CHAPTER 1

ORIGINS OF BEHAVIORAL NEUROSCIENCE

1.1 Prehistoric

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1.4.1 *Hippocrates*

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- Galen is a physician to gladiators.
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- Noticed there were large spaces (called "ventricles," or "spaces") that were filled with fluid.
- From here, we get the four humors (fluids).
- Galen thought that these fluids are what control the brain, NOT the brain structure itself. Think of the purpose of canned vegetables. The tin container does not actively contribute to the liquid / vegetables; rather, it is disposable.
- These ideas were jumpstarted by the invention of aqueducts. The movement of water was so important from aqueducts, so the idea this idea was extended to the brain.

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- *French* developed hydraulically controlled machines.
- Again, this is adding to the idea that liquids (which can flow through things and cause movements) are responsible for the brain's functionality.

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- Believed that non-humans–what he called animals–are controlled by fluid.
- From this, he posited that the human body is a material entity functioning as a machine (like animals)–these are known as reflexes.
- But, the mind is nonmaterial and free from the laws of the universe and was uniquely human.
- Question: How does the nonmaterial part of the body (the mind) communicate with the material part of the body? Through the pineal gland! This gland would move around like a joystick and would manipulate the fluid that came from the third ventricle.

1.8 The Mind/Body Problem

- What is the basic relationship between mental events and physical events?
- *Dualism*–The mind exists independently of the brain and exerts some control over it.

- Strengths: Commonsense view.
- Weaknesses: The universe is composed of matter or energy.
- Modern neuroscientific explanation: Everything the body does rests on the events taking place in specific, definable parts of the nervous system–the "mind" is the product of the nervous system activity.

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- A new world view at the end of the Renaissance.
  - Replace *Rationalism* with *Scientific Method*.
- Closer look at the substance of the brain:
  - Gray and white matter change the way we look at the brain. That is, why would these parts of the brain that are clearly different, be different if the brain is used just to move fluids around.
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- *Isaac Newton* showed it is possible to electrically stimulate nerves.
- Then, *Luigi Galvani* and *Emil du Bois-Reymond* showed that electricity can make muscles contract.
- Later on, *Hermann von Helmholtz* showed that the speed of nerve conduction is not instantaneous.
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- *Bell* and *Magendie* showed that the dorsal nerve root and the ventral nerve root are different.
  - Specifically, Bell showed that the ventral nerve root is for motor information, and Magendie showed that the dorsal nerve root is for sensory information.
- The dorsal nerve root is for sensory information, and the ventral nerve root is for motor information.
- *Dorsal* = *Sensory*: Think of the dorsal fin of a shark sensing vibrations in the water.
- *Ventral* = *Motor*: Think of a vent (like a car exhaust) pushing out movement.

- *Johannes Müller* came up with the doctrine of *Specific Nerve Energies*.
  - This doctrine states that the nature of a sensation depends on which nerve is stimulated, not on how the nerve is stimulated.
  - For example, if you stimulate the optic nerve, you will see something. If you stimulate the auditory nerve, you will hear something.
- Spawned the *Great Debate*: Is the brain a homogenous mass or is it made up of different parts?

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- *Franz Joseph Gall* and *Johann Spurzheim* thought the bumps and groves on the head were due to the size of the brain parts.
- They concluded that the size of the brain parts was correlated to the use of that part.
- This is known as *phrenology*.
- *Localization of Functions*–brain function can be localized to regions, pathways, or neurons.
  - Basically, if you cut out a piece of brain, and the animal (a pigeon) is no longer able to do a specific task, then that part of the brain is responsible for that task.
  - However, it turns out that these pigeons were able to relearn the task, so the brain is not as localized as we thought (this research is from Flourens).
- *Aggregate Field Theory*–the brain is a homogenous mass.
  - Complex brain functions emerge from the collective interactions of numerous simple neuronal activities.
  - Unlike localizationist models, this theory emphasizes the distributed nature of cognitive processes across neural networks.
- *Pierre Flourens* (1794–1867)
  - Studied the effect of brain damage with pigeons and supported the Aggregate Field Theory.
- *Paul Broca* (1824–1880)
  - Found a patient who *could speak* but could *not understand language*.
  - After the patient died, Broca found a lesion in the *left frontal lobe*.
  - This area is now known as *Broca's area*.
  - This area is responsible for *speech production*.
  - These results put us back into the realm of Localization of Function.

