

LAP Neuroscience of Addiction and Recovery

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Presentation Overview

- In this presentation, we will go over:
 - Essential parts of the nervous system
 - How the nervous system responds to intoxicating substances
 - How neuroscience helps us understand the effectiveness of 12 Step Recovery
- Key takeaways:
 - The nervous system is a remarkable system designed to keep us in balance with our surroundings
 - Substance use causes immediate and long term changes to the brain
 - Sobriety and 12 Step Groups can heal the brain, make it stronger, and create new circuits that lead to expertise in recovery

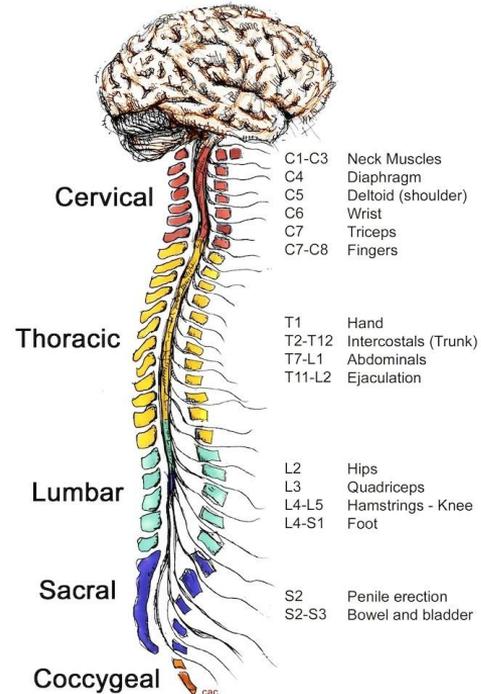
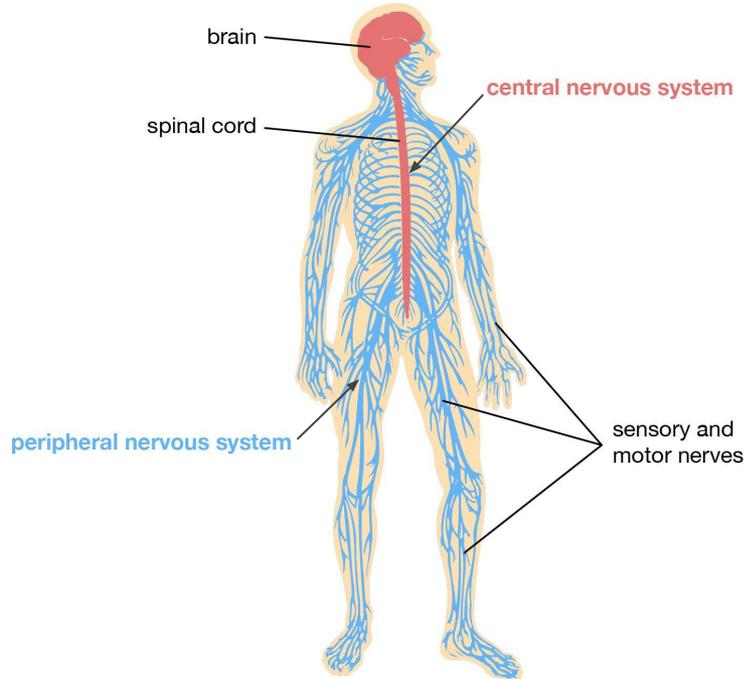




