The Brain

Brain Development

Overview

18 days after conception

Primitive streak

Outer layer of embryo thickens
Ectoderm forms a plate
Edges curl up
Make a neural tube

Neural tube

Cells inside tube become neurons & glial cells
Closed tube
Tube with 3 bulges

1. Forebrain

Cerebral cortex
Basal ganglia
Limbic system
Thalamus
Hypothalamus

2. Midbrain

Superior colliculi = vision
Inferior collicui = hearing
Homeostasis & reflexes

3. Hindbrain

Medulla oblongata
Cerebellum
Pons

Phases

1st Phase

Symmetrical Division
2 identical founder cells
Radial Glial Cells
Spread out like tree
Neurons climb tree to their proper position

2nd Phase

Asymmetrical Division
About 3 months
Divide into neuron & founder cells
End of cortical development
founder cells receive signal (cell death)

Choice 1: Anatomy

Two fists, crossed arms
4 lobes:
- Occipital
- Parietal
- Temporal
- Frontal

Frontal lobes

1. Primary Motor Cortex

2. Pre-motor Cortex

Supplemental motor

Connect directly to spine
Help, don't know how
balance?
coordination?

Prefrontal Cortex

Connects direct to spine
Not fully understood
Planning?
Spatial guidance?
Actions of others?

Posterior Parietal Lobe

3. Pre-frontal Cortex

Dorsolateral

fairly new
develops til 30
connects to basal ganglia+
working memory
damaged in Schiz
drug abuse
alcohol
?

Orbitofrontal

above the eyes
decision making
inhibit bad behavior
gambling
OCD

Ventromedial

risk
fear
decision making
regulation of emotion

Anterior Cingulate Cortex

Collar around the corpus collosum

Other Regions

Lingual gyrus

Fusiform gyrus

Hippocampal gyrus

Hippocampus

Damage to one side = retrograde amnesia
Damage to both sides = anterograde amnesia

Cerebellum

Lateral Cortiospinal Tract

Primary Motor Cortex
Red nucleus of the midbrain
Go to medulla oblongata
Cross contralateral
Medulla pyramids

Choice 2: Connections

When neurons reach home

Connect with each other
Grow dendrites & axons
Synapse formation
Synapse elimination

5 Steps of Neurons

1. Proliferation

Production of new cells
Cells along the ventricles divide to become neurons and glia.

2. Migration

Primitive neurons find their spots
Chemicals guide cells

3. Differentiation

Neurons get axon & dendrites
Makes them different
Axon grow before dendrites
During migration

4. Myelination

Glia cells produce myelin sheaths
first in spinal cord
Then in brain
Lasts til about 30

5. Synaptogenesis

Continues throughout life
Forming synapses

Age & Neurons

- Stem cells
- Nose cells always undifferentiated
- Periodically divide & make new olfactory cells

Pathfinding

- Getting axons to their spots
- Chemical Path-finding

Weiss (1924)

- grafted extra leg to a salamander
- axons grew, moved in sync with other legs
- Theory:
  - nerves attach to muscles randomly
  - variety of messages are sent
  - each one tuned to a dif. muscle

Sperry (1943)

- Severed optic nerve axons
- Rotated them 180°
- Grow back to their original target locations in midbrain

Chemical gradients

- Axons attracted by some chemicals, repelled by others
- TOPDV protein is 30x more concentrated in dorsal retina than ventral retina axons
- Highest connect to highest
- Lowest concentration axons connect to lowest

Neural Darwinism

- During development
  - Synapses form randomly
  - Selection process keeps some and rejects others
- Chemical guidance
- Neurotrophic factors
  - Muscles & synapse survival
    - produce & release NGF (nerve growth factor)
    - Not enough NGF, axons degenerate and cell bodies die
  - Neurons automatically die
    - don’t make synaptic connection
    - Apoptosis = cell death
- Neurotrophin
  - promotes survival & activity
  - Similar to NGF
- BDNF
  - brain-derived neurotrophic factor
  - most abundant neurotrophin in cortex
  - Make more than enough

- Neurotrophins are also
  - used in adult brains
  - More axon & dendrite branching
- Deficiencies of neurotrophins lead to cortical shrinking and brain diseases

Cortex Differentiation

- Different parts of cortex
  - Different shapes
  - Shape and functions depend on input received
- Transplant immature neurons
  - Become like neighbors
- Transplant later
  - Some new, some old attributes
- Experience fine tunes
  - Redesign our brain to fit (within limits)
  - Enriched environments
    - Thicker cortex
    - More dendritic branching
    - Best enrichment = activity\

Transfer

- Far transfer = do well in one, do well in other tasks
- Near transfer = practice task, do better on that task only
- Train the brain – doesn't work

Neural Plasticity

Blind from birth

- better at discriminating objects by touch
- increased activation in occipital lobe (vision) doing touch tasks
- Use occipital cortex for Braille (sighted people don't)
- Concept of straight

Learn to read as adults

- More gray matter in cortex
- Thicker corpus callosum

Music Training

- Pro musicians
  - Bigger temporal lobe (30%)
  - 2x greater response to pure tones (in auditory cortex)
- Violin players
  - larger area devoted to left fingers in the postcentral gyrus

Musician's Cramp

- Practice too much
- Fingers get jerky, clumsy & tired
- expanded representation of each finger overlaps neighbor

Writer's Cramp

- Spend all day writing

Fingers get jerky, clumsy & tired

Overruling reflexes

Antisaccade task
- Object appears in periphery
- Must look in opposite direction
- Top-down processing overruling reflex
- Improves with age unless
  - Very young; hard to look away from attention getter
  - ADHD

Age & Neurons

At 30, frontal cortex begins to thin
- Much individual variation

60+
- Synapses alter more slowly (learn)
- Hippocampus gradually shrinks
- Compensate by using more brain areas

Choice 3: Under the Brain

Thalamus

Hypothalamus

Pituitary

Pons

Basal ganglia: 4 structures

Amygdala

- left & right
- memory consolidation
- strength of emotion impacts memory strength

Optic Chiasm

Transfer neural info

left fields to right side
- inside switches
- cross your nose

Path

- eye
- optic nerve
- optic chiasm
- optic tract
- LGN
- occipital lobe

NOT IN LECTURE

Developing brain vulnerabilities

- Toxic chemicals
- Malnutrition
- Infections
- Teratogens
  - Environmental factor
  - Interfere with development
- Medication, drug, alcohol or substance
- Disease

Critical Periods

- Implantation = common blood supply
  - whatever's in mother's blood crosses
  - 10 to14 days after conception
  - 3.5 to 4.5 weeks
- Closure of the neural tube
- Central nervous system vulnerable throughout pregnancy

3 Major Substances

- Alcohol
- Phenytoin
- Chickenpox

1. Fetal alcohol syndrome

- Best known non-genetic cause of mental retardation
- (3 in 1,000)
- Infant brains are especially sensitive to alcohol
- Suppress release of glutamate
- brain's main excitatory
- neurons receive less excitation and undergo apoptosis
- Alcohol broken down more slowly
- immature liver
- Alcohol levels remain high longer
- Worse when born to alcoholic mothers
- drink more than four to five drinks/day
- No amount of alcohol is safe

2. Phenytoin (or Dilantin)

- Anti-convulsive
- used to treat epilepsy (seizure disorder)
- 10% chance of birth defects
- Fetal Hydantoin Syndrome
- If taken in the first trimester

3. Varicella (chickenpox)

- Highly infectious disease
- 95% of Americans have had it
- 90% of pregnant women are immune
- 1 out of 2,000 develop during pregnancy

A. If in pregnancy (week 1-20)

2% chance of defects
"congenital varicella syndrome"
Scars
Malformed and paralyzed limbs

B. Newborn period

5 days before to 2 after birth
About 25 % newborns become infected
About 30% of infected babies will die if not treated

Parental use of:

Cocaine or cigarettes

ADHD

Antidepressant drugs

Heart problems

Birth Defects

3-5% of newborns
Leading cause of infant mortality

Majority have no known cause

Blood-Brain Barrier

Paul Ehrlich, 1800's

Injected blue dye into animals
All tissues turned blue EXCEPT brain and spinal cord
Keeps most chemicals out of brain

Why need BBB?

Brain has no immune system
Neurons can't replicate-replace
No way to fix damage
Viruses that do enter kill you
    Rabbies
Neural disorders last whole life
    Chicken pox-shingles

How it works

Keeps out harmful chemicals
Keeps out medications
    Cancer med
    Dopamine for Parkinson's
Astrocytes form layer around brain blood vessels
    may be responsible for transporting ions from brain to blood
Semi-permeable
Endothelial cells line capillaries
    Small spaces between each
    Some things can move between them
    Loosely joined in body, large gaps
    Tightly joined in brain, blocking most molecules

Large molecules can't easily pass thru
Molecules with a high electrical charge are slowed down
Protects the brain

What can cross passively

Small uncharged molecules
    Oxygen & carbon dioxide
Molecules dissolve in fats
    capillary walls are fats

What can cross actively

An active transport system
    protein-mediated process
    uses energy to pump chemicals
    E.g., burn glucose for energy

Broken by:

Hypertension (high blood pressure)
Development (not fully formed at birth)
High concentrations of some substances
Microwaves & radiation
Inflammation
Brain injury
Infections
Alzheimer's disease
    endothelial cells shrink
    makes gaps
    harmful chemicals enter

Nourishing Neurons

Almost all need glucose
Practically only nutrient that crosses blood-brain barrier in adults
Ketones can also cross but are in short supply.
If you can't use glucose
    Korsakoff's syndrome
        thiamine (vitamin B1) deficiency
        inability to use glucose
        neuron death
        severe memory impairment

Head Injury

Open or Closed

Open head injury (penetrating)

Object enters brain

Closed head injury (skull not broke)

Concussion
Most common traumatic injury
Brain gets rattled

Causes

- Car, train, airplane accident
- Fall
- Assault
- Sports

Symptoms

- Can show immediately or develop slowly
- Unequal pupil size
- Headaches
- Obvious
- Object sticking out of head
- Fluid draining from nose-ears
- Clear or bloody
- Coma or unconscious
- Paralysis
- Seizures

Sort Of Obvious

- Slurred speech
- Blurred vision
- Lack of coordination
- Memory loss
- Stiff neck
- Vomiting more than once; children often vomit once

Not So Obvious

- Irritability (especially children)
- Mood or personality changes
- Drowsiness
- Confusion
- Loss of hearing, vision, taste or smell
- Low breathing rate
- Memory loss
- Symptoms improve, then get worse

Get immediate help if

- Loss consciousness, even briefly
- Severe headache or stiff neck
- Vomits more than once
- Behaves abnormally
- Unusually drowsy

Do

- Call 911
- Make sure breathing
- Assume spinal cord injury
- If normal breathing but unconscious
  - Stabilize head and neck
  - Hands on both sides of head

If bleeding
Press clean cloth on wound
If soaks through, don't remove it
Put another cloth over it

DO NOT

Don't wash deep head wound
Don't move or shake
Don't remove helmet
Don't pick up child
Don't drink alcohol (48 hours)

If skull fracture

Don't apply pressure to bleeding site
Don't remove debris from wound
No aspirin
Aspirin & ibuprofen can increase risk of bleeding

If vomiting

Roll the head, neck & body as one unit

Sleeping

Wake every 2 to 3 hours, check alertness
ask simple questions: "What is your name?"