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- Then, we have *Gustav Fritsch* and *Eduard Hitzig* (1870)
  - Similarly to *Luigi Galvani* and *Emil du Bois-Reymond*, they electrically stimulated the brain.
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1.12 Same Resolution?

- *Modified Aggregate Field Theory*
  - *Karl S. Lashley* (1890-1958)
    - *The Principles of Mass Action*
      - Complex behavior–such as learning–is dependent on the total mass of the brain.
    - *Equipotentiality*
      - Specialization of function is not tied to specific brain regions.
      - All parts of the cortex contribute equally to complex behavior.
    - *Vicarious functioning*
      - If one part of the brain is damaged, another part can take over.

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    Table 1.1: Key Figures in the Great Debate: Localization vs. Aggregate Theory

Localization	**Aggregate Theory**
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Gustav Fritsch	
Eduard Hitzig	

12. **Modified Aggregate Theory**: Karl Lashley emphasized mass action and equipotentiality.

Table 1.2: Key Scientists and Contributions

Scientist	**Contributions**
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SKIP CHAPTER 2

Most of the content from Chapter 2 has been blended with Chapter 3.

CHAPTER 3

STRUCTURE OF THE NERVOUS SYSTEM

3.1 Neuroanatomy

Neuroscience is the study of the nervous system. Behavioral neuroscience is understanding the nervous system's underlying behavior.

3.1.1 Nervous System Structure

Structural Nervous System

How are neurons organized into systems?

- **Central Nervous System (CNS)**
  - Brain
  - Spinal Cord
- **Peripheral Nervous System (PNS)**

Functional Nervous System

What are the 'jobs' of the nervous system?

- *Somatic Nervous System*
  - Skeletal Muscles (Striated)
  - Sensory information in
  - Voluntary motion out
- *Autonomic Nervous System*
  - Uses smooth muscles
  - Glands
  - Sympathetic Nervous System
    - Fight or Flight
    - Heart rate, blood pressure, respiration, and alertness.
  - Parasympathetic Nervous System
    - Rest and Digest
  - *Enteric Nervous System*

- A mesh-like system of neurons that governs the function of the gastrointestinal system.
- AKA: 'Second Brain'
- GI problems are correlated with psychological disorders.
- The GI track houses a lot of our microbiota.
- Fecal Microbiota Transplant
  - Rat studies showed that when a skinny rat has a fecal transplant from a fat rat, the skinny rat becomes fat. This works in reverse too.
  - Therefore, the microbiota change the *behavior* of the rat.
- Elevated Plus Maze
  - A test to measure anxiety in rats.
  - The rats with the fecal transplant from the anxious rats were more anxious.
  - **This is huge!** This shows that the microbiota can change if a rat is anxious or not!

3.2 Meninges

- Cover the outside of the nervous system.
  - Three for the CNS and two for the PNS.
  - The PNS does not use the arachnoid mater.
- *Dura Mater*
  - "Hard Mother"
  - The outermost layer.
  - Tough and fibrous.
  - Contains blood vessels.
  - Early anatomists called it "pachymeninges" because similar to elephant skin.
- *Arachnoid Mater* = "Spider Mother"
  - Middle layer.
  - Web-like structure.
  - Contains blood vessels.
  - Subarachnoid Space
    - Between the arachnoid and Pia mater.
    - Contains cerebrospinal fluid (CSF).
  - Arachnoid trabeculae

        - Web-like structures that connect the arachnoid mater to the Pia mater.
        - Allows for the subarachnoid space to be filled with CSF.

- *Pia Mater* = "Soft Mother"
    - Innermost layer.
    - Thin and delicate.
    - Flows over every sulcus (grooves), fissure (deep indentations), and gyri (bumps).
    - Follows the contours of the brain and spinal cord.

- *Meningitis*
    - Inflammation of the meninges.
    - Can cause symptoms such as headache, fever, a stiff neck, or hallucinations.

