Nueroimaging

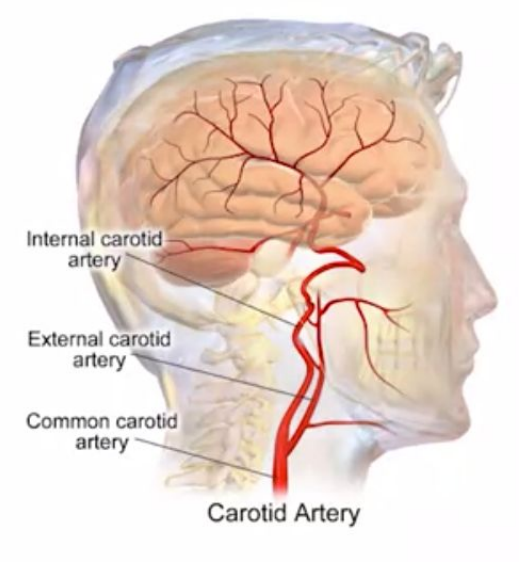
Key Focus：Voxelwise Lesion-Symptom Mapping (VLSM), Electrophysiology, Brain Mapping Methods, Connectome-based Lesion Symptom mapping, fMRI

References

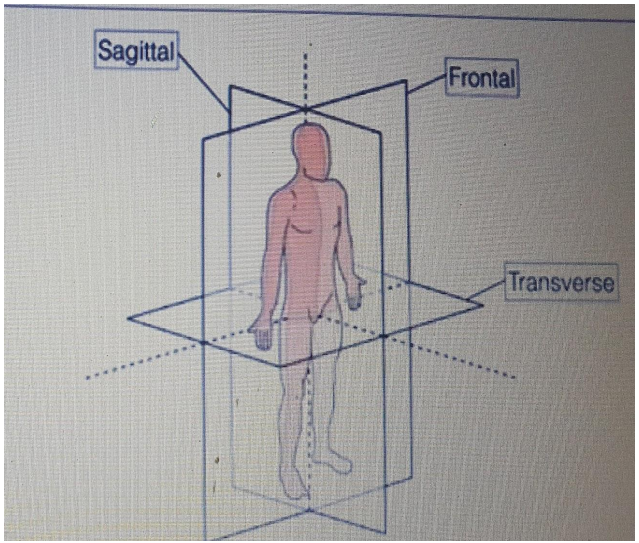
- Textbook chapter draft
- CLSM Paper
- Neuroimaging specialization

  (4 courses)

About brain - structural anatomy



Enters through circle of willis

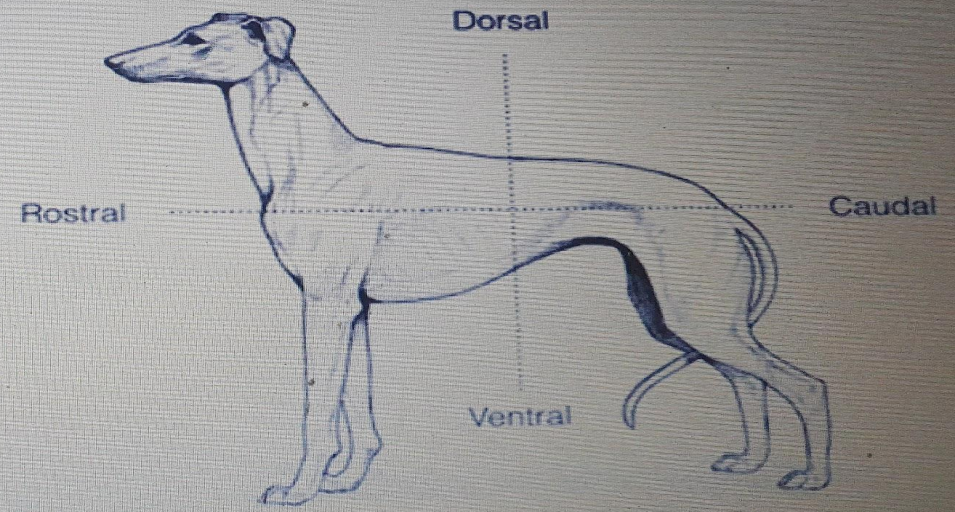


3 planes for referring to brain's organization in MRIs. This forms the basis for the concept of stereotaxic space

Structured Neurons - Columns (info processing) and layers (data transfer within different areas of brain)

Terminology in Brain Organization

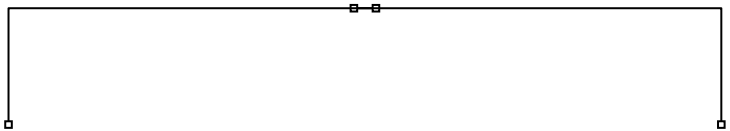
- The major axis of the body is the rostral-caudal axis:
  - Rostrum (beak)
  - Cauda (tail)
- The vertical axis of the body is the dorso-ventral axis:
  - Dorsum (back)
  - Ventrum (belly)



About brain - functional properties

- Action potentials(voltage change due to chemical transfer) are basis for communication in neurons. 2 types of neurons - excitatory and inhibitory.
- The functional anatomy involves, CSF(protection and nutrients), Grey matter(determine the transmission of action potential) and White matter(Axon bundles).
- Motor Cortex, Somatosensory cortex, Thalamus, Visual cortex, Cerebellum - Known functional areas of brain.
- Cognitive Functions like Memory, Emotions, Language, etc are also corresponding to particular areas in the brain.

