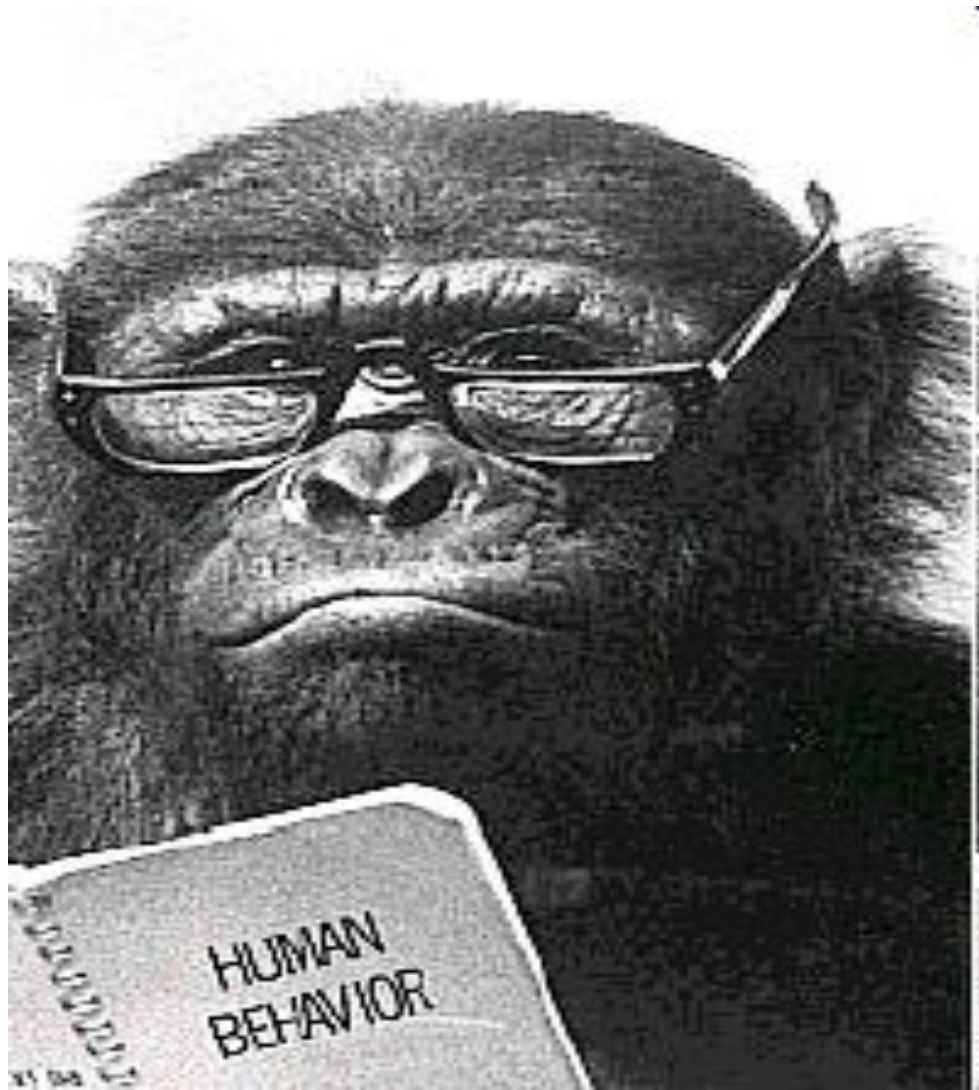


# “Talking Brains”: Neuropsychological Roots of Language



# Evolutionary Advantages of Humans (1)

## Abstract thinking.

Humans have

“*conceptual minds*”

- making generalizations;
- forming analogies;
- seeing linkages which go beyond surface characteristics.

Anatomical substrate:

Larger areas of

*association cortex*  
(*tertiary areas*).

They does not receive direct input from sensory organs but rather perceive *conceptual similarities*.

