

Chapter 2 : Brain Origins and Evolution

Tuesday, September 4, 2012

Psychology 465 Human Neuropsychology Fall 2012

1

Issues re: Evolution

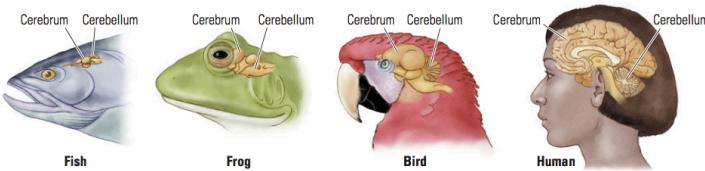
- Philosophical Issues
 - humans vs. animals - qualitative vs. quantitative difference?
- Scientific issues
 - conflicting & rare evidence
- Religious issues
 - ancient texts
 - contrary teachings
 - literal vs. symbolic interpretation
 - “7 days” vs “4.5 billion years”
 - modern ideas

Psychology 465 Human Neuropsychology Fall 2012

2

Brain Evolution

- General increase in brain size & complexity across species



Psychology 465 Human Neuropsychology Fall 2012

3

Why study animal brains?

- Understanding basic brain mechanisms
 - neurons, synapses, neural tracts & systems
 - genetic similarities are high
- Designing animal models
 - ethical issues with human research
- Evolutionary perspectives
 - similarities
 - differences in brain --> differences in behaviors?

Psychology 465 Human Neuropsychology Fall 2012

4

Evolution

- Big Picture
 - Multicellular life ~ 650 MYA
 - Mammals ~ 150 MYA
 - Homo Sapiens ~ 250 KYA
- Research Methods
 - Archeological
 - Biochemical & Genetic
 - Behavioral

Tuesday, September 4, 2012

Psychology 465 Human Neuropsychology Fall 2012

5

Genetics : Species Differences

organism	estimated size (base pairs)	# genes	gene size	# chromosomes
Homo sapiens (human)	3.2 billion	~25,000	1 gene per 100,000 bases	46
Mus musculus (mouse)	2.6 billion	~25,000	1 gene per 100,000 bases	40
Drosophila melanogaster (fruit fly)	137 million	13,000	1 gene per 9,000 bases	8
Arabidopsis thaliana (plant)	100 million	25,000	1 gene per 4000 bases	10
Caenorhabditis elegans (roundworm)	97 million	19,000	1 gene per 5000 bases	12
Saccharomyces cerevisiae (yeast)	12.1 million	6000	1 gene per 2000 bases	32
Escherichia coli (bacteria)	4.6 million	3200	1 gene per 1400 bases	1
H. influenzae (bacteria)	1.8 million	1700	1 gene per 1000 bases	1

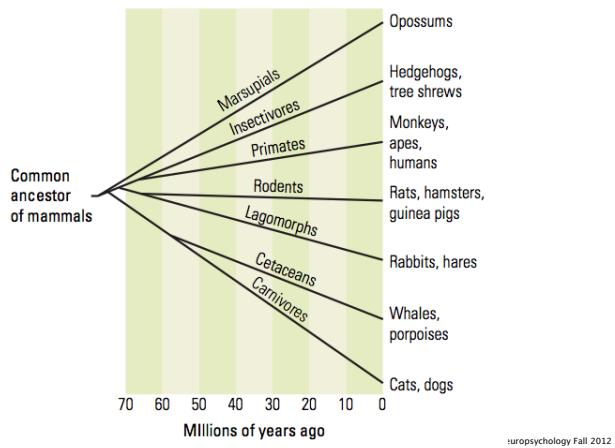
Psychology 465 Human Neuropsychology Fall 2012

6

Tuesday, September 4, 2012

Mammalian Evolution

- Common mammalian ancestor ~ 80 MYA



Tuesday, September 4, 2012

Primate Evolution

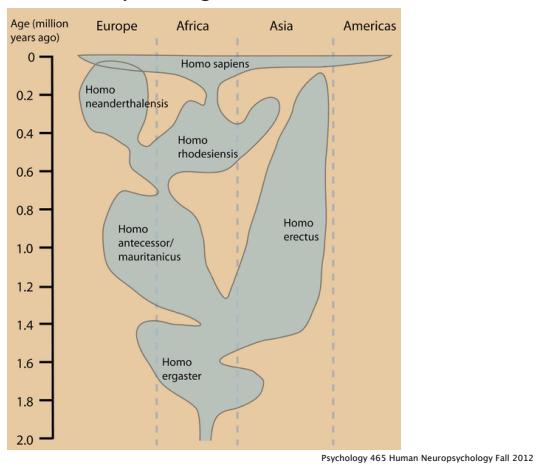
- Best research suggests hominids split from apes 5 to 8 million years ago
 - increased height
 - longer legs
 - bipedal (walk upright), ability to walk long distances
 - jaw/teeth changes : more varied diet
 - reduced sexual dimorphism
 - longer gestations
 - opposable thumbs / tool usage
 - brain size increased (300%)

