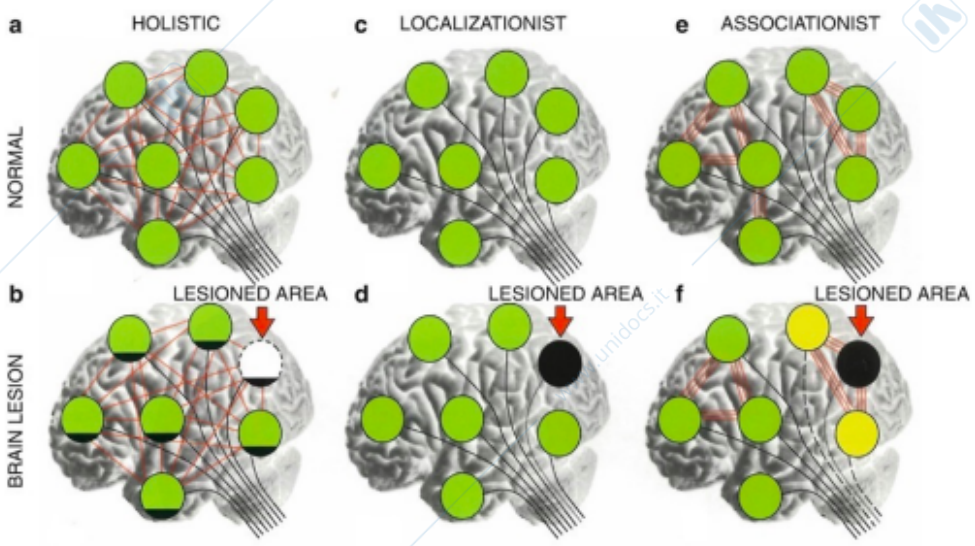
HOLISM

- Differences
  - localizationism=the brain is a mosaic, each part conducts a specific function
    - a lesion impacts only that area, not the close ones
  - associationism/connectionism: areas work together in networks, a focal lesion in an area inside a network would have an impact on other close areas (diaschisis)
  - holism: more extreme view, each region is connected with the rest of the brain and contributes to brain functions
    - a lesion affecting one area will have consequences on the whole brain, changing the whole dynamic activities
    - deficits proportional to its extent



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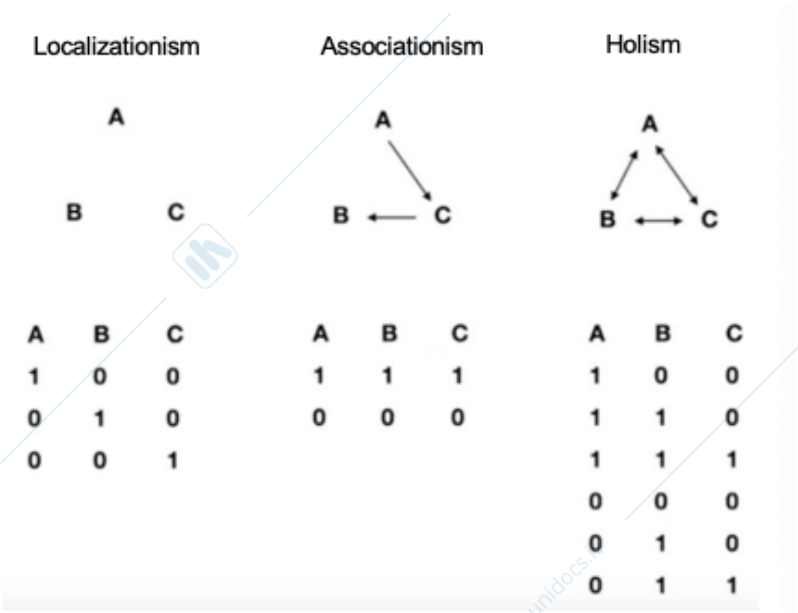
- Localizationism: each area is dedicated to a single function, if A is working we have one function, etc. → limited, as many functions as areas
- Associationism: the flow goes to A, to C, to B: the regions are connected and work together or they are disconnected and non active (only two possibilities)
- Holism: everything is connected with everything else in combinations, so we have different functions, depending on the activation
  - richness of functions of our brain, many functions possible



- McIntosh: the functional importance of an area depends on how the other regions are or are not connected with it in a dynamic way. A region can participate to many functions, there is no 1:1 connection, it depends on the context thanks to variations in its dynamic connections
    - some nodes act as switchers, “behavioural catalysts” =enable transitions between different states, without alteration of activation
    - change in activated connections, not regions
    - hippocampus: functional connectivity with cortical regions while we learn new informations, but also with subcortical regions if we are implicitly learning
        - enables to shift from one to the other