# Functional Areas of the Cerebral Cortex

## Motor areas

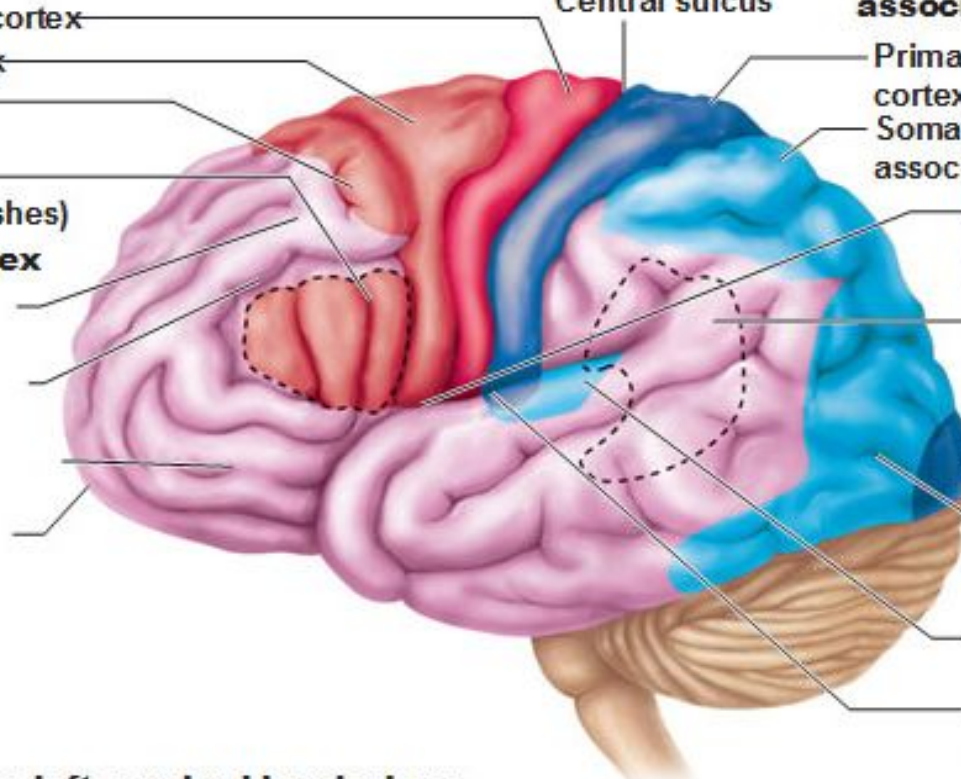
- Primary motor cortex
- Premotor cortex
- Frontal eye field
- Broca's area (outlined by dashes)

## Prefrontal cortex

Central sulcus

## Sensory areas and related association areas

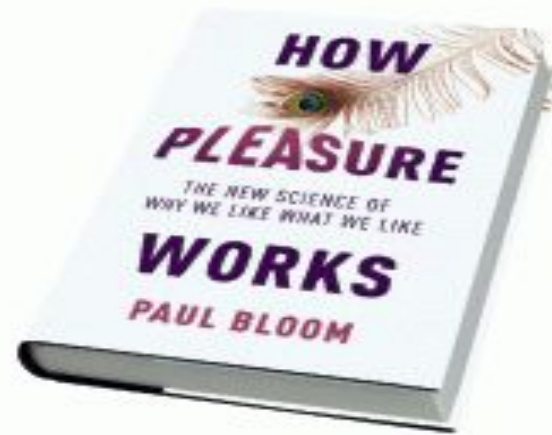
- Primary somatosensory cortex
  - Somatosensory association cortex
  - Gustatory cortex (in insula on roof of lateral sulcus)
  - Wernicke's area (outlined by dashes)
  - Primary visual cortex
  - Visual association area
  - Auditory association area
  - Primary auditory cortex
- Somatic sensation
- Taste
- Vision
- Hearing



(a) Lateral view, left cerebral hemisphere

- |  |  |
|--|--|
| <span style="display: inline-block; width: 15px; height: 15px; background-color: red; border: 1px solid black;"></span> Primary motor cortex           | <span style="display: inline-block; width: 15px; height: 15px; background-color: lightcoral; border: 1px solid black;"></span> Motor association cortex  |
| <span style="display: inline-block; width: 15px; height: 15px; background-color: blue; border: 1px solid black;"></span> Primary sensory cortex        | <span style="display: inline-block; width: 15px; height: 15px; background-color: lightblue; border: 1px solid black;"></span> Sensory association cortex |
| <span style="display: inline-block; width: 15px; height: 15px; background-color: pink; border: 1px solid black;"></span> Multimodal association cortex |  |

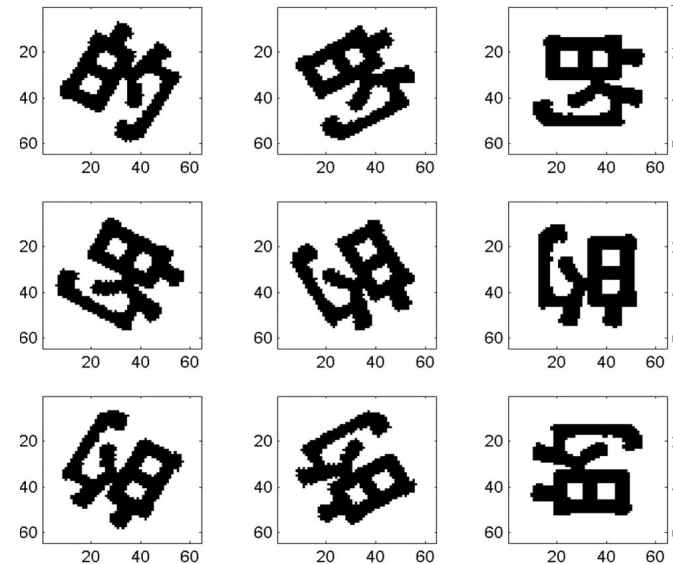
**Essentialism** - all known things and concepts have an essential reality behind them (an "Idea" or "Form"), an essence that makes those things and concepts what they are.