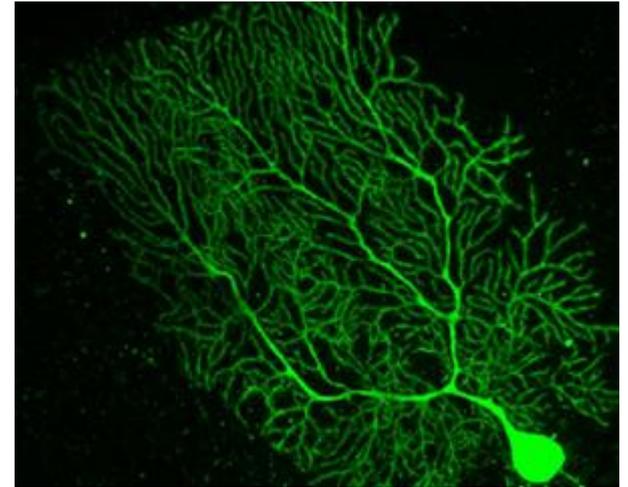
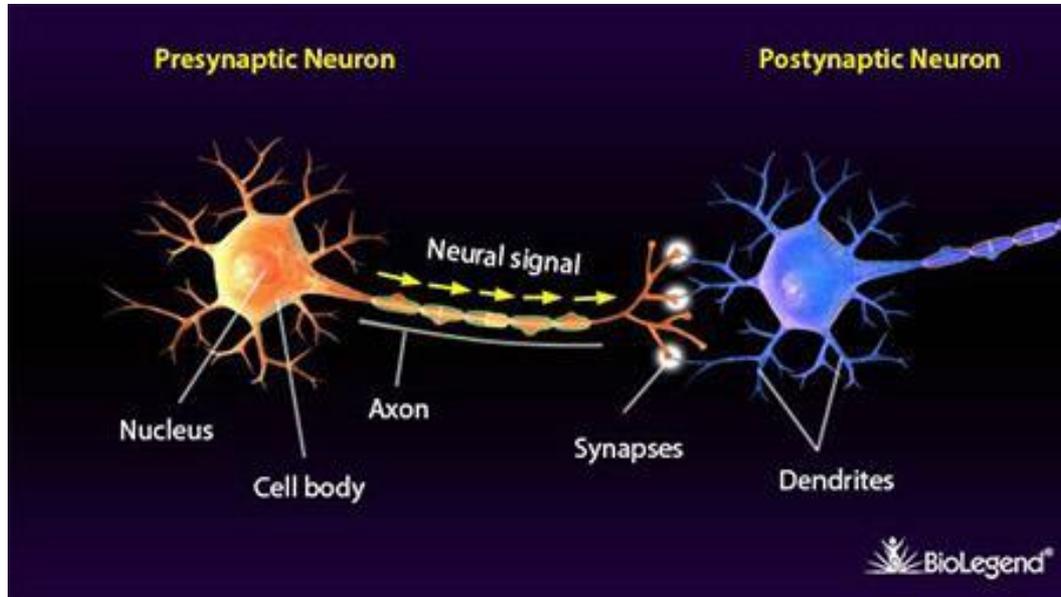
Essential parts of the nervous system