Psychology 465 Human Neuropsychology Fall 2012

8

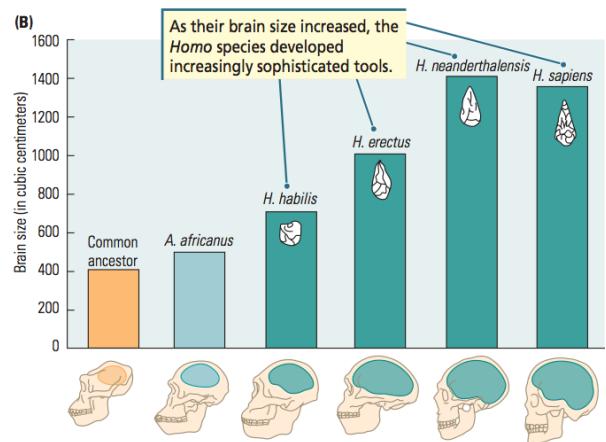
Homo Sapiens

- Homo Sapiens ~ 250,000 years ago?



Tuesday, September 4, 2012

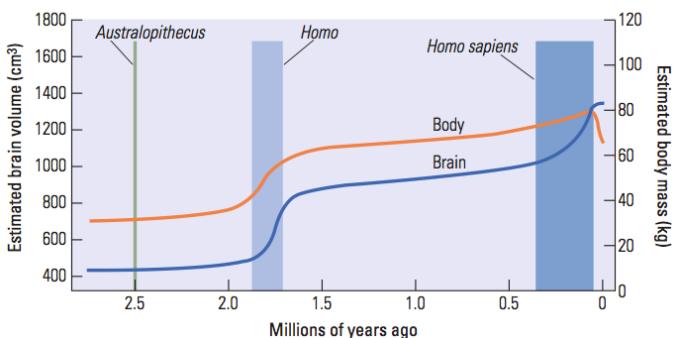
Dramatic Brain Size Increase



Tuesday, September 4, 2012

10

Dramatic Brain Size Increase



Tuesday, September 4, 2012

Big brains : Pros & Cons

- Pros:**
 - smarter
 - survival advantage
- Cons:**
 - metabolic expense
 - birth canal limitations
 - neotony : slower development
 - culture & birth as adaptation

Psychology 465 Human Neuropsychology Fall 2012

12

Encephalization Quotient (EQ)

- Roundworm *C. elegans*

- 302 of 959 cells are neurons = 30% of body
- Actual size: 

- Blue whale

- 15kg brain, but only 0.01%



- How to reconcile?

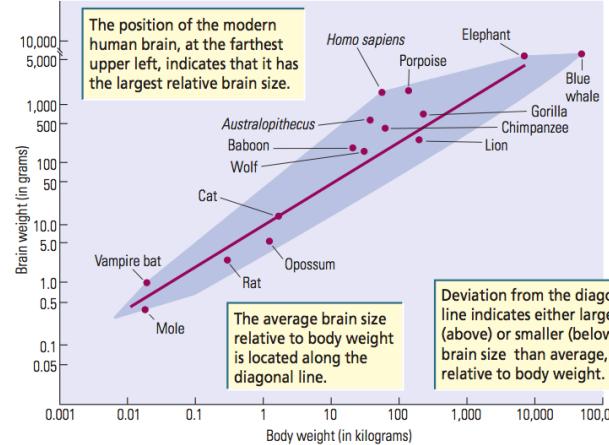
- EQ

- ratio of actual brain size to “expected” brain size
- Cat : “average” mammal : 1.0

Psychology 465 Human Neuropsychology Fall 2012

13

Brain weight vs. Body weight



Psychology 465 Human Neuropsychology Fall 2012

Tuesday, September 4, 2012

14

Encephalization Quotient (EQ)

Species	Brain Volume (ml)	EQ
Rat	2	0.4
Cat	25	1.0
Rhesus monkey	106	2.1
Chimpanzee	440	2.5
Human	1350	7.3

