FRONTAL ASSOCIATION CORTEX AND DISORDERS

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Motor, Sensory, and Association cortices in Human, Cat, and Rat
Association Areas Mediate Higher Mental Function

- Language
- Create visual art and music
- Planning
- Logical thinking
Paul Broca (1824-1880)

Leborgne, 1861
Dominant Hemisphere

• The hemisphere is more heavily involved in language is named dominant hemisphere.
The Right & Left Cerebral Hemispheres

- The right and left cerebral hemispheres are specialized for different functions (lateralization)
Areas of Higher Cortical Functions

- Language Areas:
  - *Broca motor speech area*
  - *Wernicke sensory speech area*
  - *Arcuate fasciculus*
- Prefrontal Association Cortex
- Parietal, Temporal, Occipital Association Cortex
Broca Motor Speech Area

- Areas 44, 45, in posterior part of the inferior frontal gyrus in the dominant hemisphere
- Is connected to the Wernicke speech area by the arcuate fasciculus
- Lesion: Broca aphasia
Carl Wernicke (1848-1905)
Wernicke Sensory Speech Area

- Area 22, in posterior part of the superior temporal gyrus in the dominant hemisphere
- Is connected to the Broca speech area by the arcuate fasciculus
- Lesion: Wernicke aphasia
Arcuate Fasciculus

• Underlies the supramarginal gyrus (area 40) and the frontoparietal operculum
• Connects the audiovisual association areas (areas 22, 39, and 40) with Broca speech area (areas 44, 45)
• Lesion conduction aphasia
PET (positron emission tomography) scan
Cortical dysfunctions

- **APHASIA**: a disorder of language
- **Apraxia**: difficulty performing learned skilled movements in the absence of paralysis of the muscles
- **Agnosia**: ability to touch, see or hear something, but not to recognize or know what it is
Visual Association Cortices

Angular gyrus, Written words

Dorsal stream
Motion

Ventral stream
Form, Color
Aphasia

The following must be assessed:

• FLUENCY
• NAMING
• COMPREHENSION
• REPETITION
Broca’s Aphasia
( anterior/ motor aphasia )

- **FLUENCY**: non fluent
- **NAMING**: poor
- **COMPREHENSION**: ok
- **REPETITION**: poor
Wernicke’s Aphasia
( posterior/ sensory aphasia)

- **FLUENCY**: fluent
- **NAMING**: poor
- **COMPREHENSION**: none
- **REPETITION**: poor
Conduction Aphasia

- **FLUENCY**: fluent
- **NAMING**: ok
- **COMPREHENSION**: ok
- **REPETITION**: none
Global Aphasia

- **FLUENCY**: non fluent
- **NAMING**: poor
- **COMPREHENSION**: none
- **REPETITION**: poor/none
Nondominant Hemisphere Role in Language

- Producing and comprehending the emotional, rhythmic, and musical aspects of speech (PROSODY)
- The right hemisphere system for generating and comprehending prosody is apparently organized in a fashion analogous to the left hemisphere system for producing and comprehending language.
  - Motor prosody area — Right inferior frontal gyrus
  - Sensory prosody area — Right posterior temporoparietal region
Aprosodia

• One of the first such patients described was a school teacher with right frontal damage. She had motor aprosodia.

• Motor aprosodia: inability to express of feelings (anger,...) by voice despite of existing the feelings.

• Sensory aprosodia: inability to comprehend the emotional content of speech.
Prefrontal cortex

- Areas 9, 10, 12, 46 extends from area 6 to the frontal pole (dorsolateral prefrontal cortex), and areas 11, 47 in inferior surface of hemisphere (fronto-orbital prefrontal cortex)
- Has reciprocal connections with the MD nucleus of thalamus, and via it with limbic system
- The dorsolateral prefrontal cortex has inputs from somatosensory, visual, and auditory association areas
MD Nucleus (Association Nucleus)
• Limbic prefrontal cortices are innervated by MD, as well, but are also innervated, to a significant extent, by other thalamic nuclei: anterior, intralaminar, midline, and the medial pulvinar.

• Limbic prefrontal areas uniquely reciprocate with projections to the hypothalamus, which innervates brain stem and spinal autonomic structures.

• Limbic prefrontal areas thus have rapid access to vital autonomic organs, such as the heart, lungs, and gut, during emotional arousal.