3.3 Cerebrospinal Fluid (CSF)

- Similar to blood plasma.
- Functions of CSF
    - Protection
        - Failures:
            - Brain is injured.
            - AND even Contrecoup–when the brain is injured on the opposite side of the impact–injuries.
            - *Chronic Traumatic Encephalopathy (CTE)*
                - Old name: Dementia Pugilistica (boxer's dementia).
                - Symptoms (not exhaustive): Memory loss, confusion, impaired judgment, impulse control problems, aggression, depression, Parkinson's-like symptoms, insomnia, and progressive dementia.
                - Causes ventricular enlargement. In other words, the larger your ventricles, the less brain matter you have.
                - Also causes atrophy of the fornix. The fornix is a C-shaped bundle of nerve fibers in the brain that acts as the major output tract of the hippocampus.
                - Tau are abnormally phosphorylated aggregate into tangles. They accumulate both inside neurons and even released into extracellular space.
    - The CSF also moves neurotransmitters, waste, hormones, nutrients, and other substances from one place to another.
        - For example, the CSF moves β-amyloid (in-between cells) from the brain to the blood.

- *Choroid Plexus*
  - *Ependymal cells*
    - Lines the lateral ventricles.
    - These are the cells that produce the CSF.
  - If the choroid plexus is not working properly, it can cause hydrocephalus.
  - *Hydrocephalus*
    - "Water on the brain"
    - Swelling of the brain due to the accumulation of CSF.
  - Derives from the Pia mater.

3.3.1 Flow of CSF

- *Lateral ventricles*
  - CSF is produced here and flows through the interventricular foramen.
- *Third Ventricle*
  - Looks like a duck's head.
  - Is connected to the *pituitary gland* through the *infundibulum*.
- The CSF routed through the medial longitudinal fissure and into the *Superior Sagittal Sinus*.
- *Interperducular Fossa*
  - The space between the two cerebral peduncles.
- *Interventricular Foramen*
  - Connects the lateral ventricles to the third ventricle.
- *Cerebral Aqueduct*
  - Connects the third and fourth ventricles.
- *Central Canal*
  - Connects the fourth ventricle to the spinal cord.
  - For remembering purposes, the *cerebral* aqueduct is in the *brain* and the central canal is in the spinal cord.
- *Subarachnoid Space*
  - Foramen of Magendie (Medial) and Luschka (Lateral)
    - Two tiny little holes in the fourth ventricle.

3.3.2 Dumping of CSF

- Arachnoid Villi/Granulations
  - Absorbed into blood stream from the superior sagittal sinus.

3.3.3 Getting Some CSF Out -or- Putting Something Into It

- Where would you have them stick that needle?
  - *Dural Sac*
    - Enlarged space in the lumbar region.
    - Testing and introduction of anesthetic agents.
    - Epi = Something in
  - *Lumbar Puncture*
    - AKA: Spinal Tap.
    - Tap = Taking something out

3.4 Cranial Nerves

#	Name	Type	Information Carried
I	Olfactory	S	Smell
II	Optic	S	Vision
III	Oculomotor	M	Eye movement, pupil constriction
IV	Trochlear	M	Eye movement
V	Trigeminal	B	Touch to face, motor control of mandibles
VI	Abducens	M	Eye movement
VII	Facial	B	Taste and facial expression
VIII	(Vestibulocochlear)	S	Hearing
IX	Glossopharyngeal	B	Taste and swallowing
X	Vagus	B	Taste and sensation from neck, thorax, abdomen, swallowing, control of larynx, parasympathetic nerves to heart and viscera
XI	Spinal Accessory	M	Movement of shoulders
XII	Hypoglossal	M	Movement of tongue

3.4.1 Mnemonic for Cranial Nerves

Old **Op**ie **oc**casionally **t**ries **t**rigonometry **a**nd **f**eels **ve**ry **glo**omy, **vagu**e, **a**nd **hypo**active.

3.5 Terms

- Santiago Ramon y Cajal (1911)
  - Used the Golgi stain to show that neurons are separate cells.
- *Soma* – Cell Body
- *Dendrites* – "Branches"
  - Purpose is to increase the surface area of the neuron, so it can receive the most amount of information.
- *Axon terminal botton* – The ends of the neuron that send information.
- *Glial cells* – Support cells by insulating the axon for better communication.
- *Myelin sheath* – Insulates the axon.
- *Nodes of Ranvier* – Gaps in the myelin sheath.
- *Unmylinated axons* are called grey matter.
- *Ganglion* – A collection of cell bodies in the PNS.
- *Nerve* – A collection of axons in the PNS.
- *Nucleus* – A collection of cell bodies in the CNS.
- *Tract* – A collection of axons in the CNS.