Approaches to Neuroimaging - image the CNS



Structural Imaging - anatomy/injury

Functional Imaging - metabolic/cognitive

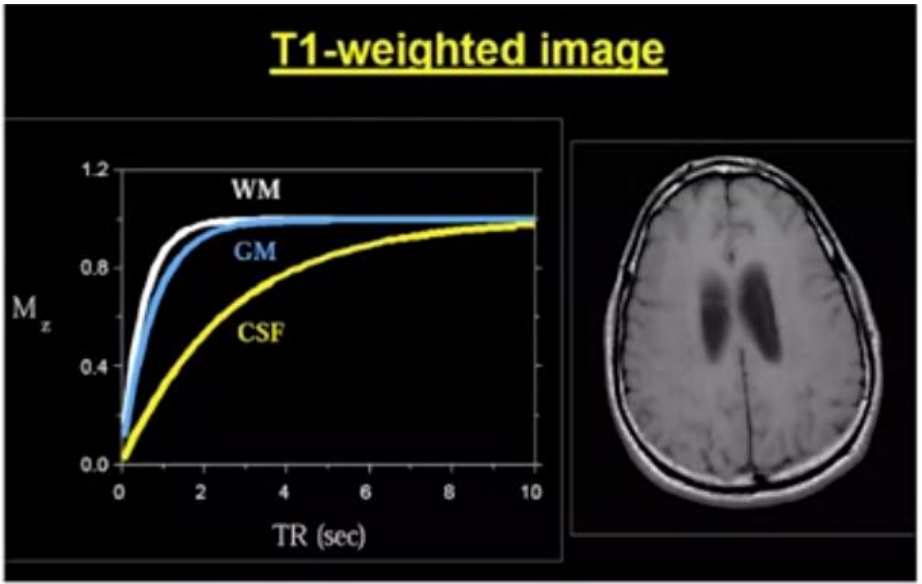
1. EEG - Measures the Electrical potentials through electrodes.
2. CT - Uses series of X-rays and then a 3-D volume formed.
3. SPECT - Uses a gamma tracer to find gamma activity in brain.
4. PET - Measures the time delay between gamma activity using 2 tracers.
5. MRI - Uses Magnetic fields to disturb H-ions in brain and the RF is measured.
6. fMRI - Use of cognitive inputs by the user.
7. DTI - Measures directionality of water in Whiter matter.
8. Spectroscopy - measures various metabolites using the fft in the MRI scan.