The nervous system is designed to sense and respond to the world around us

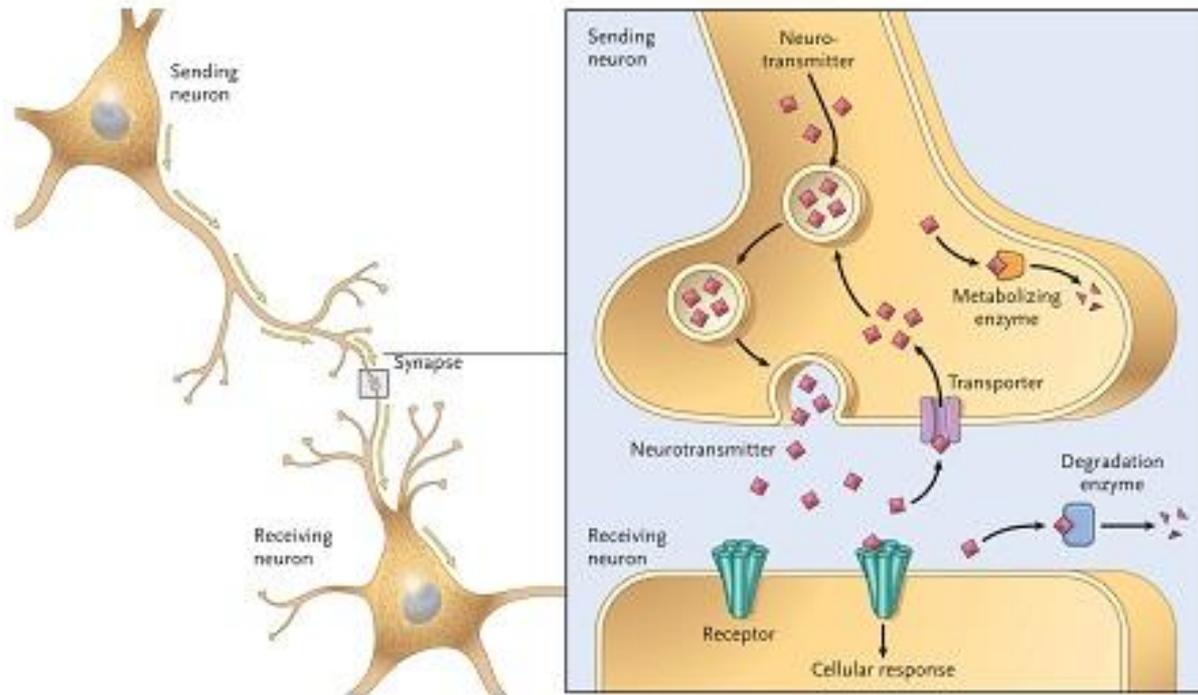
The nervous system



Neurons and synapses are the brick and mortar of the nervous system

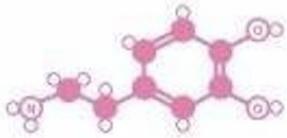


Synapses regulate nerve signaling through chemical signaling



There are 7 key neurotransmitters (1 of 2)

Dopamine



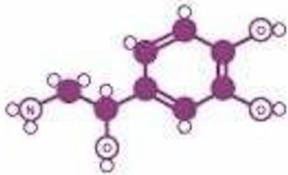
- **Motivation**
- Excitatory neurotransmitter
- Associated with reward, pleasure, arousal, learning

Serotonin



- **Mood, Meaning**
- Mood, sleep patterns, sexuality, anxiety, appetite, pain

Norepinephrine/Noradrenaline



- **Physical action**
- Key in alertness, arousal, decision-making, attention, focus

Acetylcholine



- **Cognition**
- Motivation, arousal, attention, learning, and memory, and is also involved in promoting REM sleep

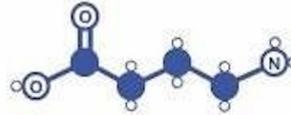
There are 7 key neurotransmitters (2 of 2)

Glutamate



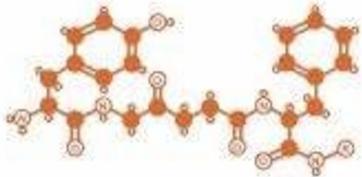
- Primary **excitatory** neurotransmitter
- Important for **thinking**, learning, **memory**

GABA



- THE Primary **inhibitory** neurotransmitter
- Essential for calming down from an excited state and sleep

