

# BRAIN AND LANGUAGE

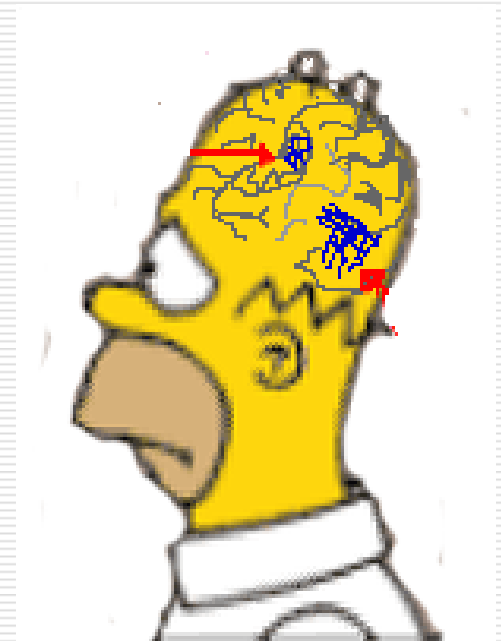
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# Specific Language Impairment

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# Introduction

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- It is a language deficit which is not accompanied by hearing impairment, low non-verbal intelligence test scores or neurological damages
  - Thus children with SLI show no signs of any other factor that usually accompanies language learning problems
  - The prevalence of SLI is about 7%
  - A child with a history of SLI in the family is a more likely candidate than a child with normal background.
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# History of SLI

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- Work in this area dates back to early nineteenth century
- In 1822, Gall published a description of children who had clear problems in language but did not display any other known disorders

“There are many children who do not speak to the same degree as other children although they understand well or are far from being idiotic.... ”

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# History (contd ...)

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- ❑ Gall's report was followed by large number of case studies published mostly by physicians
  - ❑ The authors emphasized on apparently normal non-verbal intelligence but extremely limited speech output of these children
  - ❑ Earlier, the studies focused on children with severe output limitation
  - ❑ Gradually focus widened to include children who produced multi word utterances and the grammatical deficit in these children started getting the attention
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# An example

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- Here are some brief excerpts from one english speaking child with SLI, age four year, three months. The child was shown sets of sequence pictures –

Adult: Ok, ready?

Child: Ready.

Adult: This is Jim. Tell me a story about Jim.

Child: Him going fishing. Jim hold...water. And go fish. And [unclear]

Adult: I did not hear this one.

Child: I don't know.

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# Example (contd ...)

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- ❑ The child's utterances were quite short on average
  - ❑ Omission of grammatical suffixes and function words were very common
  - ❑ On some occasions over-regularization was also seen
  - ❑ The child in question enjoyed interaction but initiations of verbal exchanges were very less. Communicative efforts were often abandoned if they were not understood on the first try
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# Language Characteristics of SLI

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- Now we will look at the production and comprehension of English by children with SLI
  - We will try and bring out the linguistic strengths and weaknesses of English speaking children with SLI
  - We will look at the lexical and syntactic abilities of children with SLI
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# The early lexicon

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- ❑ Children with SLI appear to be late in acquiring their first words
  - ❑ Earlier case studies provided evidences for this fact. Bender(1940) observed a child who failed to produce his first words until four
  - ❑ Recent studies with large number of children confirms the earlier works
  - ❑ In a study of 71 children with SLI, an average age of 23 months for first words was reported as compared to an average age of 11 months for normal children
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# The early lexicon ...

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- The types of words used by children with SLI seems to match the types observed in younger normal children
  - General nominals (names of objects, animals etc.) constitute 55% of the words whereas words referring to actions, properties constitute 12% each
  - With the onset of multi-word utterances, children with SLI show marked deviation from normal younger children. The deficiencies go beyond the general lag evident so far
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# Preschool Years

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- ❑ The studies made by Chapman, Leonard, Rowan and Weiss (1983) revealed that children with SLI acquired as many words as normal children given a large exposure to words
  - ❑ Earlier studies has suggested that lexical acquisition in children with SLI was slow
  - ❑ A new concept of “fast-mapping” in children with SLI was taken up
  - ❑ It was found that on large number of repeated exposure to novel words, both the groups acquired almost same number of words. However, on smaller exposure (say 3 times) children with SLI showed poorer results
  - ❑ It was also found that action words were not retained
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# School Years

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- ❑ Studies of school going children with SLI gave an interesting comparison. It was found that children with SLI learned object names almost as well as normal children but their learning of action names fell well below par
  - ❑ The lexical limitation is generally identified as “word finding problem” wherein a child faces difficulty in generating a particular word called for in the situation
  - ❑ This deficit has also been described as “lexical lookup” problem and problems involving “delayed speed of word retrieval”
  - ❑ The chief symptoms of word finding problems are unusually long pauses in speech, frequent use of non specific words such as “it” or “stuff”
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# School Years ...

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- One possible explanation of word finding difficulty can be attributed to problems of retrieval. This suggests that words are present in the memory but children use an inefficient means of retrieving them
  - Yet another explanation is based on the connectionist approach which claims that SLI acts as a filter which weakens the network between phonology and semantics of the word
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# Early word combinations

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- As expected age of first word combination appears to be later in children with SLI than normal children
  - Studies have revealed that children with SLI show much narrower scope of word combination
  - For a given notion of word combination like agent + action a child aged four years had only me as the agent (e.g., me do, me make etc.)
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# Verb learning

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- We have seen that lexical abilities of children with SLI is most hampered in the case of verb learning
  - It has been demonstrated that learning of verbs require exposure to the sentence frame in which the verb appears along with the event being described by the verb
  - This process of interpretation of meanings of verbs based on sentences might be the major weakness in SLI, hence accounting for the difficulty in verb learning
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# Grammatical Morphology

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- It has been found that grammatical morphology constitutes a relative weakness in children with SLI
  - In a case study by Gopnik (1990) an eight year old child with SLI exhibited errors on many inflections and function words involving tense, person, number and gender
  - Children with SLI showed lower degrees of use of regular past *-ed* with both real and nonsense verbs. They also showed fewer over-regularization error
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# Neural Mechanisms