Occipital Lobe

Overview

Five Steps To The Brain

Light
Eye
Optic Chiasm
LGN
Occipital Lobe

Light

Electromagnetic energy comes straight at you

Frequency

wave length
peak to peak
400-700 nm
longer is slower
color
spectrum
cosmic rays = very very very fast
gamma rays = very very fast
X rays = very fast

ultra violet rays = fast
visible light = medium
infared = very very slow
Tv & radio = very very very slow
electricity = very very very very slow

Amplitude

height
intensity
brightness

Absorption

Light source (sun, moon, candle)
object
absorption
reflection (shiny, smooth)
perception (see color not absorbed)

Choice 1: Eye

Human eye

Sclera

Greek for hard
1 mm thick
Fibrous strands in parallel
like fiber strapping tape
White of the eye
Covers entire ball
Not cornea & optic nerve exit
Fibers resist internal pressure
twice the atmosphere

Muscles

Held-moved by 6 tiny muscles
Nystagmus = can't hold eyes still
Strabismus (strabismic amblyopia)
Lazy Eye or Amblyopia
Eyes don't point same direction
Two don't help perceive depth
Treatment
Patch over active eye
Play action video games

Cornea

Bulges out from sclera
Smooth, neatly organized
Transparent (no blood vessels)
Very sensitive to touch (close lid)
Nourished by tears (on outside)
aqueous humor (on inside)

- 2/3 of focus of eye
- Dome-shaped
- Irregularity of surface

Astigmatism

- Inherited
- Cornea warping
- Blurred vision for lines in one direction
- Symptoms
    - squinting & blurred vision
    - headaches, eye strain
- Treatment
    - Glasses before age 3-4 years

Aqueous Humor

- Spongy tissue
- Keeps eye inflated
- Removes waste
- Mostly water
    - Also an antioxidant
    - Protects from UV rays
- Provides oxygen, nourishment to cornea & lens
- Continuously refreshed
    - In from ciliary body
    - Drained into Schlemm's canal

Glaucoma

- Blockage of aqueous humor
- Damage to iris
- Blindness

Iris

- 2 layers
- Outer layer of pigment
    - Color part of eye
    - Can be translucent (albinos)
- Inner layer of blood vessels

Pupil of the Iris

- Hole in middle of iris
- 2 sets of muscles
    - circular = close pupil
    - radial = open pupil
- Varies in size (4:1 ratio)
- Allows 16: 1 ratio of light
    - actual ratio changes with age
    - in dim light, 80 yr old has half as wide opening as 20 yr old

Advantages of small opening = depth of field

Lens

held in place by strings (zonules)
suspended
crystalline (clear protiens)
bean shaped
    diameter & thick of large aspirin
Has no blood vessels
Mostly water & protein

3 parts

elastic covering
    changes shape of lens
    controls flow of aqueous humor
epithelial
    toward edge of lens
    synthesizes proteins
lens
    Can be irregularly shaped (astigmatism, but not common)

Never stops growing

Adds fibers to edge
    center becomes thin
    some center fibers there at birth
As ages
    more dense & hard (sclerosis)
    less transparent (cataract)

Cataracts

Born with cloudy lens
    If surgically repaired at 2-6 months old
        eventually nearly normal vision
Early cataract in left eye
    limits visual info to right hem.
    face recognition

Vitreous Humor

Jelly-like, like raw egg whites
Not continuously renewed
Floaters
More liquid with age
Can become detached
    posterior vitreous detachmentor (PVD)

Retinal Circulatory System

1 of 2 blood supplies
In front of the retina

leaves shadows on retina; brain ignores
Supplies nourishment to non-receptor structures (ganglion, horizontal cells, etc.)

Choice 2: Retina

retina = net

Inner limiting membrane

Separates vitreous humor & retina
Formed by astrocytes
Feet of Müller cells (glial)
support cells for retina
act as light collectors
like a fiber optic plate
funnels light to rods & cones

Macula

Off to side
Optic nerve
Blood vessels

Macula Degeneration

Older adults (major cause of blindness)
Loss of vision in center
Can't read or recognize faces
Lose most detail of images
Dry (nonexudative)
Cellular debris (drusen)
Yellow deposits
Grow between retina & choroid
Retina becomes detached
Severity depends on
size and # of drusen
Wet (exudative)
Choroid blood vessels grow
Retina becomes detached
More severe
Treatments
Laser coagulation and meds

Fovea

Fovea centralis
In center of macula
Most cones are here
No S-cones

Fovea regions

Fovea = L & M cones; v. sharp
Parafovea = S & rods; sharpish

Periforvea
Outer region, Poor acuity
Mostly rods

Net of Layers

Ganglion cells = to brain
Amacrine cells = interneurons
Bipolar cells = connect receptors to ganglions
Horizontal cells = sharp edges (lateral inhibition)
Rods = respond to many wavelengths, shades of gray
Cones = respond to narrow range of wavelengths, color

Rods

Outside rods

narrow and cylindrical in shape
filled with rod disks
900 free-floating lamellae
Floating in cytoplasm
Contain visual purple (rhodopsin)
Like ink in laser printer
Can't process purple light

Inside rods:

cell nucleus
fiber ending in a single end-bulb (a rod spherule)

Polarization

Normal neuron
-70mV resting potential
depolarises to +40mV.
Rods resting potential is -30mV
Hit by light
Hyperpolarizes to -60mV

Connect to bipolar cells

Many rods to one ganglion
Spatial summation

Summary

Rods are peripheral
Night vision (10k more sensitive)
Target detection
Fast processing
Low quality images
Intensity & shades of gray
Sensitive to lots of wavelengths

Cones

Summary

Cones are centralized

Day vision
Target identification
Slow processing
High quality images
Color
Sensitive to specific wavelengths

Structure

Shorter, broader, and more tapered than rods
Have no visual purple
1 to 1
1 cone to 1 bipolar cell
1 bipolar to 1 ganglion cell, chain to brain
Each cone has corresponding spot in visual cortex

Midget Ganglion Cells

Small
Each cone has one
1 to 1
Each fovea cone
Direct line to brain
Exact location of point of light

Wiring

1st route is direct to bipolar cell
2nd route is to horizontal cell
horizontal then goes to bipolar

Retina

120 million rods (20:1)
6 million cones

Lateral inhibition

Horizontal cells inhibit neighbor
Inhibit bipolar cells
Activate 1 cone, tells next to stop
Give very sharp lines & edges

Bipolar cells

Separate ones for rods & cones
10+ types of cone bipolar cells
1 type of rod bipolar cells

Output channels

3 Color receptors (plus B-W)
3 Channels of information
Retina info is sorted into three “channels”

Choice 3: Color

Molecules absorb light
Even molecules come in colors

If hit by light, molecule changes

Chromophore

Form of Vitamin A
Photons changes it shape
Causes activation of large protein called an opsin

Opsin

Several types, similar process

Rods

Thermally stable
Rhodopsin

Cones

Less stable
Photopsins
Long = Red region
Medium = Green region
Short = Blue region
Respond to range of wavelengths
- Not just one color
- Varies with light intensity

Photo Receptors

Different combos of 3 pigments
Each cone detect all colors
Level of energy need varies

Color

3 Color receptors (plus B-W)
Long = slow red light
Medium = medium green light
Short = fast blue light
Rods = intensity

Retina output

Spatially encodes images
Filters & compresses data
100 times more receptors than ganglion cells
Spontaneously firing base rate
- Increase rate = excitation
- Decrease rate = inhibition

Theories of Color

1. Trichromatic

Young-Helmholtz Theory
3 types of cones
Doesn’t explain red-green color blindness

2. Opponent-Process Theory

Paired opposites:
- white-black
- red-green
- yellow-blue

Afterimages from fatiguing
Prolonged stimulation
Doesn't explain color constancy

3. Retinex Theory

Recognize color as light changes
Cortex compares inputs
Determines appropriate bright

NOT COVERED IN LECTURE

Types of ganglion cells

Midget

80% of ganglion cells
Small dendritic trees
Small center-surround fields
Small bodies; slow
Mostly from midget bipolar (1:1)
Color but weakly to contrast
Parvocellular; P pathway
B cells
Synapse only to LGN

Parasol

Respond well to low-contrast $
Center-surround large fields
Magnocellular
M pathway
A cells
Respond best to moving stimuli
Most synapse to LGN
Few to other areas of thalamus

Bistratified

Small as dust cells
10% of ganglions
Koniocellular
K pathway
Moderate # of inputs
Moderate resolution
Moderate contrast
Moderate speed
Center but no surrounds
- Always on to blue
- Always off to red and green

Misc

Photosensitive Ganglion Cells
Giant retinal ganglion cells
- Melanopsin
- Light responsive
- Circadian rhythm

Other cells too (more than you need to know now)

Ganglion cells

Retina output

Form the optic nerve (optic tract)
Leave eye through blind spot

Function

abstract & enhance cone signals
recognize diff in color
despite variations in light level = color constancy

LGN

Lateral Geniculate Nucleus
Part of thalamus collection

LGN input from

Eye
- 90% of fibers go to LGN
- 10% go to Superior Colliculus
  - controlling eye movements

Other parts of thalamus
Other parts of LGN
Brain stem
Cerebral cortex
- More input from cortex than to it
- Small signal back to cortex
  - 10 in from retina
  - Sends 4 to cortex

Development of Visual Cortex

LGN and V1 develop early
Needs real life to fine-tune them

Visual Paths

Dorsal Path (where)

To parietal lobe
3D view of the world

Damage

Have most normal vision
- can read
- recognize faces
- describe objects in detail

Ventral Path (what)

To temporal lobe
Encyclopedia

Damage

Know what things are but not where
Can't reach out and grab
Can see and grab
Can't watch TV
Can't tell what is what

Face recognition

Fusiform gyrus of inferior temporal cortex

Car model identification
Bird species
Lateral fusiform gyrus
    Left = recognizes "face-like" features in objects
    Right = determines if actual face
where temporal lobe meets occipital lobe
Vital for object & face recognition
    processing color info
    word recognition
    number recognition?
    within-category identification

Infant Vision

Infants strongly prefer: Faces
2 days old, mimic expressions
Not aware of emotional content
At 2 months: want parts in right places
Five-month old: pay same attention to happy and fearful faces
Seven-months: focus more on fearful faces

Face Recognition is a very difficult task

Lots of info to process
Gender, expression, age, pose…
Estimating age from face images is hard

Faces are so similar

Greebles
Complex 3D objects
Organized into two categories: gender & family
Expert greeble identifiers
Activity in right middle fusiform gyrus is similar to when recognizing faces
Novice greeble idenfiers
Not similar

Right hemisphere

holistic strategy

Left hemisphere

analytic strategy

Right lateral fusiform gyrus

hallucinations of faces
Charles Bonnet syndrome
Hypnagogic hallucinations
Peduncular hallucinations
drug-induced hallucinations
perception of emotions in facial $
may be related to face blindness (prosopagnosia)

Prosopagnosia = Impairment in recognizing faces

usually caused by brain injury
differ in abilities to understand face
Inability to recognize faces
No loss of vision or memory
Can identify young-old
Can indentify male-female
Not know who they are

Lateralization in face identification

Male use right hemisphere

men are right lateralized for object and facial perception

Women use left hemisphere

left lateralized for facial tasks
right or neutral for object perception

Sex differences

Men tend to recognize fewer faces of women than women do
No sex differences with male faces
Several independent sub-processes working in unison?