"one of the most exciting ideas in cognitive science is the theory that people have a **default** assumption that things, people and events **have invisible essences** that make them what they are. Experimental psychologists have argued that essentialism underlies our understanding of the physical and social worlds, and developmental and cross-cultural psychologists have proposed that it is instinctive and universal. **We are natural-born essentialists.**" (Paul Bloom, 2010)

# Evolutionary Advantages of Humans (2)

**Fast  
pattern-recognition.**



# Fast pattern-recognition

- Larger Thalamus
- More asymmetrical brain (left vs right hemisphere processing)
- Parallel processing of an information





زخمی و کھلی کھلی

سپاسگزاران

بیت المقدس

بیت المقدس

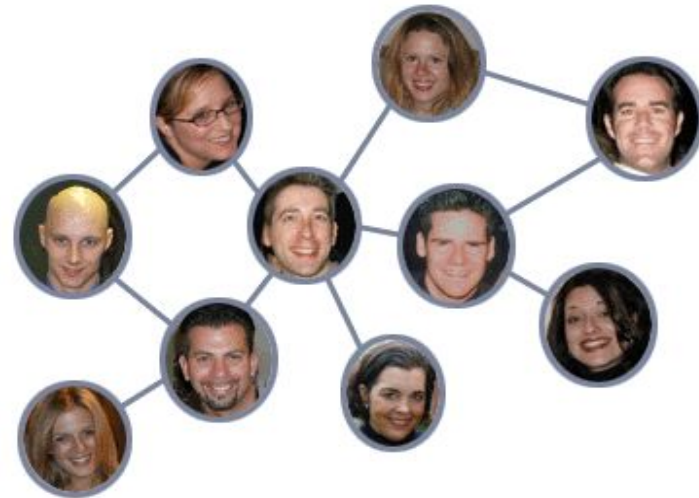
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# Evolutionary Advantages of Humans (3)

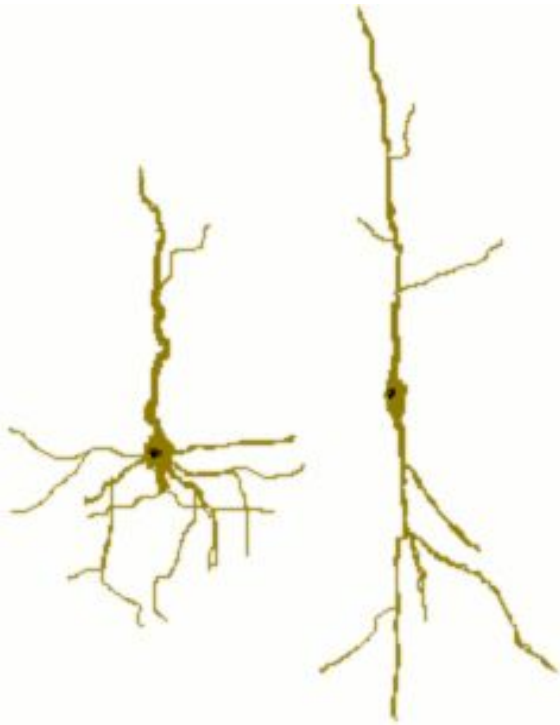
## Processing of complex social information and emotional expressions

- More folds and fissures leading to more compact use of neurons and greater opportunity for cross-communication
- Von Economo (“spindle”) neurons

# Processing of complex social information



# Von Economo (“spindle”) neurons – “Brain Cells for Socializing”



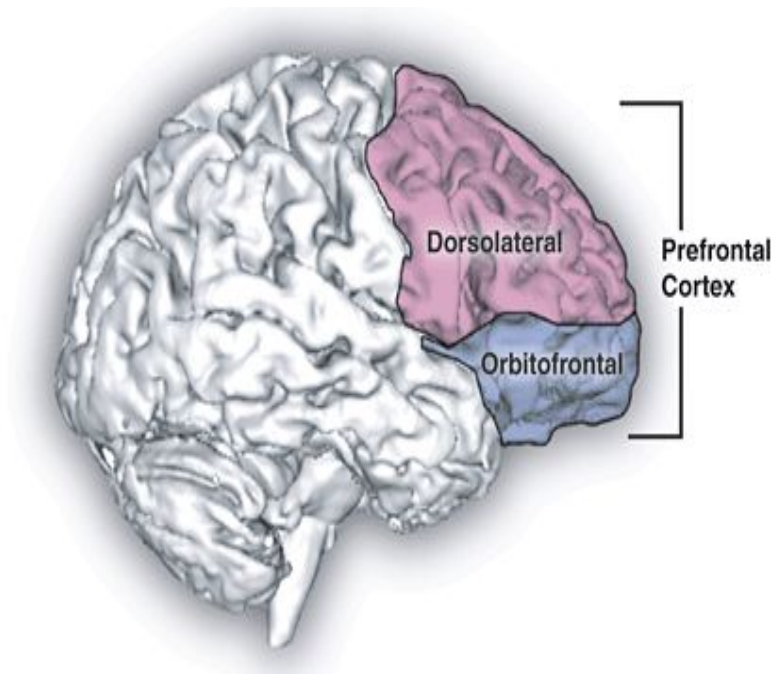
- Unique bipolar shaped morphology;
- Found in the anterior cingulate cortex (ACC), the fronto-insular cortex (FI) and in the dorsolateral prefrontal cortex (DLPFC) of humans;
- Functions: quick social information processing (from planning and self-awareness to role playing and deception).

