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Highlights:

Key words (light green 1)
Experiments (light red 1)
Other relevant stuff (light blue 1)
Perspectivation to other chapters (light yellow 1)
Perspectivation to our experiment (light magenda 1)

Chapter 1 - Introduction and basic neurophysiology

Literature: Gazzaniga et al p. 1-39

Overview of central figures

- Willis • Petty • Wren • Green • Gall • Flourens • Jackson • Wernicke • Broca • FritschandHitzig • Brodmann • Golgi • Cajal • Purkinje • Helmholz

· Franz Joseph Gall -> pheronology
· Willias -> Anna, killed child, hanged ->
· Jackson -> Topographic mappaing (Seizures in epileptic) -> Stimulate
· Broca -> Tan
· Wernicke -> Meaning
· Flourens -> **aggregate eld theory ->** Brain is a unitary system
· Brodmann -> Areas do stuff (52) -> Nissl stain -> Cytoearchitecture
· Golgi had believed that the whole brain was a **syncytium**, a continuous mass of tissue that shares a common cytoplasm.

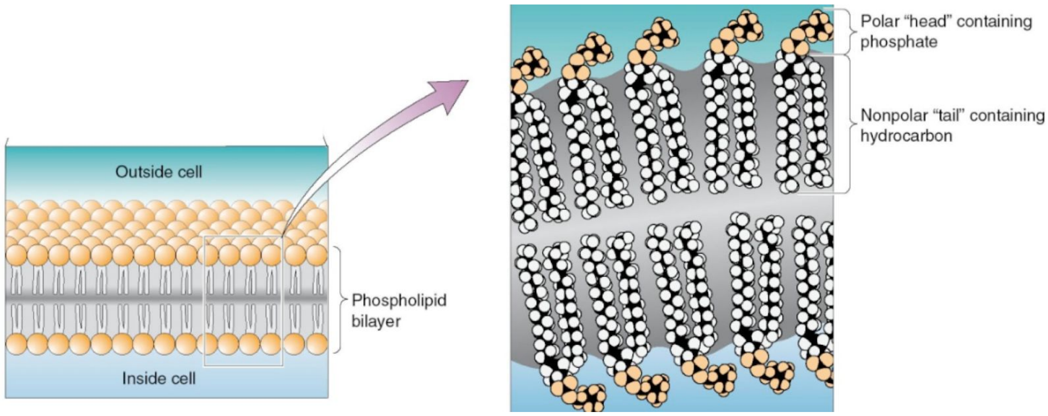
· Ramón Cajal -> neural doctrine -> Signal goes one way

  o Purkinje described first neuron in 1837 -> CEREBELLUM

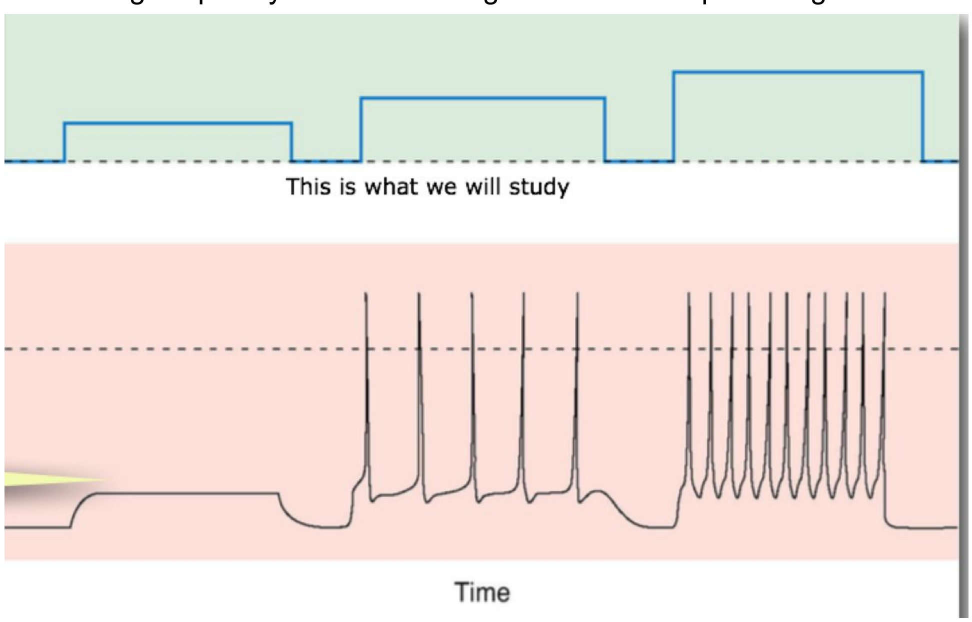
· Nissl violet stain (The soma takes up the dye (Not the dendrites etc.))
  o Layered coretc
· Intro, gestalt, throndike and skinner, Hepp and Miller (fire together – magical number 7)
  o Chomsky and language + Computer science

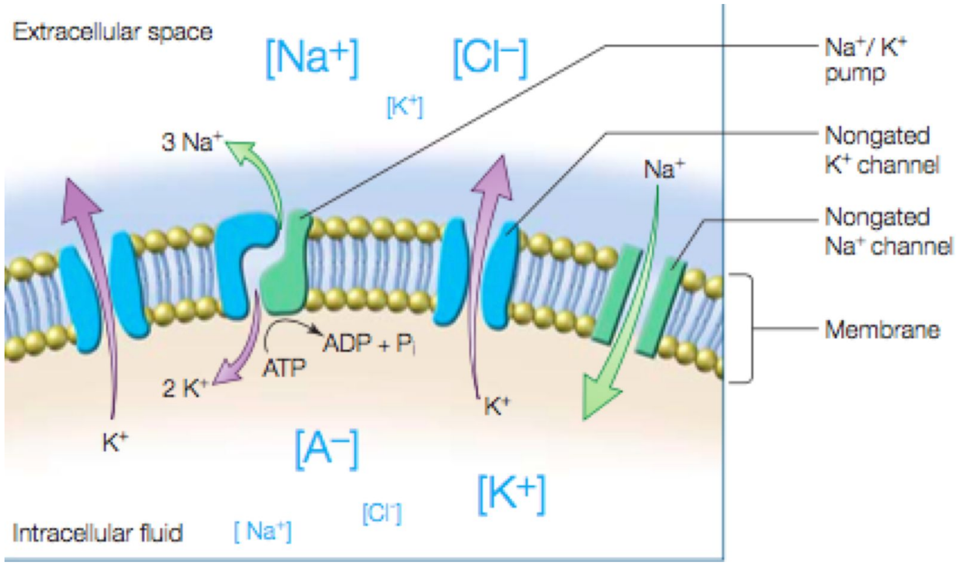
- Reflect today: **"small-world architecture,"** which is common to many complex sys- tems, including human social relations. This type of organizational structure combines many short fast local connections with a few long distance ones to communicate the results of the local processing. It also has the advantage that a smaller number of steps connect any two processing units. This design allows both a high degree of local ef ciency and at the same time, quick communication to the global network.

- **Cell -> Defectivetransmissionis the basis for many neurological and potentially psychiatric disorders.**
  - phospholipid bi-layered membrane (Whole idea with neurons) – 70 resting potential
    • Hydrophilic compounds • Dissolve in water due to uneven electrical charge (e.g., salt)
    • Hydrophobic compounds • Do not dissolve in water due to even electrical charge (e.g., oil)
    • Lipids are hydrophobic (i.e. insulating). • Contribute to resting and action potentials

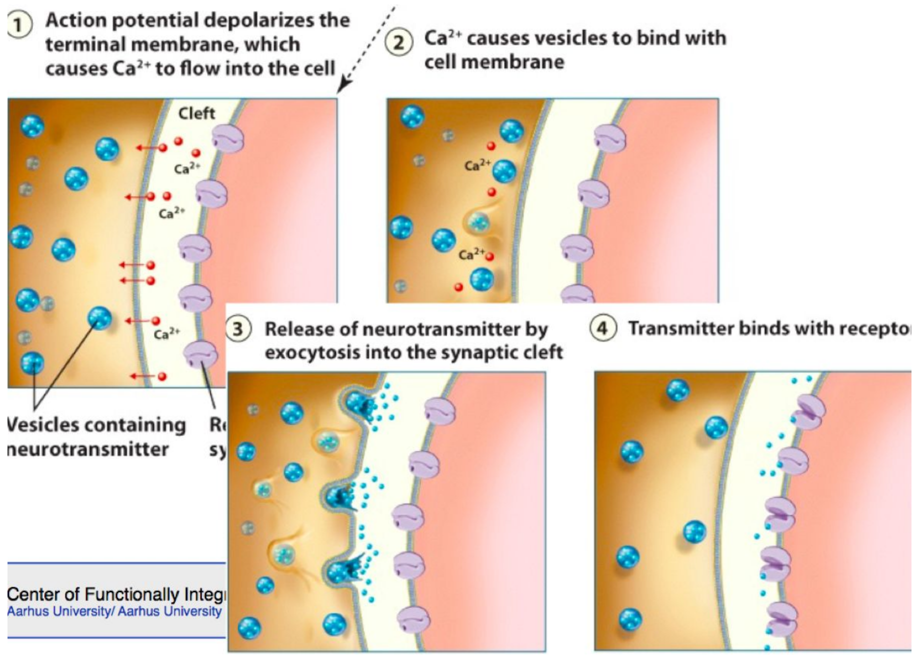


- Propagation of the action potential – Orthodromic:actionpotentialtravelsinonedirection
- – down axon to the axon terminal
- – This is due to there fractory period – Typical conduction velocity: 10m/sec – Typical length of action potential: ~2msec
    - § Not the speed of light
        - · Hurting foot - takes approx. 0.5 sec to be experienced
- Firing frequency reflects the magnitude of the depolarizing current.





- K+ more concentrated on inside, Na+ and Ca2+ more concentrated outside
- Permeability towards equilibrium (-70mv)
- The sodium-potassium pump
  - An enzyme that breaks down ATP when sodium (Na) is present
  - For each ATP three Na+ ions are moved out and tow K+ are moved in
- We need a continuous pump of ions in and out of the membrane to have to hold the electrical potential - potasium in, natrium out
  - Nongated channels works agaisnst this
- Electrical synapse: Not the most common, But important since it is much faster than chemical synpases
  - Gap junctions are also involved in the synchronization and rhythmic oscillation of hippocampal and neocortical neuronal ensembles
    - – may be important for memory formation and consolidation
- **Chemical synapse**
  - Neurotransmitter synthesis
  - Load neurotransmitter into synaptic vesicles
  - Vesicles fuse to presynaptic terminal
  - Neurotransmitter spills into synaptic cleft
  - Binds to postsynaptic receptors
  - Biochemical/electrical response elicited in postsynaptic cell
  - Removal of neurotransmitter from synaptic cleft
    - Most often taken back up into the button
    - If you wan (Antidepresive SSRI drugs), binds to the reuptake process
    - Makes sure serotonin is not taken back up, but eft for the postsynapse
    - Postsynapse would probarbly continiously depolarized
    - adaptation - postsynaptic neuron might kill of receptors



- These postsynaptic potentials can be either excitatory (depolarizing the membrane), as shown here, or inhibitory (hyperpolarizing the membrane)
- The individual set of receptors on a cell sets

Types of CNS Synapses
• Axodendritic: axon to dendrite (a)
• Axosomatic: axon to cell body (b)
• Axoaxonic: axon to axon (c)

- **Transmitter**
  - The difference between hormones and neurotransmitters is wether they are in the blood or in the synapses'

Table 5.1 The Major Neurotransmitters

AMINO ACIDS	AMINES	PEPTIDES
Gamma-aminobutyric acid (GABA)	Acetylcholine (ACh)	Cholecystokinin (CCK)
Glutamate (Glu)	Dopamine (DA)	Dynorphin
Glycine (Gly)	Epinephrine = Adrenaline	Enkephalins (Enk)
	Histamine	N-acetylaspartylglutamate (NAAG)
	Norepinephrine (NE)	Neuropeptide Y
	Serotonin (5-HT)	Somatostatin
		Substance P
		Thyrotropin-releasing hormone
		Vasoactive intestinal polypeptide (VIP)

  - Amino acids: small organic molecules—vesicles
  - • Amines: small organic molecules—vesicles
  - • Peptides: short amino acid chains (proteins)— secretory granules
    - Conditional transmitters - excitatory neurotransmitter can be the gatewaydrug for an influx of inhibitory transmitters
- **Action potential**
  - Threshold -55mlv – all or nothing – Whole soma -> Axon hillock

        - Influx of Na+
    - Charge down the axox -> nodes of ranvier
    - Hyperpolarization -> -80mlv -> voltage-gated NA+ pump doesn't work
- Glial – Cellmembrane wrapped around
    - Oligodendrocytes myelinate axons in the brain and spinal cord.
    - Schwann cells myelinate axons in the periphery of the body.
        - Node of ranvier -> axonal membrane is exposed
    - Microglial – removing damaged cells
- Astrocytes and pericytes supervise metabolic needs and control blood flow
    - Most numerous glial in brain
- Pericytes
    - regulate capillary blood flow,
    - the clearance and phagocytosis of cellular debris
    - and the permeability of the blood–brain barrier

    - Concl.
        - Information is represented (memorised) as – Short-term: Changes in membrane potentials
            - "Analog"indendrites(continuouschanges)
            - "Digital"intheactionpotential(abruptspikes)
        - Long-term: Membrane "changability" (receptor types and numbers)
        - Very long-term: Glia support and insulation (oligodendrocytes)

Chapter 1:

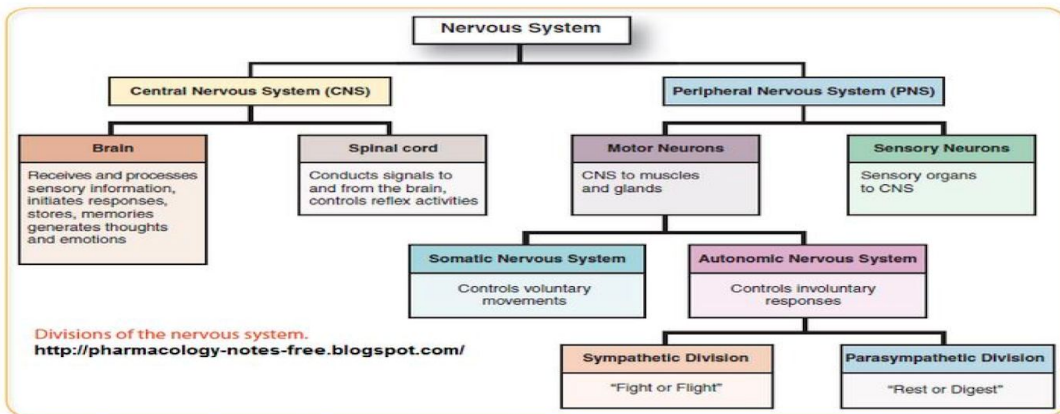
- Thomas Willis
    - Anne Green hanging → got the dead -> she survived
    - Specific brain damage → specific behavioral deficits
- Franz Goseph Gall
    - Organize brain into 35 specific functions located in the cerebral cortex
    - The part of the brain used will grow → phrenology → feel head to understand person
    - Napoleon does not believe it → Bad reading
- Marie-Jean-Pierre Flourens
    - Certain parts of the brain responsible for certain functions
    - Removed the cerebral hemispheres in animals → no perception, motor ability or judgment
    - Aggregate field theory = whole brain participates in behaviour
- Paul Broca & Carl Wernicke
    - Tan → lesion in the left hemisphere = Broca's area
        - Specific aspect of language impaired by specific lesion
    - Wernicke's area = lesion in a more posterior part of the left hemisphere
        - Talk freely, did not make sense, no understanding of language

- Brodmann & Franz Nissl
    - Brodmann: 52 distinct regions
    - Nissl: tissue stains → visualize different cell types in different regions
        - Cytoarchitectonics = how cells differ between brain regions
- Golgi & Purkinje
    - Neuron doctrine = the nervous system is made up of individual cells
        - The silver method for staining neurons → impregnated individual neurons
    - The first nervous cell described by Purkinje
- Experimental psychology
    - Associationism: Thorndike → Law of effect
    - Behaviorism: reward = habitual response (cannot explain language = innate)
    - Computationalism: digit span = limit to information processed at a time
- Related to our experiment
    - One area specific to recognizing faces → Fusiform gyrus
    - Prosopagnosia = deficit in recognizing faces → specific deficit causing specific behavior (Willis)

Chapter 2 - A guided tour of the human brain

Literature: Gazzaniga et al p. 40-69

- The brain is an organ like the heart.
- The brain may host several "organs" in one. (Modules)
-



- Neural Circuit like Knee-Jerk
- Neural Systems (Hiracical parrellel processing systems)
  - E.g. retinogeniculostriate circuit that brings information om the eye to the visual cortex is part of a system
- The brain
  - Ventral: Towards the belly
  - Dorsal: Towards the back
  - Rostral: Towards the beak
  - Caudal: Towards the tail
  - Axial (ear to ear through eyes) Coronal (Ear to ear ventral/dorsal), Sagital (mid)
  - Cerebellum vs cortex (80/20 vs. 10/80 -> neurons vs. Mass) cotex vs. subcortical
  - Commisure
    - § Tracts between hemispheres (Biggest is Corpus Callosum)
  - Ventricles
    - § Cusioning similar to in a running shoe
    - § Good to see in fMRI
    - § Liquid from neural tube
    - § Get hormones and waist out of the system
  - Spinal Cord
    - § Ventral part (towards the belly) conducts the final motor signals to the muscles

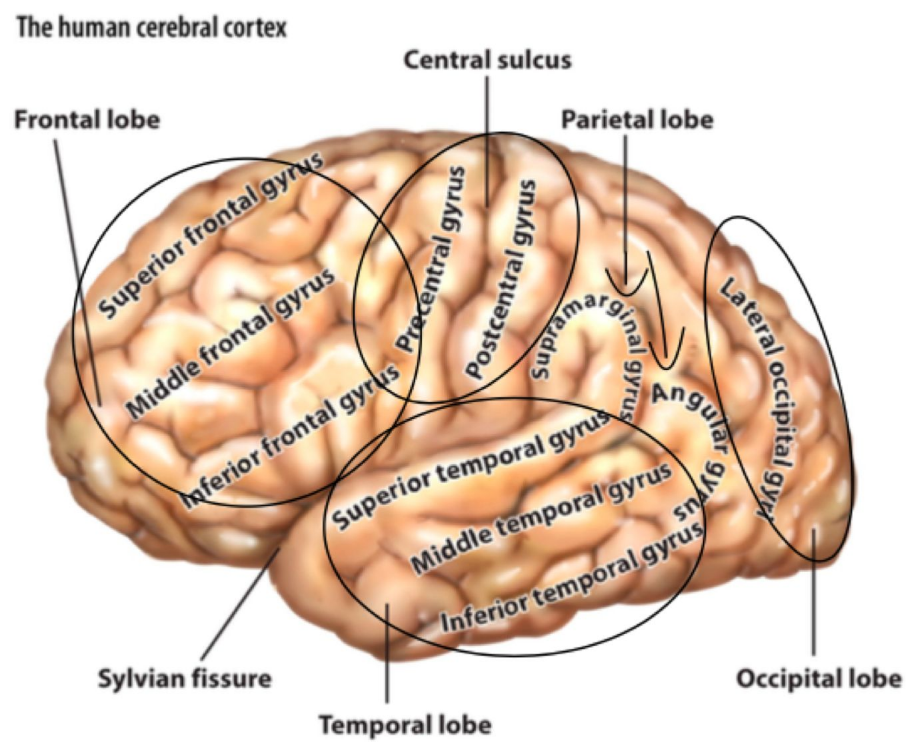
    - Dorsal part relays sensory information from the body's peripheral receptors to the brain.
    - Interneurons are relays for the brain – but also have sensory neurons that can react (e.g. knee jerk)
- Brainstem
    - Fiber house up and down - highway
        - Tecum (upper part) Relaystation for optics and audits
    - Sensory and motor processes gets carried out
    - Tegmentum
        - includes several nuclei, e.g.
        - reward circuit" with dopamine.
- Pons
    - Bridge between cortex and cerebellum
- Medulla
    - Hearth-rate, respiration, digestion, facial-muscles
    - Muscles axons cross (Right/Left hemispherical divition)
- Mid-brain
    - Supperior colliculus
        - Visual reflexes guided by perception of perifery
    - Inferior colliculus
        - Auditotry reflexes
- Cerebellum
    - Girl without - functioning A-OK
    - Bodys position in the world – Integrated information about the body
    - Boston dynamics
    - Corrections and movements are send in and out of our body simulator -> goals come in from the cortex
- Thalamus
    - Relaystation (Gateway to cortex)
    - Geniculate – Ganglion cells
        - Gets signals and relays to the important part of the neurocortex
- Hypthalamus
    - Main link between indocrine system and nervoussystem
    - Secretion of Hormones (Peturitary gland)
        - controls secretion of hormones by the anterior pituitary gland.
        - Facilitates secretion of two hormones, antidiuretic hormone and oxytocin, which are released at the posterior pituitary.
    - Circ. Rhytm andTemperature
- Limbic System

- §

- § Papez circuit -> Limbic system
- § Basal Ganglia – dopaminergic system

o cortex

- §



o Topographic correspondence – somatosensory and motorprocesses

o Sensory and association cortices

- § We really don't know what they are doing

o Two main arteries

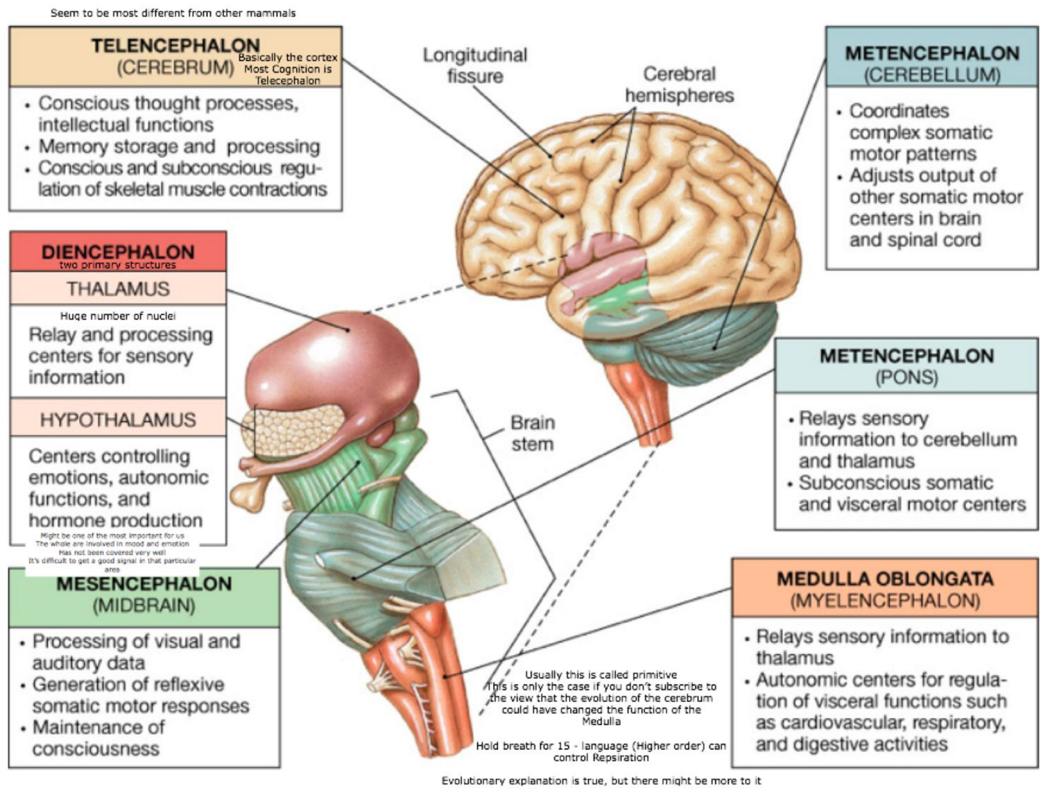
- § Split out at the circle of Willis

o

• Brains

o All have the cerebellum, the midline etc.

o Same plan, different sizes



- We're often told that our brain is special with the biggest prefrontal cortex - But it's actually not special - It's just a scaled version of the mamalian brain

GOTTLIEB'S (1992) DIFFERENT VIEWS OF DEVELOPMENT

Predetermined development:

Genes → Brain structure → Brain function → Experience

Probabilistic development:

Genes ⟷ Brain structure ⟷ Brain function ⟷ Experience

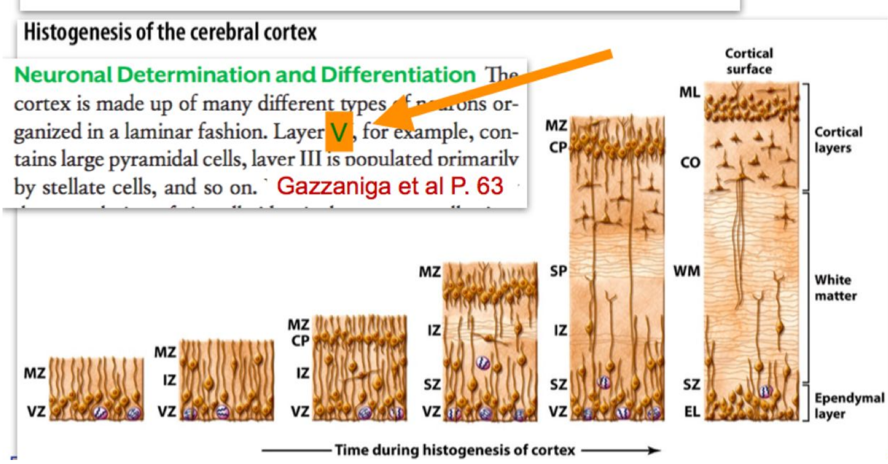
Ward 3rd ed. p. 410

- Epigenetics is the study, within genetics, of cellular and physiological phenotypic trait variations that are caused by external or environmental factors that switch genes on and off and affect how cells read genes instead of being caused by changes in the DNA sequence (Wikipedia)
- Ontogenisis
  - already after a few days of gestation, the embryo has developed into a disk-like structure with three distinct layers:
  - Ventrally is the *endoderm*, which ultimately gives rise to many of the internal organs, such as digestive system

- In the middle is the *mesoderm,* which gives rise to the skeleton and the muscles
- And dorsally is the *ectoderm*, from which the skin and all nerves are created.