Best at familiar faces

People we know
People related to
People who look like us
Same ethnicity

Object Recognition

Identifying objects
Figure & background
Respond same way even if change position, size and angle
Important for shape constancy
Changes in orientation
Moderately occluded

Changes in size
Novel examples of objects
Degraded images

Retina image varies

Size of retinal image impacted by
Distance from image
Which retina part $ impacted by
Vantage point viewed
Relative loc. of object-viewer

Rotational Invariance

Different angles & vantage points
Even if never seen before
More local features

Size Invariance

Actual or apparent size variations
But not at extremes

Translational Invariance

Moved to a new position
$ different part of retina
Still recognize it
Not absolute position in environment
Not relative position to objects

Objects with missing parts

Correctly ID if have 2 or 3 parts
Missing 1 sail is easy
Not when 1 part only

Geons Theory

The major idea: visual system extracts geons (basic shapes)
cubes, spheres & wedges…
Stored in brain as structural descriptions?
Which geons
How interrelate (cube on top of triangle)
Parse object into geons
Determine interrelations
Maybe as few as 36 geons
Local features = not enough

Dual Recognition Theory

Primal recognition

fast-acting
not higher-level cognitive processes

Higher-level processing

shading, texture, or color
top-down processing of environmental cues

Use context to ID difficult ones

Agnosia

Lose ability to recognize
Objects and shapes
Faces
Sounds
Smells

Visual agnosia

Can't recognize objects
Lesion in
- Left occipital lobe
- Left temporal lobe

Form agnosia

Can't perceive whole
Only recognize parts

Inferior Temporal Cortex

Underside of temporal lobe
Input from occipital lobe
Cells respond to physical stimuli
Cells also respond to what viewer perceives (visualizes)

Optic nerve problems

Multiple Sclerosis

One of the places it impacts
De-myelinization
Blurred vision, etc.

Striate Cortex

Development of Visual Cortex
LGN and V1 develop early
Needs real life to fine-tune them

Primary projection area

5 major layers

Striped look
V1 = 1st stage of processing
V2 = associations (circle, angles)
V3 = lower visual field
V4 = color & spatial
V5 = motion+

Primary Visual Cortex (V1)

Striate cortex in occipital lobe
1st stage of visual processing
Most visual input goes into V1

Geniculo-Striate Pathway

Striate Neurons (Neurons in V1)

1. Simple cells

Only in V1
fixed excitatory & inhibitory zones
Most have bar-shaped or edge-shaped receptive fields

2. Complex cells

In V1 or V2
Orientations of light
No fixed excitat-inhib zones
Input from combos of simple cells

3. Hyper-Complex cells

End-stopped
Bar-shaped recpt. field at 1 end
Like complex cells
But with strong inhibitory area

Columns of Cortex

Grouped in columns
Perpendicular to the surface
Arrange by specific function
    Left eye only
    Both eyes equally
    One orientation only

Feature Detectors?

Prolonged exposure decreases sensitivity
Stare at waterfall illusion
Looks like flowing upwards

Damage to V1

No conscious vision or visual imagery, even in dreams
Blind sight

Temporal

Overview

Ventral = high level vis. process
Medial = memory
Superior = cochlea
Posterior = audio-motor proces
Temporal-parietal = Wernicke

Inferior Temporal Region

Ventral stream for vision

Occipital to temporal
Under part of temporal lobe

Main input from

LGN

Parvocellular cells of V4

As info moves thru temporal

Processes larger receptive fields

Takes longer to process

Analyses more complex

Rep. of entire visual field

Uses cues to judge significance

- Attention
- Stimulus salience
- Working memory

High-level visual processing

Complex stimuli

Faces (fusiform gyrus)

Scenes (parahippocampal)

Surrounds hippocampus

Inferior temporal gyrus

Complex object features

global shape

face perception?

Medial Temporal Lobe

Declarative memory

Facts you know – L hemisphere

Events you've experienced – R

Interacts with frontal lobes

Create long-term memories

Maintain long-term memories

Long-term memory

Becomes independent of encoding process

Hippocampus & adjacent areas

No simple dichotomies

- associative vs. nonassociative
- episodic vs. semantic memory
- recollection vs. familiarity

Work together

Transfer from STM to LTM

Control spatial memory

Damage causes

anterograde amnesia

Medial Temporal Lobe

Declarative (explicit) memory

Semantic memory

Left hemisphere: Facts

Right hemisphere: Episodic memory

What I did on my vacation

Choice 1: Ear

Anatomy of the Ear

1. Outer Ear = pinna

Pinna (pinnae) - visible ear
funnels sound to ear drum
helps in sound localization
Anatomy of the Ear
Tympanic membrane
Connects pinna to ear drum
Vibrates to sound wave

2. Middle Ear

Ossicular Chain

Pre-amplifier
amplifies vibrations 20x
3 small bones

Attenuation reflex

brain senses loud sound, tenses up muscles
To prevent damage, bones don't move
Greater for low frequencies (higher freq. easier to discern)

3. Inner Ear

A fluid-filled structure
fluid is called endolymph
similar to intracellular fluid
high in potassium
low in sodium

Composed of

bony labyrinth
membranous labyrinth
suspended within bony labyrinth
delicate continuous membrane

Space between membranous & bony labyrinths

filled with perilymph
similar to cerebral spinal fluid

2 outlets to air-filled middle ear

Oval window
    filled by plate of stapes
    Fluid pressure
Round window
    pressure valve

Cochlea

Spiral-shaped tube

Has 2 connected canals
    Upper vestibular canal
    Lower tympanic canal
Separate at large end
continuous at the apex
Fluid filled (perilymph)
Has a middle canal
    Cochlear duct
    Filled with endolymph

Organ of Corti

"spiral organ"
hair cells for hearing (cilia)
Basilar membrane with hair cells rest on it
The basilar membrane separates the cochlear duct from the tympanic canal
The tectorial membrane lies above the hair cells

Stereocilia

Connected by extracellular links
Graded in height
Arranged in bundles
Pseudo-hexagonal symmetry
Moving fluid $ hair cells
Signals to brain
Perceived as sound

Hearing Loss

Bad bone conduction
Hearing aids
Bad cochlea
Implant
Dead cilia

Most Common Causes

Age (presbycusis)
    Gradual, steady loss
Noise
    Motorcycles, lawn mower
    Music in headphones
    Gun shots
    db
        0 barely audible
        20 leaves ruffling
        40 quiet suburbia
        60 speaking voice
        100 subway train
        140 jet taking off
Obstructions

- Earwax
- Objects
- Chemicals
  - Some antibiotics
  - Arsenic, mercury, tin, lead
- Head injury
  - Structural damage
- Infections
  - Middle ear (otitis media)
  - Swimmer's ear (otitis externa
  - Fluid (cold or flu)

C. Prevention

- Good genes
- Cover your ears
  - Lawn movers
  - Guns
- Don't smoke
  - Correlation, cause unknown
  - Oxygen
  - Neurotransmitters
  - Developing brain
- No loud music

Choice 2: Processing Sound

- Vestibulocochlear nerve

Cochlea but stops at

- Cochlear nuclei
- Superior olivary complex
- Vestibulocochlear nerve
- Inferior colliculus
- Thalamus (medial geniculate)
- Primary auditory cortex
- Dorsal cochlear nucleus
- Ventral cochlear nucleus
- Superior olivary complex
  - In the pons
  - Input: ventral cochlear nucleus
- Lateral superior olive (LSO)
  - Detecting ineraural level
- Medial superior olive (MSO)
  - Interaural time difference
- Inferior colliculi
  - just below superior colliculi
  - visual processing centers
  - Integrates sound source info
- Medial geniculate nucleus

- Thalamic relay system
- The LGN of sound

Auditory Cortex

- Highly organized

3 Parts (concentrically)

- Primary auditory cortex
  - Direct input from MGN
  - Tonotopically organized
    - Frequencies respond best to
    - Low at one end, high at other
  - Complete frequency map
  - Identifies loudness, pitch, rhythm
- Secondary auditory cortex
  - Interconnected
  - Process patterns of
    - Harmony
    - Melody
    - Rhythm
- Tertiary auditory cortex
  - integrates musical experience

What audio cortexl does

- Analyses
- Identifying auditory objects
- Identifying location of a sound
- Segmenting streams

How it all works

- Unclear
- Input
  - Multiple sounds
  - Occur simultaneously
- Task
  - which components go together
  - location of sounds
  - groupings based on
    - Harmony
    - Timing
    - Pitch
- Frontal & Parietal lobes too
  - Why each note played by different instrument in orchestra sounds different
  - Same pitch
- Gamma waves
  - Ss exposed to three or four cycles of 40 hertz click
  - Spike in EEG
- Hallucination 12-30 Hz
  - Left auditory cortex of schiz.

When remember song in mind

Don't perceive sound
Experience melody, rhythm & overall experience

Choice 3: Wernicke's area

Where temporal & parietal lobes meet
Understanding of written words
Understanding speech
    auditory word recognition
    mimicking words

Dominant Side

Usually left hemisphere
Resolve associative meanings
Bank---------teller

Non-Dominant Side

Usually right hemisphere
Resolve subordinate meanings
ambiguous word meaning
River bank
Money bank

Damage to this area

Receptive aphasia
Impairs language comprehend
Natural-sounding rhythm
Normal syntax
Gibberish
Also called
    Fluent aphasia
    Jargon aphasia
Nonverbal sound problems
    Animal noises
    Machine sounds

NOT COVERED IN LECTURE

Parietal Lobe

Overview

Named for overlying bone (parietal bone)
Above occipital lobe
Behind frontal lobe
Integrates sensory information
Spatial sense
Navigation

1. Somatosensory Cortex

- Visual
- Auditory
- Olfactory
- Gustatory
- Parietal lobes

2. Posterior Parietal Cortex

- Also called the Somatosensory Assoc. Cortex
- Multimedia
- Dorsal stream of vision
  - Where stream of spatial vision
  - How stream of visual action
- Used by oculomotor system for targeting eye movements
- Spatial location
- Organized in gaze-centered coordinates
  - 'remapped' when eyes move
- Input from multiple senses
- Encode location of a reach target
- Manipulation of hands
- Shape, size & orientation of objects to be grasped

Damage to right hemisphere

- Problems with visualization
- Imagery
- Neglect of left-side space
- Neglect left side of the body

Damage to left hemisphere

- Problems in mathematics
- Understanding symbols
- Reading
- Writing

Mechanical Senses

- Vestibular sensations (inner ear)
- Tactile Sensations
- Itch, touch, pressure, pain