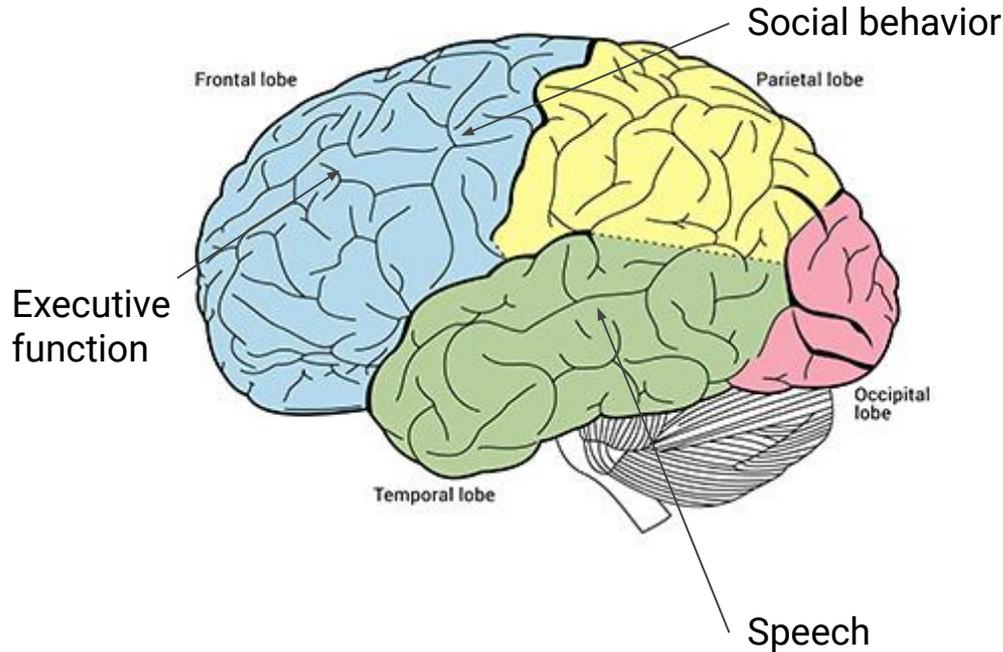
Endorphins



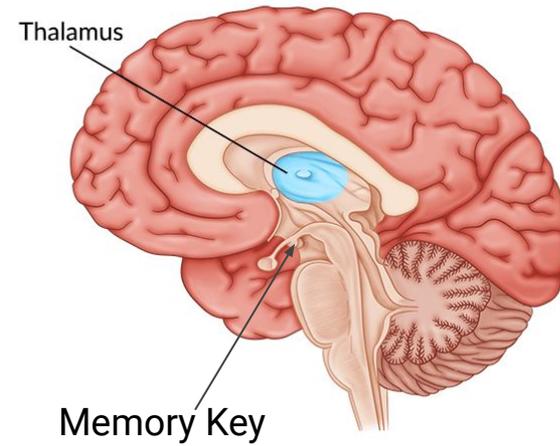
- “Feel-good” feelings
- **Reduces pain**
- Binds to Opioid receptors

Each part of the brain has a specialty

Outer (Cortical)

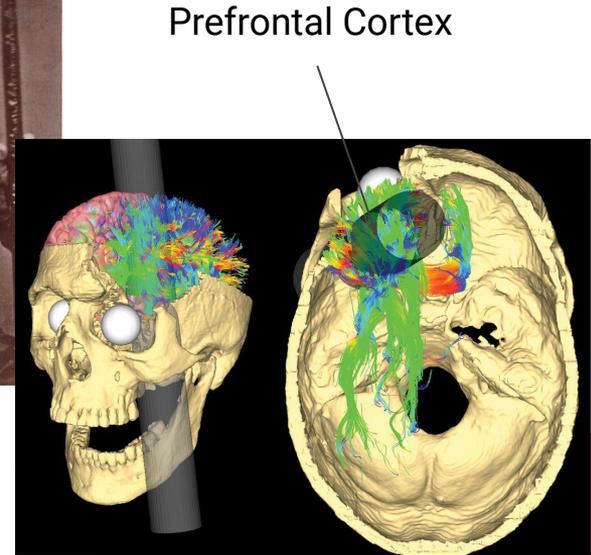
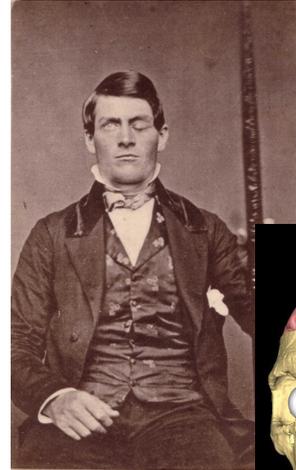


Inner (Subcortical)



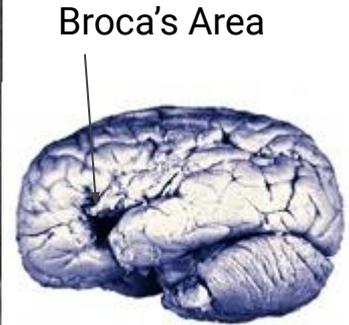
Phineas Gage taught us about the Prefrontal Cortex

- Case study: Phineas Gage
 - 25 y/o railroad foreman
 - **Tempered, hardworking, polite, well-liked**
 - In an accidental railroad explosion, iron rod penetrated through skull
- Change
 - Became **impatient, unreliable, vulgar,** “animal passions of a strong man”
 - No deficits in motor function or memory
- Insight
 - PFC and personality and social behavior