Grey Matter	**White Matter**
Cell bodies Dendrites Unmyelinated axons	Myelinated axons

Table 3.1: Gray vs. White Matter

	Gray Matter	**White Matter**
Location	**Cell Bodies**	**Axons**
CNS	Nucleus	Tract
PNS	Ganglion	Nerve

Table 3.2: Differentiation of Gray and White Matter in the CNS and PNS

3.6 Brainstem

3.6.1 Hindbrain

- *Myenlencephalon*
  - *Medulla Oblongata*
    - Enlargement of the cord.
    - Lots of gray matter.
    - *Reticular Formation*
      - A network of nuclei.
      - Regulates sleep, wakefulness, and arousal.
      - Also regulates heart rate, blood pressure, respiration, and skeletal muscle tone.
    - *Pyramids*
      - Two ridges on the ventral surface.
        - Voluntary motor system.
    - *Olives*
      - Audition and motor learning.
      - Located on the lateral surface.
- *Metencephalon*
  - *Pons* – "Bridge"
    - White matter on the outside and gray on the inside.
    - *Locus Coeruleus*
      - Produces norepinephrine.
      - The norepinephrine is sent to the forebrain.
  - *Cerebellum*
    - Caudal portion of the brain.
    - Balance, hand/eye coordination, soothes movements.
    - Shifting attention between vision and hearing, sensory timing (judging rhythms), language, emotional control, and reward valuation.
    - Cerebellar agenesis – the cerebellum is not developed.

3.6.2 Midbrain

Mesencephalon

- *Techtum* = "Roof"
  - *Superior Colliculus* – Visual Reflexes
    - Pupils opening and closing in response to light.

- *Inferior Colliculus* – Auditory Reflexes
- Colliculus = "Little Hill"
- *Pineal Gland* – Melatonin

- *Tegmentum* = "Floor"
  - *Substantia Nigra* = "Black substance."
    - Get its black coloring from the creation of dopamine.
    - Clearly, this brain structure makes a majority of dopamine (1 of 3).
  - *Red Nucleus* – Motor coordination.
    - Get its red color from iron oxidation.
    - Connects to the cerebellum for that motor coordination.
  - *Periaqueductal Gray Area* – Opioids.
    - Peri = around, so peri-aqueductual = around-the cerebral aqueduct.
    - Handles endogenous pain relief.

3.6.3 Forebrain

Diencephalon

- *Thalamus*
  - Massa Intermedia = intermediate mass. This connects the two halves together.
  - Made up of many specific relay nuclei.
    - *Lateral Geniculate Nucleus* – Vision
    - *Dorsal Medial Nucleus* – Pain
      - Routes the pain from the thalamus to the prefrontal cortex.
  - . . . and of non-specific relay nuclei.
    - *Nucleus Reticularis* – Promotes wakefulness.
      - Goes to different parts of the brain, not just one specific part like the specific relay nuclei.
- *Hypothalamus*
  - Irregular shape, size of a thumbnail.
  - Encases the ventral part of the third ventricle.
  - **Survival of the individual**
    - Eating
    - Drinking (water)
      - Salt regulation
    - *Suprachiasmatic Nucleus*

        - Circadian rhythms
        - Daily fluctuations of temperature
    - **Survival of the species**
        - Territoriality
        - Sexual activity
        - Reproduction
    - **Integration of information**
        - Endocrine system
        - Autonomic nervous system

Telencephalon

- *Corpus callosum*
    - Connects the two hemispheres.
    - Remember that the neurons in this structure go from lateral to lateral, and not from dorsal to ventral.
    - Creates the roof of the lateral ventricles.
    - Agenesis of the cc
        - AKA: Callosal Agenesis
        - Vision impairments,
        - hypotonia,
        - poor motor coordination,
        - delays in motor milestones,
            - (Such as sitting and walking.)
        - cognitive disability,
            - (Disability in complex problem solving.)
        - and social difficulties.
            - (Missing subtle social cues maybe cause of impaired fair processing.)
    - *Corpus Callosotomy* – Split brain surgeries.
        - Used to treat epilepsy.
        - Gives information about lateralization of hemispheres.
        - **Left Hemisphere**
            - language
            - serial events
        - **Right Hemisphere**
            - creativity
            - synthesis