- After 18 days the ectoderm begins to thicken, and the *neural plate* develops. A few days later a groove is created, as the neural plate begins to fold. Subsequently the folds fuse dorsally, forming the *neural tube*. The entire CNS is created from the walls of this tube, and the hollow inside becomes the fluid-filled ventricles.
- In the rostral end of the neural tube, three swellings occur:
  - - Proscencephalon or forebrain - Mesencephalon or midbrain - Rhombencephalon or hindbrain
  - The whole brain derives from these three primary vesicles
- The procencephalon differentiates into the *diencephalon,* the two *telencephalic vesicles* (which turn into the *cerebral hemispheres*) and the *optic vesicles* (which turns into the eyes). Later the *olfactory bulbs* (related to the sense of smell) sprout off the ventral surfaces of the two cerebral hemispheres.
- The diencephalon differentiates into the *thalamus* (through which almost all information in the brain pass) and the *hypothalamus* (involved in hormonal control of body and brain).
- The telencephalon differentiates into *cerebral cortex* and *cortical white matter.*

FIGURE 2.40 Histogenesis of the cerebral cortex.
Cross-sectional views of developing cerebral cortex at early (**left**) and late (**right**) times during histogenesis. The mammalian cortex develops from the inside out as cells in the ventricular zone (VZ) divide, and some of the cells migrate to the appropriate layer in the cortex. Radial glial cells form a superhighway along which the migrating cells travel en route to the cortex. CO = cortex; CP = cortical plate; EL = ependymal layer; IZ = intermediate zone; ML = molecular layer; MZ = marginal zone; SP = subplate; SZ = subventricular zone; WM = white matter.



- 6 layers – but only pyramidal cells in 5
- radial glial cells makes neurons migrate. Inside out throughout the cortex

- Afterwards the glial cells become oligodendrocytes

Protomap and Protocortex Theories

Magic? - a typical Mikkel comment

How do neurons in different parts of the brain develop specializations, in terms of what they connect to?

Radial unit hypothesis/Protomap (e.g. Rakic): regional layout is specified prenatally, with little role of experience

E.g. concentration of molecular signals determines whether a neuron has frontal or parietal characteristics

Protocortex (e.g. O'Leary): sensory experience via thalamus important for determining specialization of cortex

E.g. somatosensory cortex transplanted into visual area of rat behaves like visual cortex

Brain development likely to involve a combination of these factors

Mikkel theorizing:
The structure in itself might code for the structure (More than DNA on itself - eg. the sun for a plant. - The environment of a sun will guide the development as well)
Cells created together might influence each other and cluster naturally, with help from other environmental factors
- There's not room enough in the DNA to write the brain out

Everybody walks out the room - You'll probably get up and do the same
Maybe neurons form kind a in the same way
There's probably a lot more information in the environment than previously thought

lot's of plasticity
People born blind - will later show activation in the visual cortex
When reading with their fingers on writing plates
Might be the small world networks that plays a role in this specialising

Gazzaniga et al. p. 64, Ward 3rd ed. p. 408

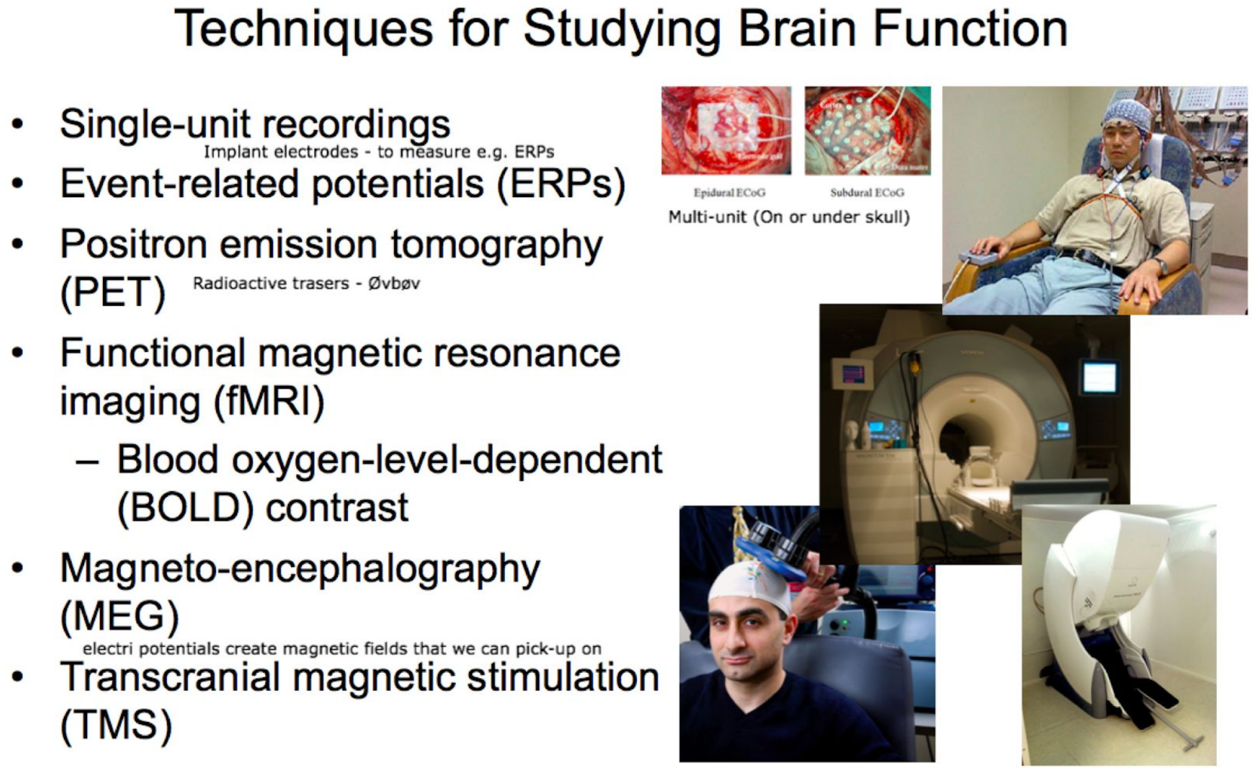
-
- Neurogenesis in adult mammals has now b n well es- tablished in o brain regions: the hippocampus and the olfactory bulb.

Gazzaniga's take-home messages

- The nervous system develops from the ectoderm, which forms a neural plate. The neural plate becomes the neural groove and eventually the neural tube.
- Neuronal proliferation is the process of cell division in the developing embryo and fetus. It is responsible for populating the nervous system with neurons.
- Neurons and glial cells are formed from precursor cells. After mitosis, these cells migrate along the radial glial cells to the developing cortex.
- The type of cell that is made (e.g., a stellate or pyramidal cell) appears to be based on when the cell is born (genesis) rather than when it begins to migrate.
- The radial unit hypothesis states that the columnar organization in the adult cortex is derived during development from cells that divide in the ventricular region.
- A belief strongly held by most neuroscientists was that the adult brain produces no new neurons. We now know that this is not the case; new neurons form throughout life in certain brain regions.
- Synaptogenesis is the birth of new synapses; neurogenesis is the birth of new neurons.

Chapter 3 - Methods of Cognitive Neuroscience with focus on fMRI

Literature: Gazzaniga et al p. 70-119 + Amaro and Barker 2006

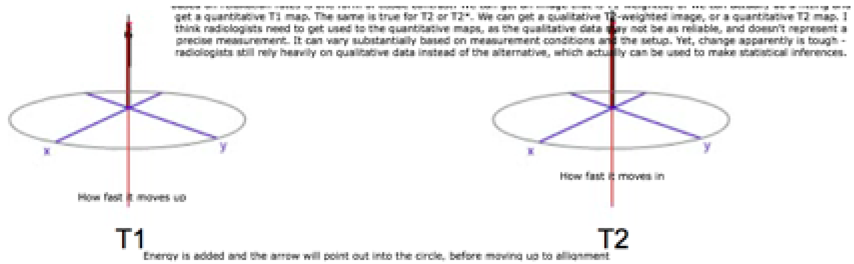


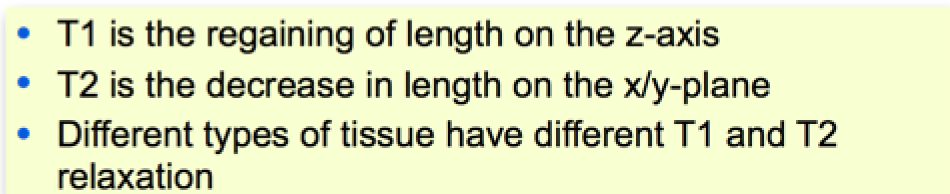
“Albert Gede (Head of CFINN before it was called CFINN), said that we look under the streetlight when we lost our key on our way home, not because we know it’s there, but because it’s where
we’re able to look”

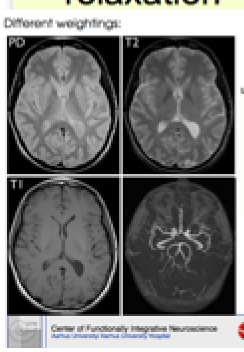
Fmri -> God introduction I amaro 2006 additional reading

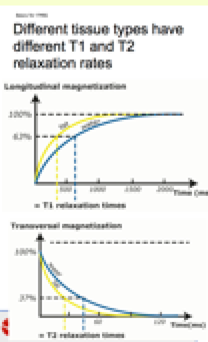
· “The MR imaging method most often used to produce information related to brain function is called BOLD (blood oxygenation level dependent) contrast imaging. This method is based on MR images made sensitive to changes in the state of oxygenation of the hemoglobin (Ogawa, Lee, Nayak, & Glynn, 1990). This molecule has diVerent magnetic properties depending on the concentration of O2; when it is fully satu- rated with oxygen (oxyhemoglobin) it behaves as a diamag- netic substance, while when some oxygen atoms have been removed (deoxyhemoglobin) it becomes paramagnetic. Within any particular imaging voxel (representing a small part of the brain) the proportion of deoxyhemoglobin rela- tive to oxyhemoglobin dictates how the MR signal will behave in a BOLD image: areas with high concentration of oxyhemoglobin give a higher signal (a brighter image) than areas with low concentration.

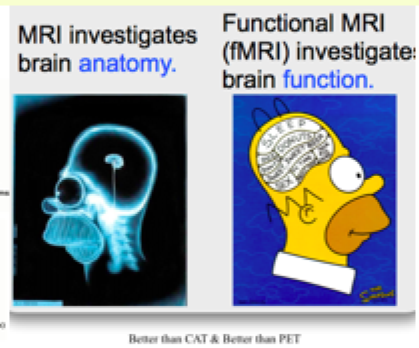
- More water -> More hydrogen -> More protons to align and emit RF-waves



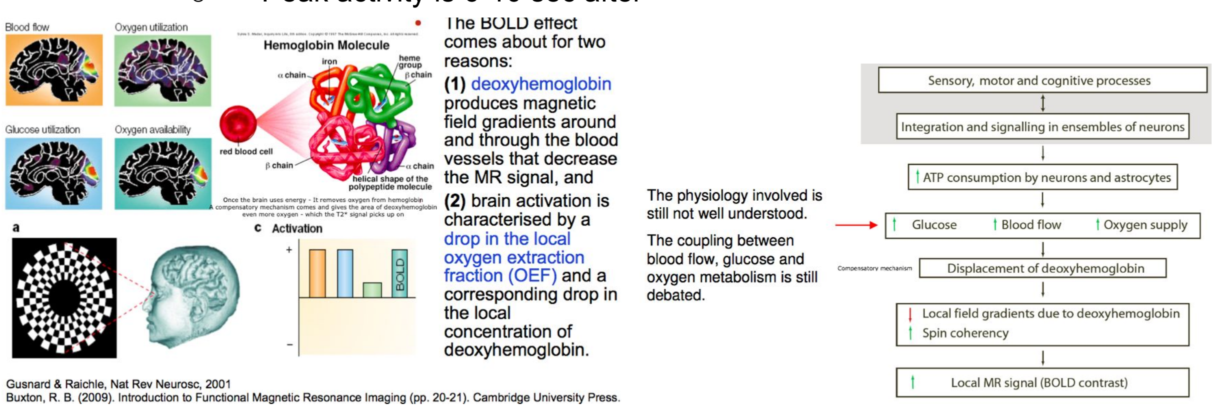
- 

- 



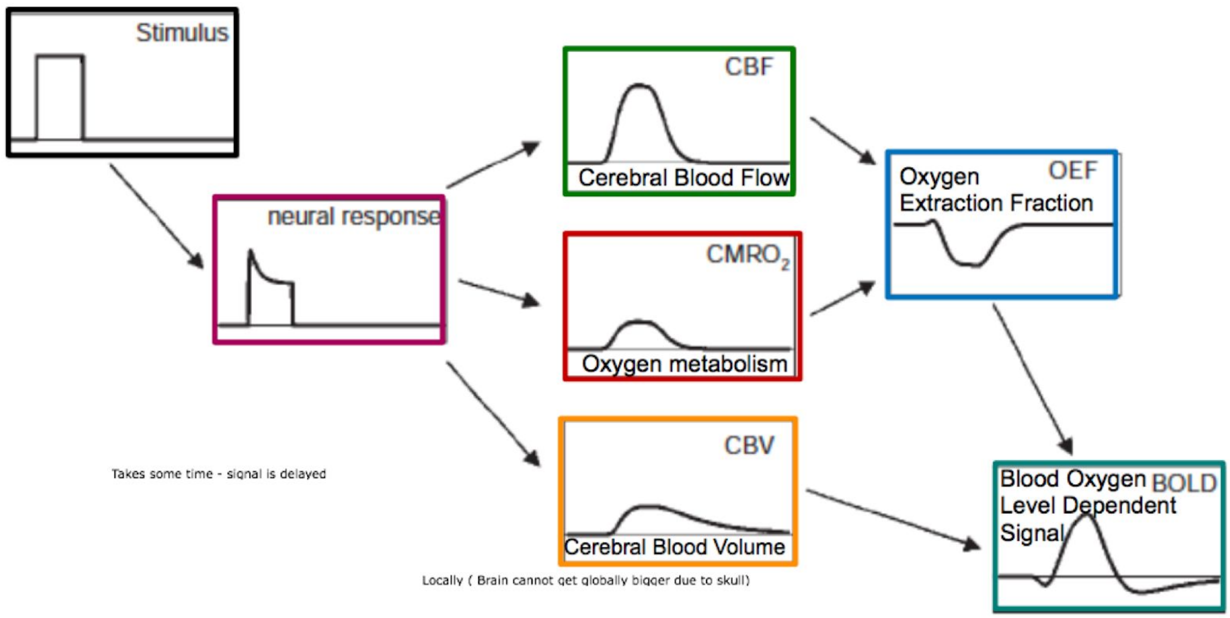


-
    - cerebrospinalfluid grey matter white matter – Different magnetic properties
- How can we measure brain activity with MR?
    - We cannot!
    - But perhaps we can measure a correlate of activity!
- BOLD effect = Blood Oxygen level-dependent
    - The BOLD signal has a significant delay relative to stimulus onset and onset of neural spiking. In the order of (3-5) seconds.
    - Peak activity is 6-10 sec after



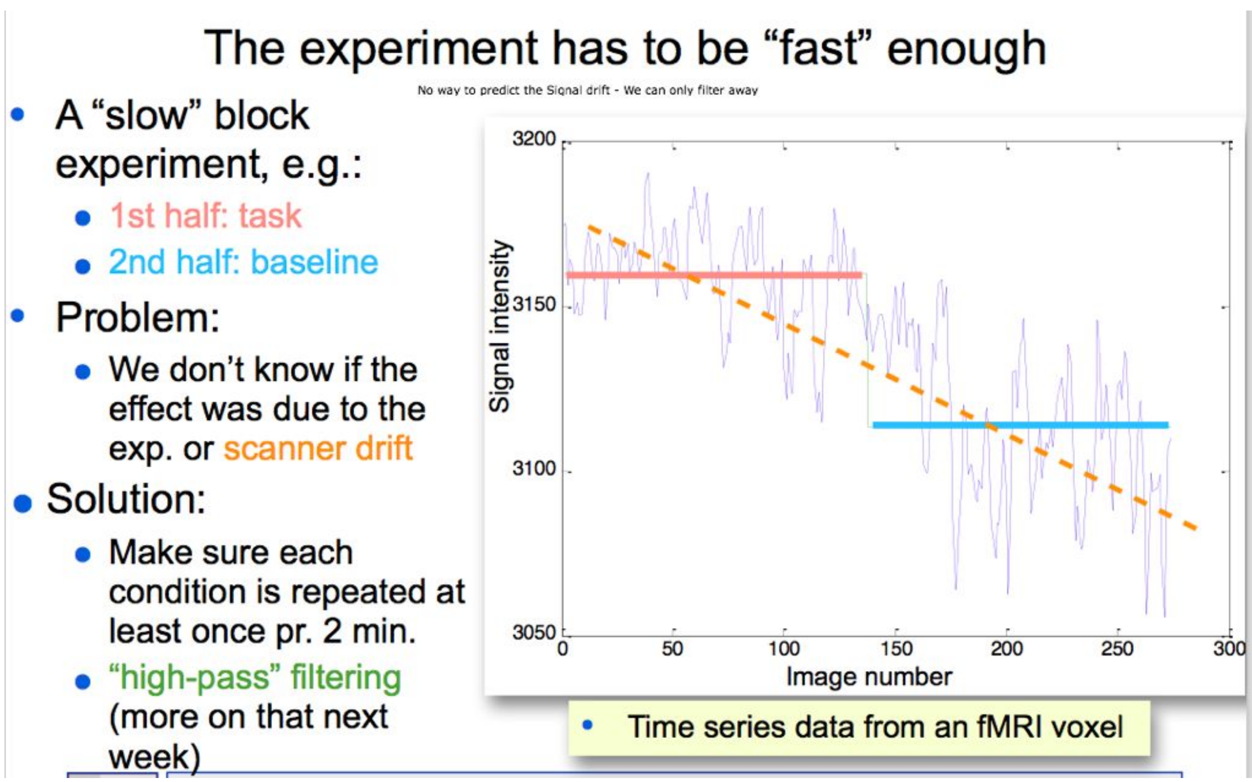
- De-Ox Blood and Ox Blood have different magnetic propertie

·



· **IMPORTANT TO POINT OUT:**

·



- Talk about event related and block design (Blood either stays in the area or drops.)
- Highpass & Lowpass filters
- In our study attention, brain adaptation, might drop, but for all conditions – so no worries

Important

- T1 & T2 -> <tissue type
- RF & different TxLength -> Placement in slices
- Amount of blood -> Amount of protons -> Amount of activity
- Paramagnetism (Deoxygenated blood) = Weakly alligns to Grand magnetic field
- Diamagnetism (Oxygenated blood) = Alligns stronger towards opposite direction of applied magnetic field

· **Positron emission tomography (PET)** measures metabolic activity in the brain by monitoring the distribution of a radioactive tracer.
  - A substance is labelled with a radioactive isotope of some sort
  - It is injected into the bloodstream or inhaled.
  - The substance enters the brain.
  - It emits a positron.
  - This positron meets with a negatively charged electron. They merge, and gamma radiation is released ➢ This radiation can be picked up by the scanner and be used to tell where the substance went

· fMRI replaced this technique
  - The PET scanner measures the photons that are produced during decay of the tracer. A popular tracer is 15O (unstable form of oxygen) because it decays rapidly and the distribution of oxygen increases to neural regions that are active.
  - Downsides: • Radioactive tracers (limited exposure) • Poor temporal resolution • Expensive
  - Pittsburgh Compound B (PiB) is a tracer that binds to beta-amyloid and is used as an in vivo assay (prøve) of the presence of this biomarker for Alzheimer's disease.

· Analysing Brain scans
  - like fingerprints, no two brains are exactly the same.
  - predictable relationship to the horizontal planes running through the anterior and posterior commissures, two large white matter tracts connecting the two cerebral hemispheres.
  - Each voxel was given a 3-D **Talairach coordinate (3-dimensional coordinate system (known as an 'atlas') of the human brain)** in relation to the anterior commissure,

- Optogenetics (Using Light to Manipulate Neuronal Activit)
- TMS -> Temporary lessions
- Lesions
  - Single dissociations:
  - • If a patient is impaired on a particular task (task A) but relatively spared on task B then this is referred to as a single dissociation.
  - Double dissociations:

        - • If one patient is impaired on a particular task (task A) but relatively spared on task B and another patient is impaired on task B, but relatively spared on task A then this is called a double dissociation.
- ▪ Brain lesions, either naturally occurring (in humans) or experimentally derived (in animals), allow experimenters to test hypotheses concerning the functional role of the damaged brain region.
  ▪ Cerebral vascular accidents, or strokes, occur when blood flow to the brain is suddenly disrupted. Angiography is used to evaluate the circulatory system in the brain.
  ▪ Tumors can cause neurological symptoms either by damaging neural tissue or by producing abnormal pressure on spared cortex and cutting off its blood supply.
  ▪ Degenerative disorders include Huntington's disease, Parkinson's disease, Alzheimer's disease, and AIDS-related dementia.
  ▪ Neurological trauma can result in damage at the site of the blow (coup) or at the site opposite the blow because

Chapter 4 - Hemispheric Specialization

Literature: Gazzaniga et al p. 120-161

Brocas:

- Sara Scott the highschool - Broca's aphasia
    - You can track her progress in regaining her abilities
        - Interesting since it indicates that the rest of the brain can neuroplasticly change to accomodate a condition like Sarahs
    - 90% of Aphasis sufferes have a stroke in their left hemisphere -> But some get it from strokes in the right hemisphere -> How is that?
    - Controversial data (Mikkel fights these kinda studies) -> Sex differences <-> Though we see no real differences
    - There's no effect of handedness

Wadatest

- injection of amobarbital - Anestisia
- Rapid and brief anesthesia of the ipsilateral hemisphere (i.e., the hemisphere on the same side as the injection; Figure 4.4). en the patient is engaged in a series of tests related to language and memory. e Wada test has consistently revealed a strong bias for language lateralization to the le hemisphere

- Face expressions
    - Both hemispheres can generate spontaneous facial expressions, but you need your left hemisphere to produce voluntary facial expressions.
    - People appear to have two neural systems for controlling facial expressions
    - Left hemispheres active facial expressions will come a bit before in the right side

Visual system lateralized

Structural Differences

- But beware: Brains look very different -> Remember that our Gyri has different folds and sizes

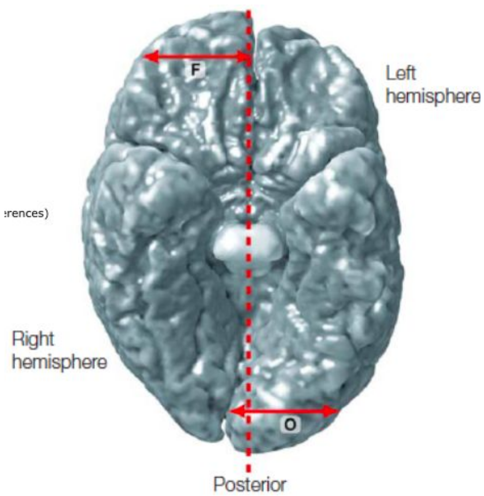


FIGURE 4.5 Anatomical asymmetries between the two cerebral hemispheres.
View looking at the inferior surface of the brain; note that the left hemisphere appears on the right side of the image. In this computer-generated reconstruction, the anatomical asymmetries have been exaggerated.