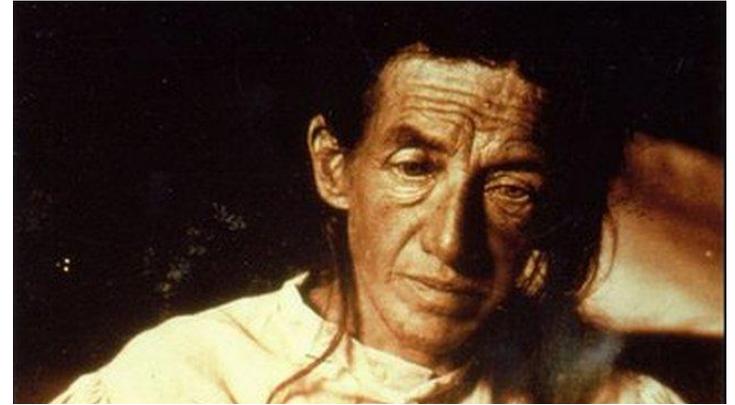
Leborgne taught us about how the brain handles speech

- Case study: Louis Victor Leborgne (Tan)
 - 50 y/o man
 - Inexplicably lost the ability to speak
 - “Tan” was the only word he uttered
 - Could understand language
- Change
 - After Leborgne’s death, found abnormal brain tissue only in the left anterior lobe
- Insight
 - Role of left anterior frontal lobe (Broca’s area) in producing, but not understanding, language



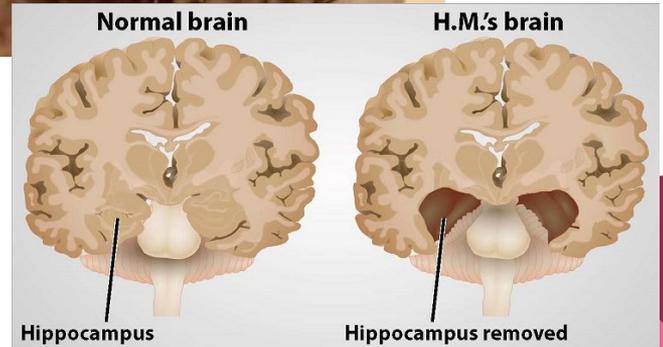
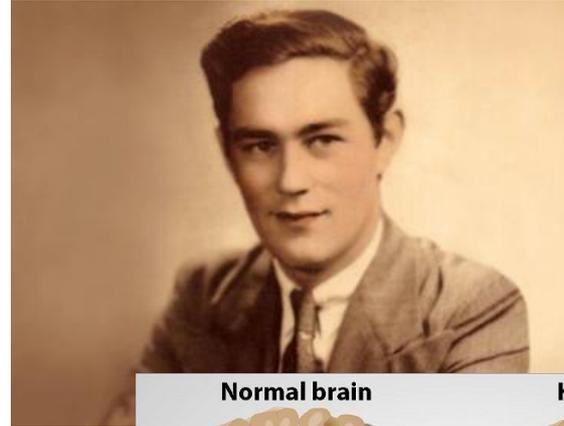
Auguste Deter showed us the role of cortex

- Case study: Auguste Deter
 - 50 y/o woman
 - Passed away after developing strange behaviors, hallucinations, and memory loss
- Change
 - Aloisius Alzheimer examined her brain under a microscope
 - Found amyloid plaques and neurofibrillary tangles - hallmark of Alzheimer's disease
- Insight
 - Role of cortex in memory loss, language, judgment, and thought