- *Basal Ganglia*
  - **Function:**
    - Initiation of Voluntary Movements.
    - Click here for Parkinson's continuation.
  - Curls laterally around the thalamus.
  - *Striatum*
    - *Caudate Nucleus* = "Nucleus with a Tail"
      - Obsessive Compulsive Disorder (OCD)
        - MIXED RESULTS
          - Too much activity, too large.
      - Romantic Love
        - Fisher, Aron, and Brown
          - Anthropologist used fMRI with a picture of neutral and romantic partners.
          - The CN activity was increased for loved one.
      - Larger in folks with incredible episodic memories (superior autobiographical memory).
        - How large? 7-8 SDs larger.
    - *Putamen* = "Shell"
    - *Nucleus Accumbens*
      - Nucleus Accumbens Septi = "Nucleus leaning against the septum."
        - Where the head of the caudate and the most anterior portion of the putamen come together.
        - Plays an important role in reinforcement, pleasure, and addiction.
  - *Globus Pallidus* = "Pale Globe"
  - *Note:* When people mention the putamen and the globus pallidus, they call it the lentiform nucleus.
- *Limbic System*
  - *Hippocampus*
    - In charge of moving memories from short-term to long-term.
    - Emotion, selective attention, learning, and memory.
  - *Amygdala*
    - In charge of emotions.
    - Fear and aggression, territoriality, odor processing, and sexual activity.
    - **Amygdala and Fear**
      - 1930's.

- Lesions to amygdala in monkeys.
- Many things happened...
  - Exploratory behavior of objects (put in mouth–hyperorality).
  - Hypersexuality.
  - Loss of fear.
    - Freezing, increased heart rate, hair standing on end, etc.
    - Lost their fear of the human experimenters.
- *Kluver-Bucy Syndrome*
  - Damaging the anterior temporal lobes.
  - Herpes encephalitis and trauma.
  - Loss of normal fear and anger responses.
- Facial mimicry
  - Seeing fear in others lead to fear expression.
  - AND has amygdala activity.
- **Other things**
  - Social networks (Bickart et al., 2010)
    - Size and complexity of social network + correlated with amygdala size.
    - MAYBE: More effectively identify, learn about, and recognize socioemotional cues.
  - Political views (Rees et al., 2011)
    - Took extreme liberals and extreme conservatives and found that the more extreme conservatives had a larger amygdala than the extreme liberals.
- **How burnout is related to your brain...**
  - Worse at suppressing negative emotions.
  - Big amygdala & weak connection to frontal lobe.

- *Cingulate Gyrus*
  - Selective attention.
  - Love (like the cingulate gyrus)
    - Same studies show increased activity for loved ones.
  - Pain.
    - Serves as alarm for distress
    - Association of the emotional components and the sensory components of pain.
    - Sympathetic pain (empathy).
    - Social rejection.
      - Eisenberger (1990s)
      - Cyberball

- A computer game where you play catch.
- The other players stop throwing the ball to you.
- The cingulate gyrus lights up.

- *Fornix*
- *Mammillary Bodies*
- *Septal Nucleus*

Cerebral Cortex

- Cortex = "bark"
- Many convolutions
  - Sulci/fissures
  - Gyri
- Gray matter.
- 6 Layers
- Four lobes
  - *Frontal Lobe*
    - Executive functions, motor control, and language production (Broca's area).
  - *Parietal Lobe*
    - Lips, toes, and spacial awareness.
  - *Temporal Lobe*
    - Memory, hearing, and language comprehension (Wernicke's area).
  - *Occipital Lobe*
    - Vision
  - **How they are separated:**
    - Frontal ↔ Parietal: *Central Sulcus*
    - Parietal ↔ Occipital: *Parieto-Occipital Sulcus*
    - Temporal ↔ Frontal/Parietal: *Lateral Sulcus (Sylvian Fissure)*
- *Nucleus Accumbens*

3.7 Parkinson's Disease

- *Bradykinesia*
  - Slowness of movement.
- *Akinesia*
  - Difficulty initiating voluntary movements.
- *Rigidity*
  - Increased muscle tone.
- *Tremors*
  - Involuntary shaking of hands and jaw most prominent at rest.

3.8 Alzheimer's Disease

- Progressive memory loss.
- Affects the cortex and hippocampus.
- Suffers from both retrograde and anterograde amnesia.