Vestibular System

- Measures
- Position-movement of head
- Pressure, bending
- Spatial orientation
- Balance
- Motion
  - objective = world moving
  - subjective = you're moving
  - pseudovertigo = rotation
- Vertigo = whirling, spinning

- Common
  - 20-30% of people
  - all ages (more common as age)
- Causes
  - cold
  - head trauma
  - chemicals
  - motion sickness
  - central nervous system (slow or no improvement)
    - spinal injury
    - Parkinson's
    - migraine
    - MS
- Projects to cerebellum, thalamus, eyes & spine
- Signals come from:
  - Semicircular canals
    - push-pull
    - rotational movements
    - lateral = horizontal (pirouette)
    - superior = anterior (head over heels)
    - inferior = posterior (cartwheels)
  - Neck muscle "stretch" receptors
  - Utricle (gravity)
- Sends signals to
  - control eye movement
  - keep you upright

Labyrinth of inner ear

- Two major components
- Semicircular system
  - rotational movements
- Otoliths
  - linear acceleration
  - Utricle = eye movement
  - Saccule = posture
  - otoconial crystals
    - heavier than gel
    - displaced during linear acceleration

Choice 1: Itch

Exists in two forms

tissue damage

- release of histamine

plants

Single spinal pathway

- slower than other tactile senses
- activates neurons in spinal cord

produce a chemical called gastin-releasing peptide

Why Itch

- Alert to remove irritation
- Scratch irritant off skin
- Not type of pain
  - Opiates less pain & increase itch
- Correlated
  - Vigorous scratching causes pain
  - Reduce pain, reduce itch
- Similar to pain but not
  - Both use unmyelinated neurons
  - Same nerve bundle
  - Both originate in skin
  - Two distinct systems
- Itch receptors
  - Only on top two skin layers
    - Epidermis
    - Epidermal
  - Itch on top, pain under skin?
  - No itch in muscles or joints
- Sensitivity
  - Evenly distributed across skin
  - Similar density to that of pain
- Neuropathic
- Itch can originate at any point along afferent pathway
- Damaged nervous system
- Diseases or disorders
- CNS or PNS
- Causes
  - Multiple sclerosis
  - Opioid use
  - Psychiatric Itch
    - Hallucinations & delusions
    - Obsessive-compulsive
    - Neurotic scratching
- Pain can reduce itch
  - Rubbing, scratching
  - Electric shock
  - Noxious heat
  - Chemicals
- More sensitive to pain
- Less sensitive to itch
- Central sensitization
  - Spinal cord input (noxious $)
  - Allodynia = exaggerated pain
  - Hyperalgesia = extra sensitivity

Contagious Itch
- Want to scratch
- Talking about it
- See someone scratch
- Mirror neurons?

Treating Itch
- Itch-scratch-itch cycle
- Self-contagious

Choice 2: Touch

Skin Mapping

4 findings:

1. Sensations not continuous across skin; localized in discrete points
2. Localization shifts over time
3. Number of pain spots > number of pressure > number for temperature
4. Specific sensations do not always directly correspond with the type of receptor found at that location in the skin

Somato-sensation

3 types of tactile sensations

1. Temperature
2. Pressure
3. Pain

1. Temperature

Two independent systems

Cold

Warm

Not Hot
- Hot is not the extreme of warm
- Both warm and cold spots respond to “hot” stimuli

Physiological zero
- Current skin temperature
- things you touch are compared to your current skin temperature

Structure
- Free endings of touch neurons
- Non-specialized endings

Not so much separate neuron

warmth receptors are slow
- Unmyelinated C-fibers

cold uses both
- C-fibers (unmyelinated)
- A delta fibers (thin myelinated)

How it works

Warm = increase firing rate

Cooling = decrease warm rate
Cold = both
= increase cool firing rate
= decrease warm firing rate
Some cold receptors
Brief pulse at high temp
paradoxical response
Paradoxical cold
Can't distinguish extreme hot from extreme cold

Temperature receptor location

Skin
Bladder
Cornea
Pre-optic & hypothalamic regions
Core temp

Up spinal cord

To thalamus

2. Touch

Pressure
Light & Deep
Use internal organ feedback

Ttouch receptors

Meissner's corpuscles
Unmyelinated nerve endings
Slow vibrations; texture changes
Lips, finger tips, palm, foreskin
Close to surface
Onset & offset
Touched a coin
Merkel's discs
Sustained touch and pressure
Close to surface
Fingertips
Slow adapting
Still holding coin
Ruffini's end organs
Sustained pressure
Slow adapting
Deep in skin
Skin stretch
Where coin is
Pacinian corpusles
Fast vibrations; deep pressure
Fast adapting (joint position)

Sudden displacements
Onset & onset
Coin leaves hand

Pressure on receptor

opens sodium channels in axon
action potential if enough NT
Body to CNS
Touch perception

Cutaneous rabbit illusion

Tapped very rapidly 6x on wrist and then 3x near elbow
Sensation of rabbit hopping from the wrist to elbow with extra illusory stop in between

Damage to somatosensory cortex (Alzheimer's)

impaired body perception
trouble putting clothes on

Choice 3: Pain

All tactile senses except pain adapt quickly
Survival function of pain

Independent systems

Sharp and dull
Treatment for one not usually effective for the other

A. Sensing Pain

Nociceptors
Bipolar neurons
Cells in dorsal root of spinal cord
Send signals on to brain
Signal skin damage
Muscles, joints and organs
Degree of pain depends on:
- Sensitivity of receptors
- Level of stimulation

Several types of nociceptors

1. Thermal nociceptors (extreme)
2. Mechanical nociceptors
   - Respond to intense pressure
   - Not Pacinian corpuscles (touch only)
3. Silent nociceptors
   - Respond to inflammation chemical
   - Once activated sensitive to thermal and mechanical stresses too
4. Polymodal nociceptors
   - Respond to everything
   - Thermal
   - Mechanical

Chemical stresses

Axons that carry pain info

Vary in diameter
Myelinated faster than unmyel.
Thicker the faster
A-alpha
Largest
Insulated
Muscles sensations
Proprioception
A-beta
2nd largest
Insulated
Touch
A-delta
Smallest of alphas; nearly as small as Cs
Thinly insulated
Pain, heat, touch
"Good pain"
Do something and it will go away
Put down hot frying pan
C fibers
Smallest
Unmyelinated
Slowest
Heat & itch
Diffuse, dull, chronic pain
"Bad pain"
Removing $ doesn't remove pain
Signals damaged tissue

Example

Stub (hurt) your toe
1. moving your foot
A-alpha propreioceptive info
2. sensation of hitting object
A-beta nerve fibers
3. pain of tissue damage
A-delta and C-nerve fibers

Primary afferent axons

Vary in diameter

A-alpha	largest	insul.
A-beta	2nd larg	insul.
A-delta	3rd largest	insul.
C fibers	smallest	unmyel.

Vary in speed

A-alpha	265 mph

A-beta	165 mph
A-delta	75 mph
C fibers	2 mph

Cognitive Factors influence pain

- Socialization
- Cultural differences
- Attention (Lamaze child birth)
- Pain is usually transitory
  - Only lasts until $ or damage removed
- Chronic Pain
  - Some condition last for years
    - Rheumatoid arthritis
    - Peripheral neuropathy
    - Cancer
- Phantom Pain
  - Upper limb, nearly 82%
  - Lower limb, 54%
  - Some have continuous pain that varies in intensity or quality
  - Phantom Pain Treatment
    - Anesthetic injections into stump; one dose can relieve for days, weeks or permanently
    - Injections of saline into soft tissue between vertebrae; pain, then relief
    - Vibration or massage

Congenital Insensitivity To Pain

- Born without sense of pain
- Rare
- Continue activity after injury
- Not detect broken bones-gash
- Often get pressure sores & damaged joints

B. Relieving pain

- Capsaicin
  - disrupts steady $ of pain cells
- Steroids
  - Cortisone injections
    - Relieve pain & joint inflame
    - Released by adrenal gland
    - Steroid hormone
    - Suppresses immune system
    - Which reduces inflammation
    - Stops trying to heal you
- Non-steroidal anti-inflam. drugs
- 3 enzymes
  - Proteins
  - Synthesized by 3 major enzymes
    - cyclooxygenase 1 (Cox-1)
    - cyclooxygenase 2 (Cox-2)

cyclooxygenase 3 (Cox-3)

All three are blocked by:
- aspirin
- ibuprofen (Advil, Motrin)
- naproxen (Aleve)

opioids (opiates)
social pain
emotional pain

Summary

Meissner's corpuscles
- nnmyelinated nerve endings
- slow vibrations
- fast vibrations
- texture changes
- onset-offset

Merkel's discs
- sustained touch

Ruffini's end organs
- sustained pressure
- slow adaptation
- fast adaptation
- skin stretch

Pacinian corpusles
- vibrations
- deep pressure
- joint position

emotional pain
histamine
hyperalgesia = extra sensitivity

Frontal Lobe

Overview

Lesions: wide variety symptoms
More than any part of brain

Involved in:

motor function
problem solving
spontaneity
memory
language
initiation

Extremely vulnerable to injury

Large in size
Located up front

Most common brain injury
Mild to moderate trauma

3 Sections

1. Primary Motor Cortex
2. Pre-motor Cortex
3. Pre-frontal Cortex

Primary Motor Cortex

M1
Pre-central gyrus
Directs motor coordination
Voluntary movement

Input

Pre-Motor area
    Plan and execute movements
Posterior Parietal Cortex
    Visual information
Supplementary Motor Area
    Planning & coordinating complex movements (requiring two hands)
Cerebellum
    Balance

Output

contains Betz cells
large neurons
long axons down spinal cord
synapse directly to motor neurons of muscles
Send info to
    Cranial nerves
    Lower motor neurons

Functions

Elicits movements
Not directly connected to muscles
Axons go to brainstem & spine
Central pattern generators control actual muscle move

Homunculus

Organized by body region
Top-down
Toes
Knee
Hip
Trunk
Stomach
Arm
Elbow
Wrist

Hand
Fingers
Thumb

Important for complex actions

Writing
Less important for coughing, sneezing, laughing, or crying

2 major actions

Elicit complex movement patterns
Also $ when imagine movement

Note:

Causes movements
Doesn't plan them
Movement needs Muscles

Other Areas

Posterior Parietal Cortex

Planning a movement
Keeps track of body position
Intention to move

Damage causes

trouble converting visual perceptions into actions
trouble finding objects in space

Supplemental motor

Plan-organize rapid sequences
pushing, pulling, and then…

Function

Preparing to do movement
Watching someone else do it

Mirror Neurons

Type of cell or function?
Some innate
Some acquired by experience
Imitating & understanding others
Modeling

Pre-Motor Cortex

Preparing for movement
Somewhat active during move
Receives info about
Where target is in space
Current position of your body

