The Nervous System

An Overview

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Nervous System

- The nervous system is a complex network of nerves that carry signals around the body.
- It directs voluntary and involuntary reaction of our body.
- Everything from the movement of our hands or blood vessel dilation to the learning new facts or being happy is related to nervous system.
- The nervous system does these by sending electrical and chemical signals between cells.

Nervous System Functions

- Gathers information from both inside and outside of the body
  - *Sensory Function*
- Transmits information to the brain&spine and processes the information
  - *Integration Function*
- Sends response to the muscles, glands so they can respond
  - *Motor Function*

Nervous System

Nervous system is divided into two parts:

1- Peripheral Nervous System

- Peripheral Nerves

2- Central Nervous System

- Medulla Spinalis
- Brain
  - Brain stem
  - Cerebellum
  - Diencephalon (thalamus, hypothalamus)
  - Brain hemispheres

Peripheral Nervous System

Peripheral nervous system divided into two parts:

1. Somatic Nervous System

- Send signals to skeletal muscle: Regulates voluntary responses
- Relays information from skin, sense organs and muscles

2. Autonomic Nervous System

- Send signals to internal organs: Regulates involuntary responses
- Relays information from internal organs
- Autonomic nervous system also divided into two groups:
  - Sympathetic nervous system
  - Parasympathetic nervous system

Autonomic Nervous System

- Sympathetic Nervous System:
  - «Fight or Flight»
  - Emergency responses
  - Control the body's response during perceived threat.
- Parasympathetic Nervous System:
  - «Rest and Digest»
  - Control the body's response while at rest.

Central Nervous System

- Medulla Spinalis
- Brain
  - Brain stem
  - Cerebellum
  - Diencephalon (thalamus, hypothalamus)
  - Brain hemispheres (Cerebral cortex)

Medulla Spinalis

- Spinal cords lies within the vertebral column.
- Ascending and descending tracts pass through medulla spinalis
- Center of the most of reflexes (They are called spinal reflexes).
  - For example withdrawal reflex

<u>Cross Section:</u>

- The central area is gray matter
  - Interneurons and cell bodies
- The surrounding area is white matter
  - Axons

Brain Stem

- Brain stem is the extension of medulla spinalis to the inside of the brain
- All the nerve fibers that relay signals between the spinal cord and brain pass through the brainstem.
- Some neurons in brainstem has distinct functions. This include the cardiovascular, respiratory function etc.
- There is a set of nuclei called «Reticular formation» It regulates sleep and wakefulness of brain.
- Brain stem is also the center of a few reflexes. Such as pupil reflex.

Cerebellum

- Cerebellum is a center for coordinating movements and for controlling posture and balance.
- It receives information from the muscles and joints and all the brain part that control movement and it regulates movement
- Cerebellum is also known that related to motor learning such as riding a bike.

Diencephalon: Thalamus

- Diencephalon consists of two parts: Thalamus and hypothalamus
- Thalamus is collection of several large nuclei
- It serves as a **station** for sensory and motor systems.
  - All sensory inputs pass through thalamus except odor.
- It does not serve as a simple door: It filters sensory information. It allows some of the information pass through; some of the information does not.

Diencephalon: Hypothalamus

- Hypothalamus lies below the thalamus
- Altough it is a tiny region (less than 1% of the brain) it is a center of autonomic nervous system: *It regulates homeostasis*
- It controls all the internal organs and endocrine system
- It also controls behaviors that related to homeostasis: such as eating, drinking
- Also, it has a role as a internal clock: Circadian rythm

Primary Areas of the Cortex

- Primary sensory and motor areas locate in cortex.
- Sensory Areas:
  - Visual areas: Occipital cortex.
  - Auditory areas: Temporal cortex.
  - Somatosensory areas: Parietal cortex
  - Olfactory Areas:
    - Small part of temporal cortex
  - Gustatory Areas:
    - Small part of parietal cortex
- Motor Areas:
  - Frontal cortex

Secondary Areas of the Brain

- There are secondary sensory and motor areas surround primary areas.
- Secondary sensory areas does more complex processing of the sensory information
- Secondary motor areas: Planning of the complex motor movements

- What is the function of other parts of the brain?

Association Areas

- Most parts of the human cortex do not related with any kind of sensory input or do not produce any motor movement.
- These areas are called as «silent areas»
- In 1870s British neurologist John Hughlings define these areas as «association cortices»
- These areas associate the information.
- Association areas are responsipble for higher level cognitive functions.

Association Areas

- Higher level cognitive functions such as memory, attention, language, problem solving, decision making, time-space perception is related to association areas.