# Evolutionary Advantages of Humans (4)

**Ability to inhibit inappropriate (but seductive and previously reinforced) behavior.**



# Prefrontal Cortex



- Inhibition of inappropriate behavior
- Free will
- Deception and pretending

# Evolutionary Advantages of Humans (5)

**“Time-traveling”:**  
Projecting  
ourselves forward  
and backward in  
time, anticipating  
of results of  
current action and  
modifying behavior  
accordingly.



# “Time-Traveling Machine”

## Orbito-frontal prefrontal cortex

- Future
- Monitoring of action performance
- Comparing strategy with the goal.
- Inhibition of inappropriate behavior

## Dorso-lateral prefrontal cortex

- Past
- Working memory
- Taking into account previous experience
- Planning of action
- Spontaneity, humor, unpredicted steps, artistic features



# Evolutionary Advantages of Humans (6)

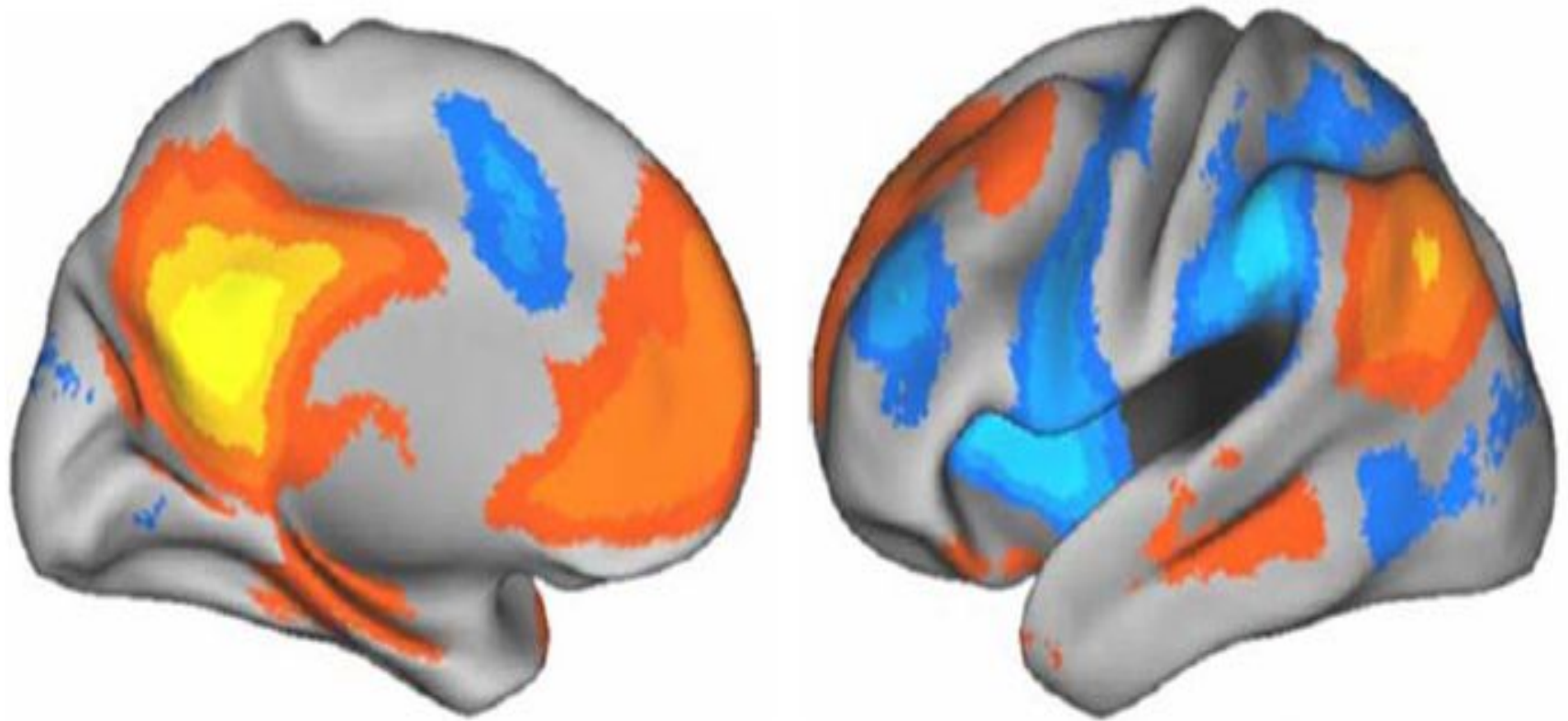
**Creating new  
images in our  
mind (mental  
synthesis,  
fantasy)**