Damage

Poorly planned movements

Cerebellum

Balance and coordination

Coordinates movements, not cause them
Regulator or timing mechanism
Timing of skilled movements
Posture and balance
More neurons than rest of brain combined
Anything require aim & timing
Point at moving object
Clapping hands
Writing, typing
Not good at discrete tasks
Good at continuous tasks; drawing continuous circle
Feel things with both hands
Decide if two objects same
Habit formation
Timing
Attention

Damage

Problems making rapid move
Clumsiness
Slurred speech
Inaccurate eye move

Alcohol

1st brain area impacted
Highly impacted by alcohol
Speaking rhythm (slur)
Can't walk straight
Finger to nose test

Cellular Organization

Input from
spinal cord
sensory systems (eyes, ears…)
cerebral cortex

Neurons characteristics:

Cells highly organized
Repeating geometrical patterns
Precisely arranged
Multiple copies of same unit

Parallel fibers

Parallel to each other
Perpendicular to Purkinje cells

Purkinje cells

Flat cells in sequential planes
Inhibit cells in cerebellum nuclei
Inhibit vestibular nuclei too
Controls timing of movement

including onset & offset

Muscles

1. Smooth muscles

Digestive sys. & internal organs
Long, thin cells
Muscles

2. Striated

Skeletal muscles
Acetlycholine causes contraction
With no acetlycholine, relaxes

3. Cardiac muscles

Smooth & skeletal combo
Looks striated
Acts like smooth
Many individual fibers
Fibers fuse together at points
One axon may innervate more than one muscle fiber
Distinctive Firing Rhythm
They just beat
Muscles

Principles

One movement per muscle
Contraction; relaxation
Antagonistic muscles
Two in opposite directions
Flexor muscles
limbs flexed or raised
Extensor muscles
extend or straighten limbs

Fast and Slow Muscles

Contractions are chemical
Affected by temperature
Fish use more muscles in cold
fewer muscles in warmer water
Muscles

Fish muscles:

Red : slow move, no fatigue
White : fast move, quick fatigue
Pink : intermediate on both

Human Muscles

Muscle fibers are mixed
Fast-twitch fibers
fast contractions, fast fatigue
Slow-twitch fibers

slower contraction, less fatigue

Aerobic: use oxygen during movement

Walking, swimming, running

Anaerobic = don't use oxygen

Short burst
Less that 2 min.
Fast-twitch fibers fatigue
Anaerobic = don't require oxygen
oxygen is needed for recovery
produce lactate and phosphate
give sensation of fatigue

People vary

amounts of fast- and slow-twitch
can increase one or the other
depending on which use

Proprioceptors

receptor that detects position
indicates movement of body part
detect stretch & tension of muscle

Stretch reflex

Also called myotatic reflex
Monosynaptic reflex
Muscle lengthens, spindle stretches
Increases nerve activity
contracts muscle, resist stretch

Muscle spindle

Kind of proprioceptor
Inside muscle
Detect changes in length
Also activates stretch reflex
Resist muscle stretch
Human Muscles
Golgi tendon organ
Located in tendons
At ends of muscles
Inhibit contraction when too intense

NOT COVERED IN LECTURE

Movements

Involuntary Movements

Consistent
Automatic responses
Not affected by reinforcements, punishments, and motivations

Pupil constricting to bright light
Reflexes

Infantile Reflexes

Infants have more
Fade with time
suppressed by maturing brain
sometimes reappear when brain damaged

Grasp reflex

Put object in hand, grasp tightly

Babinski reflex

Stroke sole of foot
Extend big toe, fan others

Rooting Reflex

Touch cheek, turn head & suck
Not pure reflex
Intensity increase when hungry

Life-long Reflexes

Knee jerk reflex
Lengthen muscle fibers
Monosynaptic reflex
Not involve brain
Knee jerk reflex
When muscles lengthen
reflexively contract
Helps in posture
Sneezing
Coughing

Most behaviors are not purely voluntary or involuntary

Most are sensitive to feedback
Ballistic movements
Once initiated, can't be altered
Completely ballistic are rare

Central pattern generators

Generate rhythmic patterns of motor output
wings flapping
fin movements

Motor programs

Fixed sequence of movements
Can be learned or built in

Motor coordination

Integration of auditory-visual info
Skilled movements
Dancing

Throwing

Conscious Decisions

Readiness Potential?
Motor cortex activity may proceed decision to move
Decisions to make movement unconscious?
Connects To Spinal Cord

Learning movements

Movement patterns more consistent from trial to trial
Inhibition of Movement

Antisaccade task

Task: Look in opposite direction of moving object on periphery of visual field
Very hard to do
Very strong tendency to watch moving object
Inhibition of Movement
Almost impossible for kids 5-7
Ability develops slowly
prefrontal cortex is one of slowest brain areas to reach maturity

Corticospinal tracts

Two tracts

Lateral corticospinal tract

Axons from
primary motor cortex
red nucleus of midbrain
Path downward
Get closer together as they go
Down thru white matter
Includes Betz cells
Lateral corticospinal tract
Path downward
Go to medulla oblongata
Cross contralateral
Medulla Pyramids
Down spine to control
Hands, fingers, feet & toes
Many cranial nerves
(called corticobulbar tract)
Facial muscles

Medial corticospinal tract

Also called
Anterior corticospinal
Ventral corticopinal
Direct pyramidal tract
Much smaller than lateral tract
Inversely related

Ipsalateral motor control

Route

Axons from
primary motor cortex
supplementary motor cortex
midbrain tectum
reticular formation
vestibular nucleus
Go to both sides of spinal cord
largely responsible for
Neck, shoulder & trunk move
Medial corticospinal tract
Control posture
Vestibulospinal: vestibular information
Tectospinal: visual information
Reticularspinal: controls muscles

Cerebral Palsy

Clumsiness is from competition of contralateral and ipsilateral paths

Parkinson's Disease

Symptoms

First symptom is loss of smell
Slow movements
Resting tremor
Rigidity
Difficulty initiating movement
Cognitive deficits
Depression (no outbursts)
But can follow visual cues
Follow parade
Climb stairs
"Step on the cracks" (sidewalk)

Incidence

1–2% of those over 65
50% more men than women
Parkinson's Disease
Progression
Gradual progressive death of neurons
Especially in substantia nigra

Substantia nigra

Less $ of motor cortex
Slower onset of movements
When over 45
Neuron loss of 1% per year
Most have enough to spare
When reach 20-30% of normal

Parkinsonian symptoms begin
Early onset
Probably genetic
Late onset
More common
Not genetic
Chances decrease if
Drink coffee
Smoke
Decaffeinated coffee and nicotine free cigarettes work just as well
Reduce damage to mitochondria
Progressive death of neurons
Gradual
Decrease in dopamine
Decreased neural activity
Atrophy
Cell death

L-Dopa Treatment

Precursor to dopamine
Crosses BBB
Hope it converts to dopamine
Not prevent continued loss
may contribute to neuron death
Harmful side effects
Effective in early stages?
Could do harm?
Doesn't stop the disease

Other Therapies

Antioxidant drugs
Dopamine agonists
Glutamate antagonists

Dorsolateral

Overview

Frontal lobes

3. Prefrontal cortex

Most anterior
Not short term storage
But if damaged, poor executive processes
10+ microscopically different cells
working memory for objects
working memory for spatial locations

Executive Functions

Working memory
Cognitive flexibility
Planning
Inhibition
Abstract reasoning
Highest cortical area involved in motor planning, organization and regulation
not exclusively responsible for executive functions
requires additional cortical and subcortical circuits

Spatial selective neurons

integrated response
sensory input
STM retention
motor signaling
Spatial selective neurons
connected to:
superior temporal lobe
posterior parietal lobe
cingulate premotor cortex

Dorsolateral

Damage causes problems with
Social judgment
Executive memory
Abstract thinking
Intentionality
Tumors produce symptoms similar to schizophrenia
Sleep deprivation inhibits activity here

Truth Telling

- Involved in lying?
- Inhibit of normal process
- People usually tell the truth

Need it for stability & function
Lucid dream states?
Hallucinations?

Schizophrenia

Psychotic disorders
“The Schizophrenias”

- 1% incidence
- More likely in US & Europe
- 10 to 100 times

Chronic patients

- under-active in dorsolateral
- lack of dopamine neurotransmitter
- abnormal activation during working memory

Demographic Data
- Slightly more common in men
- Earlier onset
- More severe

Originally: dementia praecox
- Eugen Bleuler called it schiz
- 1911

Starts as teens or early adult
- Typical onset 16 to 30
- Uncommon onset over 45

Symptoms vary
- Seem OK until share thoughts
- Sit without moving…for hours

Episodes
- Typical: not more than 6 weeks
- Symptoms come & go
- Lasts a few days
- Feel agitated

Hallucinations
- Lasts a few months

Delusions
- Last months or years

Range of severity
- Hospitalized
- Meaningful lives in communities

3-Factor Model

Disorganized thinking

Distorted thinking
- Delusions & hallucinations

Disconnected mind-motor
- Spontaneous movement
- Fluid speech
- Self control

Positive symptoms
- Happy symptoms?
- Unique to schizophrenia
- Not schiz without them

Delusions
- Unusual false beliefs
- Martians are controlling me
- Reading my mind
- Thought insertion
- “I killed someone”
- Behavior controlled by
- People on TV or movies

- Special messages
- Behavior controlled by
- Magnetic waves
- Aliens
- Believe you are someone else
- Often historical person

Hallucinations
- False sensory experiences
- Hear voices not there
- See things not there
- Voices are most common
- Hear voices
- Talk to invisible person
- Voices talk to each other
- See invisible objects or people
- Feel invisible fingers touching
- Smells

Thought disorders

1. Disorganized thinking
- organizing thoughts
- connecting thoughts
- garbled talk

2. Thought blocking
- Stop in middle of thought
- Feel thought taken out head

3. Nonsense words
- Neologisms = new words
- Disorganized speech

- Rambling sentences
- Incoherent patterns

Movement disorders
- Agitated movements
- Repeat motions over and over
- Catatonic = immobility
- Rare—treated with drugs

Negative symptoms

- Occur in other disorders
- Flat affect
- face immobile
- monotonous voice

Similar to brain damage
- poor control of eye movements
- unusual facial expressions

Negative = lack of
- Lack of pleasure

- Lack of persistence
- Social withdrawal
- Poverty of speech
- Lacks fluidity of speech; words don’t flow
- Don’t talk much, even when forced

Cognitive symptoms
- Difficult to notice
- Executive functioning
- Trouble switching tasks
- Trouble paying attention
- Trouble with working memory

Disturbed emotions
- Hyperemotional
- Depressed
- Flat affect (no emotion)

Abnormalities of perception
- Schizophrenic Art
- No difference in foreground-background
- Obsessed with objects (skulls)
- Emotionally distant
- Dark silhouettes
- Watchful eyes
- Fragments

Types

1. Disorganized
- “Hebephrenic schizophrenia”
- Inappropriate thoughts & behav.
- Don't make sense
- Severe
- Can’t do routine daily activities
- bathing & meal prep
- Hard to understand what say
- Frustration, agitation, anger

2. Catatonic
- Coma-like daze or Talk in bizarre-hyperactive
- May last month+
- Easily treated with drugs
- Can be caused by non-schiz

3. Paranoid
- Delusions
- Someone trying to harm you
- Hear voices
- Not as many memory problems
- Okay concentration
- Handle daily life okay
- Suicide risk

4. Undifferentiated
- Not meet all criteria
- Miscellaneous
- Junk term

Causes

Genetics
- Runs in families
- Environmental trigger?