- Geschwind & Letitsky studied 100 brains post-mortem
    - planum temporale , located posterior to primary auditory cortex (Wernicke's area)
    - • 65% had bigger left planum temporale • 24% were symmetric • 11% had bigger right planum temporale
    - These numbers still hold up, pretty well. But there has been 100s of thoutands studies on this the last few decades - So you'll be able to find the data you want
- Dyslexia may stem from a lack of specialised hemisphere.
    - Symmetry across hemispheres
- Corpus callosum
    - Women seem to be a greater Corpus Callosum in relation to brain size

- Posterior part of the cerebrum, anterior part of frontal lobes etc. connected symetrical parts of the hemisphere - soooo different stuff hanppens when you cut different parts
  - Heterotopic fibers connect different areas (e.g., V1 on the right to V2 on the left).
  - Homotopic fibers connect the corresponding regions of each hemisphere (e.g., V1 on the right to V1 on the left)
  - Ipsilateral connections -> Same hemisphere
- Split brain
    - Splitbrain patients often have uncurable epilepsi
    - So our patients are already strange in some sense
      - EEG measures of a seizure - Like an upredictable earthquake
      - Dangerous procedure -> Next to ventricles (Gooey stuff into cortex + fucks circulatory system)
  - Posterior Commisure contains fibers that contribute to he papillary light reflex.
  - Anterior Commisure connects regions of the temporal lobes, including the amygdalae.
    - These are partly intact in splitbrain patients

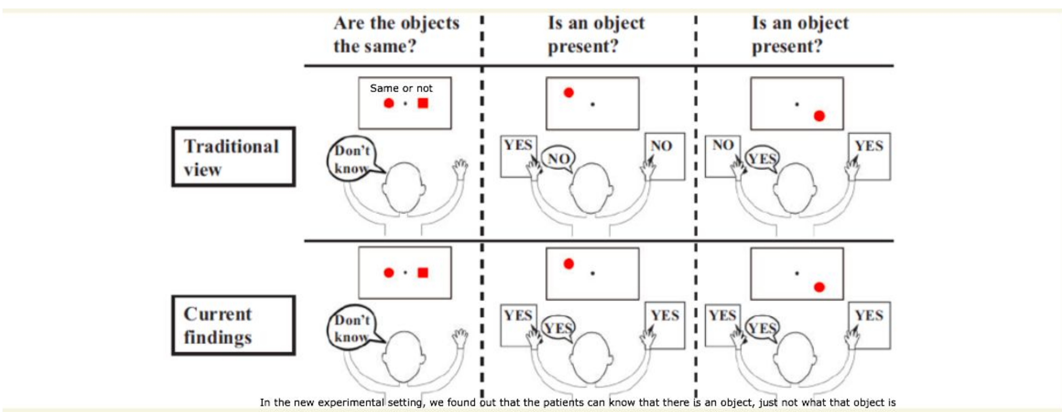


Figure 1 A depiction of the traditional view of the split brain syndrome (*top*) versus what we actually found in two split-brain patients across a wide variety of tasks (*bottom*). The canonical idea of split-brain patients is that they cannot compare stimuli across visual half-fields (*left*), because visual processing is not integrated across hemispheres. This is what we found as well. However, another key element of the traditional view is that split-brain patients can only respond accurately to stimuli in the left visual field with their left hand and to stimuli in the right visual field with their right hand and verbally. This is not what we found. Across a wide variety of tasks, we observed that split-brain patients could reliably indicate presence, location, orientation and identity of stimuli throughout the entire visual field regardless of how they responded.

- Pinto, Y., Neville, D. A., Otten, M., Corballis, P. M., Lamme, V. A. F., de Haan, E. H. F., et al. (2017). Split brain: divided perception but undivided consciousness. *Brain,* http://doi.org/10.1093/brain/aww358

- 

- There is a bias in the scientific review process to publish papers that find significant differences over papers that report no differences.
  - The effects are small and inconsistent,
  - Interpretation is problematic. What can be inferred from an observed asymmetry in performance with lateralized stimuli?
  - In the preceding examples (See slides), the advantages of the right visual field and the right ear were assumed to reflect that these inputs had better access to the language processes of the left hemisphere. Perhaps, however, people are just better at identifying information in the right visual field or in the right ear.
- The interpreter
  - Right visual field : Chicken claw
  - Left visual field : Snowy landscape
  - Showel from a list of objects and
- FFA RELEVANCE
  - The right hemisphere is also specialized for e ciently detecting upright faces and discriminating among similar faces (Gazzaniga & Smylie, 1983). e le hemisphere is not good at distinguishing among similar faces, but it is able to distinguish among dissimilar ones when it can tag the feature di erences with words (blond versus bru- ne e, big nose versus bu on nose). As for the recognition of familiar faces in general, the right hemisphere outperforms the le hemisphere in this task (Turk, 2002).
  - What about that most familiar of faces, one's own? In one study, so ware was used to morph the face of one split brain patient J.W. in 10 % increments, into that of a familiar other, Mike (Figure 4.18). e faces were asked randomly to J.W.'s separated hemispheres. en that hemisphere was asked, in the rst condition, "Is that you?" and, in another condition, "Is that Mike?" A double dissociation was found (Figure 4.19). e le hemisphere was biased towards recognizing one's own face, while the right hemisphere had a recognition bias for familiar others (Turk et al., 2002).
  -

Chapter 5 - Sensation and Perception with a focus on audition

Literature: Gazzaniga et al p. 162-227

Nanna

Vision: Light through the lens -> back surface of eye (retina) à photoreceptors: rods and cones (distinct properties) -> bipolar cells -> ganglion cells – optic nerve -> optic chiasm (cross over) à lateral geniculate nucleus through thalamus -> primary visual cortex.
Receptive field (primary cortex) à orderly mapping according to spatial representation à retinotopic maps à common for all sensory modalities
Dividing the visual cortex à discontinuities in retinotopic à figure 5.25.

Audition:
Sound waves → enter auditory canal → amplified → eardrum = vibration → air-filled middle ear – rattle tiny bones → oval window vibrates → cochlea = fluid filled. Basilar membrane → inner surface: “hair cells” – sensory receptors. (Composed of up to 200 tiny filaments: stereocilia)
Vibration at the oval window → tiny waves in fluid → move basilar membrane → move hair cells.
Location on the membrane determines FREQUENCY TUNING → thinkness of the basilar membrane varies along its length (OW = thick = high frequency)
Tonotopy = information about sound source at early processing
Deflected hair cells = mechanically gated ion channels open → positively charged K+ and Na+ flow into the cell = depolarization → release of transmitter = neural signal.

COMPARISONS BETWEEN THE AUDITORY AND VISUAL SYSTEMS

	Auditory system	Visual system
Thalamo-cortical route	Medial geniculate nucleus projects to primary auditory cortex	Lateral geniculate nucleus projects to primary visual cortex
Organizing principle of early neural processing	Tonotopic organization (orderly mapping between sound frequency and position on cortex)	Retinotopic organization (orderly mapping between position on retina and position on cortex)
Temporal and spatial sensitivity	Temporal > Spatial fast	Spatial > Temporal
Functional specialization of feature processing	Less well documented in the auditory domain	Well documented for color and movement
Higher-order context-dependent pathways	Evidence for separate auditory pathways for "what" versus "where"/"how" maybe signal is mixed between hemispheres	Evidence for separate visual pathways for "what" versus "where"/"how"

Sebber

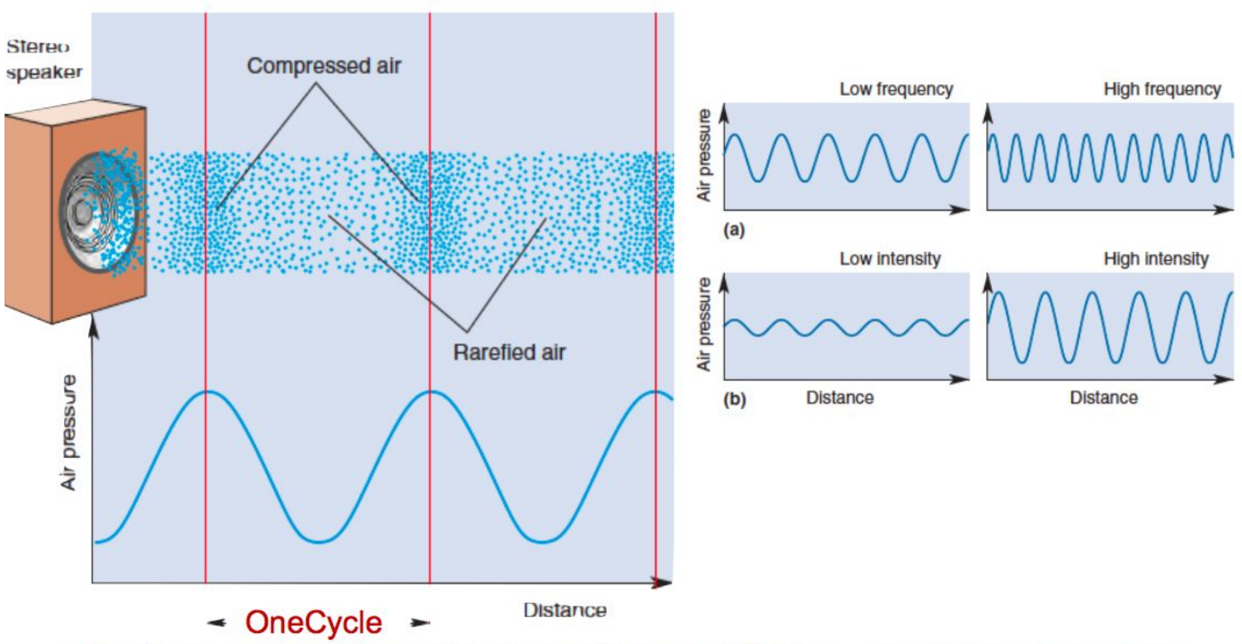
Gustation, Somatosensation, Olfaction, Vision, Audition

- Asymmetrical representations are the rule in human cognition (E.g. nasal pathway size in the nose, and delays between the ears)

Different species have different sensory ranges

Our visual sense is the one most researched

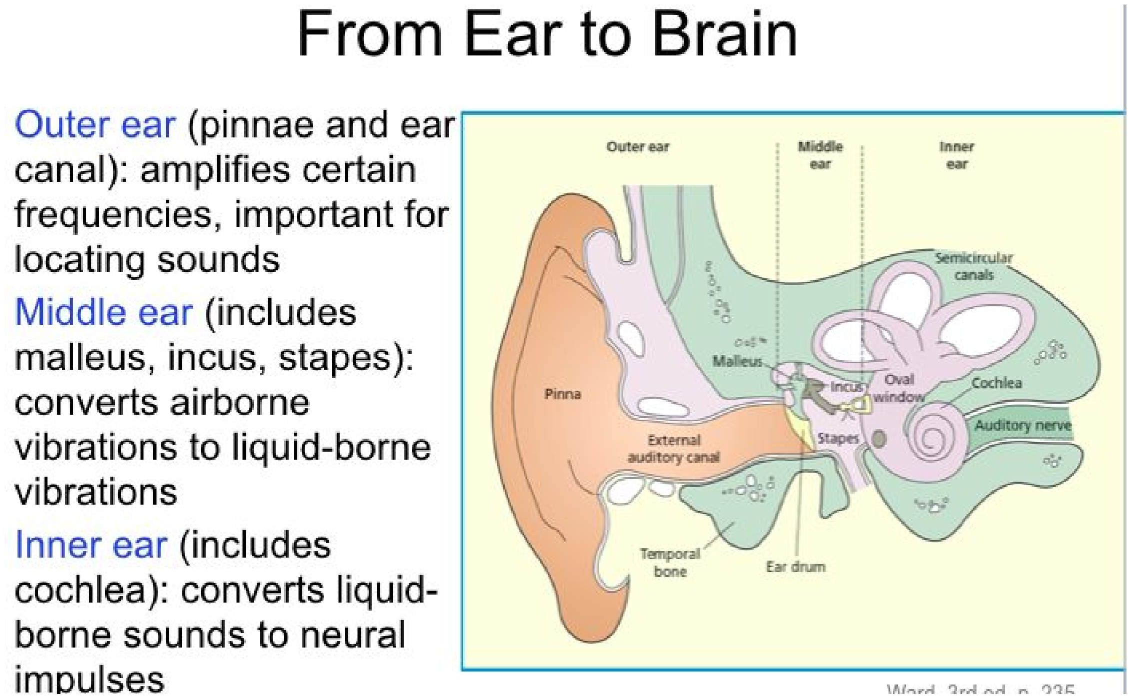
Secondary and association areas are still kinda unknown

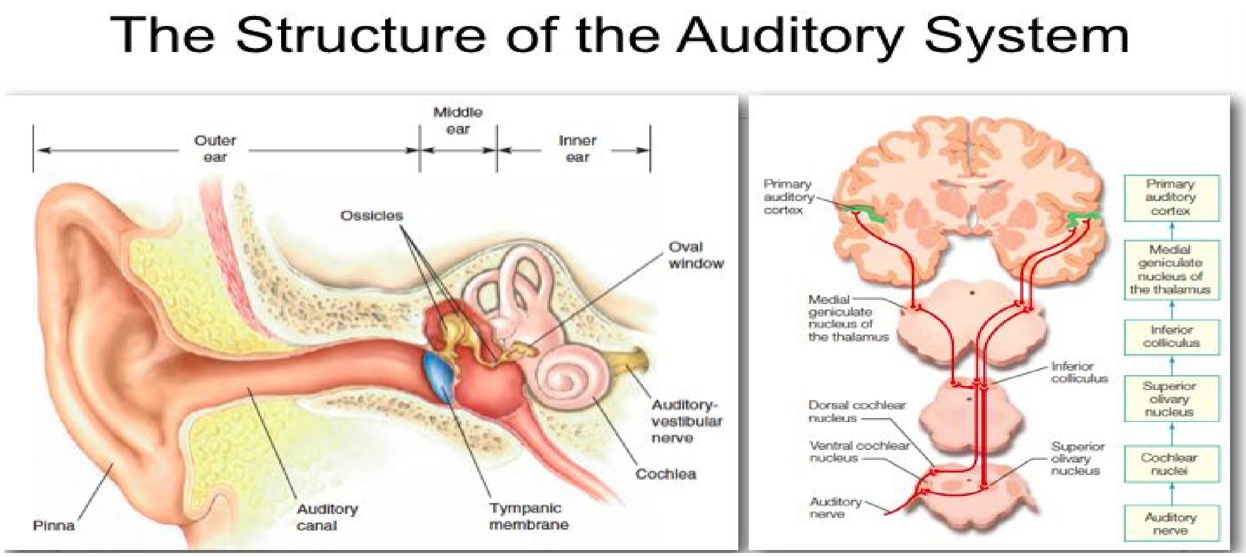


The frequency and intensity of sound waves. (a) We perceive high-frequency waves as having a higher pitch. **(b)** We perceive high-intensity waves as louder.

Amplitude is the loudnes - opposite of what happens in the brain, where strongness = frequency or "Rate of firing"

Pitch and loudness are psychological properties;
frequency and amplitude are physical properties
The two do not always correspond because one is oosychilogical (Adaptation/Habituation)





- The e cochlear nerve is also called the auditory nerve

Interestingly, the tuning of individual neu- rons becomes sharper as we move through the auditory system. A neuron in the cat's cochlear nucleus that re- sponds maximally to a pure tone of 5000 Hz may also respond to tones ranging om 2000 to 10,000 Hz. A comparable neuron in the cat auditory cortex responds to a much narrower range of equencies.
Ind d, it appears that human auditory tuning is sharper than that of all other species except for the bat.

- In the secondary cortices we have belts and parabelt areas that

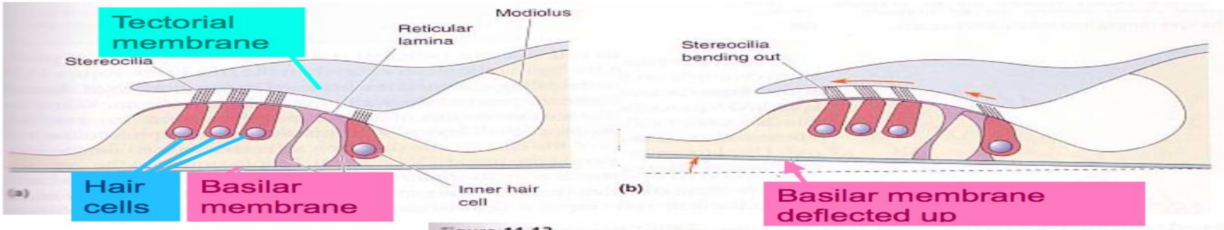


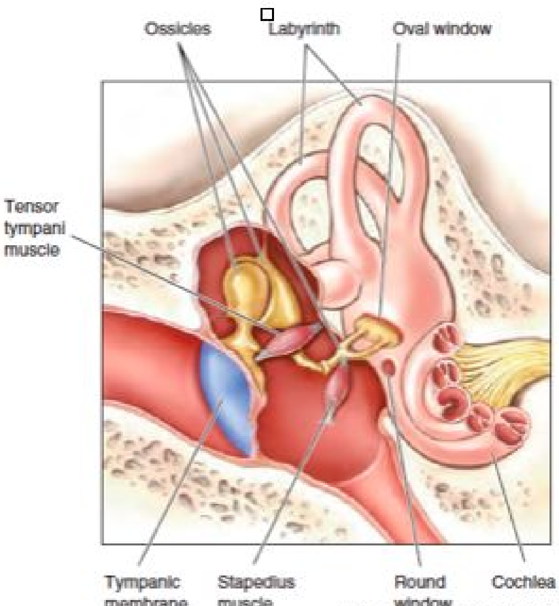
Figure 11.13
The bending of the stereocilia produced by the upward motion of the basilar membrane. (a) At rest, the hair cells are held between the reticular lamina and the basilar membrane, and the tips of the outer hair cell stereocilia are attached to the tectorial membrane. **(b)** When sound causes the basilar membrane to deflect upward, the reticular lamina moves up and inward toward the modiolus, causing the stereocilia to bend outward.

Sound produces motion in the basilar membrane relative to the tectorial membrane
Thereby bending the hairs (stereocilia) on the hair cells.

White Noise = White noise is defined as a signal with the same energy randomly distributed across all frequencies

- Can be used to relax, cancel out other background noises

High pitch = Consonant ---- Low pitch = Vowel



By contracting the tensor tympani muscle and the stapedius muscle, the chain of the ossicles becomes more rigid, thereby adjusting reactions to louder sounds.

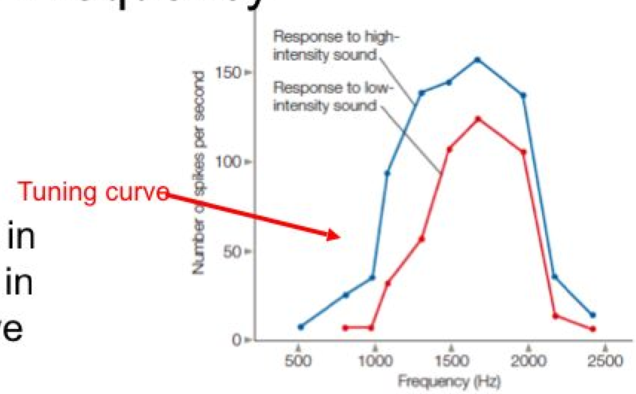
No adjustment: Dangerous to listen to abrupt loud noises

Evidence from single-cell recordings:

- Neurons in core region may respond to pure tones, but in belt/ parabelt region may respond to a range of frequencies or changes in frequency

Encoding Sound Intensity and Frequency

- Frequency tuned neurons in the auditory nerve.
- Intensity is coded in the firing rates and in the number of active neurons.



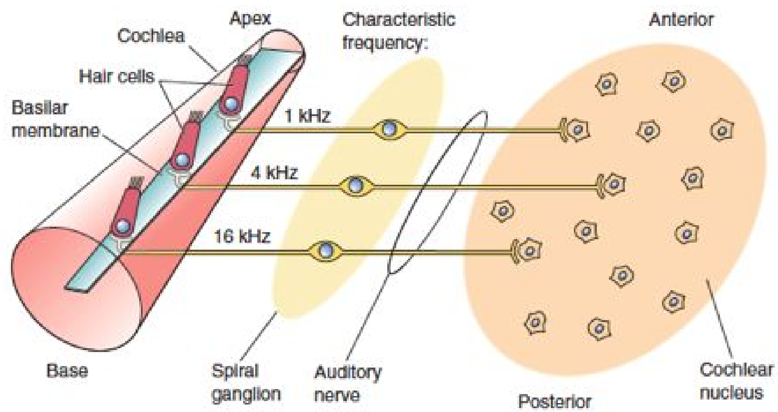


FIGURE 11.20
Tonotopic maps on the basilar membrane and cochlear nucleus. From the base to the apex of the cochlea, the basilar membrane resonates with increasingly lower frequencies. This tonotopy is preserved in the auditory nerve and cochlear nucleus. In the cochlear nucleus, there are bands of cells with similar characteristic frequencies; characteristic frequencies increase progressively from posterior to anterior.