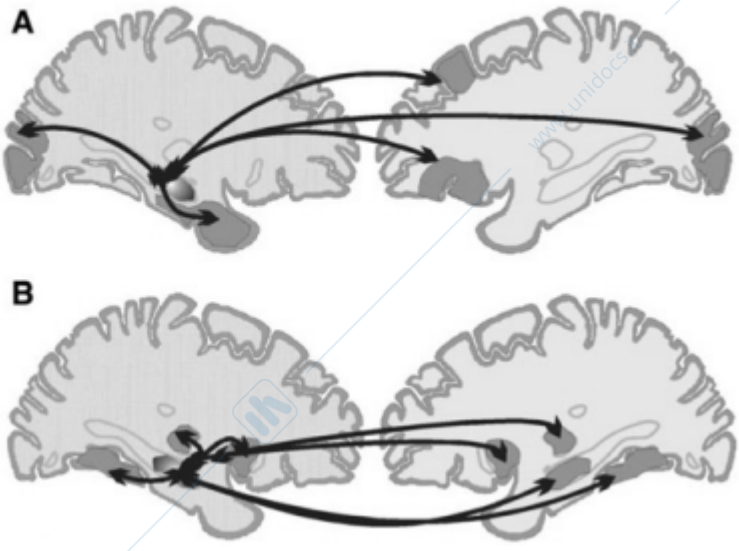


Fig. 2. Summary of the dominant functional connections of the left medial temporal lobe (MTL) in learning with **(A)** and without **(B)** awareness. Panel A shows dominant interactions, indicated by bidirectional arrows, between MTL and occipital, temporal and prefrontal cortices when learning proceeds with awareness. Panel B shows dominant interactions, between MTL with thalamus, basal ganglia, and contralateral MTL when learning proceeds without awareness. The key feature is the common involvement of the MTL, but because the regions to which it is functionally connected differ, the MTL can be related to learning in both situations.

- Holism
  - vs localizationism
    - Flourens vs Gall: spiritual and empirical reasons
      - fLourens: the brain acts as a functional whole
        - believed the soul is unitary -> breaking it down is heretic and against science and the concept of free will => believed in equipotentiality of the cortex, specific functions may be controlled by regions but could potentially be moved somewhere else. In his experiments he produced extensive and indiscriminate cortical lesions in animals, resulting in small behavioural deficits => mental functions are distributed in the whole brain
        - Against Gall's mind-brain equivalence, heretic materialism opposite to unitary soul, free will. His claim: extensive and indiscriminate cortical lesions in animals showed small behavioural deficits → mental functions are distributed in the whole brain
  - vs connectionism (connectionism is still localizationism, just based on networks rather than areas)
    - Jackson: hierarchical organisation on 3 levels, with higher cognitive functions being more distributed than lower functions
      - Hierarchical organisation of the brain, with distributed systems -> lower level (includes SC) = automatic movements (reflexes); middle level = low part of the cortex, coordinated movements and elaboration; higher level = PFC, control
      - holistic because
        - didn't assume any 1:1 correspondence between localization and function
        - after a lesion, functions can be recovered
          - ex hemi-paralysis but automatic movements still working; aphasia but patients could still say a few words
          - there might be other regions that cover the same functions so the functions do not get lost
            - functions could be supported by spared regions
            - brain=distributed systems, mediated by neurons and connections
        - the nervous system is not made by separated centers connected, but a hierarchical organization of neurons distributed, and behavior is mediated by their connections
      - but described interhemispheric differences (some functions are localized)

        - Pierre Marie: against localizationism and connectionism, “there is one form of aphasia”, the anterior aphasia is the posterior aphasia+motoric problems
            - denied the role of left frontal lobe in language
- Revival of holism in the early 20th century
    - Head: mind and brain are different, it is not possible to infer the mind from the brain
        - only simple functions (sensation and movement) are localised in the brain, there is no centre for language, aphasia can be observed in patients with focal damage, but not be used as criteria for understanding how the brain works in healthy people (cannot be generalised to healthy brains)
            - no single centre for superior functions or language
        - usually, studying brain lesioned patient can help understanding how the brain works→ cognitive neuropsychology
            - neuropsychology is not useful to understand how the cognitive system works in normal circumstances
    - Goldstein: empirical data, but localizationist functions were not empirically working on patients
        - although analysis through isolation is a necessary first step in the scientific study of the brain, his holistic approach derived by disappointment of the results of this procedure for medical practice
        - in-depth analysis of the patient (localization of performance) and follow-up through recovery (functions are distributed through the whole brain, activation of the whole nervous system for a function)
        - based on the Gestalt theory
    - Hebb: father of connectionism, first to study connection between brain and behaviour, but had unifying principles of learning
        - "when an axon of cell A is near enough to excite cell B and repeatedly or persistently takes part in firing it, some growth process or metabolic change takes place in one or both cells such that A's efficiency, as one of the cells firing B, is increased”
        - we have a great ability to form associations of coincident events => learn from the past to predict the future (adaptive), by boosting in synaptic connection for neurons that are activated at the same time -> when an axon is near enough to excite another cell and repeatedly or persistently takes part in firing it, some growth process or metabolic change takes place in one or both cells => increased efficiency in firing the other cell => Hebbian plasticity, later confirmed with the discovery of LTP/LTD, which is a kind of Spike-Timing dependent plasticity (now used for rehabilitation)
            - Hebbian rule: neurons that fire together, wire together
            - LTP corroborated this quote
        - reverberation: the brain has a reverberating system where the units…….
            -
        - cell assembly: reverberating system capable of holding an excitation and thus of bridging a gap in time between stimuli and responses, a