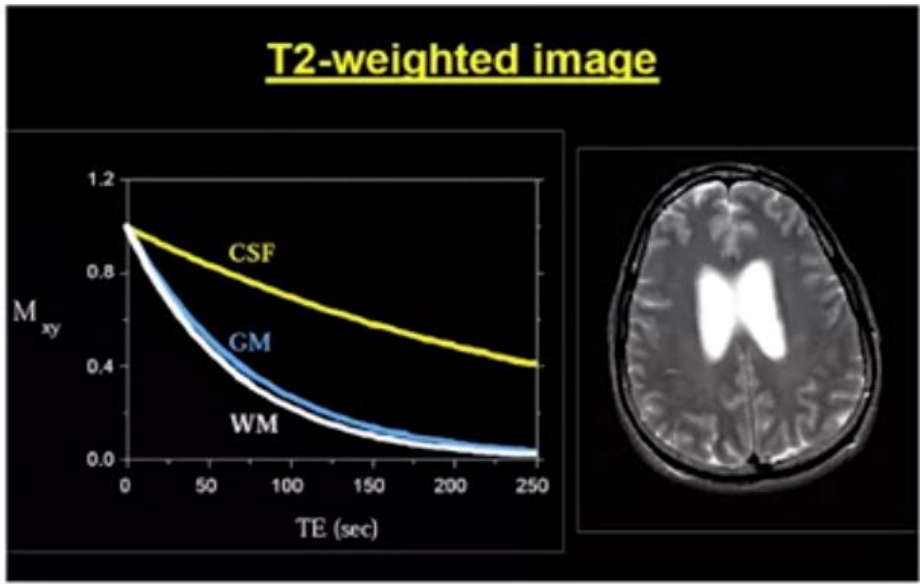
MRI - Magnetic Resonance Imaging

This is Structural Neuroimaging

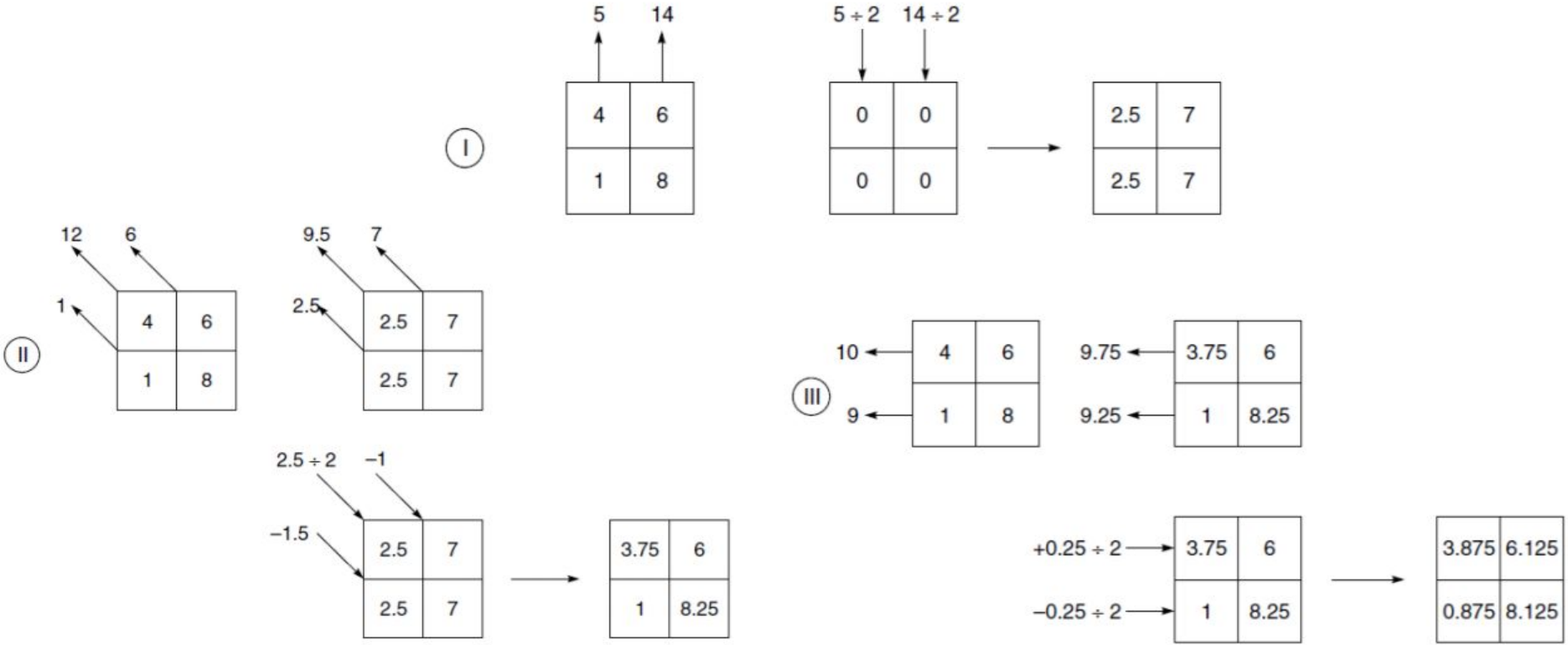
Basic Concept

The change in spin due to non-interacting and perpendicular magnetic fields give rise to longitudinal and transverse relaxation times. The Gyromagnetic ratio determines the voxel localization.





Spatial selectivity is ensured by Linear gradients

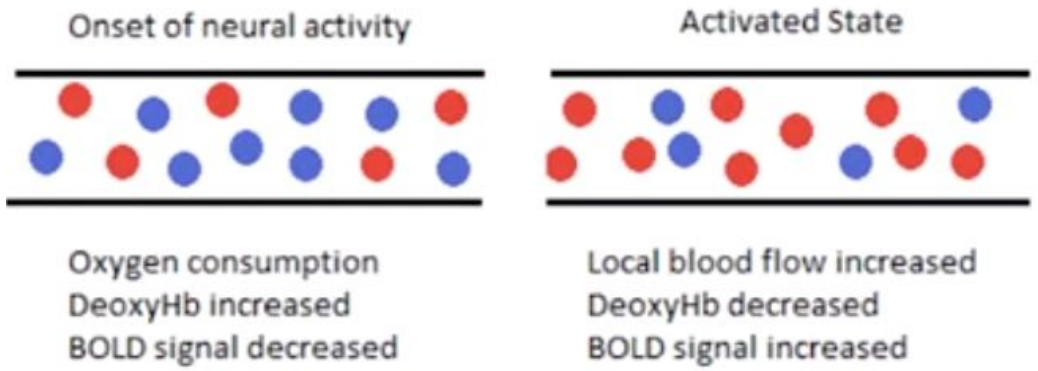


fMRI - Functional MRI

This methods develops a functional Neuroimage

Basic Concept

Oxygenated and Deoxygenated blood samples have different T2 curves. When an action is occurring, neurons get deoxygenated due to use to oxygen for communication. The generated signals correlated closely to Local field potentials i.e. input to a neural population during post synaptic phase.