Intensity cues -> Horisontal localisation

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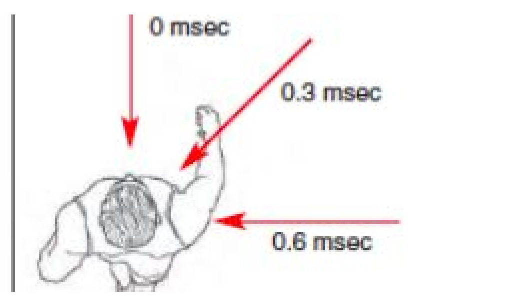
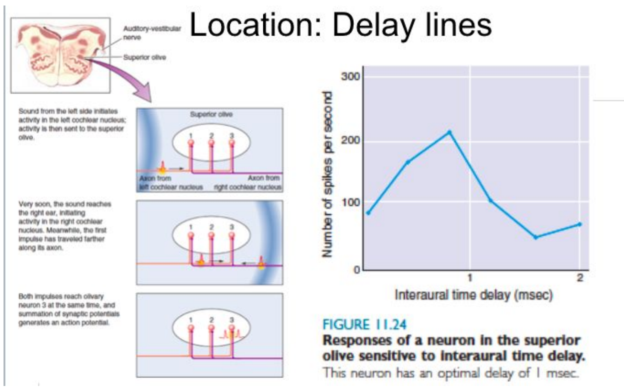
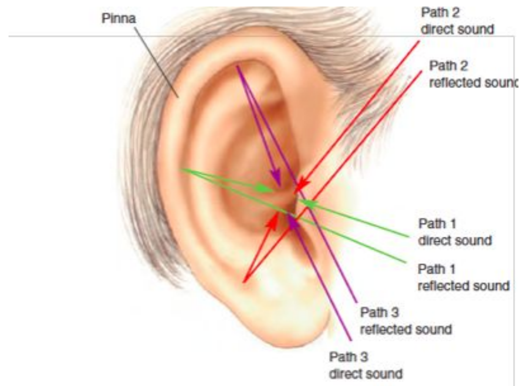


In the superior Olive we integrate the info about the horizontal plane

Localization in the vertical plane





Chapter 6 - Object recognition with a focus on faces and words

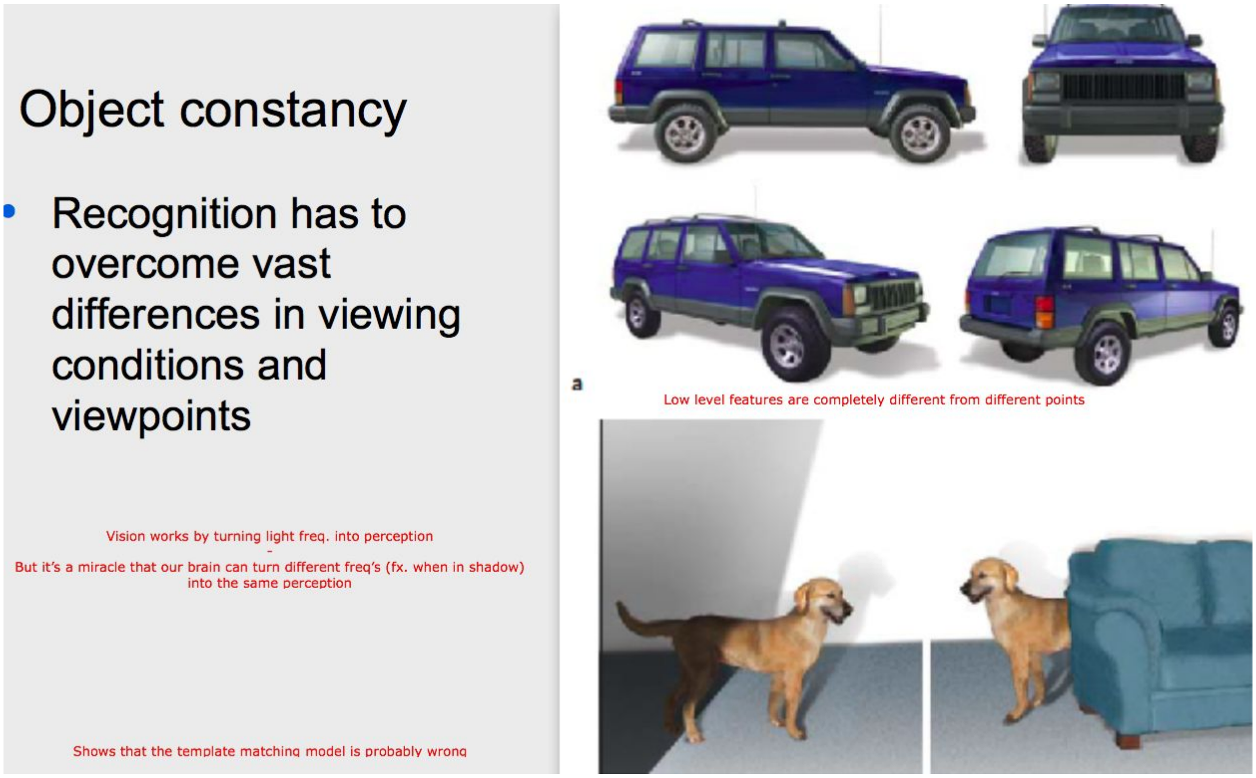
Literature: Gazzaniga et al p. 218-271 + Dehaene & Cohen 2011

Signe

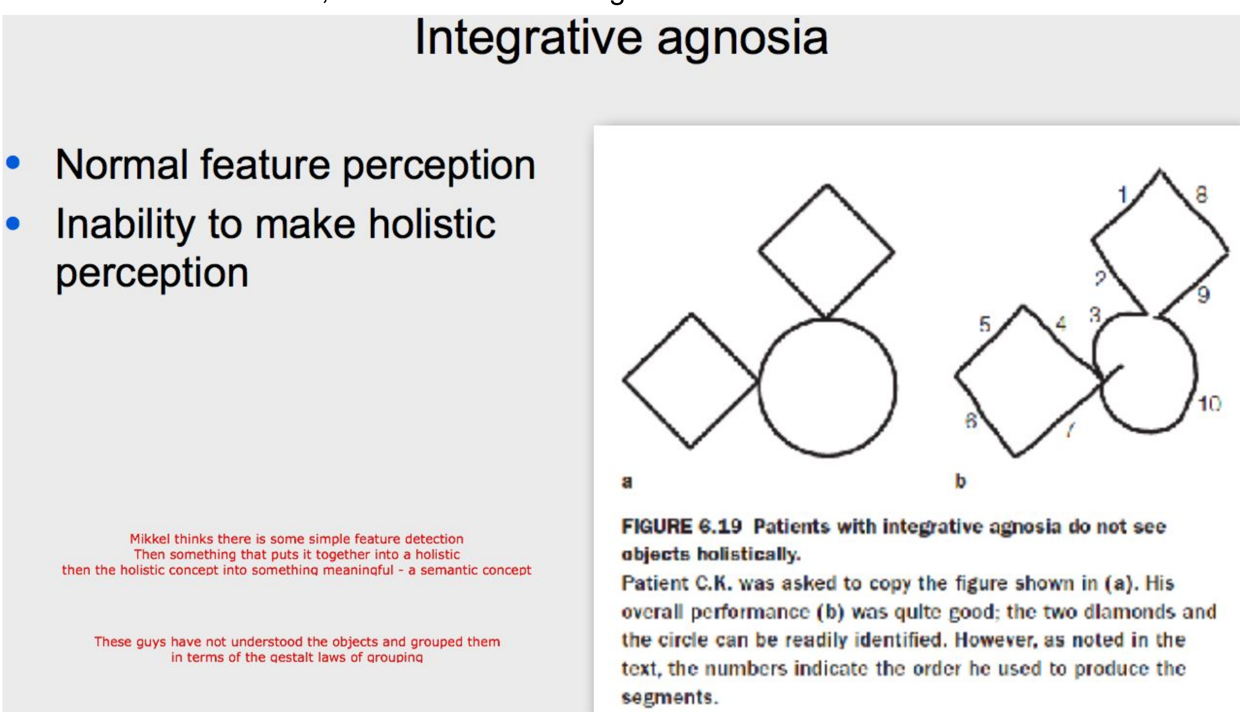
- Agnosias = deficits in recognition or failure of knowledge
  - Prosopagnosia without visual agnosia = patient W.J (sheeps not family)
  - Visual agnosia without prosopagnosia = C.K recognise faces not objects (figure 6.32)

Sebber

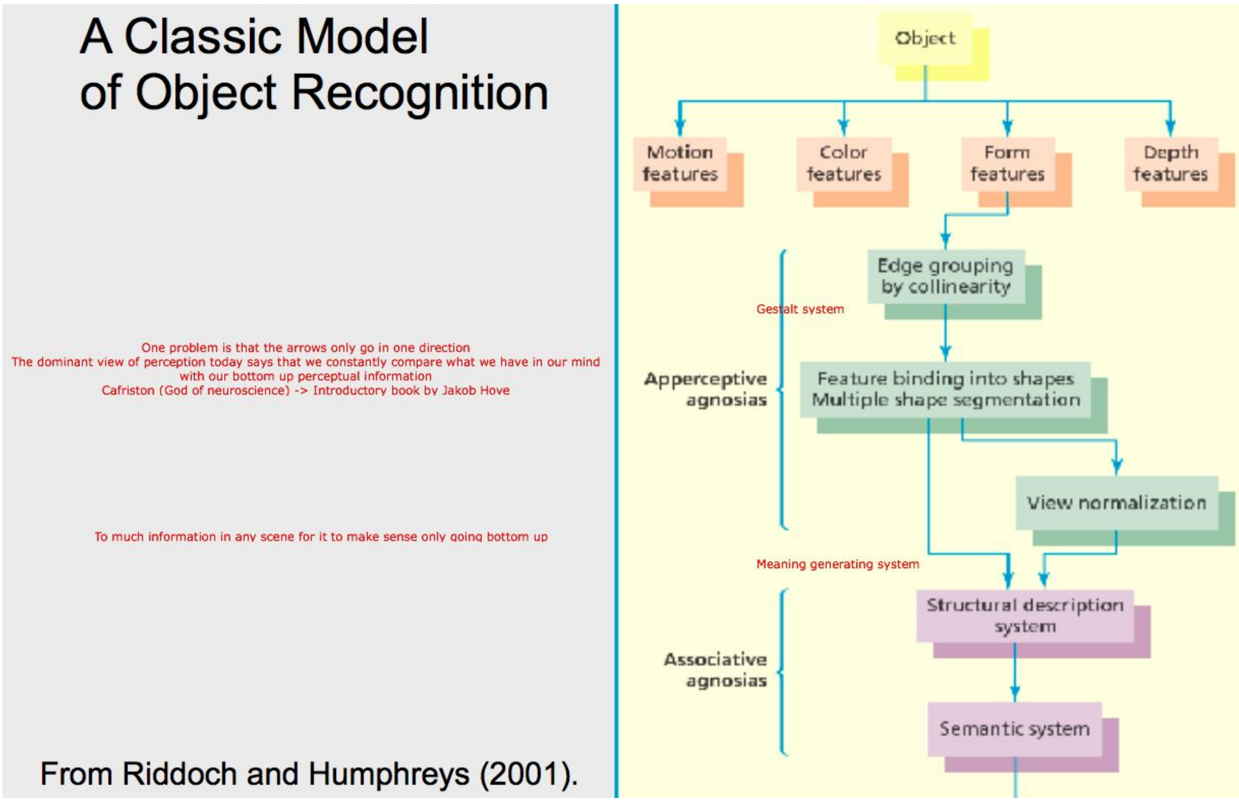
Sensation (Senses) - Perception (Internal representation) - Recognition (Semantics - meaningful intepretation)



Object constancy
View dependent theory: Template matching
View Invariant theory: FFA activation does not depend on the angle of your viewpoint. As long as all features are visible, activation won't change.



Ventral stream - What (Recogntion) pathway (Visual modality: Cells responds to the fovea) - Abstraction goes up from bars and edge detectors initially
Dorsal stream - where (How can I interact) pathway (Visual modality: Cells respond to all cells)
Represents different parts of cogntion



The term grandmother cell has been coined to convey the notion that recognition arises from the activation of neurons that are nely tuned to speci c stimuli.

Has a hard time explaining perception of novel objects

■ Ensemble theories, on the other hand, hypothesize that recognition is the result of the collective activation of many neurons.

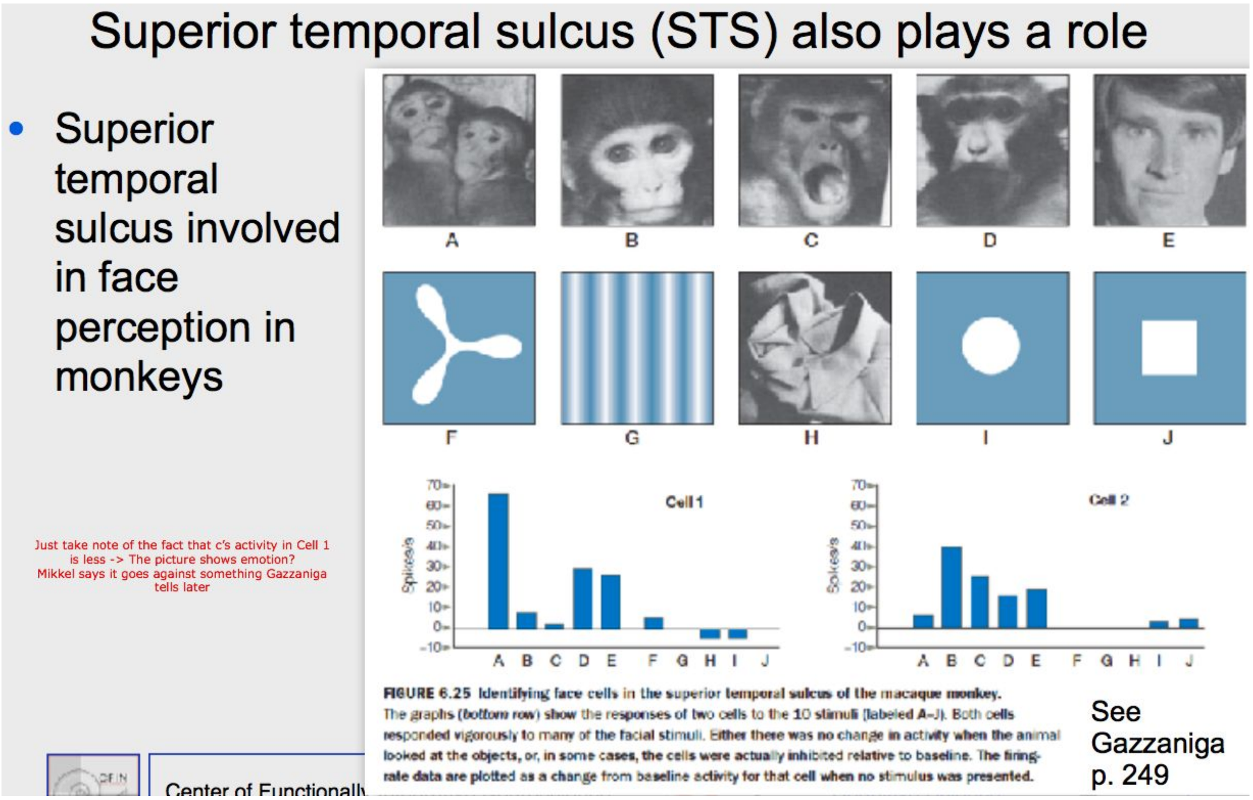
Prosopagnosia

Don't forget that brain injury in humans is an uncontrolled experiment, in which multiple regions can be a ected.

Prosopagnosia Lesion overview (Woman can't recognize her mom)

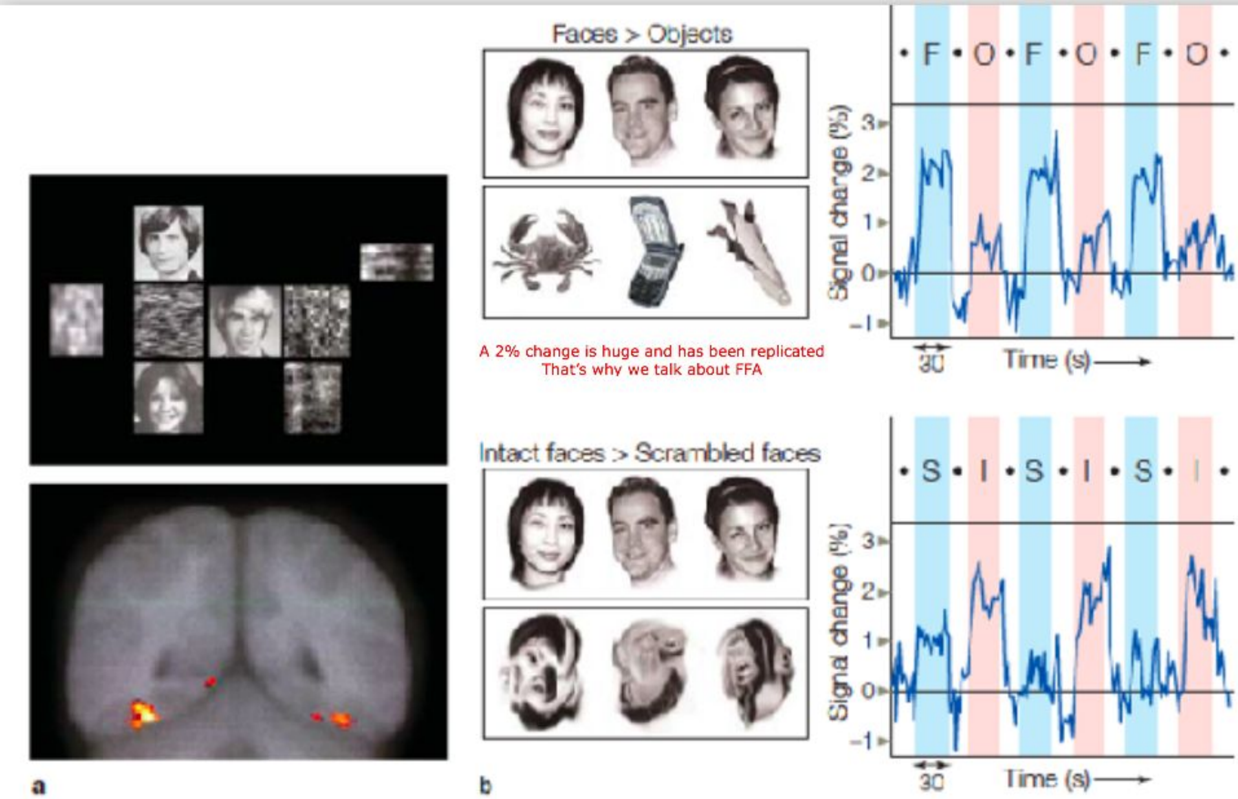
- **Most patients have bilateral occipito- temporal lesions**
- **Right hemisphere is more prominent in unilateral cases**
    - **Face recognition abilities vary**
        - **A photographer**
        - **Cannot see faces, but divide faces into boxes depending on their geometric features - e.g. Penelope Cruz fx. has a big nose**
- **Double dissociation between prosopagnosia and visual agnosia**
    - **Prosopagnosia but not visual agnosia • WJ was a sheep farmer.**

        - **After getting prosopagnosia he was still able to recognize his sheep, but not his family**
    - **Visual agnosia, but not prosopagnosia**
        - **CK could recognize faces but not objects, e.g figure**



We cannot conclude that cells like these respond only to faces, since it is im- possible to test all stimuli. Still, the degree of speci ci is quite striking, as shown by a study that combined o neurophysiological methods in a novel manner. Monkeys were placed in an fMRI scanner and shown pictures of faces or objects. As expected, sectors of the superior temporal sulcus showed greater activation to the face stimuli; in fact, thr distinct subregions in the superior temporal sulcus responded to faces (Tsao et al., 2006; Figure 6.26a).

Fusiform Face Area



STS:
One hypothesis is that the FFA is important for processing invariant facial properties, whereas the superior temporal sulcus is important for processing more dynamic features (Haxby et al., 2000). Ind d, the superior temporal sulcus not only is responsive to facial expressions but also is activated during lip reading or when monitoring eye gaze. this distinction can be observed even in the BOLD response, when the faces are presented so quickly that people fail to perceive them consciously (Jiang & He, 2006). In that study, FFA was activated in response to all faces, independent of whether the faces depicted strong emotional expressions. superior temporal sulcus, in contrast, responded only to the emotive faces (Figure 6.28).

Expertise:
Well… Nonetheless, within FFA, the brain shows a strong preference for face stimuli.

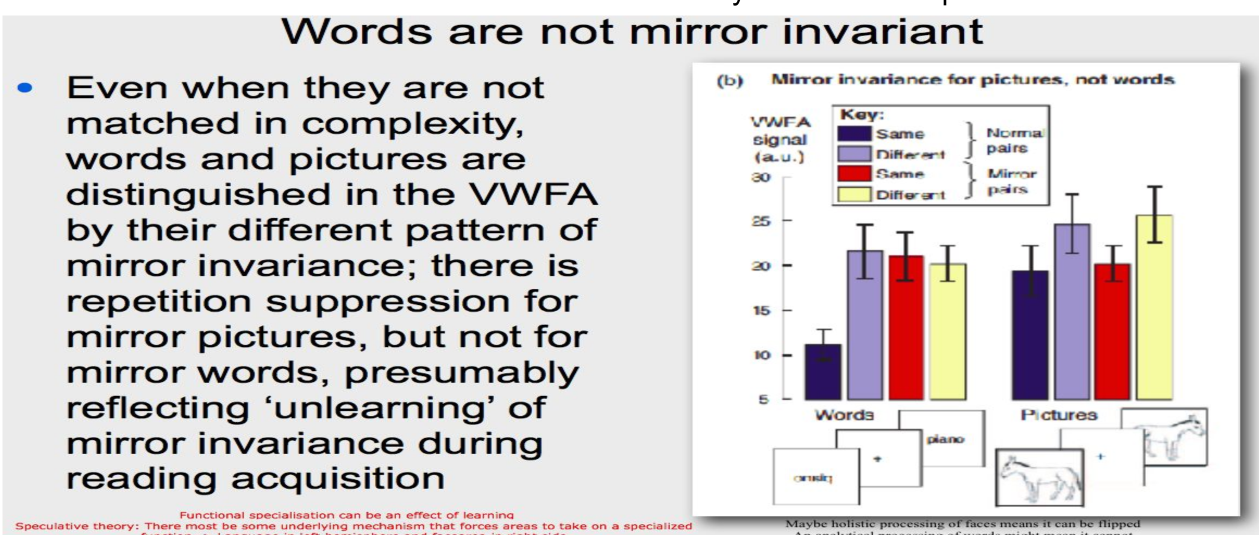
Holistic processing (See a face) vs. Analytical processing (See the vegetables)

Take a look at Figure 6.32, a still life produced by the quir 16th-century Italian painter Gi-useppe Arcimboldo. When shown this picture, C.K was stumped. He reported a mishmash of colors and shapes, failing to recognize either the individual vegetables or the bowl. But when the painting was turned upside down, C.K. immediately perceived the face. When compared to patients with prosopagnosia, individuals like C.K. provide a double dissociation in support of the hypothesis that the brain has functionally different systems for face and object recognition.

Participants were much better at identi ing an individual facial feature of a person when that feature was shown in conjunction with other parts of the person's face.
The idea that faces are generally processed holistically can account for an interesting phenomenon that occurs when looking at inverted faces.

analytic processing and holistic processing

in accord with this lat- eralization hypothesis: lesions to the right hemisphere are associated with prosopagnosia and the left with alexia. But it's not a totally clear divition between the hemispheres, since "the word superiority effect: Recognizing a letter as part of a word" is mostly situated in the "Visual Word Form Area" also in the "Analytical" left hemisphere.



One guy could distinguish between his sheep, but not faces.

Does the Visual System Contain Other Category-Specific Systems?

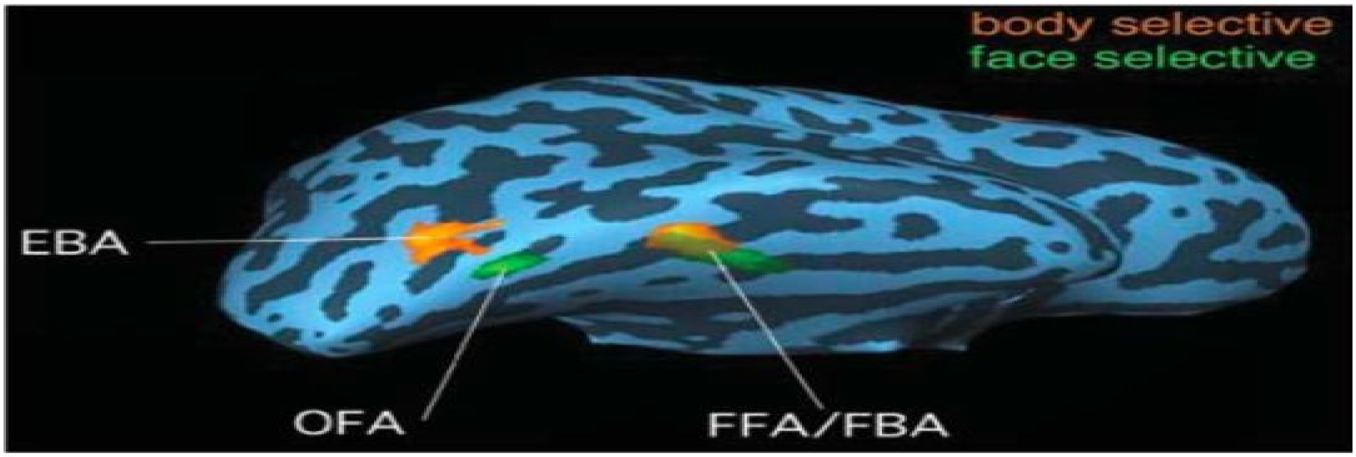
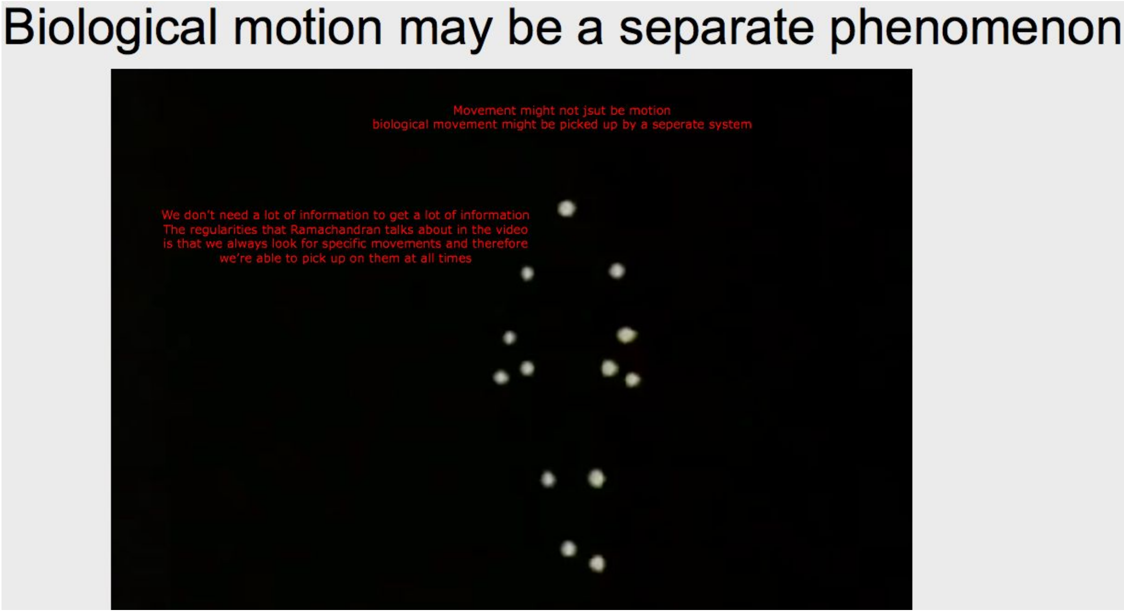


FIGURE 6.37 Locations of the EBA and FBA.
Right-hemisphere cortical surface of an "inflated brain" in one individual identifying the EBA, FBA, and face-sensitive regions. Regions responded selectively to bodies or faces versus tools. Note that two regions respond to faces, the OFA and FFA. (EBA = extrastriate body area; OFA = occipital face area; FFA = fusiform face area; FBA = fusiform body area.)