CHAPTER 6

HOW NEURONS PROCESS INFORMATION

NEW NOTES FOR 02/26/25

6.1 The Neuron

- Definition: Basic information processing unit of the NS.
- Similarities to an animal cell:
  - *Cell membrane*: Separates the inside of the cell from the outside environment.
  - *Nucleus*: Contains the genetic material of the cell.
  - *Organells*: Carry out the basic functions of the cell.
    - *Mitochondria*: Produce energy for the cell.
    - *Endoplasmic Reticulum*: Synthesizes proteins.
    - *Golgi Apparatus*: Packages proteins for transport.
    - *Lysosomes*: Break down waste products.
  - Basic cellular processes.
- Differences:
  - Special "morphology" (shape).
  - Communicate through an electrochemical process.

6.1.1 Structure of the Neuron

(Mostly a recap of Terms)

- *Soma*
- *Dendrite*
- *Axon*
- *Terminal Arboriza* – Branches at the end of the axon.
- *Terminal Buttons* – End of the terminal arboriza.
- *Axon Hillock*
- *Myelin*

- Not all axons have it.
- Glial cells / 70% Lipid / Nodes of Ranvier.
- Mutliple Sclerosis (MS) – Demyelination.

6.1.2 Support cells in the Nervous System

- Glia/Glial Cells/ Neuroglia – Support cells.
  - Capable of cell division after birth/communication.
  - Make up half of the volume, but are 10-50 times more numerous. (The other half is made up of neurons.)
  - CNS:
    - *Macroglia* – Large glial cells.
      - *Astrocytes* – Star-shaped cells that provide physical support to neurons, clean up debris, and provide nutrients to neurons.
      - *Oligodendrocytes* – "few branches (in contrast to Astrocytes)" – *Form* myelin sheath around multiple axons in the CNS.
    - *Microglia* – Small cells that remove debris from injured or dead cells.
    - *Ependymal Glia* – Line the ventricles of the brain and spinal cord. (Remember the CSF?)
  - PNS:
    - *Satellite Cells* – Provide nutrients and physical support to neurons.
    - *Schwann Cells* – Form myelin sheath around axons in the PNS. These cells are monogamists; they wrap their arms around one axon.
      - Neuronal Regeneration.
  - The Myelin Sheath is composed of Oligodendrocytes in the CNS and Schwann Cells in the PNS.
  - *Phagocytosis* – The process of engulfing and digesting cellular debris. (Done by Microglia and Schwann Cells.)

We're starting with three studies:

1. **Study 1:** Blinking:
    - Three levels of blinking:
        - Reflexive blinking. Ex: When a puff of air is directed at the eye.
        - Voluntary blinking. Ex: When you're asked to blink.
        - Endogenous blinking. Meaning: "originating from or due to internal causes."
    - *Endogenous blinking* is the focus of this study.
        - Endogenous blinks occur during reading or speaking and reflect changes of attention and changes in thought processes. The more attention required by a visual task; the fewer endogenous blinks occur.
        - More attention required is associated with fewer endogenous blinks. Especially for visual tasks.
        - **The harder the tasks → the fewer the blinks.**
        - Even when a task is not visual, there is a decrease in endogenous blink rate (EBR) during a difficult task followed by flurry of blinks when task is over.
        - **But wait!**
            - EBR has been shown to increase when a cognitive secondary task is performed concurrently, and the cognitive task does not involve visual attention.
        - **WHY?**
            - EB is a dopaminergic activity.
            - Dopamine plays a big role in selective attention.
    - Through this study, we learned that endogenous blinking (DV) is affected by cognitive load (IV)
2. **Study 2:** Cartoon Judgement:
    - Group 1 and 2 membership.
    - Follow group instructions then rate the 3 cartoons that follow on scale from 1-10.
        - 1 is NOT funny
        - 10 is VERY funny
        - Answers (Lips = Pen in lips; Teeth = Pen in teeth):

Groups	Pic 1	Pic 2	Pic 3	Average
Lips	3	3	4	$3\frac{1}{3}$
Teeth	4	4	3	$3\frac{2}{3}$
Stretch	4	5	6	5
J. Jacks	4	2	3	3