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- Now we will look into neural mechanisms used for encoding rules of languages in humans.
  - We will limit ourselves to English past tense
  - We will look at the deficits in SLI in order to study the various models proposed for past tense inflection
  - Two models under consideration are the connectionist model and the symbolic rule model
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# Brief Overview

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## □ Symbolic Rule Model –

This model proposes that the regular inflections are obtained by applying a symbol concatenation rule (-ed) whereas irregular verbs are in memory along with their past tense

## □ The Connectionist Model –

All morphological forms are processed within one type of processing mechanism (connectionist network) distributed across multiple brain regions

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# SLI as a Rule-Learning deficit

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- Primary source of data about morphological deficits of children with SLI comes from studies using sentence completion task  
e.g., *The girl likes to walk. She did the same thing yesterday; she \_\_\_\_\_*
  - Theories of SLI as a rule-learning deficit predict that children with SLI will have difficulty in producing the past tenses of regular verbs and will perform better with irregular verbs
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# Rule-Learning deficit ...

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- Children with SLI make fewer over-regularization error than normal developing children. This suggests that their creativity in producing the past tense of unheard words is limited
  - Moreover these children are also limited in producing the past tenses of non-words (which should “ideally” be word+*ed*). This again suggests that they have not encoded a rule for generating past tenses
  - However, this hypothesis fails to explain the difficulty encountered by these children in producing past tenses of irregular verbs
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# The Phonological Deficit

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- This is another hypothesis for explaining the morphological deficits in children with SLI
  - This hypothesis is based on the connectionist model which says that past tenses normally arise through integration of phonology and semantics
  - This hypothesis proposes that a perceptual deficit leads to a phonological deficit which is the direct cause of language problems in SLI
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# The Phonological Deficit ...

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- The deficit in phonology leads to a relatively small semantic representation which in turn impairs the ability to generalize from known forms
  - This limited semantic representation supports past tenses of familiar forms but does not come into play for unfamiliar forms
  - Since non-words rely completely on phonology, a phonological deficit will hamper the past tenses of non-words the most
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# Modeling SLI

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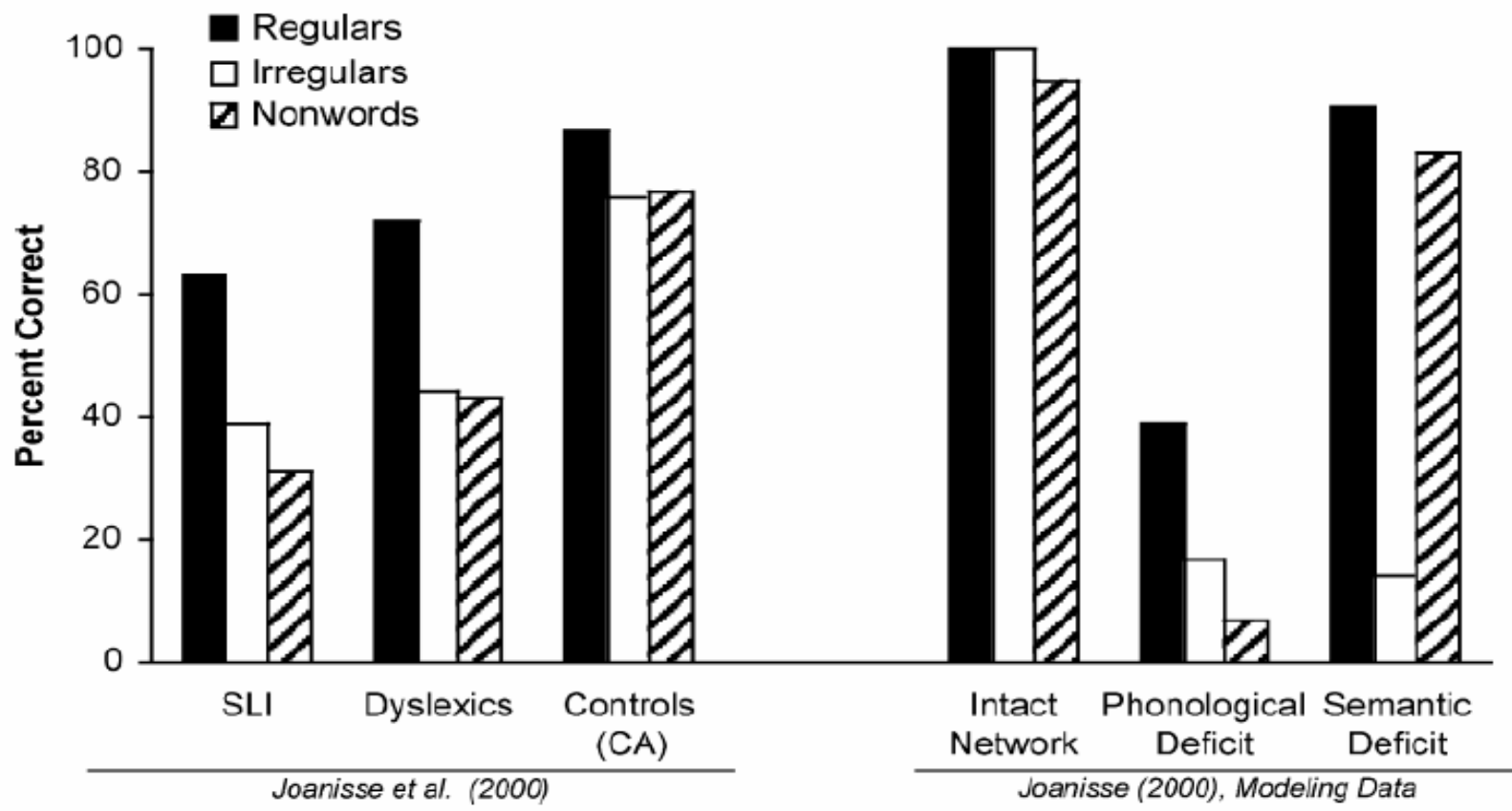
- ❑ This modeling is based on the connectionist model and was done by Marc F. Joanisse (2000). It investigated the effect of perceptual deficit on learning past tenses
  - ❑ The network was trained to associate the meanings and sounds of English present and past tense verbs
  - ❑ During training, the network showed a slight delay in learning irregular forms relative to regular forms. At the end of the training, it had learned all tasks accurately
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# Modeling...