The results showed a neat triple dissociation (Figure 6.38b–d). When TMS was applied over the rOFA, participants had problems dis-criminating faces, but not objects or bodies. When it was applied over the rEBA, the result was impaired discrimination of bodies, but not faces or objects. Fi- nally, as you have probably guessed, when TMS was applied over the rLO, the participants had difficulty picking out objects, but not faces or bodies (Pitcher et al., 2009). The latter result is especially interest- ing because the perception of faces and bodies was not disrupted

- **The difference between EBA and FBA is their analytical and hollistic nature**
    - **https://www.ncbi.nlm.nih.gov/pubmed/17596425**
    - **Specifically, we hypothesize that the EBA analyzes bodies at the level of parts (as has been proposed for faces in the OFA), whereas FBA (by analogy to FFA) may have a role in processing the configuration of body parts into wholes.**



Chapter 7 - Action and the motor system

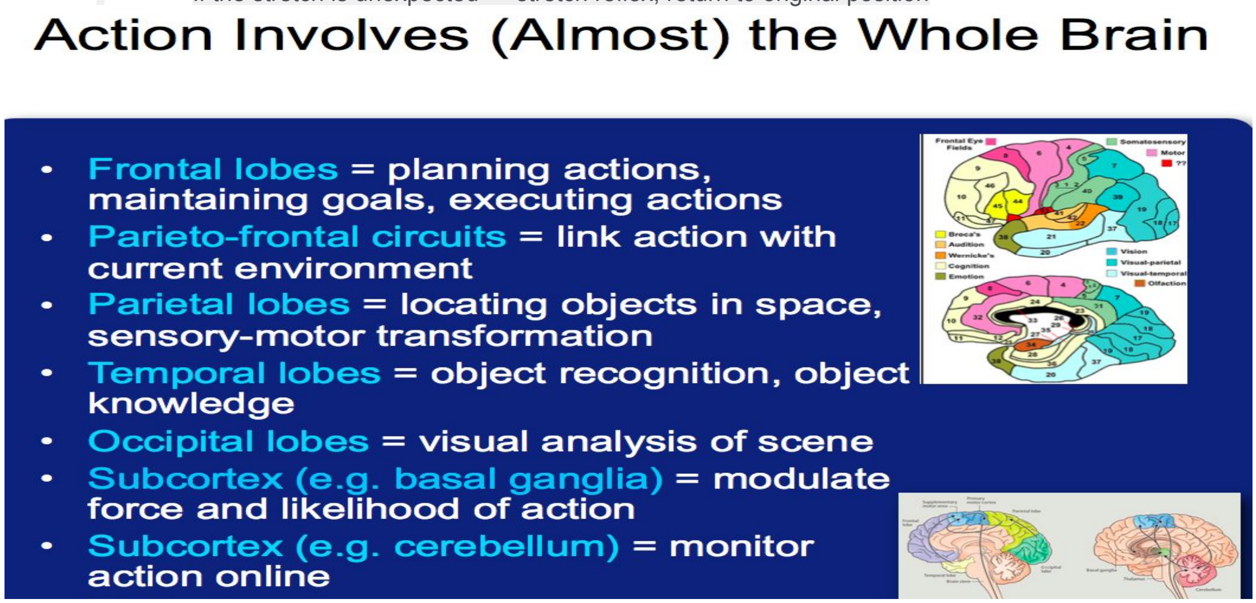
Literature: Gazzaniga et al p. 326-377 + Penfield & Rasmussen 1950 p. 11-66

Action v. Movement
• Action = the outcome of a number of cognitive processes that translate the goals and intentions of an individual into a motor output
• Action = a cognitive process
• Movement = a physical act that is not necessarily cognitive (e.g. reflexes)

Action, or motor movement, is generated by stimulating skeletal muscle fibers of an effector. An effector is a part of the body that can move.
Alpha motor neurons innervate muscle bers and produce contractions of the fibers.
for alpha motor neurons, the transmitter is aceylcholine. e release of transmitter does not modify downstream neurons, however. Instead, it makes the muscle fibers contract.
Alpha motor neurons receive peripheral input om muscle spindles, sensory receptors embedded in the muscles that provide information about how much the muscle is stretched. e axons of the spindles form an a erent nerve that enters the dorsal root of the spi- nal cord and synapses directly on corresponding e erent alpha motor neurons

- Proprioceptive neurons (muscles spindles) give continuous information about the relative position of one's own body parts and strength of effort being employed in movement
  ➢Mechano-receptor (stretch receptor) – becomes active when the muscle stretches
  ➢Axons of the spindles form an afferent nerve that enters the dorsal root of spinal cord an synapse directly on alpha motor neurons

• A lot of what we do can be done without the brain
• When muscles is stretched —> muscle spindles become active —> alpha neurons become active —> contraction
• If the stretch is unexpected → stretch reflex, return to original position



Frontal lobes - Planning Actions:
• Damage to PFC does not impair movement or execution, but actions become disorganized, and/or inappropriate for current goals
• Perseveration = repeating an action that has already been performed and is no longer relevant
• Utilization behavior = impulsive actions on irrelevant objects in the environment
• These are examples of actions automatically driven by habits and objects in the environment, rather than controlled behavior, driven by goals

apraxia—a loss of “praxis,” or skilled action
- Girl buttoning and unbuttoning her shirt
- Gut brushing his teeth with a comb

Cerebellum:
Ipsilateral organization
- Right side controls the right side of the body
- Left side controls the left side of the body

Predictive action
The cerebellum receives a copy of motor signals being sent to the muscles. It also receives massive feedback from the sensory system. By comparing, the cerebellum checks if the movement is coordinated

Motor Cortex:
Homunculus with big lips and hands - not as distinct as in the somatosensory cortex
Secondary Motor Areas Brodmann area 6

Secondary motor areas are involved with the planning and control of movement. One functional distinction be- n premotor cortex and SMA is whether the action is externally or internally guided. Premotor cortex has strong reciprocal connections with the parietal lobe, providing the anatomical substrate for external sensory-guided actions, such as grabbing a cup of co or catching a ball (s Chap- ter 6). SMA, in contrast, has stronger connections with me- dial ontal cortex, areas that we will s in Chapter 12 are associated with internally guided personal preferences and goals. For example, SMA might help decide which object to choose (e.g., co or soda), or with the planning of a sequence of learned actions (e.g., playing the piano)

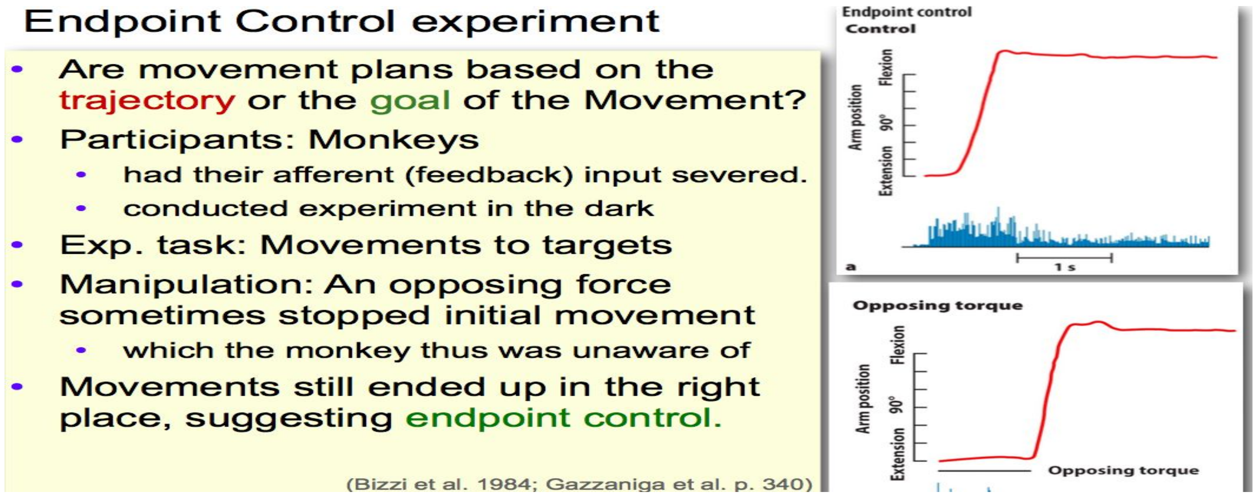
A Hierarchical View of Action (cont.)

- More basic cognitive mechanisms in action include:
- Object recognition (ventral "what" route)
- Locating an object in space (dorsal "where" or "how" route)
- Linking object shape and location with limb positions and motor commands (sensory-motor transformation)
- Knowledge of the present state of the body (somatosensation) and position of limbs in space (proprioception - Unconcious = cerebellum.)
- Selecting a specific movement (direction, force etc.)
- Generating the movement
- Monitoring the progress and outcome of the action (feedback)

Basal Ganglia

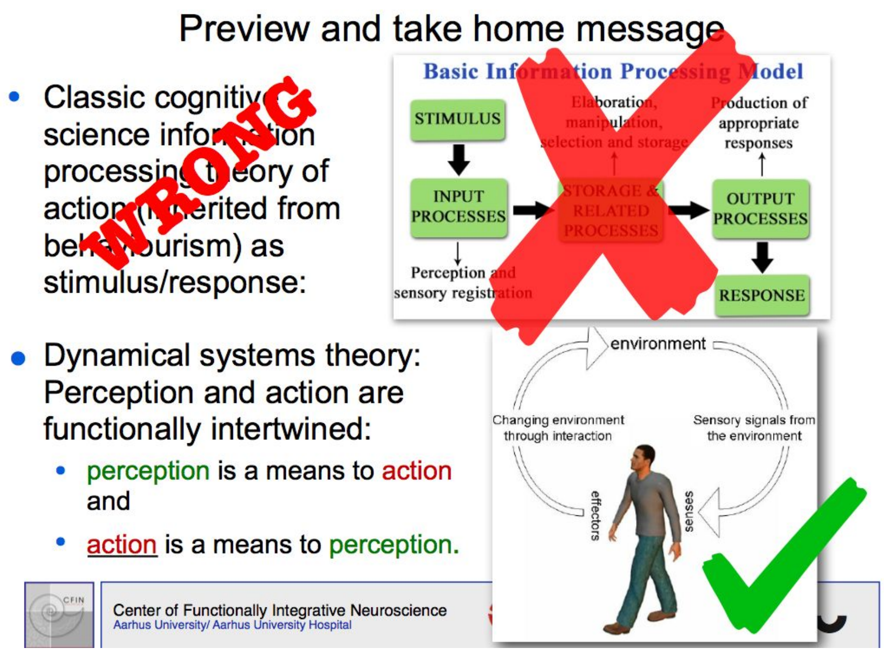
Parallel processing works ne for planning, but at some point, the system must commit to a particular action. thee basal ganglia appear to play a critical role in movement initiation.

- Processing within the basal ganglia takes place along two pathways (DeLong, 1990). the direct pathway involves fast, direct, inhibitory connections om the striatum to the GPi and SNr. e indirect pathway takes a slower, roundabout route to the GPi and SN
- cortical motor areas can be viewed as a competi- tive process in which candidate actions compete for control of the motor apparatus. e basal ganglia are positioned to help resolve the competition. e strong inhibitory baseline activi k ps the motor system in check, allowing corti- cal representations of possible movements to become ac- tivated without triggering movement.



Motor cortex neurons show directional tuning
Monkey study about levers and light
cells in motor areas show directional tuning, or exhibit what is referred to as a preferred direction
Mikkel: In reality, probably much more complicated and context dependent!
Population vector: All the cells have a vote for a prefered direction and can be described as vectors of activity levels - the sum of those can be called the population vector and can be predicted before the actual movement is performed.
More paths
Cisek (2005) developed his model based on evidence obtained in single-cell recordings from the premotor cortex of monkeys. In each trial of his study, the animal was presented with o targets, either of which it could reach with its right arm. A er a delay period, a cue indicated the target location for the current trial. During this delay period, neural signatures for both movements could be observed in the activity of premotor neurons, even though the animal had yet to receive a cue for the required action. these signatures can be viewed as potential action plans. With the onset of the cue, the decision scales were tipped. Activity associated with movement to that target became stronger, and activi associated with the other movement became suppressed.

Is doing nothing an action?
Given that the world/time is never stable, doing nothing is actually a fairly complex task...



Perception-action coupling

Continuity between the different aspects of motor cognition can be traced to William James and Roger Sperry. Sperry argued that the perception–action cycle is the fundamental logic of the nervous system.

Perception and action are functionally intertwined:

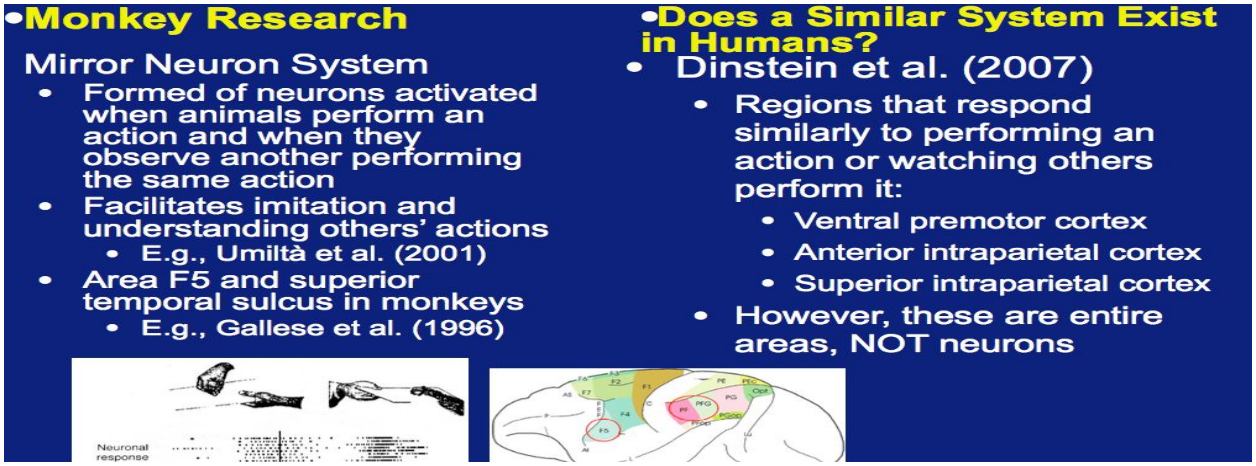
- perception is a means to action and
- action is a means to perception.

The vertebrate brain has evolved for governing motor activity with the basic function to transform sensory patterns into patterns of motor coordination.

Scientists studying vision are fond of claiming that over 50 % of the brain is devoted to this one sensory system, but a motor control chauvinist could reasonably argue that over 50 % of the brain is devoted to the control of action. One such self-proclaimed chauvinist, Daniel Wolpert (echoing Charles Sherrington), goes so far as to claim that the only reason we have a brain is so that we can move in an adaptable manner

Predictive coding -> Our choices are always influenced by our past choices

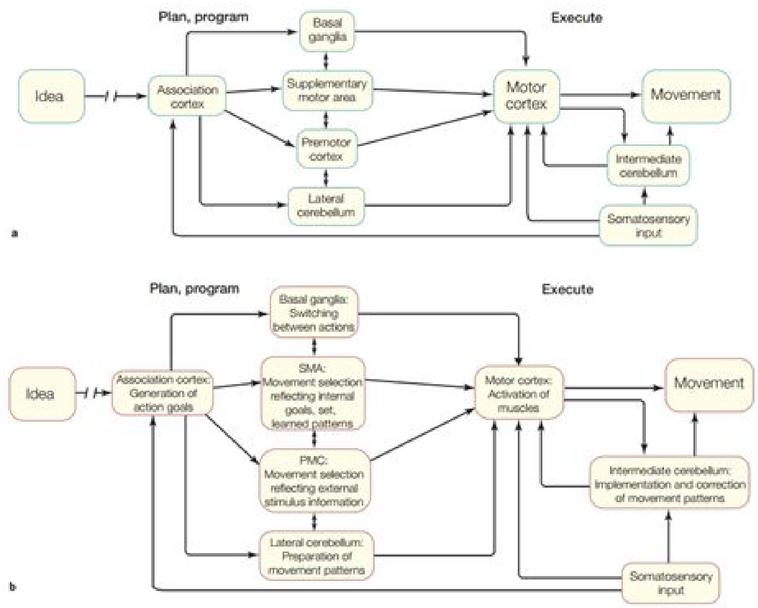
Mirrorneurons



"Our proposal is that the development of the human lateral speech circuit is a consequence of the fact that the precursor of Broca's area was endowed, before speech apperance, with a mechanism for recognizing actions made by others. this mechanism was the neural prerequisite for the development of interindividual communication and finally of speech." (p. 190)
Rizzolatti, G., & Arbib, M. A. (1998). Language within our grasp
Critique:
• Action execution and action understanding dissociate in humans
• Damage to the hypothesized human mirror system does not cause action understanding deficits.

Parkinson
Substantia nigra
L-Dopa (a synthetic cousin of dopamine that is highly e ective in compensating for the loss of endogenous dopamine)

Cats and their gait patterns
also cut the dorsal root fibers in the spinal cord, removing all feedback information from the effector. Even under these extreme conditions, the cat was able to generate rhythmic walking movements when put on a ki treadmill (Figure 8.9). us, neurons in the spinal cord could produce an entire sequence of actions without any descending commands or external feedback signals.These neurons have come to be called central pattern generators.



Chapter 8 - EEG and ERP with a focus on language

Literature: Gazzaniga et al p. 95-103, 491-500 + Luck 2014 + Näätänen et al. 1997

Methods for the Study of Neural Function

Single-cell recording enabled researchers to describe the response characteristics of individual elements.

- Although the surest way to guarantee that the electrode records the activity of a single cell is to record intracellularly, this technique is di cult, and penetrating the membrane equently dam- ages the cell. Thus single-cell recording is typically done extracellularly.
    - Computer algorithms are subsequently used to differentiate this pooled activi into the contributions from individual neurons.

Multiunit recording

- Multiunit recordings from motor areas of the brain are now being used to allow animals to control artificial limbs just by thinking about movement.

- Used to look a visual Cells that are responsive when a stimulus is presented in its receptive field.

EEG - electroencephalogram.

- Surface electrodes, usually 20 to 256 of them embedded in an elastic cap, are much bigger than those used for single- cell recordings
    - scalp passively conduct the electrical currents produced by synaptic activity

- ERPs are thus better suited to addressing questions about the time course of cognition rather than to localizing the brain structures that produce the electrical events.

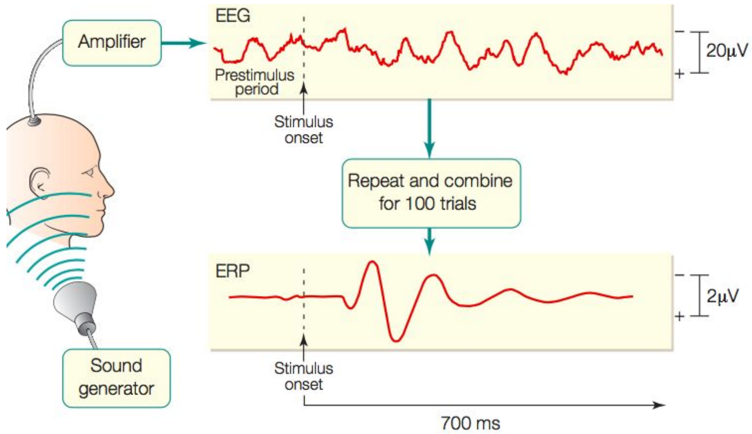
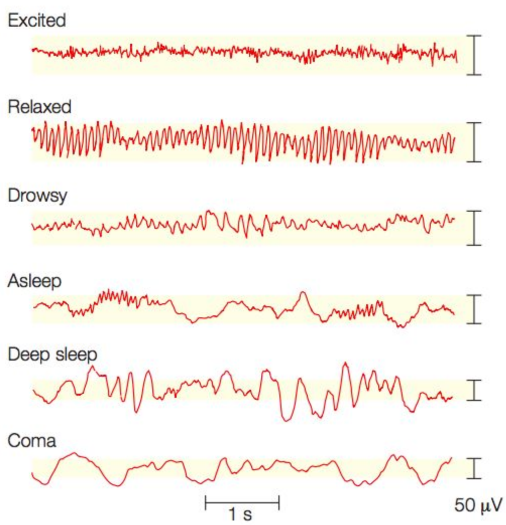
- 

FIGURE 3.24 Recording an ERP. The relatively small electrical responses to specific events can be observed only if the EEG traces are averaged over a series of trials. The large background oscillations of the EEG trace make it impossible to detect the evoked response to the sensory stimulus from a single trial. Averaging across tens or hundreds of trials, however, removes the background EEG, leaving the event-related potential (ERP). Note the difference in scale between the EEG and ERP waveforms.

- Synchronized and oscillatory activity of groups of neurons. Presumably, recognizing something requires not only that individual neurons fire but also that they fire in a coherent manner. This coherent firing is what produces the rhythms of the brain. The rhythms are defined by the frequency of the oscillations; thus, alpha refers to frequencies around 10 Hz, or 10 times per second
- 

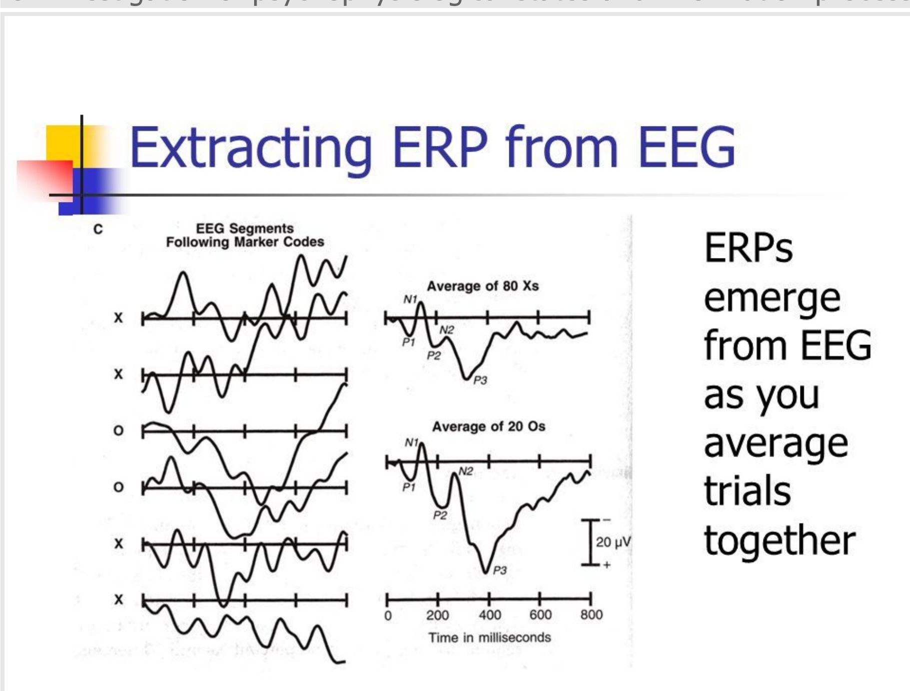
- The components of the waveform are named according to its polarity, N for negative and P for positive, and the time the wave appeared after stimulus onset. Thus, a wave tagged N100 is a negative wave that appeared 100 milliseconds after a stimulus.
    - After a stimulus, the earliest components are connected with sensory processing and occur within the first 100 ms. This trait has made them an important tool for clinicians evaluating sensory systems.
    - Waves that occur 100 ms after the stimulus presentation are no longer solely derived from sensory processing, but are modulated by attention.
    - The N100 and P100 waves are associated with selective attention.

- The N200 wave is known as the mismatch negativity component. It is found when a stimulus is physically deviant from the preceding stimuli, such as when a G tone is heard after a series of C tones.
- The P300 wave is seen when an attended stimulus is presented, especially if the stimulus is relatively rare.
- The N400 component is observed when a stimulus is unexpected. It differs from the N200 in that the surprise event here might be a violation of semantics (e.g., “The cow jumped over the banana”), rather than a physical change.

MEG

- MEG has two drawbacks. First, it is able to detect current ow only if that ow is oriented parallel to the surface of the skull. magnetic fields generated by the brain are extremely weak. To be effective, the MEG device requires a room that is magnetically shielded from all external magnetic fields, including the Earth’s magnetic field.

EEG VS ERP Electroencefalograpy (**EEG**) is the recording of intrinsic electrical activity in the brain, based on the propagation of electric impulses along a nerve fibre when the neuron fires. EEG is typically analyzed in frequency bands that correspond to different mental states, e.g. is the alpha-frequency (8-13 Hz) associated with a relaxed mental state. By recording small potential changes in the EEG signal immediately after the presentation of a sensory stimulus it is possible to record specific brain responses to specific sensory, cognitive and other mental events. This method is called Event-Related Potentials (**ERPs**) and is one of the classic methods for investigation of psychophysiological states and information processing.