# “Neurology of Fantasy”

- **Default mode network** is a network of brain regions that are active when the individual is at **wakeful rest**.
- It is **negatively** correlated with brain systems that focus on **external** visual signals.
- Its subsystems include part of the **medial temporal lobe** for **memory**, part of the **medial prefrontal cortex** for **theory of mind**, and the **posterior cingulate cortex** for **integration**, along with the adjacent ventral **precuneus** and the medial, lateral and inferior **parietal cortex**
- Alzheimer's disease, autism, PTSD and schizophrenia **decreases** default mode activity, meditation and psychotherapy – **improves** it.

# Default-Mode Networks (DMN)



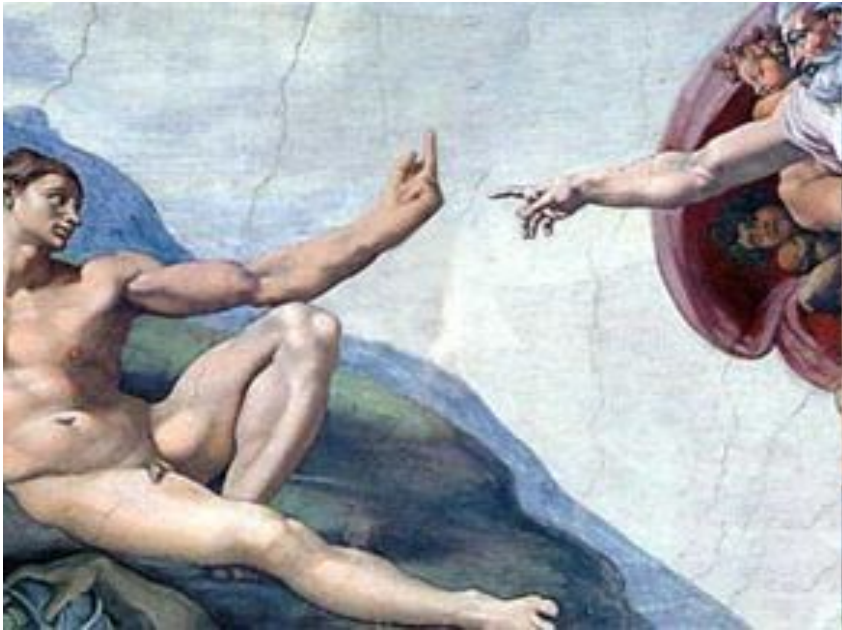
# Upper Paleolithic Revolution

50 000 years ago *Homo sapiens* began to demonstrate an ability to use complex symbolic thought and express cultural creativit



# Evolutionary Advantages of Humans (7)

## Reciprocal Altruism



# Evolutionary Advantages of Humans (8)

**Flexible,  
Hierarchical  
and  
Grammatical**



# The Origins of Language

**“Pooh-pooh”  
theory:**

Language evolved  
from noises  
associated with  
strong emotions



# The Origins of Language

## “Bow-Wow”

### Theory:

Speech arose through people imitating the sounds of environment, especially animal calls, the use of onomatopoeic words





# The Origins of Language

## “Yo-He-Ho” Theory:

Speech evolved  
from sounds  
made to  
resonate with  
natural sounds



# The Origins of Language

## “Sing-Song” Theory:

Language evolved  
from noises made  
while playing or  
dancing



# Modern Theories of Language

Language as a combination of 4 abilities:

1. The ability to **categorize**. Categorization makes it easier not only to perceive the information but to store and retrieve it. Categorization is a hierarchical process.

*Example:*

animal → bird → waterfowl → duck

*Anatomy:* upper temporal fissure

# 2. The ability to label categories.

Words are ultimate categorizers.

Anatomy of “labeling”:  
Inferior temporal lobe



### 3. The ability to **sequence** behavior.

Sequencing means *ordering certain types of movements* to make syllables.