Old egg-sperm theory
- Older parents more schiz children

Children of schiz patients
- Less than ½ become schiz
- Inherit susceptibility to environmental factors?

Why likely genetic component
- Men & women about equal
- Men slightly more
- Men have earlier onset
- Men have more severity
- About 1% worldwide

Runs in families
- 1% in general population
- 10% when parent or sibling
- 15% in fraternal twin
- 50% when identical twin

Pure genetic effect = 100%
- greatest environmental similarity
- monozygote

Adopted Children
- One study
- 12.5% siblings in same environ.
- None adopted had schiz

Correlated factors
- Women with schizophrenia
- drink & smoke during preg?

Not one single gene
- 10+ genes are more common in schizophrenics
- DISC1 gene (disrupted in schizophrenia 1)
  - Controls production of dendritic spines
  - Controls generation of new neurons in hippocampus

Other genes linked to
- brain development
- glutamate synapses
- hippocampus & prefrontal cortex connections

Combo of Genetics & Environment

Dopamine hypothesis

- Over-activity of DA synapses

- In mesolimbic pathway?

DA agonists-antagonist effects
- All treatment drugs block DA receptors
- Chlorpromazine
- Originally used to prevent surgical shock
- Dramatically effective
- Reduces symptoms of schizophrenia
- DA agonists cause schiz sympts
- Cocaine
- Amphetamine
- L-DOPA

DA agonists cause schiz sympts
- Elation, euphoria
- Similar to start schiz. episode

Paranoid delusions
- Maybe caused by increased DA input to amygdala
- in emotional responses for aversive events

DA neurons release more DA?
- Clozapine
- atypical antipsychotic drug
- blocks D4 receptors
- in nucleus accumbens
- Part of the reward circuit

Caused by excess activity at some dopamine synapses
- Evidenced by
- Drugs that help
- Drugs that aggravate

Aggravaters
- Cocaine
- Amphetamine
- LSD

Dopamine not cleaned up?
- Schiz have twice as many D2 receptors occupied by dopamine as normal

Dopamine not sole cause
- Drugs that block dopamine receptors
- do so immediately
- but effects on behavior build up
- gradually over 2 or 3 weeks

Glutamate Hypothesis

Caused by poor glutamate functioning
- dopamine inhibits glutamate
- Mixed evidence

Schiz
- release less glutamate
- in prefrontal cortex & hippocampus
- release less glutamate

- have fewer glutamate receptors

Phencyclidine (PCP)
- blocks NMDA glutamate receptors
- produces symptoms similar to schiz
- induces both negative and positive symptoms
- Doesn't produce psychosis in preadolescents
- produces more severe symptoms than schiz

Risky to increase glutamate
- Too widely used

Don't stimulate directly

Working on glycine (amnio acid)
- enhances NMDA effects
- not effective antipsychotic
- increases antipsychotics effects

Brain abnormalities

MRI & CT studies
- Found loss of brain tissue in patients with schizophrenia

Ventricles
- Relative size of lateral ventricles
- 2+ size of control subjects

Mild Brain Abnormalities
- Less than average gray matter
- Larger than average ventricles
- Smaller thalamus
- left hemisphere slightly larger

Worst in
- left temporal lobe
- frontal lobe

Immature or poorly developed
- dorsolateral prefrontal cortex
- deficits in memory & attention

Smaller cell bodies
- in frontal cortex & hippocampus

Environmental Causes

Famine during pregnancy
- (especially thiamine deficiency)

Predictors

- More likely if mother underweight
- More likely if low birth-weight
- More likely if Rh incompatible

Nneurodevelopmental hypothesis

- Schiz caused by abnormalities to nervous system during prenatal or neonatal periods

Prenatal and Neonatal

- Mother's nutrition

- Premature birth
- Low birth weight
- Complications during delivery

Rh-negative & baby Rh-positive

- may trigger immunological rejection by mother
- hearing deficits
- mental retardation
- twice usual probability of schiz
- 2%

Season-of-birth effect

- Winter, slightly greater
- Nutrition
- viral infections
- fever and influenza

Flu (or other viral illness)

- More likely if born during late winter and early spring
- More likely in cities than countryside

More likely far from equator

- Decreased winter temp?

Infections

Childhood infections

- Such as toxoplasma gondii
- memory disorders, hallucinations, and delusions
- bacteria only reproduces in cats
- more likely to have a pet cat

Diagnosis

Confused with drug abuse

Can't show abuse causes schiz

- Self medication
- Makes treatment less effective

Prodromal = pre-symptoms

- Self-isolation
- Increased unusual thoughts
- Increased suspicions
- Family history of schiz

Self-diagnosis as bipolar

- Or something "less sever"

Drugs can help-hurt

Some drugs make it worse

- Marijuana
- Amphetamines
- Cocaine

Smoking

- 3x likely addicted to nicotine
- 90% in schiz

- Schiz worse during withdrawal

Chlorpromazine (Thorazine)
- 1st drug successful

Antipsychotic drugs
- Primarily work by blocking dopamine receptors

Phenothiazines
- class of neuroleptic drugs
- includes chlorpromazine

Try several medications
- Not all work the same for all
- Best combination, right dose

Relapse
- Stop taking meds
- Feel better, think don’t need
- Interact with other drugs
- Interact with alcohol

Antipsychotic medications
- available since mid-1950's
- Chlorpromazine (Thorazine)
- Haloperidol (Haldol)
- available since mid-1950's
- Perphenazine (Etrafon)
- Fluphenazine (Prolixin)
- "atypical" antipsychotics
- Clozapine (Clozaril)
- psychotic symptoms
- Hallucinations
- breaks with reality
- Clozapine (Clozaril)
- Side effect for clozapine
- Agranulocytosis = loss of white blood cells
- Risperidone (Risperdal)
- Olanzapine (Zyprexa)
- Quetiapine (Seroquel)
- Ziprasidone (Geodon)
- Aripiprazole (Abilify)
- Paliperidone (Invega)
- Old & new ones about equally effective

Side effects
- Worse when start
- Last few days for most
- Dizzy when changing positions
- Blurred vision
- Drowsiness
- Rapid heartbeat
- Sensitivity to the sun

- Skin rashes
- Major weight gain
- Rigidity of joints
- Muscle spasms
- Restlessness
- Tremors

Tardive dyskinesia
- Caused by long term use
- Can't control mouth muscles
- Tremors & involuntary move
- Caused by prolonged blocking
- Of dopamine receptors in basal ganglia
- Usually in pill or liquid form
- Some are shots given monthly

New Drugs
- Mesolimbocortical system
- Where antipsychotics impact?
- Set of neurons
- Project from midbrain tegmentum to limbic system

New drugs (atypicals)
- Don't cause movement problems
- Less intense effects on dopamine type D2 receptors
- Stronger effects at D4 and serotonin 5-HT2 receptors

Atypical antipsychotics
- More effective?
- Better with positive symptom
- Not so much with negative
- Don't improve overall quality of life any better

Long-term drug treatment
- Antipsychotic drugs not cure
- Don't fully treat condition
- Don't work for 1/3 of patients
- Serious side effects
- Similar symptoms to Parkinson's disease
- Slow movement, lack of facial expression, general weakness

NOT IN LECTURE

Phineas Gage

First indication can survive major brain trauma
- Lost 1+ frontal lobe

Working on a railroad
- Gage (then 25)
- Foreman on work gang
- Blasted a path through rock

- R&B Railroad, Vermont

Process
- Bore a hole, add blasting powder
- Put in a fuse, add sand
- Pack it in with tamping iron
- 3’ 7’’ long and 1¼ inch diam.
- 13 pounds
- Tapered

September 13, 1848 4:30pm
- No sand added
- Rod entered on left side of face
- Tapered part first
- Passed thru back of left eye
- Out the top of his head
- Landed 80 feet away

Don’t know much about his life
- Before or after accident
- Can’t gauge the Gage

Retained
- Normal memory
- Speech & motor skills

Changed?
- Mood, irritability, impatient
- Personality
- Exaggerated after his death
- No longer Gage

“American Crowbar Case”
- Localization of functions
- Both sides

Damage to frontal lobe
- Describe best course of action
- But seek immediate gratification

Orbitofrontal

Overview

Basic functions

Dorsolateral

Last to myelinate
Sleep deprivation
Executive Functions
Working memory
Cognitive flexibility

Planning

Orbitofrontal

named by location
above eye orbits
least explored
least understood
sometimes considered part of limbic system
anatomically the same as ventromedial
Vary by person
Considerable individuality

Research Difficulties

OFC is close to sinuses
air filled
Hard to image (MRI, etc)

Function

Cognitive processing
Decision making
Sensory integration
Affective value of reinforcers

Controls

social adjustment
responsibility
mood
drive
Expectation of rewards-punish
Compare expected with actual
Intuitive judgments

Extensive connections

Reciprocal connections
Ventral & dorsal visual streams
Auditory-spatial processing
Phonetic processing
All sense modalities

Damage

Lesions
feel no regret
Damage causes problems with
decision-making
emotion regulation
reward expectation

ADHD

dysfunction of reward circuitry
controlling motivation
reward

impulsivity

Obsessive-Compulsive

Executive functioning
Impulse control

Addictions

Dopaminergic activation of reward circuits
Compulsive behavior
Increased motivation take drug
Drug addiction
Decision making
Reward system
Compare expected reward/punishment with actual reward/punishment
activated during intuitive coherence judgements

Auditory Processing

Distinct pathways
phonetic processing
rostral stream
auditory-spatial processing
caudal stream
extensive overlap

Visual Processing

Both ventral & dorsal streams
integration of spatial and object processing
Medial portion of orbitofrontal
connect with hippocampus
cingulate
thalamus
Lateral portion of orbitofrontal
connections with amygdala
association cortex

Lateral OFC

stimulus-outcome associations
evaluation of behavior
encode new expectations about punishment and social reprisal
conflict resolution
suppressing negative emotions
approach-avoidance situations
game of chicken

Damage

inappropriate displays of anger
inappropriate responses to anger
left lateral
defensive
present self in “angelic light”
Low volume

experiencing “fear of God”
higher volume in left lateral
score higher on Machiavellian personality traits

greater thickness

outgoing and uninhibited
Greater thickness in ventromedial cortex: shy and inhibited

Visual discrimination test

Extinction

DON’T PRESS BUTTON

OFC damage: gotta press!
Disinhibited behavior
Excessive swearing
Hypersexuality
Poor social interaction
Drug, alcohol & tobacco use
Little empathy
Compulsive gambling

Visual discrimination test

reversal learning
presented pictures A and B
Learn rewarded for picking A
When rule set, switch
Damage to OFC, stay with A