Molaison gave us great insight into the formation of memory

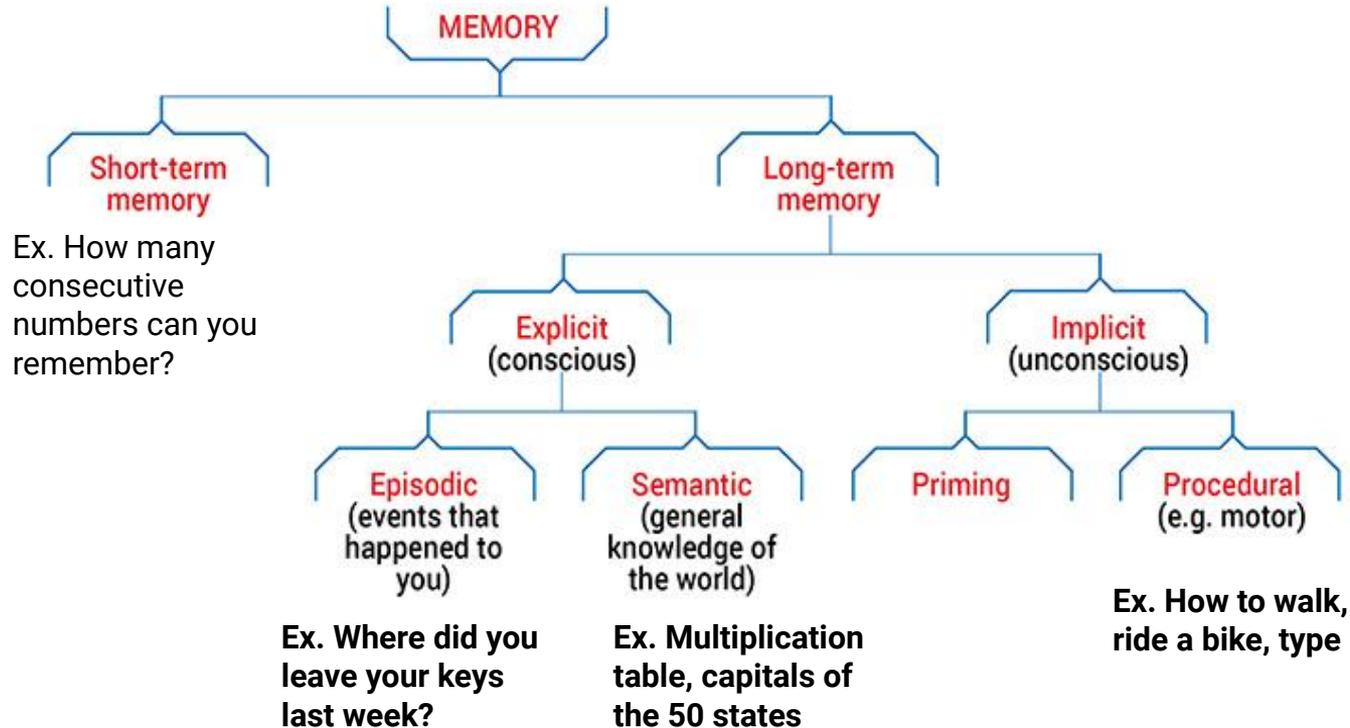
- Case study: Henry Gustav Molaison (HM)
 - 29 y/o man with severe epilepsy
 - Experimental surgery to control epilepsy
- Change
 - Surgery seemed to quell epilepsy
 - Lost ability to make semantic memories, but could still form procedural memories
- Insight
 - Memory of experiences is managed by the thalamus