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- Now, the training process was altered a bit. Small amount of random noise were added to the phonological representations of the training words, thus simulating a deficit in perception of speech
  - This newly trained model showed a pattern of past tense production which was consistent with SLI
  - Compared with intact model, this model was poorer at learning all three types of past tenses
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# SLI and Genetics

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- ❑ For many years genetic factors as a possible cause of SLI was ignored
  - ❑ But when the focus shifted to child's family background, the concept of linguistic input to the child gained importance
  - ❑ Samples and Lane (1985) described a family in which all the six children had SLI
  - ❑ It was reported that approximately 30% of the immediate family members of children with SLI had language problems
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# SLI and Genetics ...

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- ❑ However, studies have revealed large number of cases in which language problems are limited to the child
  - ❑ There can be two possible interpretation of this dual finding
  - ❑ One possible interpretation is that there are different causes of SLI, some are genetic, others not
  - ❑ Other possibility is that although genetic factor is present but with incomplete penetration. Thus there must be additional factors causing SLI
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# Neuroanatomical correlates in SLI

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- ❑ An autopsy study of brain of four males with a history of SLI was made by Galaburda, Sherman, Rosen, Aboitiz, and Geschwind in 1985
  - ❑ One of the key findings was a symmetry of plana temporale
  - ❑ This is located in the upper portion of temporal lobe in each hemisphere
  - ❑ Typically the planum temporale of left hemisphere is larger than the right one
  - ❑ In the case of these individuals the two plana were of the same size
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# MRI scan

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- Plante looked for such left-right hemisphere symmetries in children with SLI using MRI techniques
  - Shape and location of planum temporale present obstacles to measurement from MRI scans. Hence she measured a broader area around the sylvian fissure – the perisylvian area
  - Like plana temporale, the perisylvian area also shows left-right asymmetry with the left hemisphere exceeding the right hemisphere in size
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# MRI scan ...

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- ❑ One of the studies involved a boy with SLI age 4;9 and his normally developing dizygotic twin
  - ❑ The child with SLI showed symmetry of left and right perisylvian area which resulted from abnormally large right perisylvian area
  - ❑ This finding was aided by subsequent studies of MRI scans from eight boys with SLI age 4;2 to 9;6
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# Results

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- ❑ Six of the eight children showed deviation from usual left greater than right
  - ❑ Three out of these six showed symmetry of left and right perisylvian area due to unusually large right perisylvian area
  - ❑ The other three had the right perisylvian area larger than the left
  - ❑ These studies were extended to parents. Seven of the eight parents showed atypical configuration. This was consistent with the genetic aspect of SLI
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# Remarks

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- The studies seems to establish that a larger than usual right perisylvian area constitutes a condition which disfavours language learning
  - However, there have been cases with atypical configuration with no language problems.
  - Moreover, nearly one-fourth of the brains studied failed to show the normal configuration of larger left perisylvian area
  - Thus it is debatable whether unusually large right perisylvian area is the biological reason for SLI
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# APHASIAS

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MOTHER IS CINK  
DRYING DISH  
WATER TO FLOOR, SHOES  
BOY IS FALLING  
GIRL IS WANTING LAUGH

The mother is attempting to dish the dishes, but  
the other is running and running.  
the boy is standing and standing and reaching  
for a cookie from the place.  
the furniture is ashamee and about to fall.  
the girl is reaching and forling for a cookie.

# Meaning of Aphasia

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## □ Oxford Concise Medical Dictionary

- A disorder of language affecting the generation of speech and its understanding and not simply a disorder of articulation. It is caused by disease in the left half of the brain (the dominant hemisphere). It is commonly accompanied by difficulties in reading and writing.

## □ Webster's Revised Unabridged Dictionary

- Loss of the power of speech, or of the appropriate use of words, the vocal organs remaining intact, and the intelligence being preserved. It is dependent on injury or disease of the brain.
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# Defining Aphasia (Positions, theories and their proponents)

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- Impairment in one's ability to make propositional statements  
Propositional (Jackson, 1879)
  - Inability to adopt an abstract attitude  
Gestalt (Goldstein, 1948)
  - General language impairment that crosses all language modalities  
Unidimensional (Schuell, Jenkins, Jimenez-Pabon, 1964)
  - Disturbances of symbolic formulation and expression  
Multimodal (Head, 1926)
  - A reduced capacity to store, switch and monitor and to do many other steps necessary for the brain to process information  
Cybernetic (Porch, 1994)
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# Defining Aphasia ...

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- An acquired impairment of the cognitive system for comprehending and formulating language, leaving other cognitive capacities relatively intact  
Cognitive (Davis, 1993)
- An acquired impairment in language and cognitive processes that underlie language and is caused by organic damage to brain; characterized by reduction in and dysfunction of language content, form and use and the cognitive processes that underlie language such as understanding memory or thinking  
Psycholinguistic (Chapey, 1994)
- An impairment of the ability to use or comprehend words, usually acquired as a result of a stroke or other brain injury

NAA - [www.aphasia.org](http://www.aphasia.org)

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# Aphasia: Syndrome Approach

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## □ Goodglass and Kaplan

- 1981 – A neurological disorder resulting from damage to those regions of the cerebral hemispheres that form the anatomical basis for the human capacity for language
  - 2001 - Aphasia refers to the disturbance of any or all of the skills, associations and habits of spoken and written language produced by injury to certain brain areas that are specialized for these functions. Disturbances in communication that are due to paralysis or incoordination of the musculature of speech or writing or to impaired vision or hearing are not, of themselves, aphasic
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# Clinical Syndromes of Aphasias

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- Need to associate clusters of signs or syndromes with anatomy of the lesions in the brain producing them
  - Various classification schemes because lesions vary in exact size and location and response of individuals to them may also be different. Children seem to show different responses to the same lesions.
  - Two views on classification: Localizationists vs. Antilocalizationists
    - Every type of linguistic behaviour can be localized in a particular part of the brain
    - An integrated unit like a hologram and damage to one part will affect the functioning of a brain as a whole
    - Our study here would be in harmony with localization
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# Clinical Syndromes of Aphasia ...