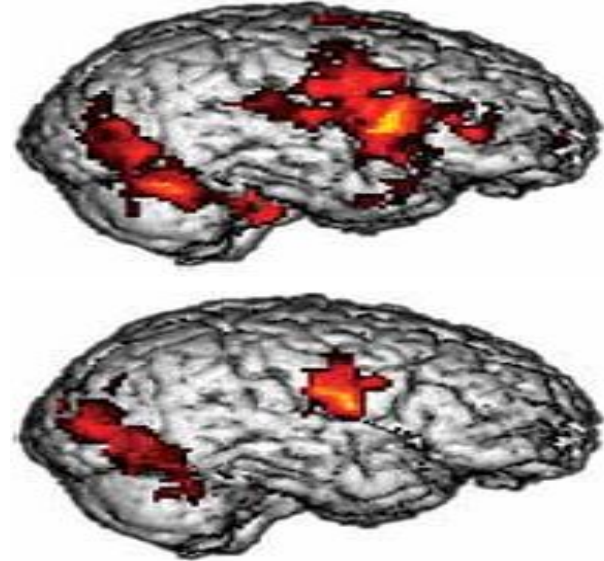
Anatomy: Left-hemisphere lesions are associated with deficits in the repetition of limb movements and oral movements.

So, left hemisphere does **selection and ordering** of both: **speech** and **nonspeech movements**.

# 4. The ability to mimic.

*Anatomy:*

“mirror neurons” in frontal cortex discharge both when the monkey *makes* a movement and when it *observes* somebody else making movements.



Speech areas of the left hemisphere contain “mirror neurons” as well.

“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 and inaccessible to experiments.”