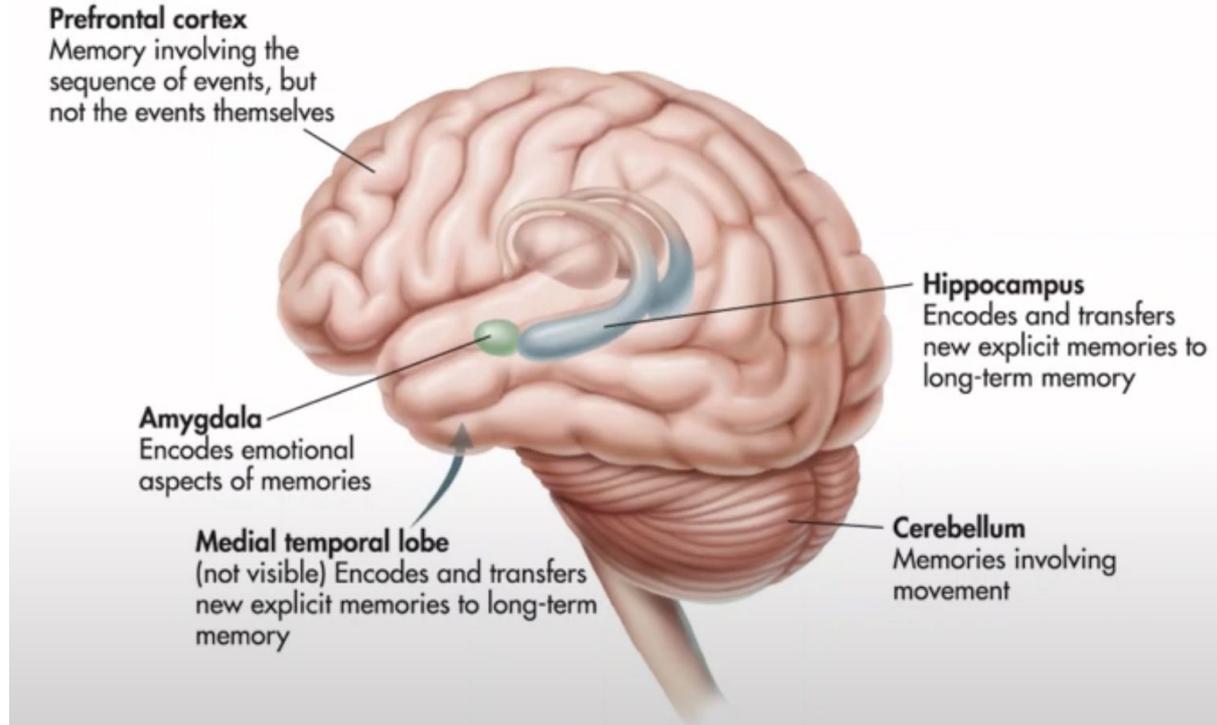


Neuroscience of Memory

There are many different kinds of memories



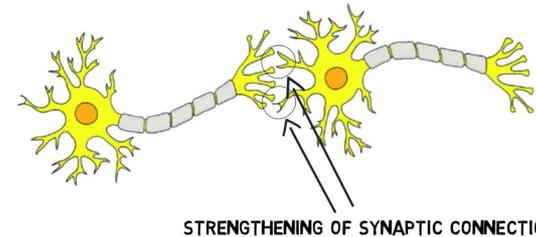
The brain is a memory making organ



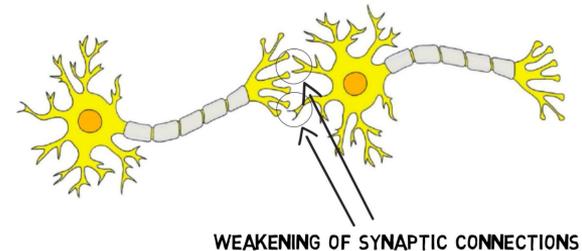
Memories are circuits of neurons that learn to fire together

- Long Term Potentiation (LTP) = Learning
 - Frequent neuronal activation -> **stronger connections**
 - Important for memory and learning
- Long Term Depression (LTD) = Forgetting
 - Less frequent neuronal activation -> **weaker connections**
 - Important for resetting previous synaptic changes

LONG-TERM POTENTIATION (LTP)



LONG-TERM DEPRESSION (LTD)