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- On the basis of characteristics of speech output, aphasia can also be broadly divided into fluent and non-fluent aphasia.
  - **Fluent aphasia:** The flow of speech is not hampered, articulation is easy but the speech is not meaningful. There is difficulty in finding words and comprehension.
  - **Non-fluent aphasia:** The flow of speech is impaired (interrupted and awkwardly articulated) but meaningful. Comprehension appears to be better than production.
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# Further classification

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- ❑ Aphasias can be further divided into various types depending upon what signs the patients show
  - ❑ There can be reduced language output as well as reduced comprehension, repetition and naming
  - ❑ Apart from spoken language impairments, we also find additional impairments in reading and writing
  - ❑ If we consider naming impairments to be common to all aphasias, then we can have eight different syndromes
  - ❑ Again there are problems like:
    - these signs may vary across individuals
    - syndromes are not stable even though the anatomy is
    - most syndromes are polytypic – that is they are defined by several criteria
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# A P H A S I A S

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## □ Non-fluent:

- Broca's Aphasia
- Chronic Broca's Aphasia
- Acute Broca's Aphasia
- Transcortical Motor Aphasia

## □ Fluent:

- Wernicke's Aphasia
- Anomic Aphasia
- Conduction Aphasia
- Transcortical Sensory Aphasia

## □ Others:

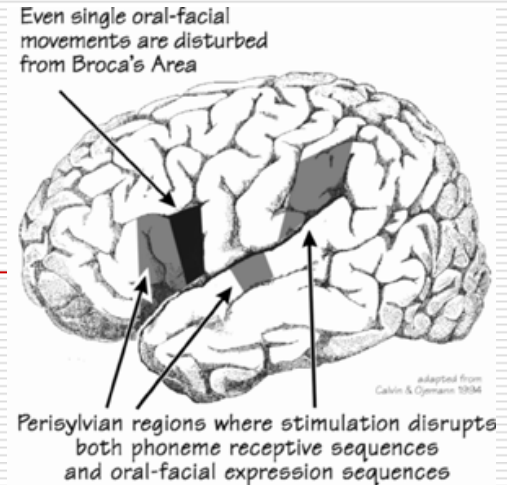
- Global Aphasia
- Mixed Transcortical Aphasia

## □ Other Aphasias:

- Crossed Aphasia
  - Aphasia in left-handers
  - Mixed Non-fluent Aphasia
  - Subcortical Aphasia
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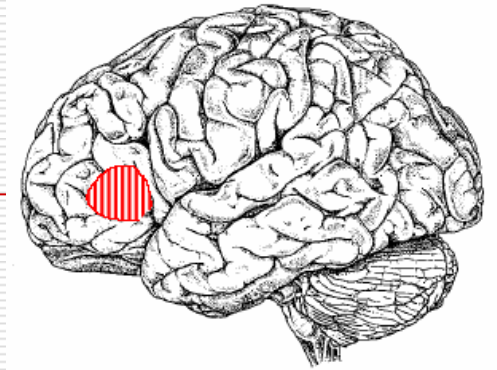
# Global Aphasia

- ❑ Most severe of all aphasiae- significant impairment in all aspects of language
- ❑ Language output is severely limited and comprehension is very impaired
- ❑ No repetition, naming or writing
- ❑ Buccofacial and limb apraxia are common, right hemiplegia may also occur
- ❑ Most typical lesion undercuts the entire perisylvian region
- ❑ Much clinical variability is seen – ranging from frontal lesions to deep subcortical temporal lesions
- ❑ Prognosis is poor – eventually patients may improve comprehension and qualify for severe Broca's aphasia



# Broca's Aphasia

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- ❑ Language output is non-fluent, articulation is poor, volume and speech quality are reduced
  - ❑ Speech is telegraphic – sentences are short (2-3 words) and grammatically simple (noun-verb combinations)
  - ❑ Relational words (articles, conjunction, modifiers) are very uncommon in speech
  - ❑ Repetition is poor, literal paraphasia may occur, word finding is poor
  - ❑ Apraxia, right hemiparesis, depression, low frustration tolerance
  - ❑ Broca's area can thus be related to articulation of speech (either engineering or producing articulation)
  - ❑ A study of fractional cases of Broca's aphasia might prove to be helpful
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# A look at Broca's aphasia patients

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- "What is your name?"  
"Litha."  
"Litha?"  
"No, *Litha!*"
  
  - *Child:* "Want other one spoon, Daddy."  
*Father:* "You mean, you want the other spoon."  
*Child:* "Yes, I want other one spoon, please Daddy."  
*Father:* "Can you say, 'the other spoon'?"  
*Child:* "Other...one...spoon."  
*Father:* "Say 'other.'"  
*Child:* "Other"  
*Father:* "Spoon."  
*Child:* "Spoon."  
*Father:* "Other spoon."  
*Child:* "Other...spoon. Now give me other one spoon."
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# Fractional Cases

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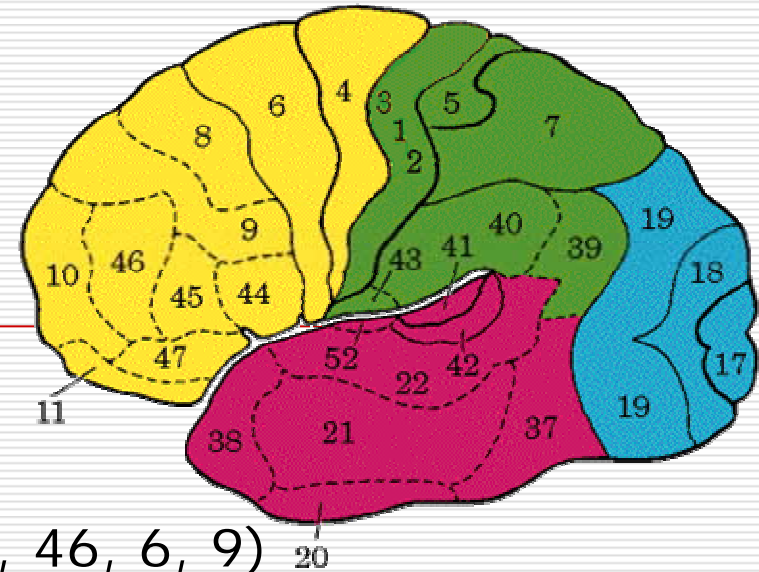
## □ Chronic Broca's Aphasia