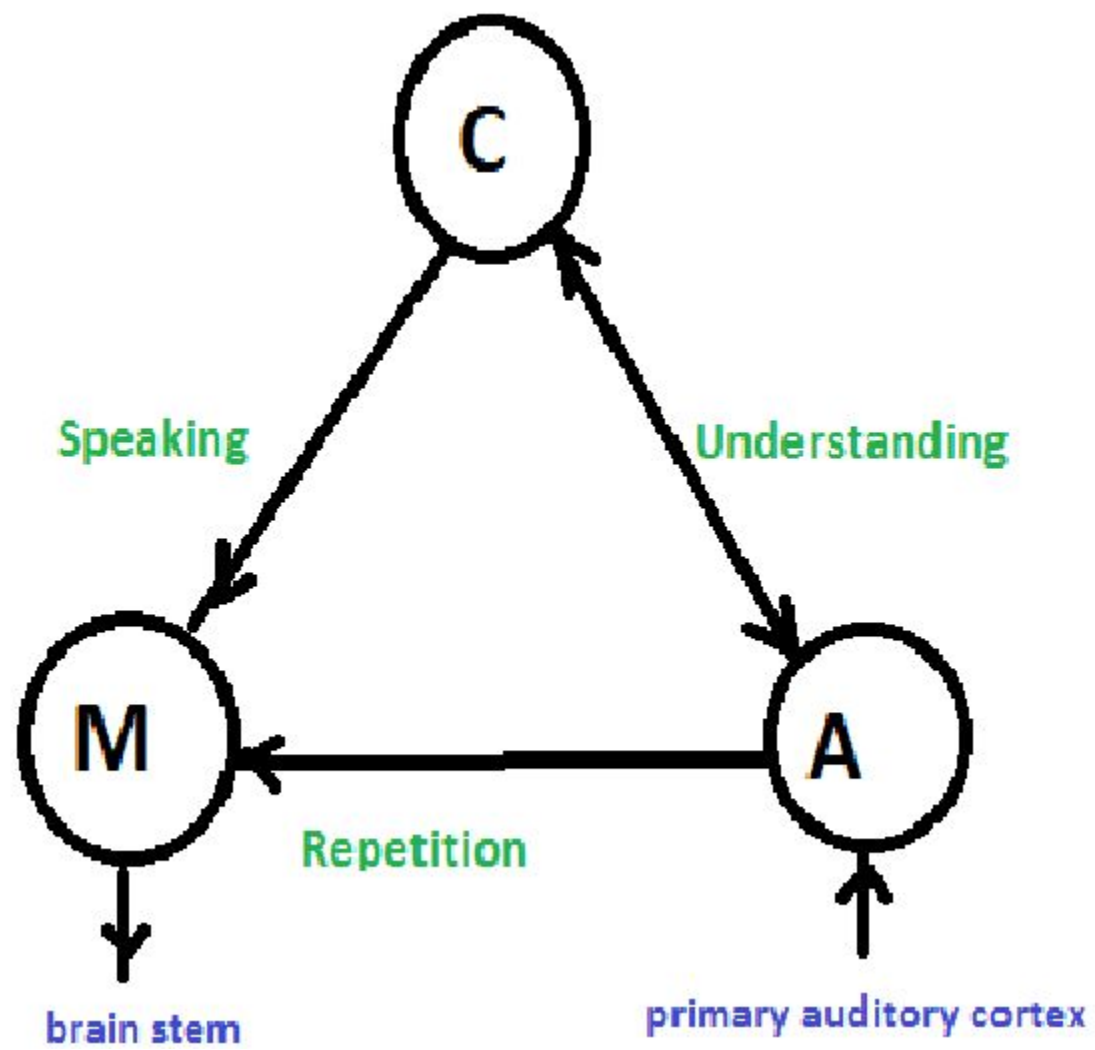
-V.S. Ramachandran

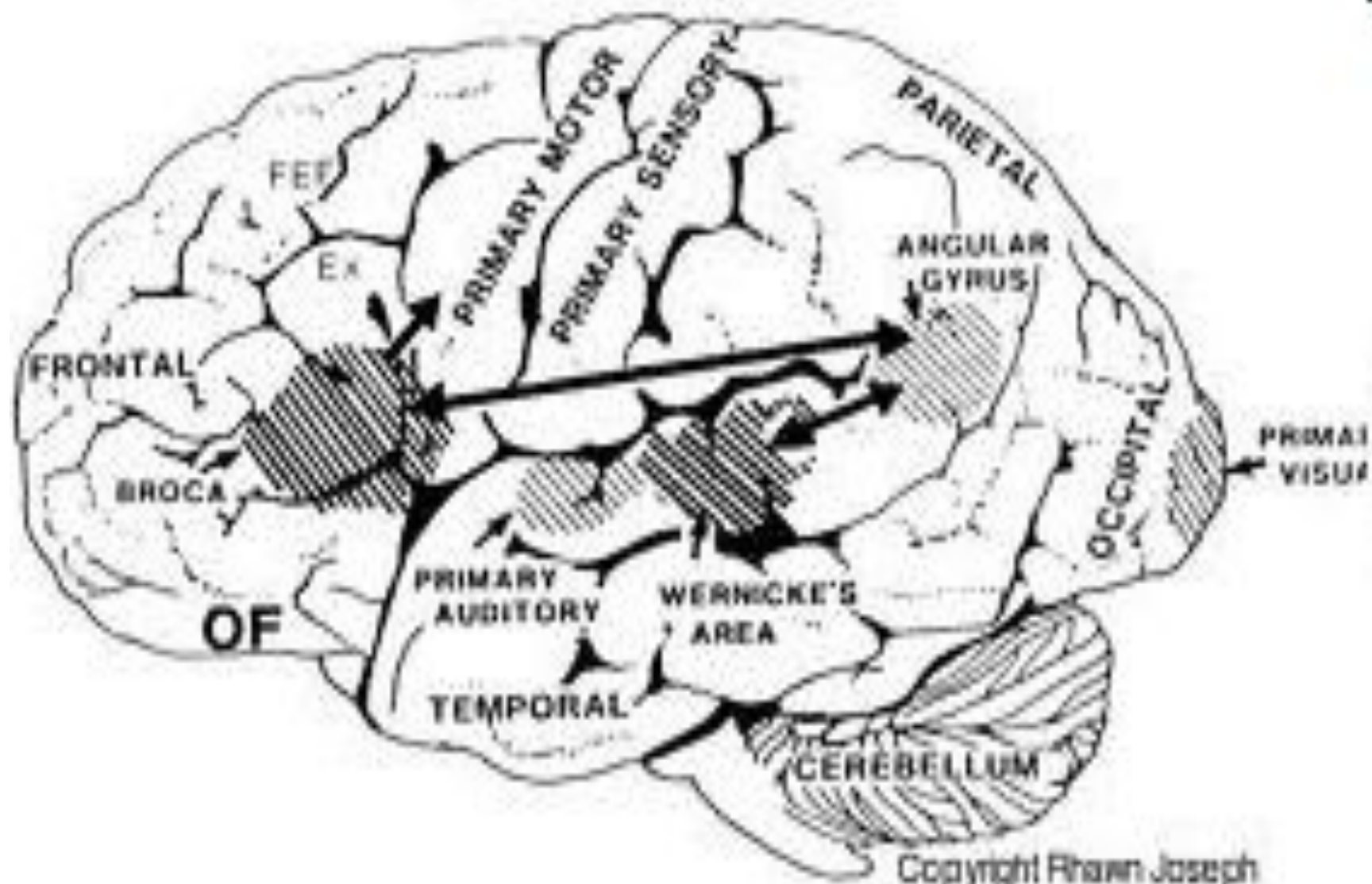
# Genetic studies of speech development

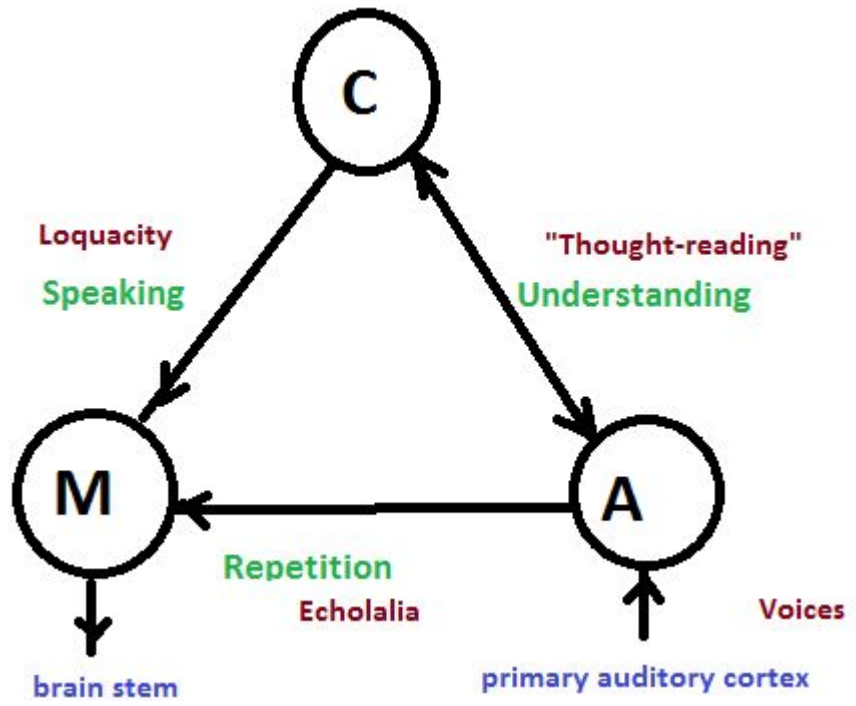
“Developmental” genes which help to regulate lots of other genes. They are activated early (prenatally) and provide prompted growth of the brain.

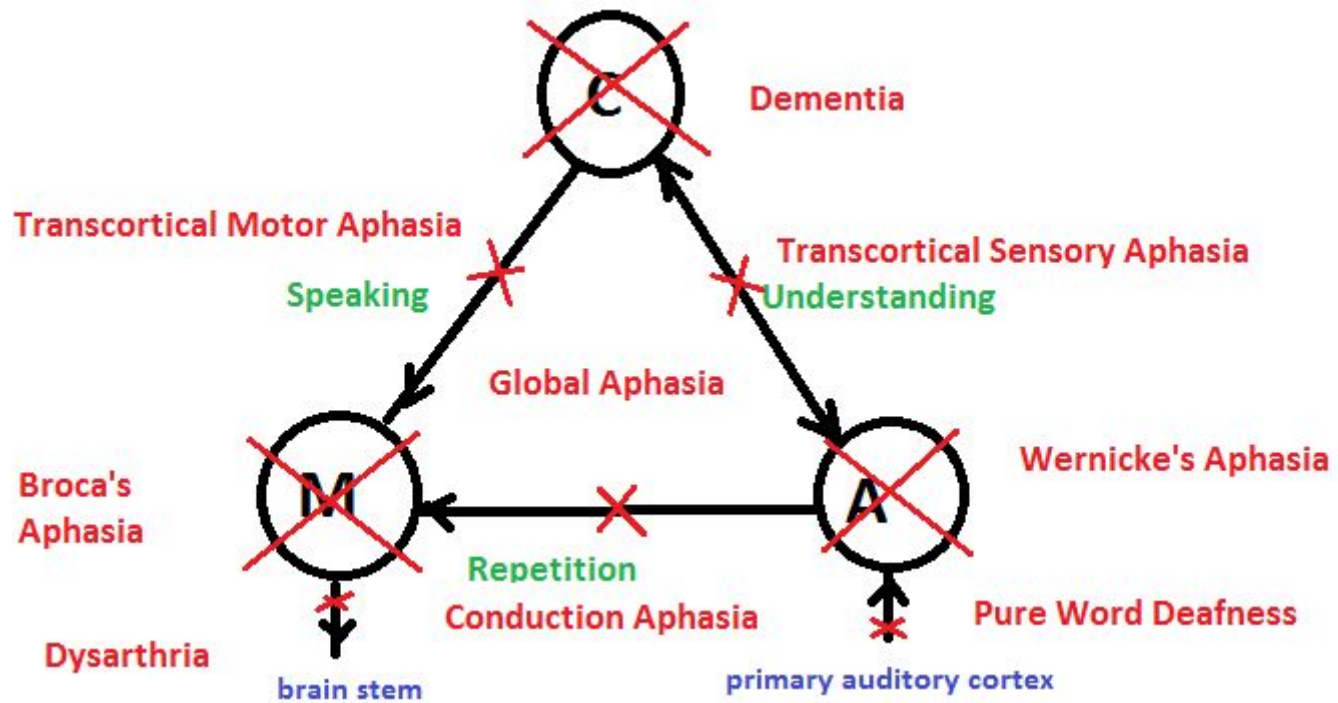
- FoxP2-gene, expresses in cells, related to language areas (7q31).
- HAR1-gene (Human Accelerated Region Gene).
- ASPM.
- Microcephal gene.











# Broca's Aphasia

- Patient understands speech but has to labor to produce it;
- Nonfluent, sparse, effortful, melodically flat, slow speech,
- Pauses between words are more frequent than words,
- Using of gestures;
- Choice of words is correct (esp. nouns)
- Failure to use grammatical words;
- “Telegraphic style”;
- Difficulties in understanding of “reversible” passive sentences.