Chapter 9 - Memory & Emotion

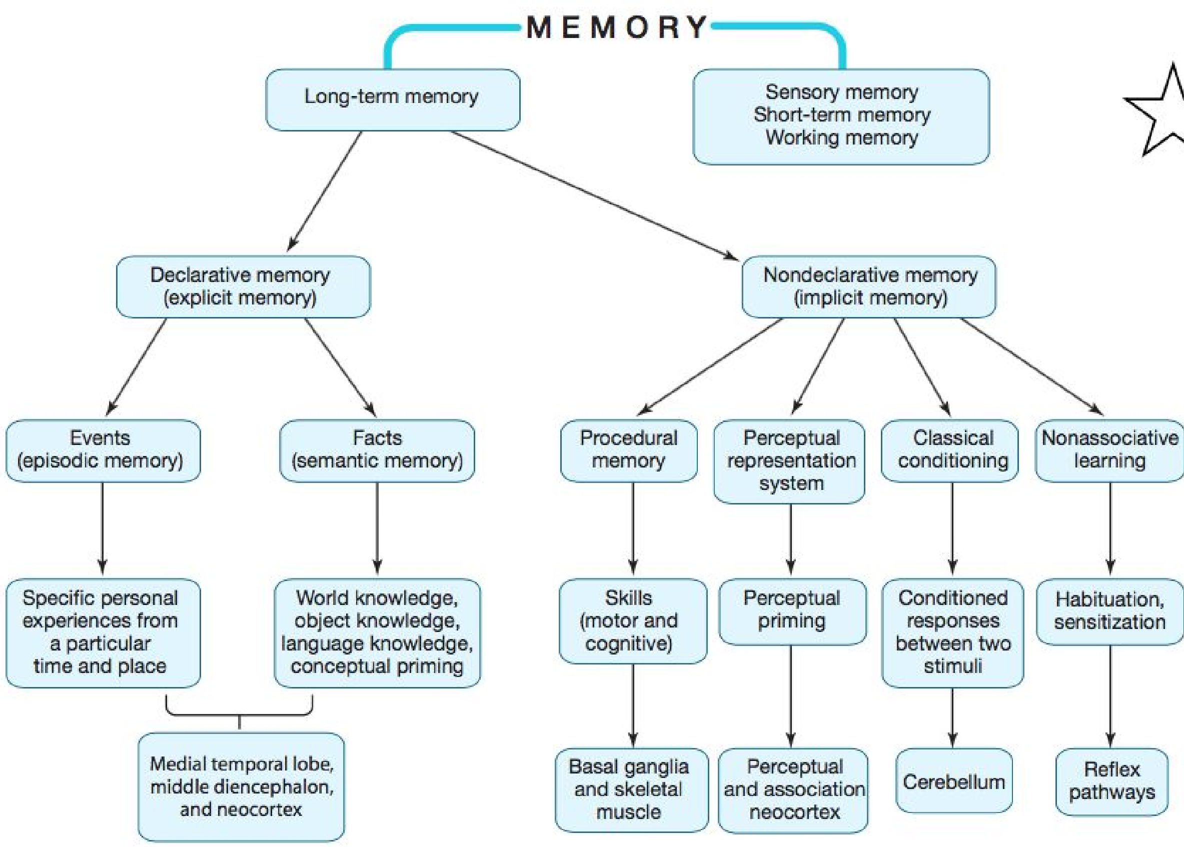
Literature: Gazzaniga et al p. 378-467

Memory

Learning is the process of acquiring that new information, and the outcome of learning is memory.

ABLE 9.1 Types of Memory

	Characteristic of Memory			
ype of Memory	**Time Course**	**Capacity**	**Conscious Awareness?**	**Mechanism of Loss**
ensory	Milliseconds to seconds	High	No	Primarily decay
hort-Term and Working	Seconds to minutes	Limited (7 ± 2 items)	Yes	Primarily decay
ong-Term Nondeclarative	Days to years	High	No	Primarily interference
ong-Term Declarative	Days to years	High	Yes	Primarily interference



Learning and memory have many stages, including encoding (acquisition and consolidation), storage, and retrieval.

The Anatomy of Memory

- What is known as the medial temporal lobe memory system is made up of the hippocampus and the surrounding rhinal and parahippocampal cortices.
- Other areas involved with memory include the prefrontal cortex, the parietal cortex, and subcortical structures.

Memory Deficits: Amnesia

- Anterograde amnesia is the loss of the ability to form new memories, as in the case of H.M.
- Patient H.M. developed amnesia after bilateral removal of his medial temporal lobes to treat epilepsy.
    - Can learn procedural knowledge
- Retrograde amnesia is the loss of memory for events that happened in the past.
- Retrograde amnesia tends to be greatest for the most recent events, an effect known as a temporal gradient or Ribot's Law.
- Patients with retrogade amnesia may have normal short- term memory as shown by digit span tests.

Short-Term Forms of Memory

- Traditional memory theories include two main distinctions about how we learn and retain knowledge: by how long the information is retained and by what type of information the knowledge contains.
- Memory classified by duration includes sensory memory, lasting only seconds at most; short-term memory, lasting from seconds to minutes; and long-term memory, lasting from days to years.
- Echoic memory is sensory memory for audition (intervals of 9 to 10); iconic memory is sensory memory for vision (visual stimulus lasts only 300 to 500 ms.).

  MMN - Beep Beep Beep, deviant BAH -> You will se a Mismatch negativity in EEG.

- Working memory extends the concept of short-term memory: It contains information that can be acted on and processed, not merely maintained by rehearsal.

  Baddeley and Hitch: This three-part working memory system has a central executive that controls two subordinate systems: the phonological loop, which encodes information phonologically (acoustically) in working memory; and the visuospatial sketch pad, which encodes information visually in working memory.

recall of lists of words is poorer when many words on the list sound similar than when they sound dissimilar, even when the dissimilar words are semantically related. this finding indicates that an acoustic code rather than a semantic code is used in working memory, because words that sound similar interfere with one another, whereas words related by meaning do not.
- Visuaspatial sketchpad - mostly located in right hemisphere.

- Long-term memory is split into two divisions divided by content: declarative and nondeclarative. Declarative memory is knowledge that we can consciously access, including personal and world knowledge. Nondeclarative memory is knowledge that we cannot consciously access, such as motor and cognitive skills, and other behaviors derived from conditioning, habituation, or sensitization.
- Declarative memory can be further broken down into episodic and semantic memory. Episodic memory involves conscious awareness of past events; it is our personal, autobiographical memory. Semantic memory is the world knowledge that we remember even without recollecting the specific circumstances surrounding its learning.
- Procedural memory is a form of nondeclarative memory that involves the learning of various motor and cognitive skills. Other forms of nondeclarative memory include perceptual priming, conditioned responses, and non- associative learning.

  Priming: if the word lists are presented auditorily and the word arrangement completion is done visually, then the priming is reduced, suggesting that priming re ects a PRS (perceptual representation system) that subserves structural, visual, and auditory representations of word form.

- Different types of information may be retained in partially or wholly distinct memory systems.

The Medial Temporal Lobe Memory System

- The hippocampus is critical for the formation of long-term memory.

  Converging evidence for the role of the hippocampus in forming long-term memory also comes from patients with amnesia caused by lesions in regions connected to, but outside of, the medial temporal lobes (e.g., damage to the diencephalon). Damage to these midline subcortical regions can be caused by stroke, tumors, trauma, and metabolic problems like those brought on by chronic alcoholism, such as Korsako 's syndrome.

  - Lesions to areas around the hippocampus can influences its abilities. The interconnectedness of the brain renders it hard to say if a lesion to one area actually means that area is responsible for the brainfunctions at hand.

- Cortex surrounding the hippocampus is critical for normal hippocampal function in memory.
- The delayed non-match to sample task is used to assess memory in non-human primates.

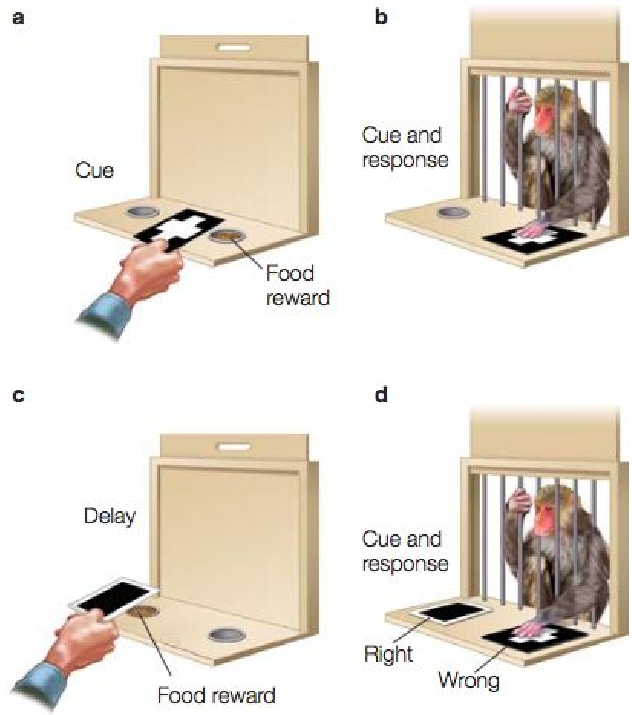


FIGURE 9.19 Delayed nonmatch-to-sample task.
(a) The correct response has a food reward located under it. **(b)** The monkey is shown the correct response, which will yield a reward for the monkey. **(c)** The door is closed, and the reward is placed under a second response option. **(d)** The monkey is then shown two options and must pick the correct response (the one that does *not* match the original sample item) to get the reward. Here the monkey is shown making an error.

- The amygdala is not a crucial part of the system for episodic memory, but it is important for emotional memory.

  When lesions of the hippocampus and amygdala were made but the surrounding cortex was spared, the presence or absence of the amygdala lesion did not affect the monkey's memory. While Lesions that damage the hippocampus directly, or damage the input– output relations of the hippocampus with the neocortex (Figure 9.23), produce severe memory impairments.

- Neurons that activate when rats are in a particular place and facing a particular direction have been identified in the hippocampus and are called place cells. They provide evidence that the hippocampus has cells that encode contextual information.

  For instance, when electrodes were implanted in the rat hippocampus, certain cells, later known as place cells, red only when the rat was situated in a particular location and facing a particular direction (O'K fe & Dostrovs , 1971). A particular place cell may become silent when the animal moves to a different environment, but then assume a location-speci c ring in that new area. As the animal moves about an environment, the activi of speci c CA1 and CA3 hippocampal neurons correlates with speci c locations. is study led to the idea that the hippocampus represented spatial contexts (O'K fe & Nadel, 1978), the where in context memory. It was soon found to be involved in spatial navigational learning.

Watermaze + mice

Procedural knowledge = Paths

Explicit knowledge = Context of explicit knowledge

Imaging

- Functional MRI evidence suggests that the hippocampus is involved in encoding and retrieval for episodic memories that are recollected. Areas outside the hippocampus, especially the entorhinal cortex, support recognition based on familiarity (As seen in tests on familiarity of an item list).
- Neuroimaging has confirmed the neural basis of memory demonstrated by animal and lesion studies and has provided some notable new findings—including, for example, evidence that the hippocampus and surrounding parahippocampal and perirhinal cortices may play different roles in memory, supporting different forms of recognition memory.

  A model known as the binding of items and contexts (BIC) model proposes that the perirhinal cortex represents information about specific items (e.g., who and what), the parahippocampal cortex represents information about the context in which these items were encountered (e.g., where and when), and processing in the hippocampus binds the representations of items with their context (Diana et al., 2007; Ranganath, 2010). As a result, the hippocampus is able to relate the two types of information about some- thing that the individual encounters. is form of memory is referred to as relational memory. So, to recognize that something is familiar, perirhinal cortex is sufficient; but to remember the full episode and everything related to it, the hippocampus is necessary. (perihinal cortex can act on some kind of abstracted knowledge)
- The researchers found a dissociation between two medial temporal lobe regions (Figure 1). In the hippocampus bilaterally, false items elicited more neural activity than did new items, and as much activity as true items. But in the left parahippocampal gyrus, a region surrounding the hippocampus, closely related false items elicited about the same amount of activity as new items and signicantly less activity than true items. In other words, the hippocampus responded similarly to true and false items, and the parahippocampal gyrus responded more strongly to true than to false items.

Because true and closely related false items were similar in their semantic content but differed in sensory content, these results suggest that the hippocampus is involved in the retrieval of semantic information, whereas the parahippocampal gyrus is involved in the retrieval of sensory information.

Ranganath and Richey propose that these two systems support different forms of memory-guided behavior. connecting the parietal lobe to memory, which hasn't been done before, because Retrosplenial lesions can produce both retrograde and anterograde amnesia.

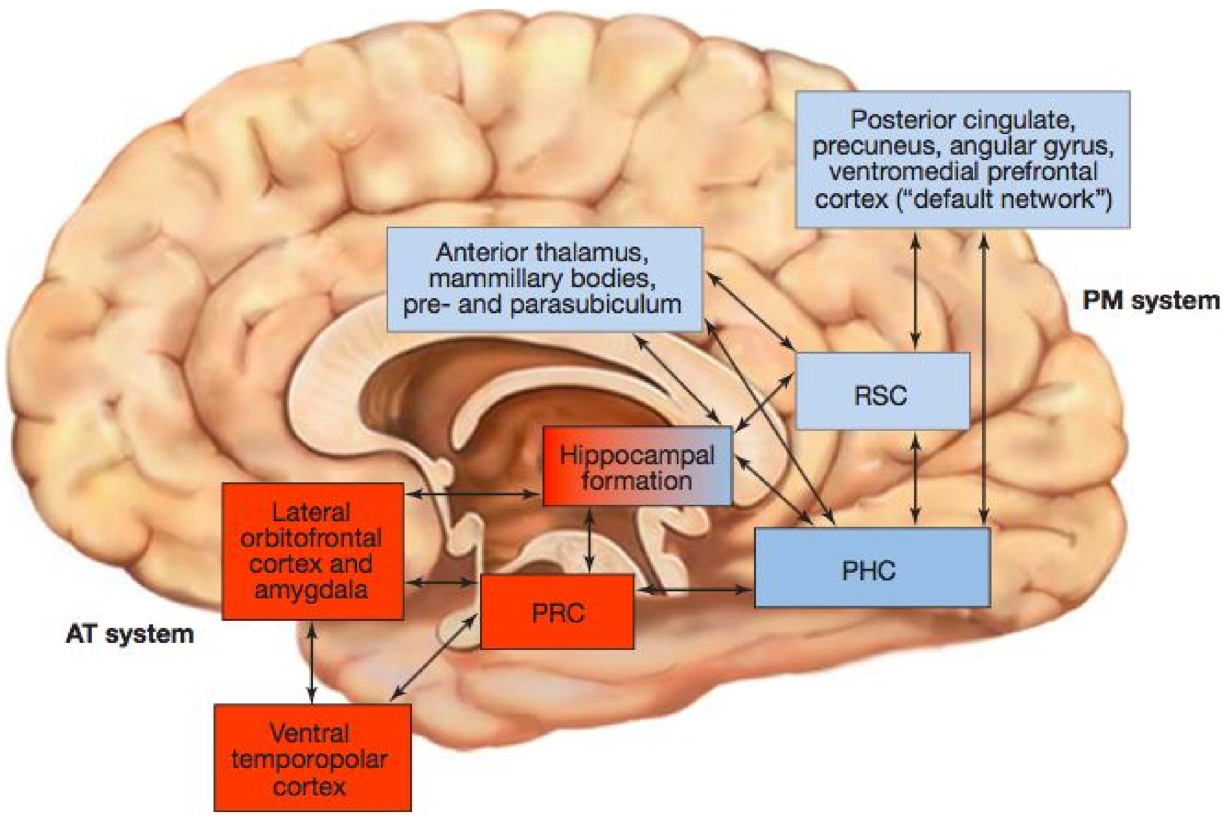


FIGURE 9.35 Model of two neocortical systems for memory-guided behavior. The components of the anterior temporal (AT) system are shown in red. The posterior medial (PM) system is shown in blue. Regions with strong anatomical connections are indicated with arrows.

- The PRC in the anterior system supports memory for items, and it is involved in familiarity-based recognition, associating features of objects, and making fine-grained perceptual or semantic discriminations. Ranganath and Richey suggest that the overall cognitive job of the anterior system (in collaboration with the amygdala, VTPC, and lateral orbitalfrontal cortex) may be to assess the significance of entities.
- The PHC and RSC, which are not traditionally included in medial temporal lobe systems, support recollection-based memories, such as memory for scenes, spatial layouts, and contexts. These

researchers also propose that this system, together with the other posterior medial system structures, may construct mental representations of the relationships between entities, actions, and outcomes.

- Some support for this theory comes from neurological patients. Recall that along with hippocampal damage, Alzheimer's disease, with its episodic memory impairment, is associated with severe disruptions in the retrosplenial cortex, posterior cingulate, precuneus, and angular gyrus, which together are the proposed posterior medial system. In contrast, patients with semantic dementia, which is characterized by a loss of knowledge about objects, have extensive damage to the anterior temporal lobes.

Memory Consolidation

- Two prominent theories of long-term memory consolidation are the standard consolidation theory and the multiple trace theory.

The standard consolidation theory -> Larry Squire -> representations of an event are distributed throughout the cortex come together in the medial temporal lobe where the hippocampus binds them. the bound information is slowly transferred and replaced by a permanent memory trace in the neocortex. Consolidation occurs after repeated reactivation of the memory creates direct connections within the cortex between the various representations. This process takes place when an individual is either conscious or asleep.

multiple trace theory -> Lynn Nadel and Morris Moscovitch -> suggests that only the long-term stores for semantic information rely on the neocortex while some aspects of episodic memory, consolidated or not, continue to rely on the hippocampus. In this formulation, a new memory trace, composed of a combination of attributes, is set down in the hippocampus every time a memory is retrieved: the more times a memory is retrieved, the more traces are set down. Slowly, the common elements of the traces are extracted into "gist" information and then stored as semantic memory elsewhere in the cortex. This theory suggests that episodic memories degrade over time and are slowly converted to semantic memory.

- both models agree on one point: Memory consolidation via the hippocampus is rapid.
- Lesions to the anterior temporal cortex can cause severe retrograde amnesia.
- neuroimaging studies suggesting that memories are stored as distributed representations throughout the neocortex, involving the regions that originally encoded the perceptual information along with the regions representing information that was associated with this incoming information. As noted already in this chapter, the medial temporal lobe may coordinate the consolidation of this information over time.

Cellular Basis of Learning and Memory

- In Hebbian learning, if a synapse is active when a postsynaptic neuron is active, the synapse will be strengthened. Long-term potentiation is the long-term strengthening of a synapse.

- 3 Rule of LTP

1. Cooperativity . More than one input must be active at the same time.

2. Associativity . Weak inputs are potentiated when co-occurring with stronger inputs.

3. Specificity . Only the stimulated synapse shows potentiation.

- NMDA receptors are central to producing LTP but not to maintaining it. It is dependent on the neurotransmitter glutamate, the major excitatory transmitter in the hippocampus.

  The Mg ions can be ejected from the NMDA receptors only when the cell is depolarized. Thus, the ion channel opens only when two conditions are met: (1) when the neurotransmitter glutamate binds to the receptors, and (2) when the membrane is depolarized duo to AMPA receptors allowing an ion influx The effect of Ca influx via the NMDA receptor is critical in the formation of LTP.

  One hypothesis is that LTP raises the sensitivity of postsynaptic AMPA glutamate receptors and prompts more glutamate to be released presynaptically. Or perhaps changes in the physical characteristics of the dendritic spines transmit EPSPs more effectively to the dendrites. Finally, via a message from the postsynaptic cell to the presynaptic cell, the efficiency of presynaptic neurotransmitter release is increased.

mice lacking the NMDA receptor function are able to form spatial memories, but they don't use them when confronted with ambiguous local cues, suggesting that the NMDA receptor function is more subtle than previously thought (Maford, 2012)

High frequency action potential -> AMPA open longer -> NMDA release Magnesium -> Growthfactors + more AMPA

Sleep

hippocampal cells tended to replay not only with spatial coordination but also in the same temporal sequence of neuronal ring in which they were learned.

Thus two mechanisms are involved in replaying an activity: the reverse waking replay of neural activity, and the sleep-related replay, in which activity is replayed in the same temporal order as it was experienced. Some- thing about the sleep-related forward replay is appar- ently related to memory consolidation. But the reverse waking replay must be doing something different. Foster and Wilson propose that it re ects a mechanism that permits recently experienced events to be compared to their "memory trace" and may, potentially, reinforce learning.

Emotions

It has become apparent that emotion is involved with much of cognitive processing. Its involvement ranges from influencing what we remember (Chapter 9), to where we direct our attention (Chapter 7), to the decisions that we make (Chapter 12). Our emotions modulate and bias our own behavior and actions

Agreed upoN:

- Emotions are made up of three psychological components—a physiological response, a behavioral response, and a subjective feeling—that have evolved to allow humans to respond to significant stimuli. The underlying mechanisms and timing of the components are disputed.
  - Mood -> Longer intervals
  - Emotion -> In the moment

Neural systems

- The Papez circuit describes the brain areas that James Papez believed were involved in emotion. They include the hypothalamus, anterior thalamus, cingulate gyrus, and hippocampus. Later, MacLean included the amygdala and the orbitofrontal cortex. The limbic system includes these structures and the amygdala, orbitofrontal cortex, and portions of the basal ganglia.
- Investigators no longer think there is only one neural circuit of emotion. Rather, depending on the emotional task or situation, we can expect different neural systems to be involved.

Categorizing emotions

- Emotions have been categorized as either basic or complex, or varying along dimensional lines.

- Six basic human facial expressions represent emotional states: anger, fear, disgust, happiness, sadness, and surprise.
  considerable debate continues as to whether any single list is adequate to capture the full range of emotional experiences, most scientists accept the idea that all basic emotions share three main characteristics. they are all innate, universal, and short-lasting human emotions.
  Pride and shame might e.g. also be basic

- Complex emotions (such as love) may vary conceptually as a function of culture and personal experiences.
  Even if we accept that basic emotions exist, we are still faced with identifying which emotions are basic and which are complex

- The dimensional approach, instead of describing discrete states of emotion, describes emotions as reactions that vary along a continuum.
  Such as valence (pleasant or unpleasant, positive or negative) and arousal (very pleasant to very unpleasant)
  Approach or Withdraw is a second dimensional approach characterizes emotions by the actions and goals that they motivate

- Researchers do not agree on how emotions are generated, and many theories exist.
  Jame-Lange: You don't run because you are afraid, you are afraid because you become aware of your bodily change when you run.
  Canon-Bard: Parallel emotional systems: Fast through cortex (I'm scared) and slow through hypothalamus (sympathetic nervous system - fight or flight)
  Appraisal: Richard Lazarus: Quick risk/benefit analysis of situation
  Subjective: Different people have different reactions
  Singer–Schachter Theory: blend of the James–Lange and appraisal theories. Singer and Schachter proposed that emotional arousal and then reasoning is required to appraise a stimulus before the emotion can be identified.
  Constructivist Theories: Lisa Barrett: First we form a mental representation of the bodily changes that have been called core affect (Russell, 2003). this representation is then clasified according to language-based emotion categories. Barret suggests that these categories vary with a person's experience and culture, so there are no empirical criteria for judging an emotion
  Evolutionary Psychology Approach : From this viewpoint, an emotion is not reducible to any one category of e ects, such as e ects on physiology, behavioral inclinations, cognitive appraisals, or f ling states, because it involves coordinated, evolved instructions for all of them together.
  LeDoux's High Road and Low Road: fast hardwired fight-or-flight response & slow cognition

(whoa, that looks suspiciously like an Ursus arctos horribilis, good thing I've been keeping in shape)
A emotion (feels scared)

Amygdala

- The amygdala is the most connected structure in the forebrain (Cortex + some more) (13 nuclei).
  3 parts.
- The amygdala contains receptors for many different neurotransmitters and for various hormones.
- The role that the amygdala plays in emotion is still controversial.

they approached novel or frightening objects or potential predators, such as snakes or human strangers. Not just once, they did it again and again, even if they had a bad experience.

Interactions

- Fear conditioning is a form of classical conditioning in which the unconditioned stimulus is aversive. It is a form of implicit learning.
  Classic example of fear-conditioning: Korsakoffs example: One day Claparède concealed a pin in his palm that pricked his patient when they shook hands. e next day, once again, she did not remember him; but when he extended his hand to greet her, she hesitated for the first time.
- The unconditioned response is the response naturally elicited (without training) by the unconditioned stimulus. The conditioned response is the response that is elicited (with training) by the conditioned stimulus. Usually the unconditioned response and the conditioned response are the same (e.g., the startle response in the rat), but they have different names depending on what elicits the response.
- Patients with bilateral amygdala damage fail to acquire a conditioned response during fear conditioning, indicating that the amygdala is necessary for such conditioning to occur.
- Information can reach the amygdala via two separate pathways: The "low road" goes directly from the thalamus to the amygdala; the "high road" goes from the cortex to the amygdala.