- It often emerges out of global aphasia
- Damage to dorsolateral frontal, rolandic, opercular and anterolateral parietal regions
- Critical to this aphasia is the sub-cortical extension of the lesion

## □ Acute Broca's Aphasia

- Involves frontal operculum, lower motor cortex and subcortical white matter
  - Even after recovery, patients have paraphasias, speech impairment and impaired repetition
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# "Broca's Area" Lesion



- Associated areas
  - Frontal operculum (44, 46)
  - Dorsolateral frontal cortex (44, 46, 6, 9)
- Suggests the existence of a frontal-caudate regional network required for complex output procedures: syntax and narrative discourse at the minimum
- Damage to the lower motor cortex suggests the existence of a local (rolandic) network for articulation and some aspects of prosody
- All these fractional and variant cases of Broca's aphasia show recovery
  - sometimes by reorganizing cerebral functions to allow right brain control of speech

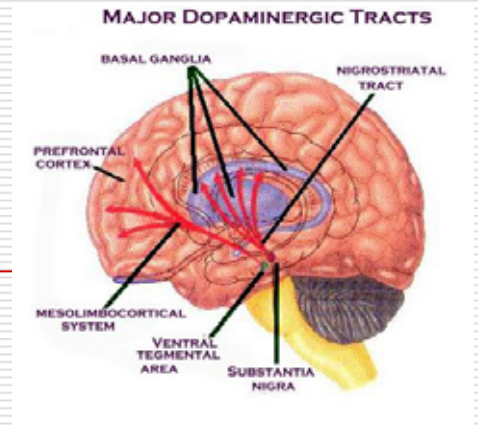
# Transcortical Motor Aphasia

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- ❑ Language output is non-fluent: initiation block, reduction in phrase length, simplification of grammatical form
  - ❑ Patients of TCMA are initially mute and may remain mute for many days
  - ❑ Echolalia (particularly incorporation) is observed
  - ❑ Repetition, articulation and oral reading are normal
  
  - ❑ The classical patient has a large dorsolateral frontal lesion extending deep into the white matter
  - ❑ Connections between the Broca's area and Brodmann's Area 6, pre-motor area or basal ganglia are severed
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# Fundamental Deficits

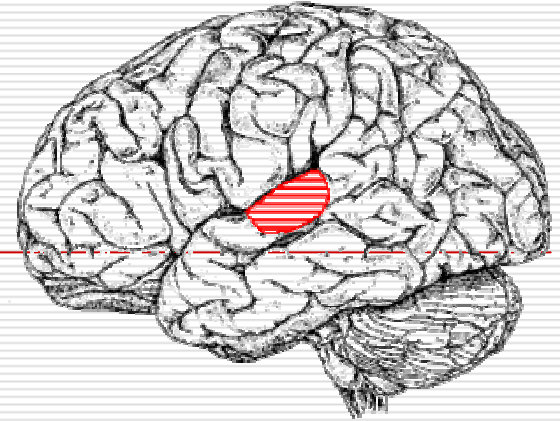
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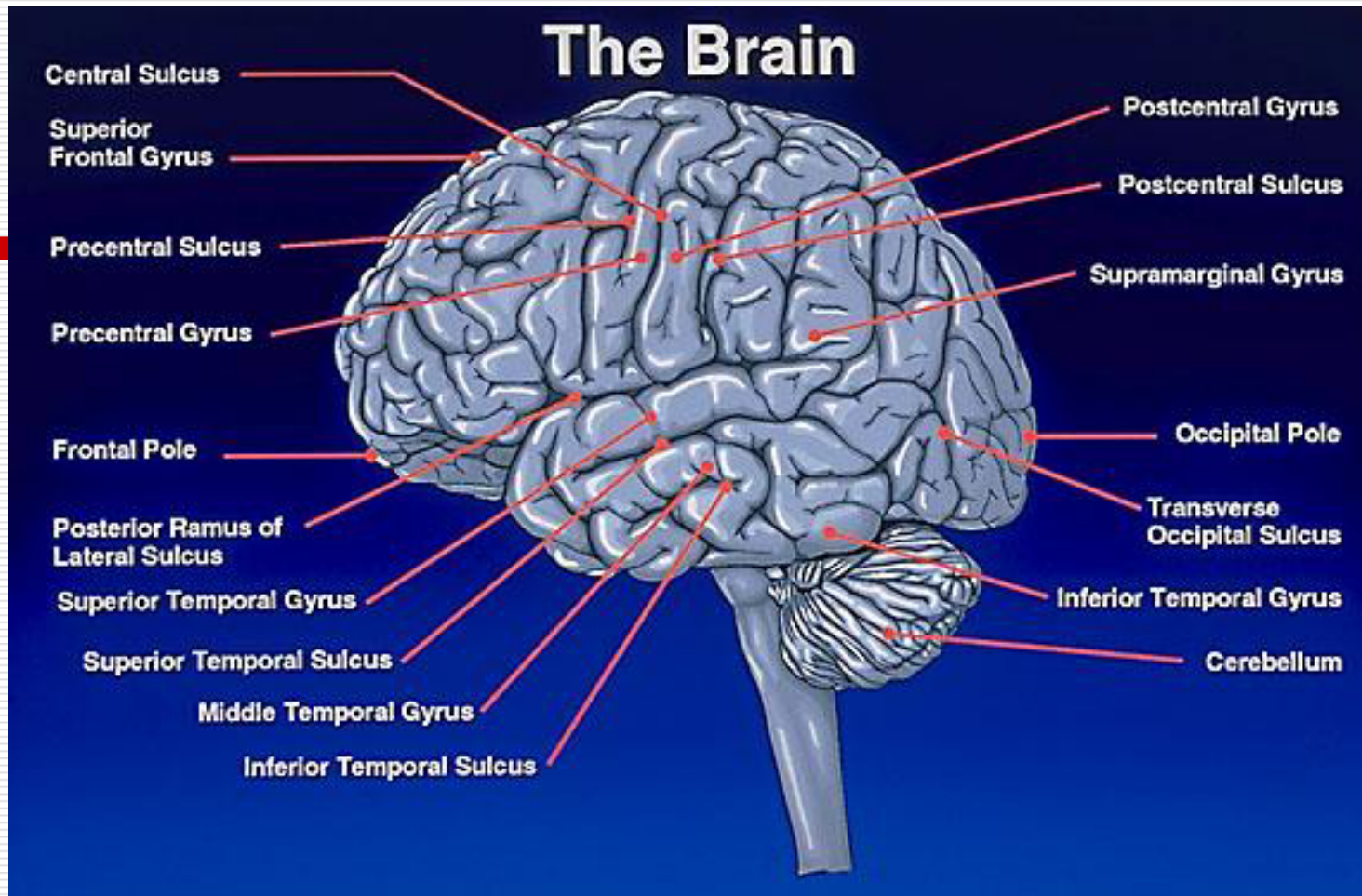
- Generative language tasks
    - limited capacity to generate complex syntax
    - cannot respond to open ended questions
    - attribute to large dorsolateral frontal lesions
  - Reduction in activation to speak (or write)
    - medial frontal damage
    - reduced activation is due to loss of ascending dopaminergic pathways
    - supported by improvement in fluency and speech rate after administration of direct dopamine agonists
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# Wernicke's Aphasia



