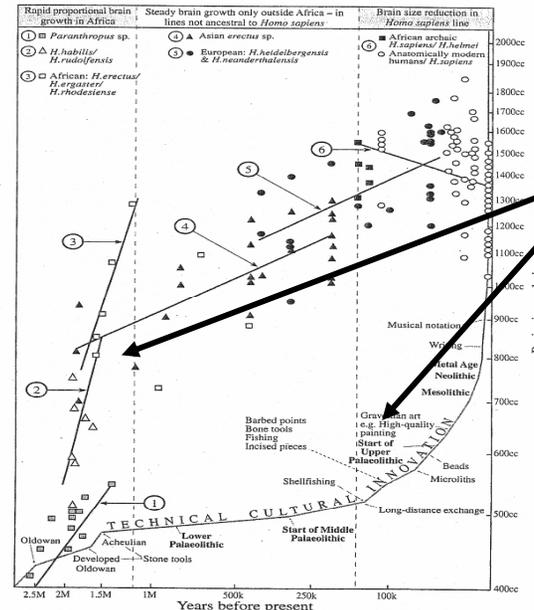
- Time depth of around 100,000 years, to the root of present-day mtDNA variation
- Could clicks be a precursor to vocalization?

Why was speech so critical?

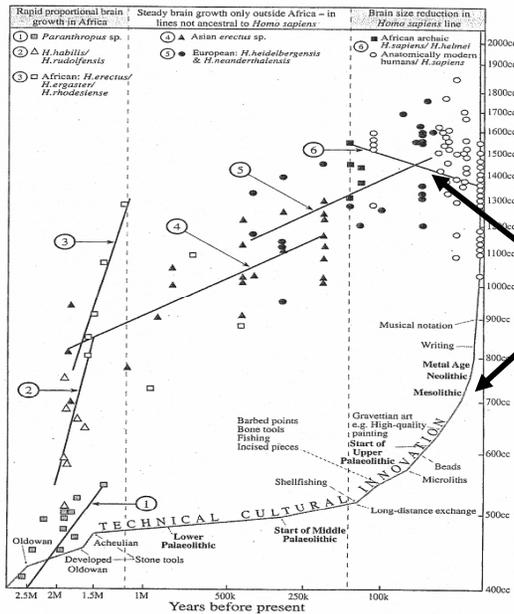
- It freed the hands for manufacture
- Allowed pedagogy, so that manual skills could be explained and demonstrated in parallel
- Communication at night, lower energy demands, manufacture of weaponry, etc, gave *H. sapiens* the edge over Neanderthals and *H. erectus*

Also explains the late emergence of manufacture, and the “human revolution”

Corballis, M. C. 2004. The origins of modernity: Was autonomous speech the critical factor? *Psychological Review*, 111, 543-552.

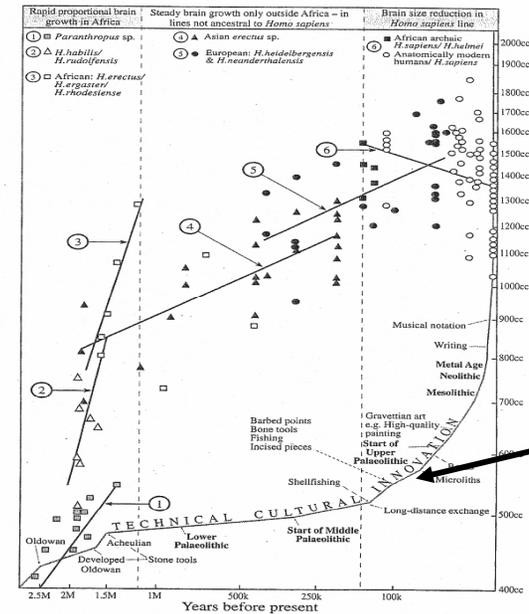


Technology lags behind increase in brain size



Technology lags behind increase in brain size

Technology advances rapidly in *H. sapiens* while brain size decreases slightly



Technology lags behind increase in brain size

Technology advances rapidly in *H. sapiens* while brain size decreases slightly

Autonomous speech emerges about here?

Summary

- Manual communication enhanced with bipedalism
- Develops into “language” with increase in brain size from 2 million years ago (Pleistocene)
- Facial and vocal elements gradually added
- Mutation of *FOXP2* 100,000 yrs ago the final step in emergence of autonomous speech in *H. sapiens*
- So *H. sapiens* comes out of Africa and conquers all

FOXP2 mutation just the final step?

- Other changes toward speech:
 1. Larynx descends to create right-angled vocal tract
 2. Increased innervation of tongue
 3. Increased breath control involving thoracic muscles
- All these changes occurred relatively late in evolution of *Homo*