Signals sent by this pathway, sometimes called the low road, reach the amygdala rapidly (15 ms in a rat), although the information this pathway sends is crude. At the same time, sensory information about the stimulus is being projected to the amygdala via another cortical pathway, sometimes referred to as the high road. e high road is slower,taking 300 ms in a rat, but the analysis of the stimulus is more thorough and complete

- The amygdala is also important for explicit memory of emotional events. First, the amygdala is necessary for normal indirect emotional responses to stimuli whose emotional properties are learned explicitly, by means other than fear conditioning. Second, the amygdala can enhance the strength of explicit (or declarative) memories for emotional events by modulating the storage of these memories.

  The hippocampus is necessary for the acquisition of explicit or declarative knowledge of the emotional properties of a stimulus, whereas the amygdala is critical for the acquisition and expression of an implicitly conditioned fear response.

  During the instructed-fear paradigm, patients with amygdala damage were able to learn and explicitly report that some presentations of the blue square might be paired with a shock to the wrist. In truth, though, none of the participants ever received a shock. Unlike normal control participants, however, patients with amygdala damage did not show a potentiated startle response when the blue square was presented, though she could describe that she was aware of the conditioned connection.

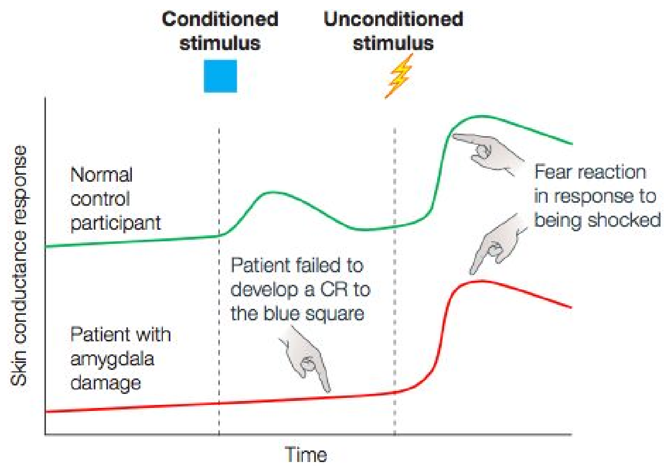


FIGURE 10.12 S.P. showed no skin conductance response to conditioned stimuli.
Unlike control participants, S.P. (red line) showed no response to the blue square (CS) after training but did respond to the shock (the US).

  The amygdala is not necessary for learning this hippocampal-dependent task, but it is necessary for the arousal- dependent modulation of memory for this task. The more active the amygdala, the stronger the memory

  If a rat with a normal amygdala is aroused immediately a er training, by either a physical stressor or the administration of drugs that mimic an arousal response, then the rat will show improved retention of this task. e memory is enhanced by arousal. In rats with a lesion to the amygda- la, however, this arousal-induced enhancement of mem- ory, rather than memory acquisition itself, is blocked

- Attention, perception, and decision making are all affected by emotion. Damasio proposed the somatic marker hypothesis, which states that emotional information, in the form of physiological arousal, is needed to guide decision making

Based on our current understanding, three aspects of emotions influence decision making.

1. Your current emotional state.

2. Your anticipatory emotions; the ones that occur before you make your decision.

3. Based on personal experience, the emotion that you expect to f l a er you have made the decision.

It appears that the **OFC** damage results in the inability to respond to changing patterns of reward and punishment.

medial OFC, the anterior cingulate cortex, and the anterior hippocampus correlated with increasing regret. e more the choice was regretted, the greater the activity of the medial OFC

What function is served by having emotions play such a role in decision making? Ellen Peters (2006) and her colleagues suggest that experienced f lings about a stim- ulus and f lings that are independent of the stimulus, such as mood states, have four roles in decision making.

1. they can act as information.

2. they can act as "common currency" be n disparate inputs and options (you can feel slightly aroused by a book and very aroused by a swimming pool).

3. they can focus attention on new information, which can then guide the decision.

4. they can motivate approach or avoid behavior decisions.

Emotion and Social Stimuli

- The amygdala appears to be necessary for automatically deriving information from the eyes of others when identifying emotional facial expressions. This ability is especially critical for the proper identification of fear, because the defining characteristic of fear is an increase in the volume of the eye whites.

  Stunningly, the investigators could induce S.M. to overcome her deficit by providing her with a simple instruction: "Focus on the eyes." If told to do so, she no longer had any di cul identi ing fearful faces

- the right orbitofrontal cortex (OFC; s Figure 10.3b) was increasingly active when participants viewed increasingly expressive angry faces. this region was not active when participants viewed sad faces. these results suggest a role for the OFC in explicit emotional labeling of angry faces.

- Participants who showed more racial bias as measured by the IAT showed greater amygdala activity during the presentation of black faces. But is this really what was happening?

For brief presentations, where the evaluation must be made quickly and automatically, the amygdala is activated, and the activation is greater for black faces than for white faces. With longer presentations, when controlled processing can take place, amygdala activation is not signi cantly di erent be n races. Instead, signi cantly more activi occurred in the right ventro-lateral prefrontal cortex during viewing of black faces than of white faces. Cunningham's team proposed that there are distinct neural di erences be n automatic and more controlled processing of social groups and that the controlled processing may modulate the automatic evaluation.

Maybe it's not about race, but about in-group / out-group bias

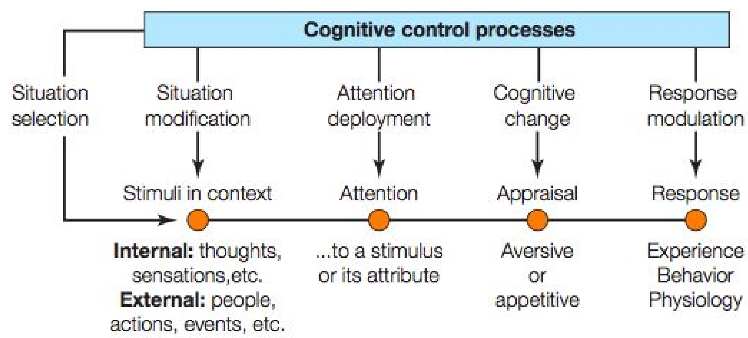
Kurzban and colleagues (2001) found that when categorization cues stronger than race are present (e.g., one's group is a team wearing green shirts and the opposing group wears red shirts), the categorization based on race nearly disappears.

When looking at faces, the activity of the amygdala increases with the degree of difference from a categorically average face.

- The amygdala is activated by novel stimuli independent of valence and arousal.

Cognitive Control

FIGURE 10.20 **Diagram of the processing steps proposed by Ochsner and his colleagues for generating an emotion and how the emotional outcome might be regulated by cognitive control processes** **(blue box).**
The arrows pointing down from the cognitive control processes indicate the effects of different emotion regulation strategies and which emotion generation stage they influence.



- Emotion regulation is complex and involves many processes.

Reappraisal is a cognitive- linguistic strategy that reinterprets an emotion-laden stimulus in nonemotional terms. For instance, a woman wiping the tears om her eyes could be crying because she is sad; or, on reappraisal, she may simply have some- thing in her eye she is trying to remove. Suppression is a strategy in which we inhibit an emotion-expressive behavior during an emotionally arousing situation (for instance, smiling when you are upset)

Only reappraisal actually reduced the disgust experience. But suppression actually increased sympathetic activation, caus- ing participants to be more aroused, and this increased sympathetic activity lasted for a while after the film ended (Gross, 1998b)

- Emotion regulation is dependent on the interaction of frontal cortical structures and subcortical brain regions & Different emotion regulation strategies have different physiological effects.
  In the self-focused group, participants were instructed to imagine them-selves or a loved one in the negative scene (increasing negative emotion); to view the pictures in a detached way (decreasing negative emotion); or, in the control condition, simply to look at the image.
  - but indicated that down-regulation took more effort

What about the amygdala? Amygdala activation was modulated either up or down depending on the regulatory goal: Activi increased when the goal was to enhance negative emotion and decreased when the goal was to reduce it.

Other Areas, Other Emotions

- Different brain areas are associated with the processing of different emotions. The orbitofrontal cortex is activated when identifying angry facial expressions and hearing angry prosody, and the anterior insula (tucked between the frontal and temporal lobes in the Sylivan fissure) is linked to identification and experience of disgust.

- The insula appears to play a broad role in integrating affective and cognitive processes.

  Interoception: Interestingly, people with a bigger right insula are be er at detecting their heartbeats than are people with a smaller right insula (Critchley et al., 2004), and those same people are also more aware of their emotions (L. Barre et al., 2004).

- Happiness: Flow: fully engages your a ention, and o ers immediate f dback at each step that you are on the right track and pulling it o .

TAKE-HOME MESSAGE

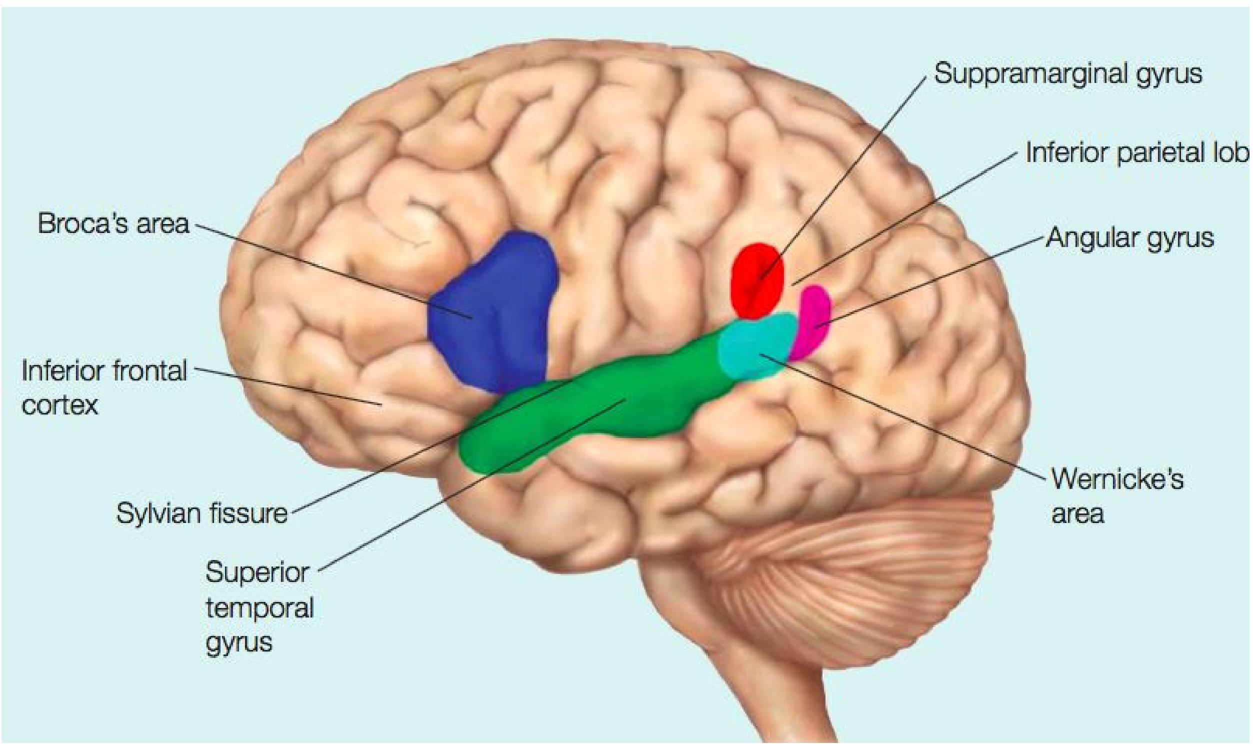
Ultimately, understanding how we perceive and experience emotion will require studying the interactions of a diverse set of neural structures.

Chapter 10 - Language

Literature: Gazzaniga et al p. 468-505

NATURAL LANGUAGE - LANGUAGE ARISING IN BRAIN

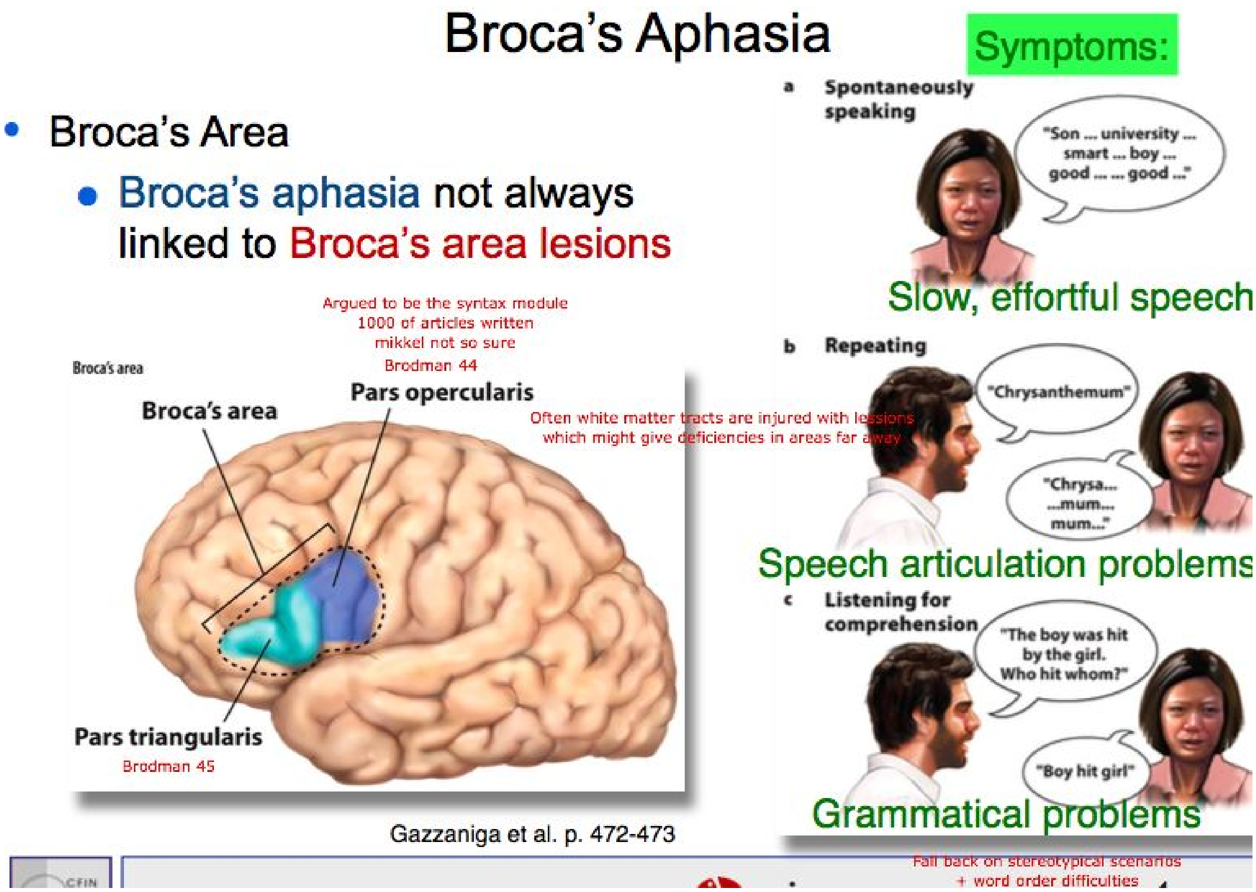
- Anomia is the inability to find the words to label things in the world. It is not a deficit of knowledge.
  - HW (Left hemisphere stroke) : could retrieve adjective better than verbs, but his retrieval of nouns was the most severely affected.
    - He knew what an object was and its use. He simply could not produce the word.
    - The experience is called the tip-of-the-tongue phenomenon. H.W.'s problems further illustrate that the ability to produce speech is not the same thing as the ability to comprehend language
- Split-brain patients as well as patients with lateralized, focal brain lesions have taught us that the left-hemisphere network involving the frontal, parietal, and temporal lobes around the Sylvian fissure, is especially critical for language production and comprehension. (Parasylvian language network)



- The right hemisphere does have roles in language. The right superior temporal sulcus plays a role in processing the rhythm of language (prosody), and the right prefrontal cortex, middle temporal gyrus, and posterior cingulate activate when sentences have metaphorical meaning.

Brain Damage and Language Deficits

- Language disorders, generally called **aphasia**, can include deficits in comprehension or production of language resulting from neurological damage.
    - Aphasia may also be accompanied by speech problems caused by the loss of control over articulatory muscles, known as **dysarthria,** and deficits in the motor planning of articulations, called speech **apraxia**.



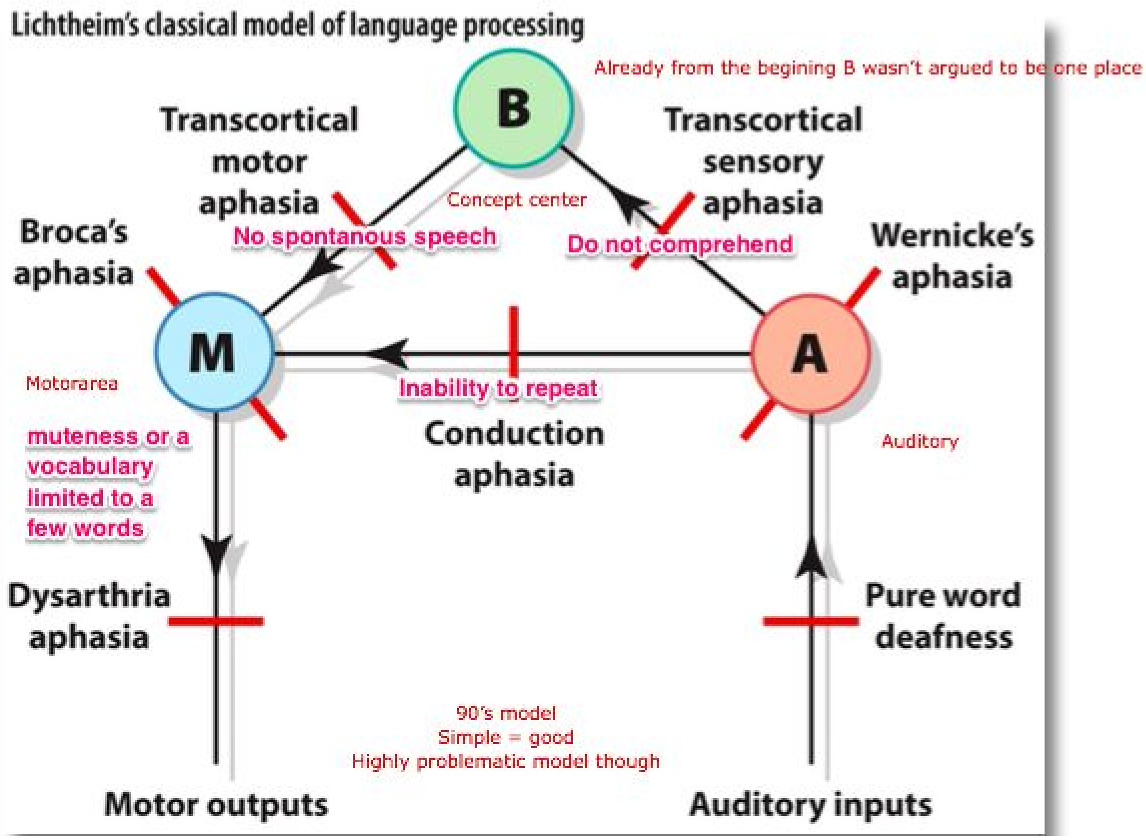
- Remember Sarah Scott - stroke at 19 years old

- Patients with **Broca's aphasia** have problems with speech production, syntax, and grammar, but otherwise comprehend what is said or written fairly well. (TAN)
    - The lesions that produce Broca's aphasia may not be limited to the classically defined Broca's area in the left inferior frontal cortex.

      Leborgne's lesions extended into regions underlying the superficial cortical zone of Broca's area, and included the insular cortex and portions of the basal ganglia (Dronkers et al., 2007).

Agramatic aphasia: Only understand the most easy sentences (boy kicked the girl)

- People with Wernicke's aphasia have severe comprehension deficits but can produce relatively fluid speech; it is, however, rather meaningless. Originally linked to damage solely in Wernicke's area (the posterior superior temporal gyrus), today Wernicke's aphasia is also linked to damage outside the classic Wernicke's area.
- Aphasia can also result from damage to the connection between Wernicke's and Broca's areas (the arcuate fasciculus). Conduction aphasia is the disorder that results from such damage, and people with this type of aphasia have problems producing spontaneous speech as well as repeating speech.



Conduction aphasics can understand words that they hear or see and can hear their own speech errors, but they cannot repair them. they have problems producing spontaneous speech as well as repeating sp ch, and sometimes they use words incorrectly

Classical localizationist model

Global apahsia : Extensive left-hemisphere damage - U know nothing John Snow

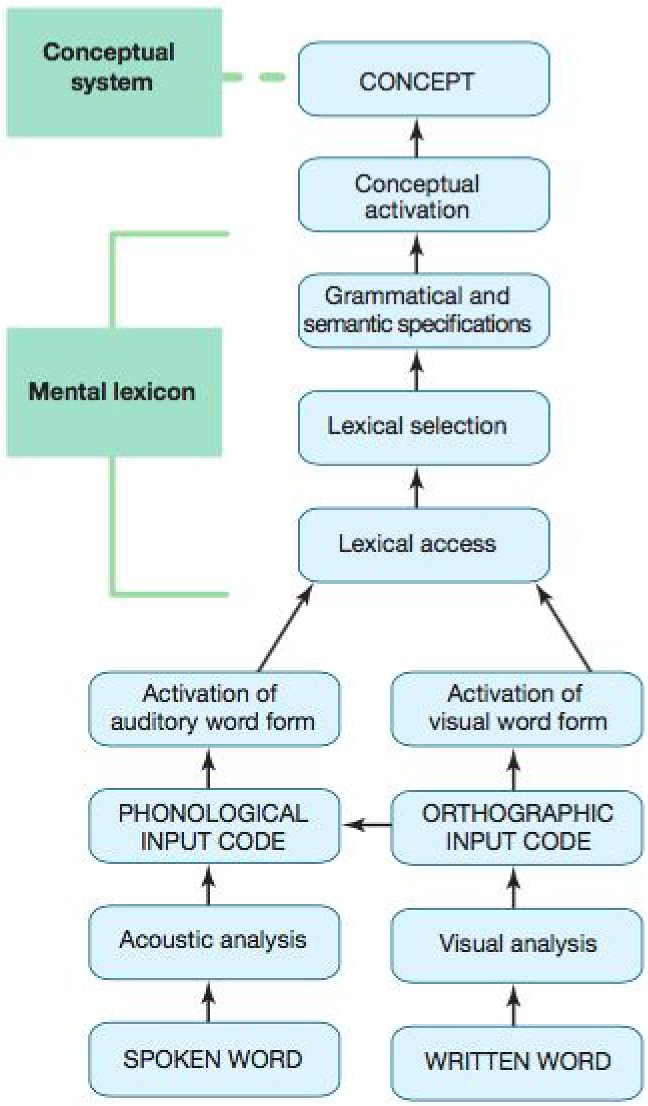
Everybody agrees that it is a stupid model, but it's simple so we use it anyway
The tide has turned away from a purely locationist view, and scientists have begun to assume that language emerges from a network of brain regions and their connections.

- Part of the problem is that the original lesion localizations were not very sophisticated. Another part of the problem lies in the classification of the syndromes themselves: Both

Broca's and Wernicke's aphasias are associated with a mixed bag of symptoms and do not present with purely production and comprehension deficits, respectively.

The Fundamentals of Language in the Human Brain

- The mental lexicon is the brain's store of words and concepts. (Different models - but they agree that some things must happen:)



Lexical access refers to the stage(s) of processing in which the output of perceptual analysis activates word-form representations in the mental lexicon, including their semantic and syntactic a ributes. **Lexical selection** is the next stage, where the lexical representation in the mental lexicon that best matches the input can be identified (selected). Finally, to understand the whole message, **lexical integration** integrates words into the full sentence, discourse, or larger context.

mental lexicon must be organized in a highly efficient manner. It cannot be merely the equivalent of a dictionary. If, for example, the mental lexicon were organized in simple alphabetical order, it might take longer to find words in the middle of the alphabet, such as the ones starting with K, L, O, or U, than to nd a word starting with an A or a Z. Fortunately, this is not the case.