- Most common of the fluent aphasias – language output is fluent
  - Major impairment is semantic - content seems to be meaningless (jabberwocky) or empty
    - *" The stockety wance on my holiday, it ate up the laddersby until, you know, we fell it over and then he danced wither the meal. "*
  - Paraphasias are common
    - Verbal: cup or knife for spoon
    - Literal/ Phonemic: smoon for spoon
    - Neologistic: snopel,
  - Speech is paragrammatical because of semantic ambiguity
  - Repetition and naming are poor
  - Anosognosia (lack of awareness) of their communication problems is common
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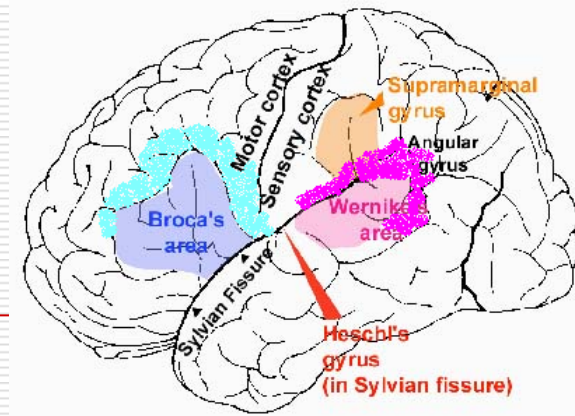


Lesion: damage to the superior temporal gyrus to the end of the sylvian fissure

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# "Wernicke's Area" Lesion

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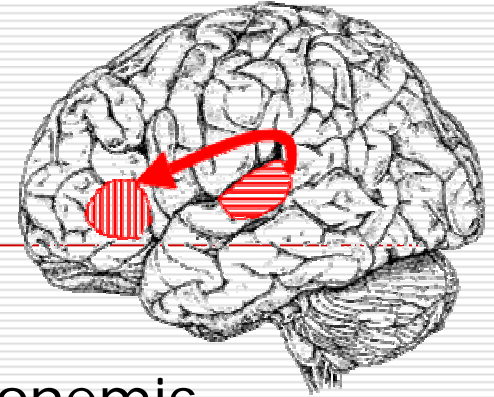
- ❑ Auditory comprehension is severely impaired so auditory language system must be temporal
  - ❑ Key regions for word retrieval are inferior temporal and middle temporal/ angular gyrus transition
  - ❑ Lexical-semantic function is broadly distributed in the posterior association cortex
  - ❑ PET studies
    - recovery of comprehension is proportional to the recovery of blood flow in the left hemisphere
    - recovery is also related to shift in activation to semantic tasks from left temporal to right temporal
    - show the importance of posterior association cortex for recovery of comprehension
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# Anomic Aphasia

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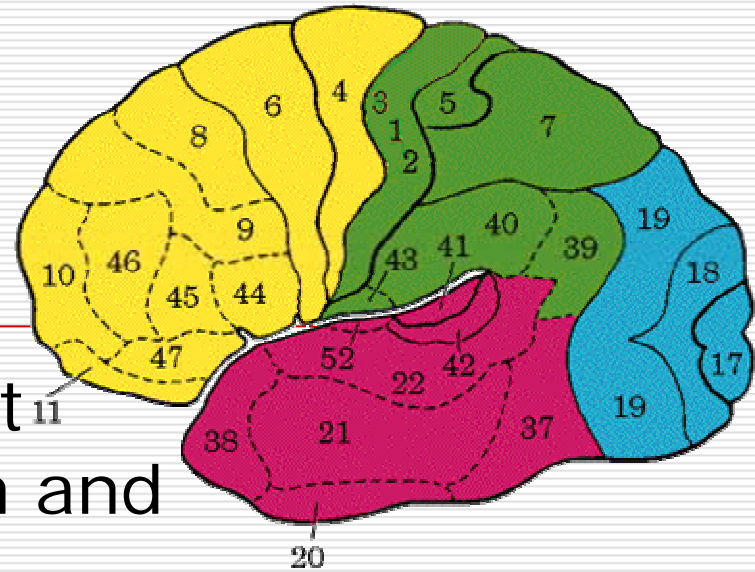
- It is a much less homogeneous grouping than other classical syndromes
  - Naming or word retrieval is the only deficit – circumlocution is common
    - "had one of them up there"
  - Comprehension, repetition is good and paraphasias are rare
  - It can be localized with the least reliability of all syndromes
  - When caused by the temporal parietal area there may be alexia and agraphia
  - When caused by dorsolateral frontal lesions, there are no accompanying signs
  - When it is the residual of Broca's aphasia, accompanying signs are as expected of those disorders
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# Conduction Aphasia