- There are 3 association areas:
  - Parieto-occipito-temporal area
  - Limbic area
  - Prefrontal area

Parieto-occipito-temporal Association area

- It is middle of the parietal, occipital and temporal areas
- It collects:
  - Somatosensory information from parietal areas;
  - Visual information from occipital areas;
  - Auditory information from temporal areas
- This association area collect and associate these inputs and create a representation about environment.
  - ➢ Spatial perception
- Space = environment around you
- Ability to perceive objects and relationship among objects in the space = spatial perception

Neglect Syndrome

- Damages in parietal areas cause hemispatial neglect syndrome.
- Deficit in awareness of stimuli on one side of space eventhough there is no sensory loss
- Patient believes that the one side of their world does not exist

Neglect Syndrome

- Patients neglect the contralateral side of the damage:
  - Mostly right hemisphere damage cause neglect syndrome. So, typically left side of the space is ignored.
- Patients have no problem got sensory inputs. It is a problem of associate the information.
- Very common disorder. It can be caused by various different pathological conditions. It affects to 60% of stroke patients.

Limbic Association Area

- Limbic association area is located medial part of frontal cortex and temporal pole
- Limbic association area connstitute limbic system with cingulate cortex and subcortical structures (basal ganglia, hypocampus, amygdala).
- It is primarily associated with emotion and motivation.
- Reward system and memory formation is also related with it.

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- Case of bilateral amygdala damage result of a rare genetic condition
- She has no capacity to experience fear = «the woman with no fear»
- Excessive risk taking
- Emotion and memory deficits

Phineas Gage

After the accident;

- He was consciuous
- No noticable diffuculty with speech
- No sensory loss
- No motor dysfunction
- His memory intact
- Normal intelligence

➢ What is prefrontal cortex responsible for?

Phineas Gage

- Behavioral changes!
- His personality changed dramatically

  = «He is no longer the same person»
- Before the accident;
  - He was polite, responsible, well-liked, hardworking, very good person
- After the accident;
  - He become rude, selfish, agressive, antisocial.
  - Lack of concern for the future.
  - Impulsiveness
  - Failure the obey social rule

Phineas Gage

- Isolated prefrontal cortex damage.
  - Sensory and motor functions did not change because the brain areas that related to this functions intact.
- Only dysfunction is about aspects that related to prefrontal cortex
  - Orchestration of thoughts and actions in accordance with goals
  - Planning complex behaviors
  - Decision making
  - Moderating correct social behavior
  - Personality

Prefrontal Corteks

- Humans have particularly large frontal lobes compared to other animals.
- The prefrontal cortex is the last portion of the brain to fully develop
  - It does not fully develop until age 25.
  - Therefore, children do not have complex decision making ability or planning skills like adults.

Cerebral Asymmetry

- Each hemisphere specializes in certain behavior and cognitive abilities
- Corpus callosum;
  - is a large set of axons (200 million nerve fibers)
  - Connect two hemisphere
  - Allow two hemispheres to exchange information and coordinate

Cerebral Asymmetry

- Complementary specialization of hemispheres:
  - Left Hemisphere;
    - Rapid and analytical operations
    - Logic
    - *Language*
    - Lesions of left hemisphere end up with linguistic disorders (aphasias).
  - Right Hemisphere;
    - Visuospatial relations
    - Creativity
    - Face and emotion recognition
    - Lesions of right hemisphere end up with perceptual disorders (agnosia).
- Both hemispheres work equally!

Language

- Language is a system which uses voice, symbol and gestures to communicate
- Complex language is unique human behaviour.
- Aphasia: is the partial or complete disturbance in lingual skills following the brain damage.

Language

- In 1861, Paul Broca discover relationship between language and **left** frontal lesion in patient with aphasia
- Area called Broca's Area which locates in frontal cortex
- Aphasia which related to this area is called Broca's Aphasia:
  - Patient can understand language
  - Can speak meaningful but lots of error
  - Nonfluent, slow speaking
  - Aware of their own language errors
  - Diffuculty of speech production
  - It also called 'motor aphasia'

Language

- In 1874 Carl Wernicke discover relationship between different kind of language disorder and left temporal cortex lesion
- Area called Wernicke's area
- Aphasia which related to this area is called Wernicke's Aphasia:
  - Trouble with speech comprehension
  - Fluent speaking
  - Speaking is smooth but does not make sense
  - Unaware of their own language errors and surprised when other cannot understand them

Language

Repetition of spoken words:

- The auditory system process the sounds
- Sounds are understood as meaningful words in Wernicke's area.
- In order to repeat the words, word-based signals are passed to Broca's area from Wernicke's area
- Broca's area is sent this signal to the nearby motor areas that control moving the speech muscles.

➢ **More complex models have been proposed for linguistic functions.**

THANK YOU