- **Facial Feedback Hypothesis**
  - Selective activation or inhibition of facial muscles has a strong impact on emotional responses to stimuli.
  - Zygomatic major muscle.
    - When we had the pen in our teeth, we were activating the zygomatic major muscle.
    - This muscle is responsible for smiling.
  - Our data supported this hypothesis with a probability of $p < 0.02$.
- **Arousal**
  - Increased heart rate in many emotions.
  - Heart rate and attraction
    - 1973 Dutton and Aron
      - Shaky high bridge vs. low stable bridge.
      - Woman on the other side who is asking questionnaire questions (faux DV).
      - She gave her phone number to the guys once they got done answering the questions.
      - The actual DV was the amount of phone calls she received and the sexual content in questionnaire answers.
      - The high bridge group had more sexual content in their messages.
    - 15 minutes of physical activity, then rate attractiveness of potential mates.

Psychophysiology: Behavioral, cognitive, emotional, and social events are all mirrored in physiological processes.

The idea is that we can get a peep into your psychology by looking at what your biology is doing.

Sleep: EEG (Electroencephalogram; measuring brain activity), EOG (Electrooculogram; measuring eye movement), EMG (Electromyography; measuring muscle movement), ERP (Event-Related Potential; measuring event-related potential).

When your brain is hooked up to the ERP and you are asked either task relevant-stimulus, important stimulus, or surprising stimulus, it will produce a higher p—300 amplitude compared to otherwise. Think about how this would be used for interrogating a suspect, for

example.

Then, there are n—350 amplitudes which are activated when we are asleep, and we hear our name, for example.

Notice the implications of this with sleeping: the more tired you are (or closer to falling asleep), the harder it will be to find the p—300 amplitude.

Omitted Stimulus Paradigm – Given a constant stimulus, this is the phenomena wherein there is a gap in the pattern. This will result in a higher p—300 amplitude.

Polygraph: Respiration, GSR (EDA), Blood flow, Blood pressure, and heart rate.

With a polygraph, we're looking at all the components of the peripheral nervous system. That is, when we're "looking at " a polygraph, we're not measuring lying, but all the physiological responses that are associated with lying.

6.2 EDA

- *Electrodermal Activity*
  - Old name: Galvanic Skin Response
  - Measuring sympathetic nervous system activity by detecting sweat gland activity by measuring the conductance of an electrical signal from one electrode to another.
  - More rapid conductance with more activity.
  - Particularly good for emotion.
  - Maybe attention.
  - This also is a good measure for the sympathetic nervous system because it is the only one that can enervate the sweat glands.

6.2.1 What if I Want to Know

- If you're lying
- Cognitive or emotional states when you're sleeping
- If you're attending to stimuli I'm presenting

Psychophysiology is different from Physiological Psychology. Note that Psychophysiology is where mind/behavior is the IV, and physiology is the DV. Similarly, Physiological Psychology uses the same IVs and DVs, but notice that we are manipulating the physiological psychology to measure psychology. Remember the independent variable is first (mnemonic).

Examples

- Present snake photo or not. Then measure effects on physiology that evidence fear.
- Presenting in-group and out-group photographs. Then measure effects on physiology that evidence prejudicial cognition.
- Drugs: Measure effects on psychology (behavior/aggression)
- Lesion: Measure effects on psychology (cognition/memory)
- Manipulate heart rate: (behavior/attractiveness ratings)
- Electrical Stim of Brain [tDCS (transcranial direct current stimulation)]: Measure effects on psychology (mood/emotion/depression)

6.3 EEG

- Activity in large groups of neurons.
- Difference in electrical activity at a reference point and site of interest.
- You get: Wavelike patterns.
- *International 10-20 system*.
  - Fz, Fp1, Fp2, F7, F8, F3, F4, T3, T4, Cz, C3, C4, T5, T6, Pz, P3, P4, O1, O2.
    - F = Frontal
    - T = Temporal
    - C = Central
    - P = Parietal
    - O = Occipital
    - Odd numbers = left hemisphere.
    - Even numbers = right hemisphere.
    - Z = Midline
- Researchers use *visual inspection* to look at the EEG data.
- Measurements
  - *Frequency* – $\frac{1}{\text{time}}$ (in Hz)
  - *Amplitude* – Height of wave (in μV)

6.4 Neurofeedback

- Learn to control your brain activity.
  - See the activity
  - Get reinforcement or punishment
  - Make changes

- Even if you don't "know" what you're doing, you can still learn to control your brain activity.