• Limbic prefrontal areas are also the major targets of pathways from the hippocampus (CA1 and subiculum), which reach the ACC and, to some extent, the orbitofrontal cortex.
Prefrontal-Hippocampal Interactions

- Considerable research supports the idea that a direct pathway from the HPC and subiculum to the mPFC is critically involved in cognitive and emotional regulation of mnemonic processes. More recently, evidence has emerged that an indirect pathway from the HPC to the mPFC via midline thalamic nucleus reuniens (RE) may play a role in spatial and emotional memory processing.
Other connections

Appraisal of emotional state and potential regulatory strategies based on context and goals
Appraisal of exteroceptive sensations based on current goals/needs.
Appraisal of actions based on expected outcomes, motor costs, task context, and social goals.
prefrontal cortex and executive control
Prefrontal cortex

• Owing to its proximity to the premotor and motor cortex and to the relevance of its connections with both the cortical sensory areas and also the limbic system, the prefrontal cortex seems to be centrally involved in the selection, organization, and verification of motor or behavioral programs that are elaborated to respond to either external or internal stimuli.
Prefrontal cortex

- The dorsolateral prefrontal cortex is important for spatial processing of afferent information and for the organization of working memory.
- The ventrolateral prefrontal cortex is concerned with the mnemonic processing of objects.
- Evidence from surgical lesions (prefrontal lobotomy) or pathological damage suggests a role for the prefrontal cortex in the normal expression of emotions (affect) and the ability to predict the consequences of actions.
- The medial prefrontal cortex is important in auditory and visual associations, and widespread changes in prefrontal activation are associated with calculating, thinking and decision making.
Behavioral Disorders Produced by Frontal Lobe Damage

These will be listed under three main headings:

1. Psychomotor disorders and planning disabilities;
2. Disorders of abstract thinking
3. Disturbances of social and emotional behavior.
Psychomotor Disorders

• Reappearance of primitive reflexes:
  1. Grasping reflex
  2. Forced groping reflex
  3. Oral and sucking responses

• Tendency to perseverate in previous motor programs:
  The tendency to perseverate in a previous established motor pattern, without modifying this activity according to new circumstances; such as copying a circle in drawing.
Planning Disabilities

• Stages of behavioral programs:
  1. Preliminary analysis of the situation, designed to evaluate the basic information required to choose the most appropriate behavioral program;
  2. Elaboration and orderly execution of the program, maintaining the state of stable cortical activation and using verbal instructions to regulate behavior;
  3. Verification of the accomplished activity, matching the execution of the program to the initial aims and to the changing demands of the milieu.
All these stages can be severely impaired by frontal lobe lesions.

1. **Disability to preliminary analysis** when the patient is requested to solve a complex behavioral task, but impulsively initiate unplanned solving attempts without considering the circumstances;

2. During the execution of the program, the patient is **unable to pay sustained attention** to the task conditions, and often lose the set or forget the instructions. Even if they repeat the instructions to themselves, this verbal activity has no impact on the patient’s behavior;

3. **No control is exerted** by the patient upon their performances and no effort is made to match the results obtained with the initial conditions. Thus, although sometimes able to recognize that their performance is wrong (or even to identify the locus of error, if the performance is repeated by the examiner) they do not try to make use of this knowledge to correct errors.
Impairment of Abstract Thinking

• The patient is unable to sort cards adequately on the **WCST** (Wisconsin Card Sorting Test), but nevertheless can verbalize (i.e. abstract) the requested criterion.

• Perhaps this apparent conflict could be resolved by recognizing that what is impaired in frontal patients is not so much the abstract thinking as the abstract attitude.
WCST (Wisconsin Card Sorting Test)
Disturbances of Social and Emotional Behavior

(1) Personality changes
(2) Inappropriate social behavior

- The lesions in Dorsolateral areas present a hypokinetic syndrome, with apathy, reduced sexual interest, lack of spontaneity and total unconcern; whereas lesions in orbital areas show a hyperkinetic syndrome, with increased motor activity, lack of inhibitions, socially inappropriate behavior, facetiousness and “Witzelsucht”.
Differences between Dorsolateral and Orbital Lesions

• Thalamocortical connections are different:
  \textit{orbital cortex} receives projections from the \textit{medial part of MD nucleus} (which in turn receives afferents from the \textit{septal region});
  \textit{dorsolateral cortex} receives projections from the \textit{lateral part of the MD nucleus} (which receives afferents from \textit{various limbic and brain stem structures}).
Possible Etiologic Factors

- Tumors (meningiomas, butterfly gliomas)
- Trauma, particularly frontal basal fractures
- Atrophic processes (particularly Pick’s disease)
Thank You
The End