Extinction

Punished for either A or B
rules don’t reversing

Iowa Gambling Task

Simulation
decision making
Bechara & Damásio
4 virtual decks of cards
choose card, win money
choose card, lose money
Goal of game
As much money as possible
Reward
Penalty
Choose cards by gut reaction
Start with $2000 (monopoly $)
Don’t know how many cards in deck (it’s virtual)
Original study had 100
Deck A and B
$100 reward
Deck C and D
$50

Deck A and B
$100 reward Large penalty
Deck C and D
$50 Small penalty
Same loss
Differ in distribution
number of trials
Bad deck = lose faster
over enough time will make a net loss
Good deck = lose slower
Good deck = win some
other enough time will make a net gain

After 10 cards

healthy show "stress" reaction
GSR if hover over bad deck
Damage to amygdala
never develop GSR
After 40-50 cards
Healthy
stick to the good decks
OFC damage
stick with bad deck
know losing money

Criticism

design

SGT (another task)

100 trials of uncertainty
Healthy
focus on immediate gain-loss
unable to hunch long-term outcome
Probabilistic Learning
must pass up potential large immediate rewards for small longer-term rewards
Warning cues feel like excitement & pleasure?
Healthy
Sample cards from each deck
40-50 cards, stick with good deck
OFC damage
Stick with bad deck
Even if know it's a bad deck
Schiz & OCD
perseverate (persevere)

Faux pas Test

Series of vignettes
Social occasion
Said but should not have said

Awkward occurrence
Faux P as
Identify what awkward
Identify why awkward
Identify how would have felt
Identify factual control fact
OFC dysfunction
Understand the story
Can't judge social awkward
vignettes
said something should not have said
awkward occurrence
1st used with autism

Acquired brain injury

disinhibited behavior
poor social interaction
excessive swearing
hypersexuality
compulsive gambling
drug, alcohol & tobacco use
low empathy

Alzheimer's disease

neurofibrer tangles in this area
Endoplasmic reticulum
Transport system
Axon support
Collapse
Neuro-tangles
Brain proteins fold abnormally

Tau protein

Tangles in cell bodies
Clump together
Interfere with neuronal activity

Amyloid protein

Cause plaque between neurons
Apolipoprotein E
Prevents plague removal
Causes cell loss

Progressive disease

Symptoms get worse with time

Symptoms

Inappropriate emotional R
Decline in intellect
Confused thinking
Memory loss

Repeated questioning
inappropriate emotional R
Violence

Memory

Better procedural vs declarative
Better implicit vs explicit
Acquire new skills but not remember learning them

Age related

Likelihood increases with age
Strikes 50% of those over 85

Genetic components

Person with Down's syndrome
(3 copies of chromosome 21)
Always acquire Alzheimer's in middle age
Early onset
chromosome 1 & 14
Late onset
chromosome 10 & 19

Environmental component

50% no relatives with disease
Yoruba people of Nigeria
high-risk genes
low incidence
Maybe due to diet?
low-calorie, low fat, low salt diet
Treatment to improve memory
Increase glucose & insulin
Acetylcholine activator drugs
Diet rich in antioxidants?
Block Aß42 production, inoculate with small amounts of Aß42
Inter-neuron plaque
Addiction
OFC, nucleus accumbens & amygdala
striato-thalamo-orbitofrontal circuit

Addiction

involved in development of addictive behavior
dopaminergic activation
reward circuits
Addicts show deficits in orbitofrontal, striatal, and thalamic regions
Cocaine withdrawal
Increased OFC activity
proportional to drug craving
during protracted withdrawal
(3–4 months)

reduced activity
decreased activity
detoxified alcoholics
significantly less benzodiazepine receptors
OFC to thalamus to accumbens
Bidirectional
Orbitofrontal Cortex
mediodorsal nucleus of thalamus (involved in memory)
nucleus accumbens
Reinforce
Drug administration
Drug effects
Addiction associated with
compulsive behavior
repetitive behavior
drive
anticipated conditioned response
impulsivity
loss of control
craving

Ventromedial

Review

1. Dorsolateral

Last to myelinate
Sleep deprivation
Working memory
Planning

2. Orbitofrontal

Gambling strategies
Alzheimer's tangles
Drug addiction

Comparison

Pepsi	blind test
Coke	sighted test

Dorsolateral

Higher order rules
Brand recognition

Ventromedial

Strong emotional reactions
Sugar, salt & carbonation!

Overview

vmPFC

Anatomically

No difference between orbitofrontal and ventromedial
Only differ in connections

Functions

processes risk & fear
Decision making

Inhibition of emotional responses

rapidly developing during adolescence and young adulthood
connects with amygdala
bilateral lesions severely impair personal and social decision making but retain intelligence

less associated with social functions

more with emotion regulation

bilateral lesions

Difficulty choosing between options with uncertain outcomes
risk
ambiguity
Impairs learning from mistakes
make same decisions again & again
even if have negative consequences
Choose immediate rewards
blind to future consequences

Right hemisphere vmPFC

Detecting irony, sarcasm, and deception
If damaged:
Easily influenced by misleading advertising
"false tagging mechanism“
provides doubt and skepticism
regulates interaction of cognition and affect
empathic responses

Emotion regulation

social emotions
compassion, shame & guilt
moral values
anger & frustration tolerance

Obitofrontal

pleasure responses

ventromedial prefrontal cortex

preference judgement
PTSD

ventromedial prefrontal cortex

reactivating past emotional associations and events

Left vs Right
Right
intellectualization, emotional isolation
Left
projection, splitting, verbal denial, and fantasy

Gender Social Cues

gender stereotpyes
categorize gender-specific names, attributes, and attitudes
Damage to vmPFC
consciously make moral judgments without error
in hypothetical situations
not in real life
make decisions inconsistent with professed moral values

Ventromedial

Includes anterior cingulate cortex
Wraps around corpus collosum

Two Computers

Left and Right Hemispheres
Each controls contralateral side
Except taste & smell
Uncrossed; own side of tongue
Work together
Control trunk & facial muscles
Staying Connected

Corpus Callosum

Set of axons interconnect hemisphere
Exchange information
Neural fibers
Wide, flat bundle
Connects L & R hemispheres
Under cortex
Largest white matter structure
200–250 million axons
Fast transmission (myelinated)

Genu = anterior (knee)

Thin axons
Connect prefrontal cortexes
Larger in musicians

Truncus = middle (body)

Thick axons
Connect motor cortexes
M1, premotor & supp. motor

Splenium = posterior portion

Soatosensory info
Parietal lobes
Visual cortexes

Sexual Dimorphism

Different size in men & women?
No

R. B. Bean,1906
Larger is intelligence
Men
Race
Ultimately refuted

Larger in left-handed?

11%
Dyslexic children
have smaller CC

Childhood

Gradually thickens as grow
Slow growth til about age 10
Eventually develop adult patterns
Young children behavior similar to split-brain people

Fabric identification task

Five-year olds
Equally well w/ one or two hand
Three-year olds
90% more errors w/ two hands
Lateralization of Function

Epilepsy

Seizures = excessively synched neural activity
Most treated with drugs (90%)
More severe, tissue ablation
Lateralization of Function
Neural activity rebounds between
prolongs seizures
Extreme cases, severe CC
Called split-brain people

Split-Brain People

Present input of object to L field
Info goes to R hem (noses cross)
Independence
Draw circles
One with each hand

One hand going faster
Present input of object to L field
Info goes to R hem (noses cross)
L hand controlled by R hem
Can point to it with L hand
Can't do it with right hand
Present object input to R field
Info to L hem (noses cross)
Can name or describe what see
Language in L hem (95%; 80%)

Each hem. can process info
Multitask

For a few weeks
Feels like two people in one body
Competition vs Cooperation
Take item off grocery shelf with L
Return them with R
Normal
Cooperation
Flash different word to each visual field at same time
Report combined concept
Flash toad to left & stool to right
Get
Eventually lessens some
Brain uses smaller connection routes to avoid conflicts
CC not the only path
Just the biggest
Other epilepsy surgeries

HM

Henry Molaison (1926-2008)
1 generalized seizure a week
began bilaterally
medial aspects of both temporal lobes
Removed both of H.M.'s medial temporal lobes (in 1953)
included most of
hippocampus
amygdala
adjacent temporal cortex
Post-surgery symptoms
Major seizures almost completely eliminated
Minor seizures down to 1-2 day
IQ increased (104 to 118)
Normal short-term memory
Moderate retrograde amnesia

loss for events shortly before

Post-surgery symptoms

Severe anterograde amnesia
memory loss for events after
Can't transfer anything to LTM
Everything is forgotten when attention shifts
Impaired ability to form LTM
newer words (for him)
Jacuzzi
granola
regarded as nonsense
When distracted
underestimate his own age by 10+ years
Can't form episodic memories
memories of a single event
could describe previously learned facts
not recount personal events
Retained ability to
Weakly retain semantic (factual) memories
Difficult to describe the future

HM's Implicit Memory

Mirror Drawing
First to show improvement in HM
Spatial –motor learning
Implicit learning
Rotating Disc
Keep pen on target
(rotating disk)
Improved over 7-day period
Each time saw task, claimed he had never seen it before

Hippocampus

Temporal lobe & Dorsalmedial
Semi-circle
if damaged, amnesia
not accident or around it
remember before & after accident
if small damage
Retrograde amnesia
Can't remember past
Just before accident
if bilateral damage
Anterograde amnesia
Can't form new memories
Consolidation memory
move from short to long term
not necessary to retrieve info

must work to put into long term
Reproduces patterns during sleep
Encodes patterns
Sparse representations (non-overlapping)
Sparse encoding allows quick learning
Componential encoding
9x9 pixel bit map
81 pixels
Componential encoding like cortex
efficient; good for generalization
Sparse encoding
uses 13 lines
Trains cortex
repeats pattern over time
Repeats pattern over time
Find L in field of Ts
Patterns repeated
Ss unaware of pattern
Without damage
No “thinking” required
Improved over time
Priming
Damage
No improvement

Amnesia

Types
retrograde amnesia = before
anterograde amnesia = after
Progression
Normal cognition
Retrograde amnesia
Coma
Confusion
Anterograde amnesia
Normal cognitive function

TERMS

1% incidence
120 million rods (20:1)
140 jet taking off
16:1 ratio of light
18 days after conception
2 days old, mimic expressions