serial order of assemblies provides the neural basis for a train of thought => bridge between neurophysiology and the molar conceptions of psychology: relates individual neurons to psychological phenomena (e.g. learning and memory)

- a serial order of inter-connected cell assemblies provides the neural basis for a “train of thought” from one cell assembly to another

- Lashley
  - coined the term “Neuropsychology”
  - father of Holism, theorized the law of integration=the whole is more than the sum of its parts
    - the interaction of different brain areas lead to different functions→ beyond associationism
    - the organization of the brain is a relational framework in which specific reactions can happen; interaction of components leads to functions that can be implemented by the brain as a
    - whole
  - empirical model, called training/ablation method=trained rats in navigating a labyrinth through trials and errors, then using systematic lesions of cortical tissue to see if the rats forgot the acquired memories of location
    - forgetting dependent on the amount of the brain tissue, not on the region→ law of mass action=memory is not localised, but distributed across the cortex
      - higher functions are distributed
    - a functional deficit following lesion of part of the cortex is related more to the amount than location of lesion (in association cortex)
    - be careful: we can use the volume of brain lesion as a regressor of no interest in our statistical analysis
      - to demonstrate the localization of a function with a lesion study, it’s mandatory to exclude the effect of the total volume of damage (covariation)
  - criticism
    - maze task is complex and requires many functions (not just memory) and brain areas (task impurity issue)
    - lesioning large sections at one time affect various functions
      - no actual proof of holism or against localizationism/connectionism
  - law of equipotentiality=any part of a functional area of the brain can perform the function associated with the area
    - principle for recovery of function: a part of the area can perform the function even if all the region is damaged
      - if a part of the brain is damaged, an intact part within that same functional area can take over its function
      - all cortical areas can substitute in sustaining learning
    - taking vicariously the functions of other areas if damaged
    - criticism

        - explainable by plasticity, which has limits: extremely large lesions cannot be recovered from
        - not compatible with cases as HM (he never recovered the functions, even though other parts were spared)
            - too old
        - in contrast with diaschisis
- Criticism against holism
    - Sperry: studied split-brain models in animals and humans => the two hemispheres do different things (against holism)
        - used the resection of CC as a treatment for drug-resistant epilepsy and proved that the hemispheres can function independently
        - left = interpreter: understanding the outside reality and making sense of it, right = visuo-spatial functions => against the laws of mass action and equipotentiality.
    - Irle: the localisation matters on the type of lesion: some improved performances (hypothesised disrupted reciprocal inhibition network, at time improvement proportional to lesion dimension => paradoxical functioning
        - some lesions led to (apparently paradoxically) improved performance, perhaps based on reciprocally inhibitory networks, sometimes with larger size leading to better performance
    - Duncan: observed a system of frontal and parietal regions, called the Multiple Demands System (MDS), which is active for complex, multi-component behaviour
        - in all realistic behaviour goals are achieved by assembling a sequence of subtasks, which are separately defined and solved: the problem is not only to control isolated steps of thought or behaviour, but to organise a task into its sub-components
        - identified common pattern of brain activation in response to many cognitive challenges
            - similar to the task positive network model=this region is activated for challenging tasks with a high attentional demand, complementary to the DMN
        - evidence for multiple demand system
            - neuropsychology and animal lesion studies: frontal lesion = disruption of the structure of complex behaviour (omission of relevant components, insertion of irrelevant ones, unfulfilled goals) => disorganisation of functions
            - neuroimaging: lesions in fronto-parietal regions cause problems with fluid intelligence, lesions outside don't
            - single unit recordings in animals: the network is activated for all high-demanding tasks, independently from the specific kind of tasks
                - Freedman: monkeys learned to distinguish cats, dogs and morphs of the two (with different %), they recorded fire rates of single neurons in prefrontal cortex
                    - some became very selective in the category selected, even very similar images were

extremely categorised: decision-making neurons could discriminate the exemplars
    - then the monkey relearned a classification, having to forget the past one
        - some similar neurons that were able to discriminate the previous categories, were now able to discriminate the new ones→ very flexible in learning new associations
- frontal activation foci from different tasks involving
    - response conflict
    - task novelty
    - number of elements in working memory
    - working memory delay
    - perceptual difficulty