- A morpheme is the smallest unit of language that has meaning.
- A phoneme is the smallest unit of sound that makes a difference to meaning.
- **Semantic (meaning) relationships between words are an organizational principle of the mental lexicon. This makes words easier to recognize when they follow a related word that primes their meaning.**

  It is not exactly clear how many features would have to be stored. For example, a table could be made of wood or glass, and in both cases we would recognize it as a table. Does this mean that we have to store the features "is of wood/glass" with the table concept? In addition, some words are more "proto typical" examples of a semantic category than others, as reflected in our recognition and production of these words. When we are asked to generate bird names, for example, the word robin comes to mind as one of the rst examples; but a word like ostrich might not come up at all, depending on where we grew up or have lived.

  Lot's of models with decision trees and semantic networks (Strength and distance between connections are determined afrom how related they are)

  Priming -> Bread and butter -> Semantics is an organizable principle

  In sum, it remains a matter of intense investigation how word meanings are represented.

- Patients with neurological damage may name an item with an incorrect but semantically-related word (e.g., "animal" for "horse"), which supports the idea that the mental lexicon contains semantic networks of related meanings clustered together.
- Syntax refers to the way in which words in a particular language are organized into grammatically permitted sentences. (Sentence structure)
- Grammar refers to the structural rules that govern the composition of words, phrases, and sentences in a particular natural language. (Permissible word rules - e.g. s at the end for plural)
- Also shown in neurological evidence from different disorders → support semantic network idea because related meanings are substituted or confused

- Warrington studied category-specific agnosia → found that semantic memory problems fell into semantic categories (living vs non living)
- Suggested that the problems were reflections of the types of information stored with different words in the semantic network
- The living categories rely more on visual features, whereas non living categories are identified by their functional features.
    - ➢ So suggest that semantic memory is organized by features of an object (visual vs functional)
    - Other studies have shown that: there is a correspondence between the place of lesion and the type of semantic deficit
    - ➢ "The patients whose impairment involved living things had lesions that included the inferior and medial temporal cortex, and often these lesions were located anteriorly. The anterior inferotemporal cortex is located close to areas of the brain that are crucial for visual object perception, and the medial temporal lobe contains important relay projections from association cortex to the hippocampus, a structure that has an important function in the encoding of information in long- term memory."
    - ➢ "in our brains, conceptual representations of living things versus human-made tools (non-living) rely on separable neuronal circuits engaged in processing of perceptual versus functional information."

Language Comprehension

- Activation of the perceptual features occurs in primary cortices within the first 100 ms a er a picture is presented; activation of more detailed semantic representations occurs in the posterior and anterior ventral–lateral cortex begin 150 and 250 ms; and starting around 300 ms, participants are able to name the specific object that is depicted in the picture, which requires the retrieval and integration of detailed semantic information that is unique to the specific object.

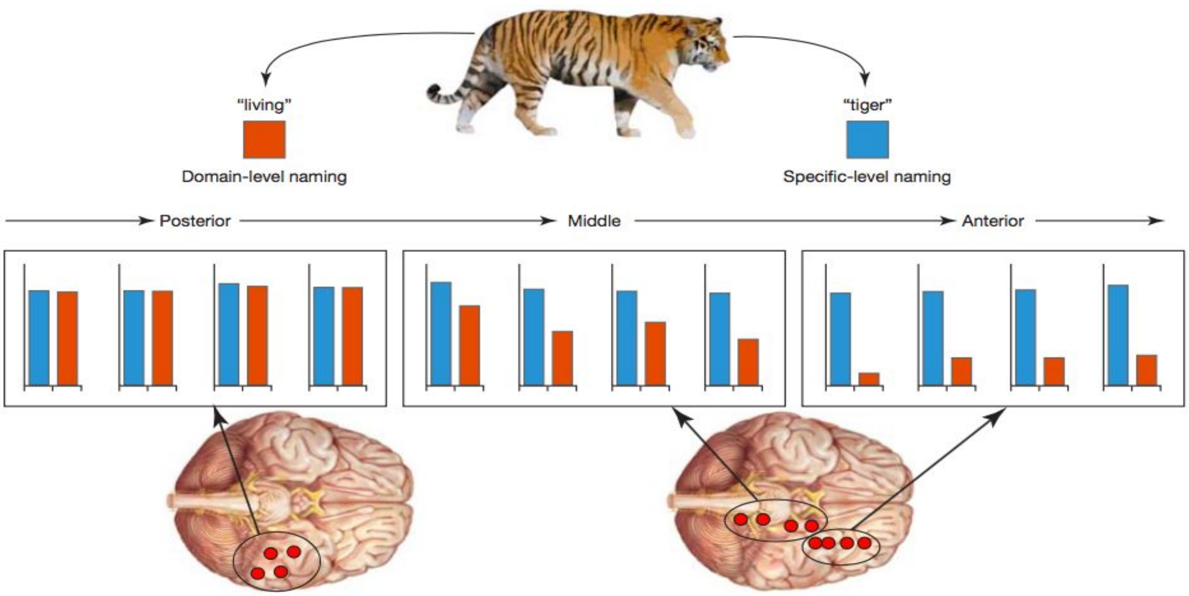


FIGURE 11.7 The anterior temporal lobes are involved in naming living things. When identifying the tiger at the less complex domain level (living things), activity was restricted to more posterior occipitotemporal sites (red bars). Naming the same object stimulus at the specific-level (blue bars) was associated with activity in both posterior occipitotemporal and anteromedial temporal lobes.

- The babies can understand all phonemes - but atune themselves to one languages phonemes.
- There are no pauses between phonemes in speech that correspond to words. (English language 40 phonemes)
- The prosody of speech is the rhythm and the pitch of the speaker's voice. (Early stage of processing)
- Sound comprehension involves the superior temporal cortex. People with damage to this area have pure word deafness (Although they could process other sounds relatively normally, these patients had speci c di culties recognizing sp ch sounds.)
- Distinguishing speech from nonspeech sounds occurs in the mid-portion of the superior temporal sulcus (STS), but no lexical-semantic information is processed in this area. (Heschl's gyrus = Auditory cortex - haven't filtered sounds yet)
- Spoken-word recognition processing proceeds anteriorly in the superior temporal gyrus (STG): Phoneme sound processing appears localized to the left mid-STG, integration of phonemes into words appears localized to the left anterior STG, and processing short phrases appears to be carried out in the most anterior locations of STS.

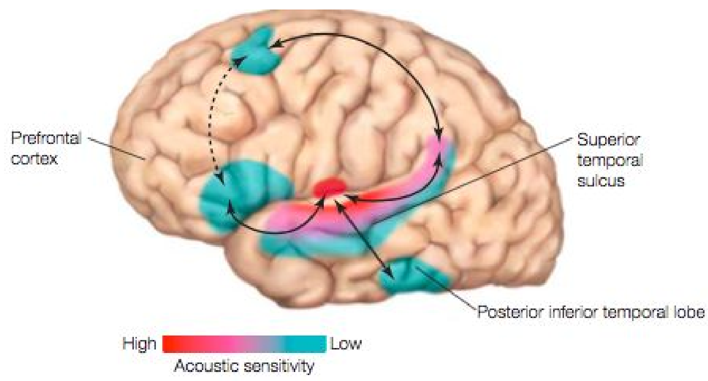


FIGURE 11.10 Brain areas important to speech perception and language comprehension. Acoustic sensitivity decreases moving anteriorly and posteriorly away from primary auditory cortex, while speech sensitivity increases. Anterior and posterior regions of the superior temporal sulcus are increasingly speech specific. Posterior inferior temporal lobe and prefrontal regions are also important during speech processing. Heschl's gyrus (primary auditory cortex; red spot) is not speech specific, but is instead activated by all auditory inputs.

Written Input: Reading Words

Reading

- McClelland and Rumelhart model top-down + bottom-up - 3 Layers
    - information from the higher cognitive levels, such as the word layer) are allowed to influence earlier processes that happen at lower levels of representation (the letter layer and/or the feature layer).
    - The word superiority effect can be explained in terms of the McClelland and Rumelhart model, because the model proposes that top-down information of the words can either activate or inhibit letter activations, thereby helping the recognition of le ers.
- Selfridge's model, one letter is processed at a time in a serial manner between "image demons"

▪ Written-word processing takes place in occipitotemporal regions of the left hemisphere. Damage to this area can cause pure alexia, a condition in which patients cannot read words, even though other aspects of language are normal.

▪ Occipitotemporal regions of the left hemisphere may be specialized for the identification of orthographic units.

Stimulation mapping

Stimulation of between 100 and 200 patients revealed that aspects of language representation in the brain are organized in mosaic-like areas of 1 to 2 cm2.
These mosaics usually include regions in the frontal cortex and posterior temporal cortex. In some patients, however, only frontal or posterior temporal areas were observed. The correlation between these effects in either Broca's area or Wernicke's area was weak; some patients had naming disruption in the classic areas, and others did not. Perhaps the single most intriguing fact is how much the anatomical localizations vary across patients. This finding has implications

for how across-subject averaging methods, such as PET activation studies, reveal significant effects.

The Role of Context in Word Recognition

- Three classes of models attempt to explain word comprehension: *Modular models, interactive models* (all types of information can participate in word recognition. In these models, context can have its influence even before the sensory information is available, by changing the activational status of the word-form representations in the mental lexicon.) and *hybrid models* (information is provided about word forms that are possible given the preceding context, there- by reducing the number of activated candidates.)

- Lexical selection can be influenced by sentence context. (addressed the question of modularity versus interactivity)

- Lexical access and selection involve a network that includes the middle temporal gyrus (MTG), superior temporal gyrus (STG), and the ventral inferior and bilateral dorsal inferior frontal gyri (IFG) of the left hemisphere.

    - Left MTG and STG are important for the translation of speech sounds to word meanings.

- Syntactic parsing is the process in which the brain assigns a syntactic structure to words in sentences.

    - Noam Choms illustrates this. the sentence “Colorless green ideas sleep furiously” is easier to process than “Furiously sleep ideas green colorless.” this is because the first sentence, even though meaningless, still has an intact syntactic structure

- In the ERP method, the N400 is a negative-polarity brain wave related to semantic processes in language, and the P600/SPS is a large positive component elicited after a syntactic and some semantic violations.

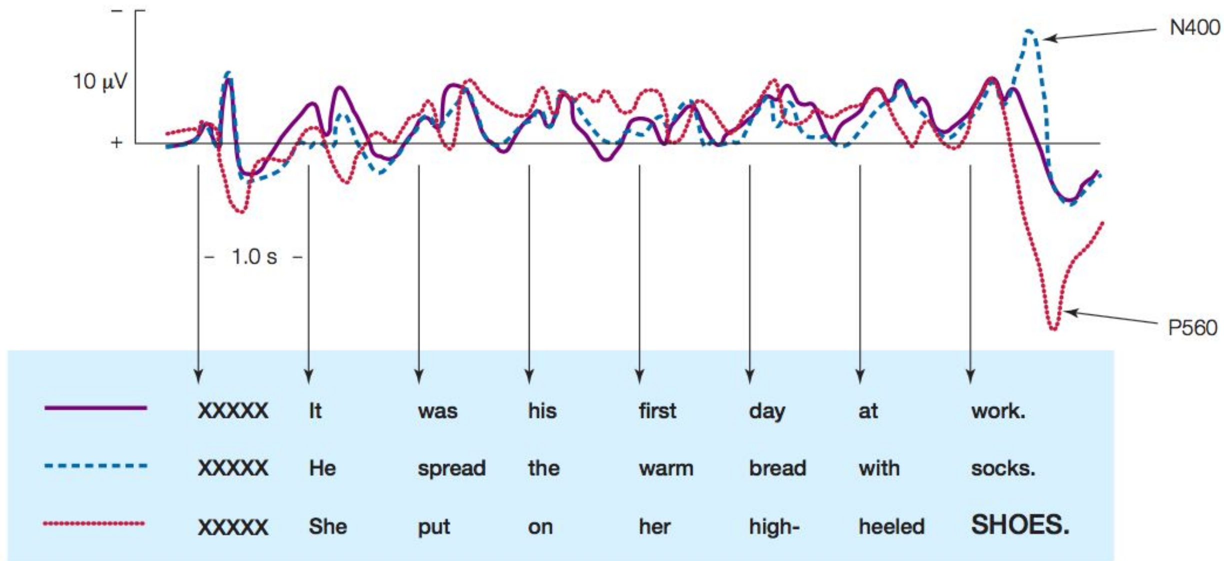


FIGURE 11.16 ERPs reflecting semantic aspects of language.
ERP waveforms differentiate between congruent words at the end of sentences (*work* in the first sentence) and anomalous last words that do not fit the semantic specifications of the preceding context (*socks* in the second sentence). The anomalous words elicit a large negative deflection (plotted upward) in the ERP called the *N400*. Words that fit into the context but are printed with a larger font (*SHOES* in the third sentence) elicit a positive wave (P560) and not the N400, indicating that the N400 is not generated simply by surprises at the end of the sentence.

In aphasics with moderate to severe comprehension de - cits (low comprehenders), the N400 effect was reduced and delayed.

- Syntactic processing takes place in a network of left inferior frontal and superior temporal brain regions that are activated during language processing.

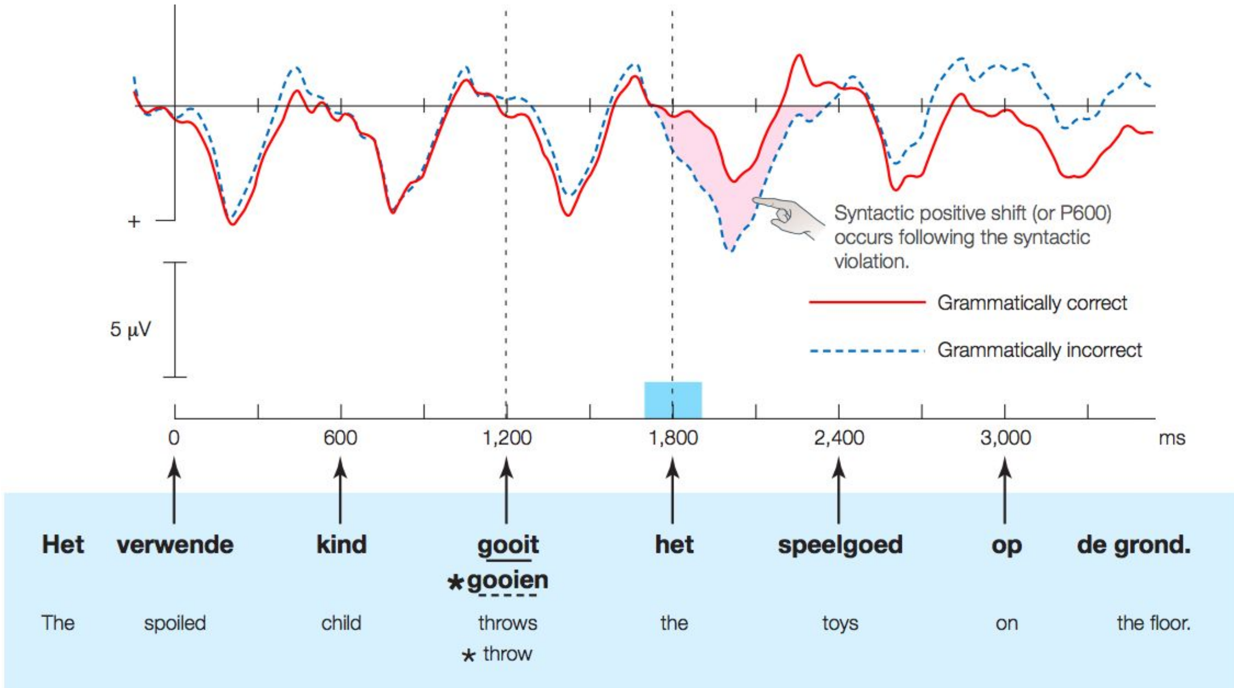


FIGURE 11.17 ERPs reflecting grammatical aspects of language.
ERPs from a parietal (Pz) scalp recording site elicited in response to each word of sentences that are syntactically anomalous (dashed waveform) versus those that are syntactically correct (solid waveform). In the violated sentence, a positive shift emerges in the ERP waveform at about 600 ms after the syntactic violation (shaded). It is called the syntactic positive shift (SPS), or P600.

Neural Models of Language Comprehension

- Models of language involve unifying information from linguistic inputs or from retrieved linguistic representations with stored knowledge.

FIGURE 11.21 Memory–unification–control model.
The three components of the model are shown in colors overlaid onto a drawing of the left hemisphere: the memory component (yellow) in the left temporal lobe, the unification component (blue) in the left inferior frontal gyrus, and the control component (purple) in the lateral frontal cortex.

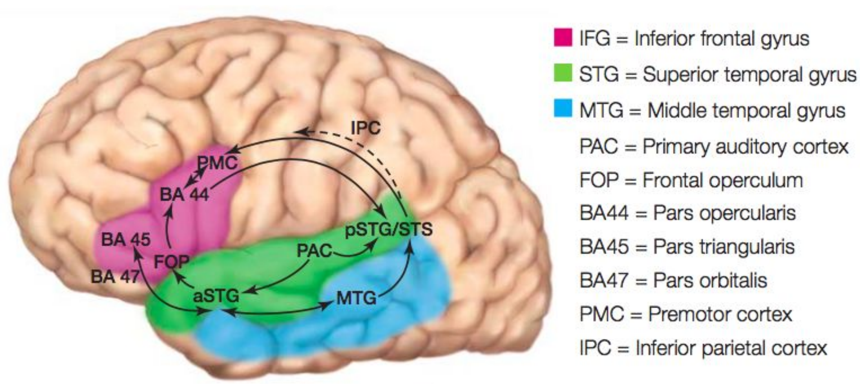


FIGURE 11.22 Cortical language circuit proposed by Angela Friederici, consisting of two ventral and two dorsal pathways.
The black lines indicate direct pathways and direction of information flow between language-related regions. The broken line suggests an indirect connection between the pSTG/STS and the MTG via the inferior parietal cortex. The ventral pathways are important for comprehension of the meanings of words. The dorsal pathway that connects to the premotor cortex is involved in speech preparation. The other dorsal pathway connects Broca's area (specifically BA44) with the superior temporal gyrus and superior temporal sulcus and is involved in syntactic processing.

- White matter tracks in the left hemisphere connect frontal and temporal lobes to create specific circuits for speech, semantic analysis, and syntactic processing.

Neural Models of Speech Production

- Models of language production must account for the selection of the information to be contained in the message; retrieving words from the lexicon; sentence planning and grammatical encoding using semantic and syntactic properties of the word; using morphological and phonological properties for syllabi cation and prosody; and preparing articulatory gestures for each syllable.

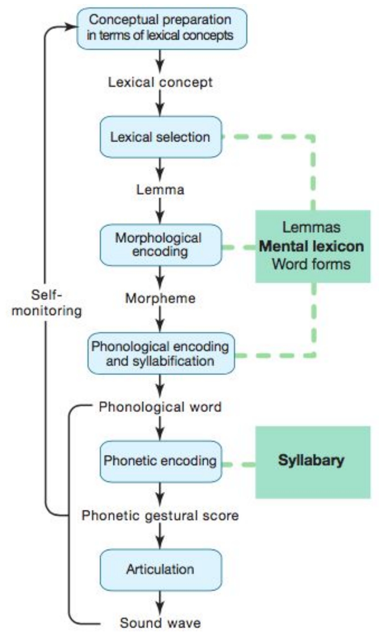


FIGURE 11.23 Outline of the theory of speech production developed by Willem Levelt.
The processing components in language production are displayed schematically. Word production proceeds through stages of conceptual preparation, lexical selection, morphological and phonological encoding, phonetic encoding, and articulation. Speakers monitor their own speech by making use of their comprehension system.

- Each stage in Levelt's model for language production occurs serially, and its output representation is used for input to the next stage. It avoids feedback, loops, parallel processing, and cascades, and it fits well with the findings of ERPs recorded intracranially.

the first wave, at about 200 ms, appeared to reflect lexical identification. the second wave occurred at about 320 ms (Figure 11.25b) and was modulated by inflectional demands. It was not, however, modulated by phonological programming. this was seen in the third wave (Figure 11.25c) that appeared at about 450 ms and reected phonological encoding. In naming tasks, sp ch pically occurs at 600 ms. Sahin and coworkers could also s that motor neuron commands occur 50–100 ms before speech, putting them just a er the phonological wave. These findings provide support for serial processing,

- In contrast to the modular view in Levelt's model, interactive models such as the one proposed by Gary Dell (1986) at the University of Illinois suggest that phonological activation begins shortly a er the semantic and syntactic information of words has been activated. Unlike modular models, interactive models permit feedback from the phonological activation to the semantic and syntactic properties of the word, thereby enhancing the activation of certain syntactic and semantic information.

Evolution of language

- Noam Choms took the view in 1975 that language was so different from the communication systems used by other animals that it could not be explained in terms of natural selection.

- Animal calls can carry meaning and show evidence of rudimentary syntax. In general, however, animal calls tend to be inflexible, associated with a specific emotional state, and linked to a specific stimulus.

- Many researchers suggest that language evolved from hand gestures, or a combination of hand gestures and facial movement.

Tomasello emphasizes that unlike vocalizations, using gestures requires knowing the a entional state of the communicating partner. No good making a gesture if no one is paying a ention to you. He concludes that primate gestures, which are exible, socially learned, and require shared a ention, are more like human language than primate vocalizations, which pically are in exible, automatic, and independent om shared a ention. Tomasello suggests that language evolved om gestural communication.

Interestingly, nonhuman primates have li le cortical control over vocalization but have excellent cortical control over the hands and arms (Ploog, 2002).

- Areas that control hand movement and vocalizations are closely located in homologous structures in monkeys and humans.

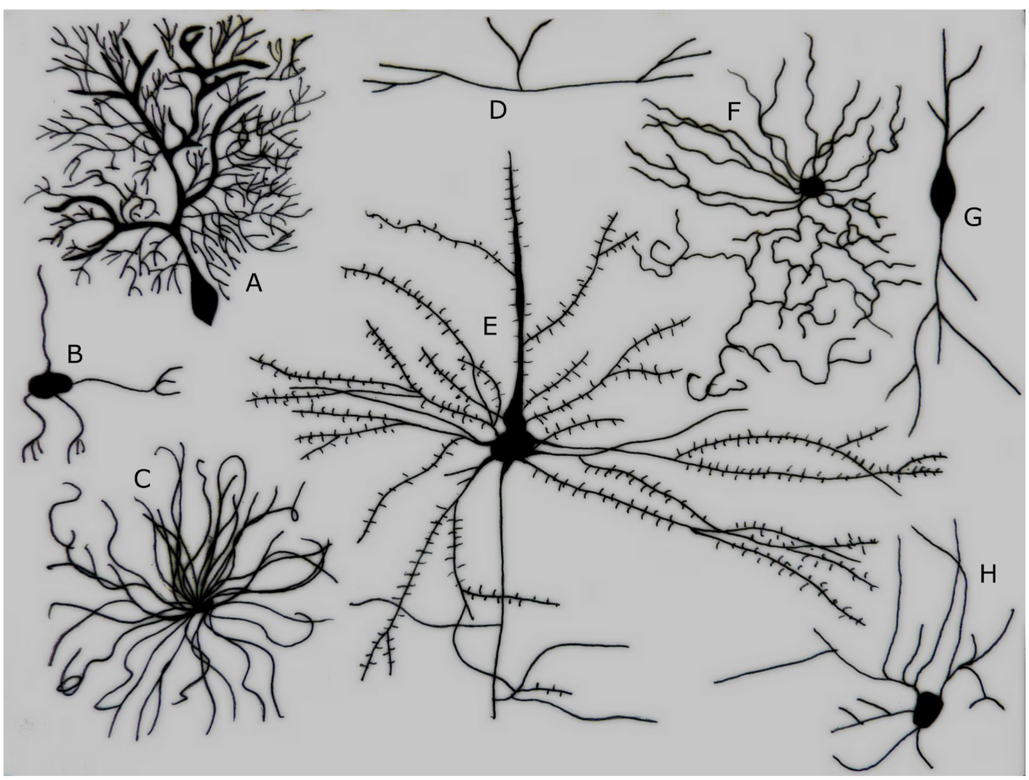
We know that the le hemisphere controls the motor movements of the right side of the body, both in humans and the great apes. Chimpanzees exhibit preferential use of the right hand in gestural communication both with other chimps and with humans (Meguerditchian et al., 2010), but not when making noncommunicative gestures. is behavior is also s n in captive baboons suggesting that the emergence of language and its pical le lateralization may have arisen from a left lateralized gestural communication system in the common ancestor of baboons, chimps, and humans.

Chapter 11 - Cognitive Control and Summary

Literature: Gazzaniga et al p. 506-558

Cool extra ressources

Type of neurons



Different Types of Neurons (click to enlarge). A. Purkinje cell B. Granule cell C. Motor neuron D. Tripolar neuron E. Pyramidal Cell F. Chandelier cell G. Spindle neuron H. Stellate cell (Credit: Ferris Jabr; based on reconstructions and drawings by Cajal)