Psychology 465 Human Neuropsychology Fall 2012

15

Cortical Structure

- Human brains are more specialized
- Development is slower
 - requires more parenting
- New skills/abilities can replace older ones, making room
 - e.g. color vision & depth perception reduce need for sense of smell

Psychology 465 Human Neuropsychology Fall 2012

16

Brain Size vs. Intelligence

- Interspecies:
 - strong correlation
- Intraspecies:
 - weak correlation
- Controversy:
 - *The Mismeasure of Man* (Gold, 1981)
 - Faulty research, racist & nationalistic biases
 - Germans : “Germans have largest brains”
 - French : “French have largest brains”

Psychology 465 Human Neuropsychology Fall 2012

17

Intelligence Tests

- IQ tests favor left hemisphere behaviors
- How many forms of Intelligence are there?
 - One? Spearman’s *g*
 - Two? Verbal IQ, Nonverbal IQ?
 - Eight? Gardner’s multiple intelligences

Psychology 465 Human Neuropsychology Fall 2012

18

Tuesday, September 4, 2012

Tuesday, September 4, 2012

Gardner's 8 Intelligences

- logical-mathematical (*)
- verbal-linguistic (*)
- spatial (*)
- musical
- bodily-kinesthetic
- naturalist
- interpersonal
- intrapersonal

Tuesday, September 4, 2012

Psychology 465 Human Neuropsychology Fall 2012

19

Evolution of Culture

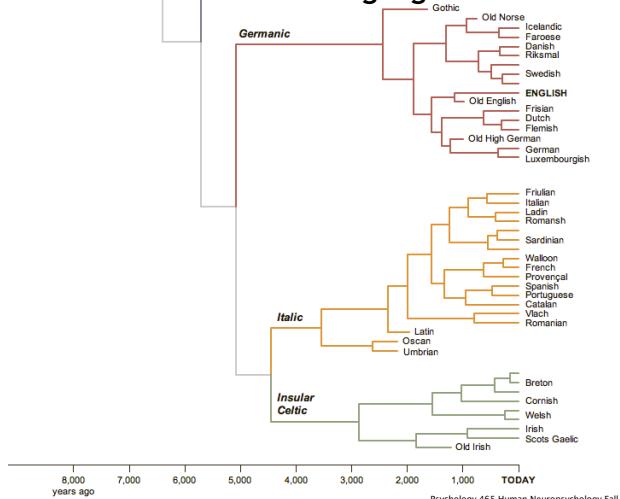
- 25,000 years ago: First art
- 9000 years ago : agriculture, animal husbandry
- 5000 years ago : written language

Tuesday, September 4, 2012

Psychology 465 Human Neuropsychology Fall 2012

20

Evolution of Language



Tuesday, September 4, 2012

Psychology 465 Human Neuropsychology Fall 2012

21

Sacks “A man of letters”

- Sacks (2010), *The Mind's Eye*, p. 53-81
- Howard Engel
 - Canadian author of Benny Cooperman detective novels
- Symptoms
 - Newspaper looked to be in foreign language
 - verbal confusion (forgot name, address, relationship to son)
 - visual field blind spot
 - object agnosia
- Diagnosis
 - Prank?
 - Stroke
 - left hemisphere, occipital lobe injury
 - could still write

Tuesday, September 4, 2012

Psychology 465 Human Neuropsychology Fall 2012

22

Alexia sine Agraphia

- Alexia without Agraphia
- Ability to read : gone
- Ability to write : normal
- Can read one's own writing? No
- Broca's area:
 - motor images of words (how to say a word)
- Wernicke's area:
 - auditory images of words (how to understand a word)
- Similar brain area for written words?
 - would it be on opposite hemisphere?
 - probably a disconnection syndrome similar to Conduction aphasia

Tuesday, September 4, 2012

Psychology 465 Human Neuropsychology Fall 2012

23

Evolution of Language : Wallace vs. Darwin

- Sacks (2010), *The Mind's Eye*, p. 71
- Background:
 - human written language ~ 5000 years ago
 - human evolution ~ 250,000 years ago
 - not enough time for biological evolution for written language
- Wallace:
 - evidence of “divine gift”
- Darwin:
 - “I hope you have not murdered too completely your own and my child”
- Modern theory:
 - “Exaptation” - redeployment / recombination of existing visual/verbal skills

Tuesday, September 4, 2012

Psychology 465 Human Neuropsychology Fall 2012

24