fMRI Experiment types

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1. Time series analysis -> Analysing the bulk response of the fMRI over time and observing the activity. This also involves observing the correlational attributes of spatial areas of the brain.
2. Functional Connectivity -> This allows us to observe the anamolity and similarity between individual voxels on a time-series scale to observe their connectivity for any functional action potential.

Theory of dissociations

The brain is not an cohesive and single unit. Different parts have their significant functions that allow the brain to manage all stuffs.

Dissociations

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1. Single -> Focusing on single patient and monitoring only the effects due to that. Technically, it has no reference and is subjected to various disturbances like abnormal sensitivity to for the harder task.
2. Double -> Focusing on brain activity of 2 individuals working on exactly opposite fashion. This strongly suggests that each task requires at least some unique mental structures and/or operations that could be selectively disrupted in such a manner that the ability to accomplish each task could be impaired independently of the other.

Lesion-Behaviour Mapping

It is proposed that the cognitive behaviour can be predicted from lesion analysis and that a set of individual having same kind of symptoms have same lesion features

Methods in brief

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1. Lesion overlap and subtraction analysis -> This is a trivial method of simply deriving mathematical difference in the spatially average lesion characteristics.
2. VLSM -> Lesion-Symptom method assumes that a functional characteristic is an consequence of a structural defect. Unsupervised method wherein each voxel is passed through a binary test and the statistical distribution of individual voxel type determines the occurrence of t-test. This is achieved by analyzing continuous behavioral data on a voxel-by-voxel basis.

Methods in brief

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3. VBM -> This uses the VLSM method with weightaged binary voxel text approach.
4. Multivariate analysis -> An approach capable of showing how different spatially distributed patterns of activity across the same set of voxels may be related to different experimental conditions and hence to different mental representations or processes.

Event related potentials

EEG patterns that are time-locked with the presentation of stimuli.
This method doesnot have a very good spatial resolution.

ERP - Event related potential

- P1 (P100): A positive deflection peaking around ~ 100 ms. Responsible for Initial Perception.
- N1 (N100): A negative deflection peaking between ~ 90 and 200 ms after the onset of the stimulus. Responsible for Perception and attention.
- P2 (P200):A positive deflection peaking between ~ 100 - 250 ms after the onset of the stimulus. Responsible for Interpretation.
- N2 (N200):A negative deflection peaking between ~ 190 and 300 ms after the stimulus onset. Responsible for classification.

- P3 (P300):A positive deflection peaking between ~ 300 and 400 ms after the stimulus onset. Cognitive processing (e.g., Memory updating).
- P50:occurs approximately 50 ms (between 40 and 75 ms) after the presentation of a stimulus (e.g., auditory clicks). Used to measure sensory gating. Sensory gating (gating or filtering) describes neurological processes of filtering out redundant or unnecessary stimuli in the brain from all possible environmental stimuli. Sensory gating prevents an overload of irrelevant information in the higher cortical areas of the brain by paying attention largely to the target stimulus.
- N300:Recent finding, related to semantics.
- N400 and P600: Language processing

Connectome-based lesion-symptom mapping

LSM methods do not need to pre-defined region of interests or even define an experiment with pre-defined conditions(as needed by fMRI).

Key points of the paper

- LSM can precisely point out which nuerons were reuired for a particular task. There might be many nuerons involved in the task, but we need the ones that are required for that task.
- Yet, LSM is not scalable and hence, is not useful in functional studies. It can not show the effect created by that task in the brain.
- In VLSM, one is no longer required to predefine regions of interest with continuous boundaries or sub-regions with different functions.
- In addition, since the t-test uses the continuous behavioral scores, one does not need to classify patients into two discrete groups using arbitrary cutoff scores

- A whole-brain connectome approach measures the strength of the connection between all possible pairs of ROIs
- CLSM extends grpah theory and proablistic tractography to determine the structurally connected ROIs with respect to the VLSM detected regions. This also weighs on the functional connectivity.
- The statistical relationship between structure and function in CLSM is based on link weights (e.g. fiber count or connection probability).
- One of the biggest drawback of this method is that it assumes direct point-to-point connection for behavioural features to be connected.