- ❑ Language output is fluent
- ❑ Content is paraphasic usually literal/ phonemic – attempt to produce repeated approximations of the word are called conduit d'approche
- ❑ Repetition is poor, auditory comprehension is normal
- ❑ Generally there is damage to supramarginal gyrus
- ❑ Classical correlation was with the arcuate fasciculus, a bundle of nerve fibers that lies below the supramarginal gyrus in the temporal lobe and connects Broca's and Wernicke's areas
- ❑ Critical areas for phonological processing
  - supramarginal gyrus
  - temporoparietal short association pathways

# Transcortical Sensory Aphasia



- ❑ Repetition is preserved but there is no comprehension and propositional speech
- ❑ Semantic processing is affected and hence semantic paraphasia dominates
- ❑ Occurs when Broca's area, Wernicke's area and the arcuate fasciculus are undamaged but are cut off from the rest of the brain by infarcted tissue
- ❑ Lesions in middle and inferior temporal gyri
- ❑ Such lesions would be found in Brodmann's areas 37, 22, and 39

# Mixed Transcortical Aphasia

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- ❑ Comprehension is impaired and naming is poor
  - ❑ Repetition is preserved
  - ❑ Echolalia and fragmentary sentence starters are common
  - ❑ MTA requires a combination of the lesions of TCMA and TCSA
  - ❑ Patients are mute initially. When they speak it is like patients with TCSA.
  - ❑ Most cases are due to large frontal lesions in the region of TCMA lesions.
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# Crossed Aphasia

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- The review which we have done is valid for right-handers with lesions of the left hemisphere
  - About 2 to 5 % of the right-handed population (though it can range from 1 to 13 %) becomes aphasic after a lesion in the right hemisphere
  - These patients fall into two categories
    - About 70% have standard aphasias associated with corresponding lesions in the left hemisphere
    - The rest 30% have striking anomalies in the aphasia-lesion relationship
    - In this group, mild syndromes can occur despite large lesions
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# Crossed Aphasia ...

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- ❑ Conduction aphasia has been seen despite large perisylvian lesions
  - ❑ In other patients with similar lesions, transcortical sensory aphasia or anomia have been described
  - ❑ Patients with crossed aphasia generally have a better capacity for recovery
  - ❑ These anomalous cases may suggest possible lateralizations of phonologic and semantic functions
  - ❑ Alexander and co-workers even propose a genetic basis for inheritance of handedness and laterality
  - ❑ The biological basis of crossed aphasia however remains unknown
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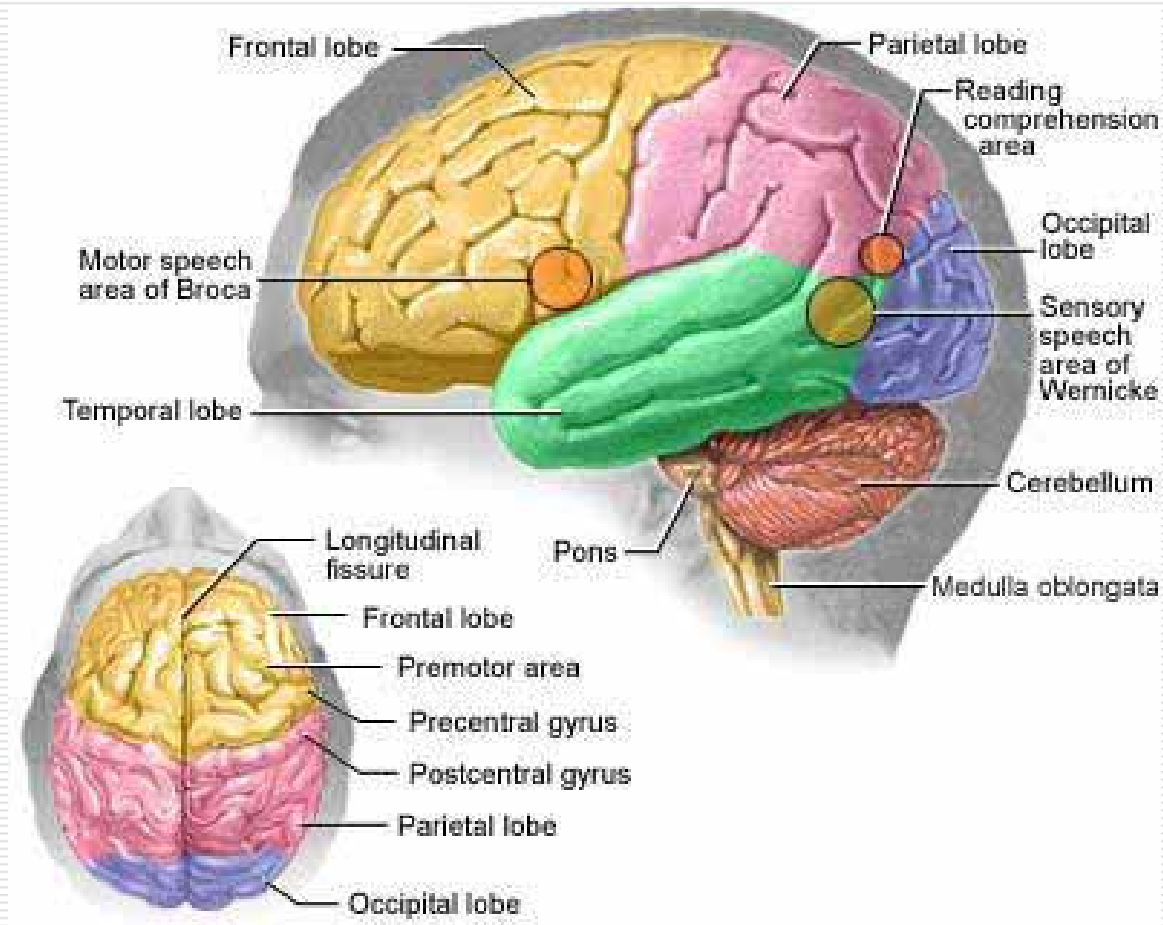
# Aphasia in left-handers