2 fists, crossed arms
2 identical founder cells
2/3 of focus of eye
20 leaves ruffling
3 channels of information
3 color receptors (plus B-W)
3 concentric parts
3 enzymes for pain
3 small bones
3 types of cones
3 types of tactile sensations
3D view of the world
3-factor model of schizophrenia
4 lobes
40 quiet suburbia
400-700 nm
60 speaking voice
-70mV resting potential
9x9 pixel bit map (81 pixels)
A-alpha fibers (largest, myelinated)
A-beta nerve fibers (large, myelinated)
abnormal activation
abnormalities of perception
absorption
abstract reasoning
acetlycholine
acquired brain injury
active transport system
addiction
A-delta fibers (thin, myelinated)
ADHD
adopted children
aerobic: use oxygen during movement
afterimages
agitated movements
agnosia
agranulocytosis = loss of white blood cells
alcohol
allodynia = exaggerated pain
Alzheimer's disease
Alzheimer's tangles
amacrine cells = interneurons
American Crowbar Case
amnesia
amphetamines
amplitude

amygdala
amyloid protein
anaerobic = don’t require oxygen during movement
anesthetic injections into stump
antagonistic muscles
anterior cingulate cortex
anterior corticospinal
anterograde amnesia = after
anti-convulsive drugs
antidepressant drugs
antioxidant drugs
antipsychotic drugs
antisaccade task
aphasia
Apolipoprotein E
apoptosis = cell death
aqueous humor
aripiprazole (Abilify)
aspirin
astigmatism
astrocytes
asymmetrical division
atrophy
atypical antipsychotics
auditory cortex
auditory-spatial processing
Babinski reflex
bacteria
bad bone conduction
bad cochlea
bad deck = lose faster
bad pain
ballistic movements
Bank---------teller
basal ganglia
BDNF
Betz cells
bilateral lesions
bipolar cells = connect receptors to ganglions
birth defects
bizarre-hyperactive talk
Bleuler, Eugen = coined term schizophrenia
blind spot
blind to future consequences
Blood-Brain Barrier
brand recognition

brightness
C fibers (small, unmyelinated)
capsaicin
cardiac muscles
cataract
catatonic = immobility
central pattern generators
cerebellum
cerebral cortex
cerebral palsy
chemical gradients
chemical guidance
chlorpromazine (Thorazine)
chronic pain
ciliary body
circadian rhythm
circular muscles = close pupil
cloudy lens
clozapine (Clozaril)
cocaine
cochlea
cold
color
coma
coma-like daze
complex cells
compulsive behavior
compulsive gambling
concussion
cones
conflict resolution
congenital varicella syndrome
connecting thoughts
conscious decisions
contagious itch
core temp
cornea
corpus collosum
corticospinal tracts
cortisone injections
cosmic rays = very very very fast
craving
critical periods
cross contralateral
crystalline (clear proteins)
cutaneous rabbit illusion

cyclooxygenase 1 (Cox-1)
cyclooxygenase 2 (Cox-2)
cyclooxygenase 3 (Cox-3)
D2 receptors
D4 receptors
DA agonists
DA receptors
dB
decaffeinated coffee
decision-making
declarative (explicit) memory
deep pressure
delusions
de-myelinization
depth of field
differentiation
DISC1 gene (disrupted in schizophrenia 1)
disinhibited behavior
disorganized speech
disorganized thinking
disturbed emotions
dopamine
dopamine hypothesis
dorsal stream of vision (where)
dorsolateral prefrontal cortex
Down's syndrome
drug addiction
drug administration
drusen
dry macular degeneration
early onset
Ehrlich, Paul
emotional pain
empathic responses
endolymph
epidermal
epidermis
epilepsy
episodic = symptoms come & go
epithelial
extensor muscles
face recognition
false sensory experiences
false tagging mechanism
farsighted
fast adaptation

fast-twitch fibers
Faux pas Test
feet of Müller cells (glial)
fetal alcohol syndrome
Fetal Hydantoin Syndrome
fin movements
firing rate
first in spinal cord
flat affect
flexor muscles
floaters
flu (or other viral illness)
fluent aphasia
fluid speech
fluphenazine (Prolixin)
forebrain
form agnosia
founder cells
fovea
fovea (fovea centralis)
frequency
frequency map
frontal lobe
fusiform gyrus
Gage, Phineas
gambling
gamma rays = very very fast
ganglion cell
garbled talk
gender stereotpyes
Geniculo-Striate Pathway
genu = anterior (knee)
Geons Theory
glaucoma
glutamate
glutamate antagonists
glutamate hypothesis
Golgi tendon organ
good deck = lose slower
good pain
grasp reflex
gray matter
Greebles
GSR
hallucinations
hallucinations (auditory)
haloperidol (Haldol)

harmony
head trauma
hear voices
hearing loss
Hebephrenic schizophrenia
hindbrain
hippocampal gyrus
hippocampus
histamine
HM (Henry Molaison, 1926-2008)
homunculus
horizontal cells = sharp edges (lateral inhibition)
hyperalgesia = extra sensitivity
hyper-complex cells
hyperemotional
hyperpolarization
hypersexuality
hypertension (high blood pressure)
hypnagogic hallucinations
imagery
imagine movement
immediate gratification
implantation = common blood supply
implicit memory
impulsivity
inappropriate displays of anger
inappropriate emotional responses
inappropriate thoughts & behavior
incidence
incus
infantile reflexes
inferior = posterior (cartwheels)
inferior collicui = hearing
inferior temporal gyrus
inhibition
initiation
inner ear
intensity
intentionality
interaural time difference
inter-neuron plaque
intuitive judgments
involuntary movements
Iowa Gambling Task
ipsalateral motor control
iris

itch
itch receptors
jargon aphasia
knee jerk reflex
koniocellular
Korsakoff's syndrome
l cones (long)
lack of dopamine neurotransmitter
lack of fluidity of speech
lack of persistence
lack of pleasure
late onset
lateral = horizontal (pirouette)
lateral corticospinal tract
lateral fusiform gyrus
lateral geniculate nucleus (LGN)
lateral inhibition
lateral superior olive (LSO)
lazy eye (amblyopia)
L-DOPA
L-Dopa treatment
left fusiform: recognizes "face-like" features in objects
left hemisphere: elements, stories & semantic memory
left lateralized for facial tasks
LGN
light
light & deep touch
linear acceleration
lingual gyrus
low birth weight
LSD
M1
macula
macular degeneration
magnocellular
mechanical nociceptors
mechanical senses
medial corticospinal tract
medial geniculate nuclei (MGN)
medial superior olive (MSO)
medial temporal lobe
medulla oblongata
medulla pyramids
Meissner's corpuscles
melody
memory consolidation

Merkel’s discs
mesolimbic pathway
mesolimbocortical system
MGN
midbrain
middle ear
midget ganglion cells
migraine
migration
monosynaptic reflex
mood
motion sickness
movement disorders
Multiple Sclerosis
muscle spindle
muscles
Musician’s Cramp
myelination
myotatic reflex
naproxen (Aleve)
nearsighted
neologisms = new words
neural Darwinism
neural plasticity
neural tube
neurofibrer tangles
neuroleptic drugs
neurotic scratching
neurotrophic factors
nicotine
night vision
NMDA glutamate receptors
nonsense words
nucleus accumbens
nutrition
nystagmus
object features
object recognition
obsessed with objects (skulls)
obsessive-compulsive
occipital lobe
OFC
Olanzapine (Zyprexa)
onset & offset
open or closed head injuries
opioids (opiates)

opponent-process theory of color
opsin
optic chiasm
optic nerve (optic tract)
orbitofrontal
Organ of Corti
ossicular chain
otoconial crystals
otoliths
oval window
Pacinian corpuscles (touch only)
pain
paliperidone (Invega)
parafovea = S cones & rods; sharpish
parallel fibers
paranoid
paranoid delusions
parasol cells
parietal lobe
Parkinson's disease
parvocellular cells
path-finding
peduncular hallucinations
perceived color
periforvea
perilymph (similar to cerebral spinal fluid)
peripheral neuropathy
perphenazine (Etrafon)
phantom pain
phencyclidine (PCP)
phenytoin (Dilantin)
phonetic processing
photopic system
photopigments
photopsins
photosensitive ganglion cells
physiological zero
pinna = outer ear
pitch
polarization
polymodal nociceptors
poor control of eye movements
posterior parietal cortex
posterior parietal lobe
posterior vitreous detachmentor (PVD)
poverty of speech

pre-amplifier
prefrontal cortex
premature birth
pre-motor cortex
pressure
primary auditory cortex
primary motor cortex
priming
primitive streak
problem solving
prodromal = pre-symptoms
progressive disease
proliferation
proprioceptors
prosopagnosia = impairment in recognizing faces
pseudo-hexagonal symmetry
pseudovertigo = rotation
psychiatric itch
psychotic disorders
psychotic symptoms
PTSD
pupil of the iris
Purkinje cells
quetiapine (Seroquel)
radial glial cells
radial muscles = open pupil
raw egg whites
receptive aphasia
red nucleus of midbrain
red-green color blindness
reflexes
remapped when eyes move
repetitive behavior
resting potential
resting tremor
restlessness
reticular formation
retina = net
retinal circulatory system
retinex theory of color
retrograde amnesia = before
reversal learning
reward circuit
rheumatoid arthritis
rhodopsin
rhodopsin (visual purple)

rhythm
right fusiform: determines if actual face
right hemisphere: whole picture, face recognition & episodic memory
risperidone (Risperdal)
rod
rod disks
rods
rooting reflex
rostral stream
rotating disk
round window
Ruffini's end organs
runs in families
s cones (short)
schizophrenia
schizophrenic art
Schlemm's canal
sclera
S-cones
scotropic system
season-of-birth effect
secondary auditory cortex
seizures = excessively synched neural activity
self control
self medication
self-isolation
semantic memory
semicircular canals
sex differences
sexual dimorphism
SGT (another task)
sharp & dull pain
side effects
silent nociceptors
simple cells
skin mapping
skin stretch
sleep deprivation
slow adaptation
slow vibrations
slow-twitch fibers
smells
smooth muscles
sneezing
social judgment
social pain

social withdrawal
somatosensory associative cortex
somatosensory cortex
sound localization
sparse encoding
spatial summation
split-brain people
stapes
stereocilia
stimulus salience
stretch reflex
striate cortex in occipital lobe
striated
subjective = you're moving
substantia nigra
suicide risk
superior = anterior (head over heels)
superior colliculi = vision
superior olivary complex
superior temporal lobe
supplementary motor cortex
sustained pressure
symmetrical division
synapse elimination
synapse formation
synaptogenesis
tactile sensations
tardive dyskinesia
target detection
target identification
Tau protein
temperature
temporal lobe
teratogens
tertiary auditory cortex
The Schizophrenias
thermal nociceptors (extreme)
thiamine deficiency
thought disorders
thought insertion
tonotopic map
TOPDV protein is 30x more concentrated in dorsal retina
touch
tremors
trichromatic theory of color
truncus = middle (body)

Truth Telling
ultra violet rays = fast
under-active dorsolateral
undifferentiated
unequal pupil size
unmyelinated
unusual facial expressions
unusual false beliefs
unusual thoughts
utricle (gravity)
V1 = 1st stage of processing
V2 = associations (circle, angles)
V3 = lower visual field
V4 = color & spatial
V5 = motion+
varicella (chickenpox)
ventral path (what)
ventromedial prefrontal cortex
vertigo = whirling, spinning
vestibular sensations (inner ear)
vibrations
viral infections
visual agnosia
visual discrimination test
vitreous humor
vmPFC
voluntary movement
warm = increase firing rate
wave length
Weiss (1924)
Wernicke's area
word recognition
working memory
working memory for objects
working memory for spatial locations
Writer's Cramp
X rays = very fast
yellow-blue color blindness
Yoruba people of Nigeria
Young-Helmholtz Theory of color
ziprasidone (Geodon)