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- ❑ Left-handers make up 10% of the total population but are a much more heterogeneous group
  - ❑ Again, about 70% of left-handed aphasics have left-brain lesions and 30% have right-brain lesions
  - ❑ About 15% would be aphasic after a lesion of either hemisphere (have bi-lateral language representation)
  - ❑ Proportion of cases with anomalous aphasia-lesion relationships is higher than in right-handers
  - ❑ It is also claimed that they have better recovery than right-handers (does it point towards bilateral language capacity?)
  - ❑ Since the biological basis of handedness and lateralization is unknown, it is an open question as to how do these anomalies occur.
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# Conclusion

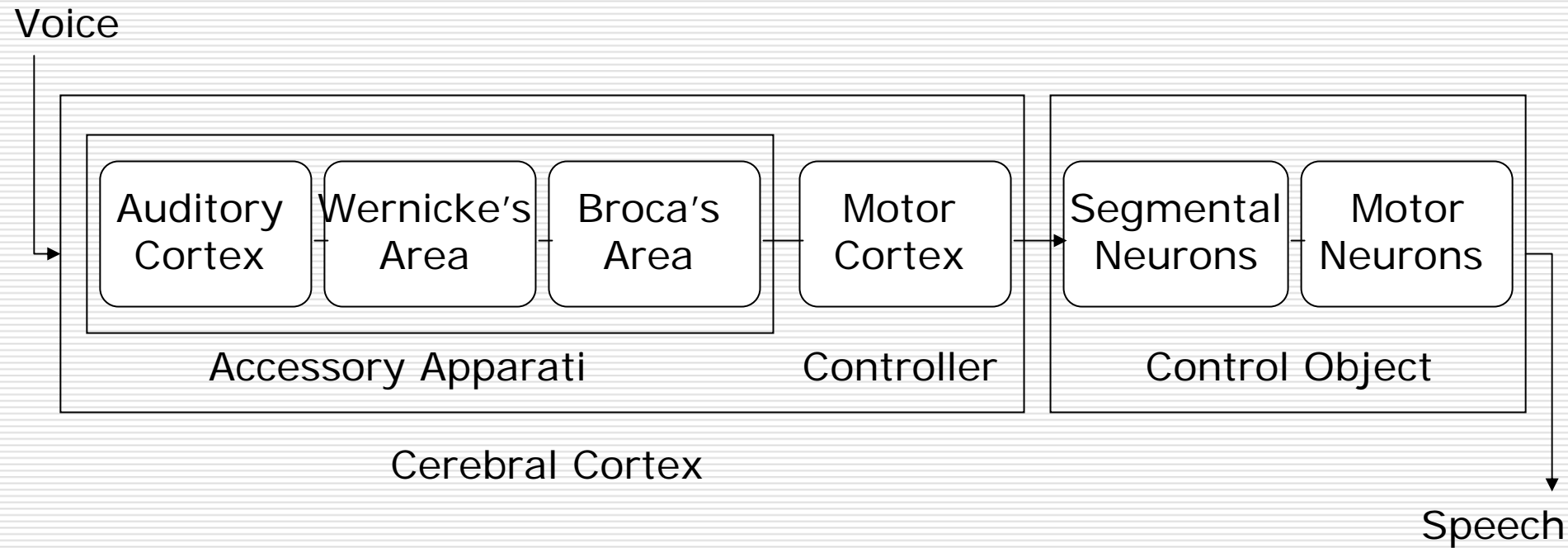
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# Classic Model of Language Organization

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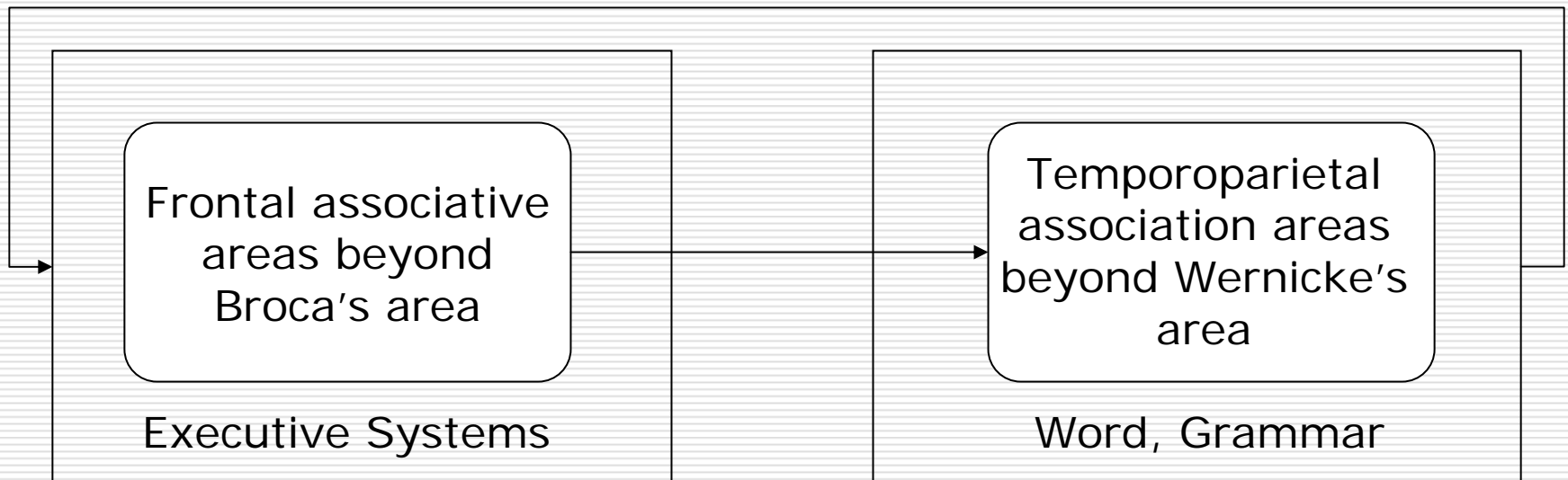
## Hearing and Speech



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# Verbal Thought

Comprehension



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THANK YOU !!!

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Any Questions?