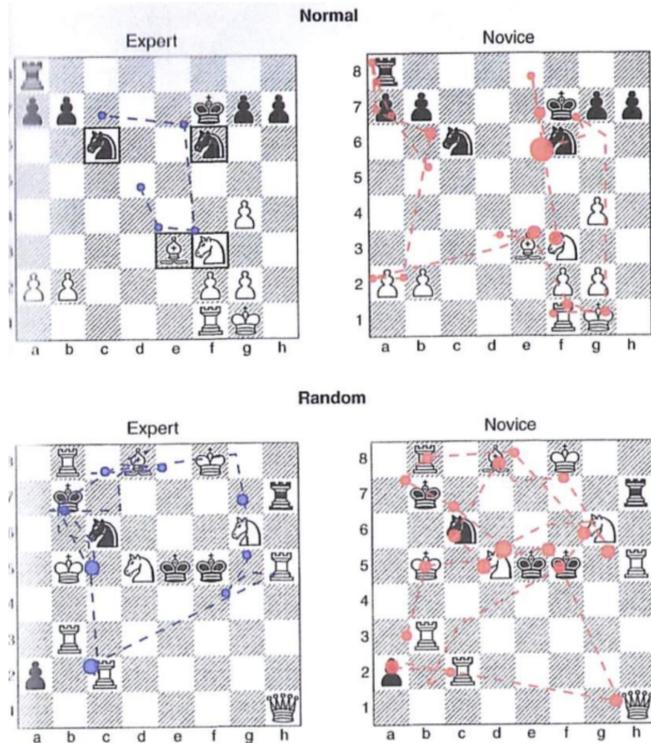
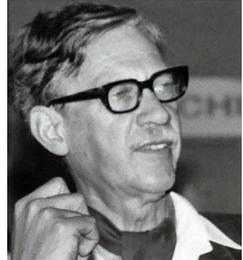
Neuroscience of Expertise

Overview of Expertise

What is the difference between a chess grandmaster and a novice?

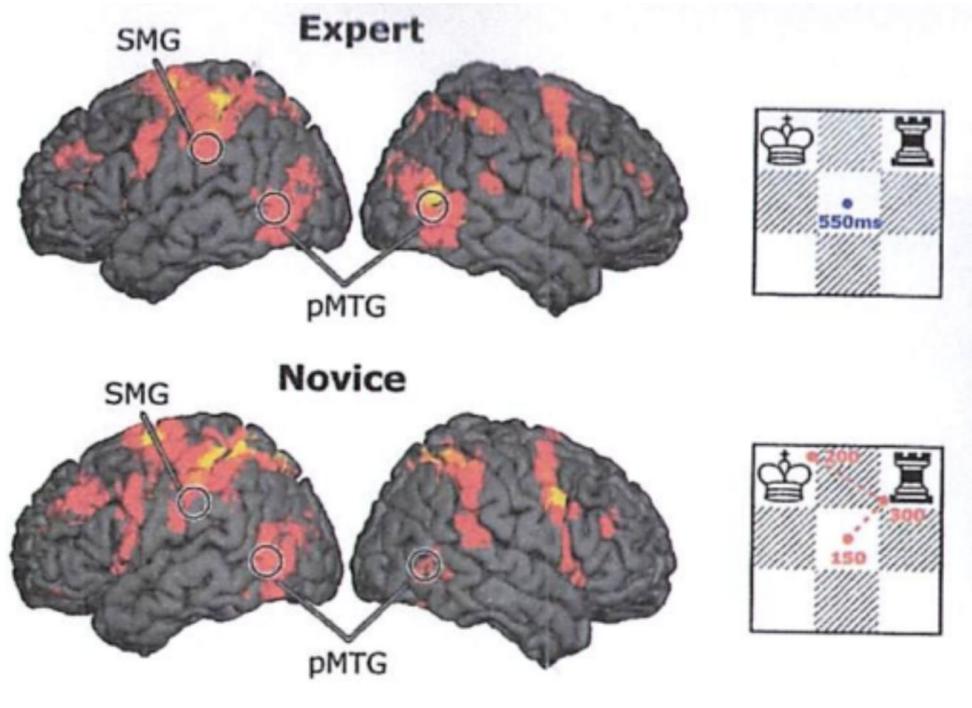


Expertise is the ability to see the meaning of a situation quickly and respond accordingly



- Adrienne de Groot
- Study
 - 10 minutes given to look for best move
 - Think-aloud technique
 - Experts initially noticed completely different aspects than novices
 - Normal vs. random setting
 - In random settings, experts and novices had similar outcomes
- Conclusion
 - Chunking - initial phase of categorizing the positioning were vastly different (thinking less)
 - Context is key

Experts use more memory and less thinking, while novices think more to compensate for inexperience





Brain response to alcohol use

Alcohol: Case Study



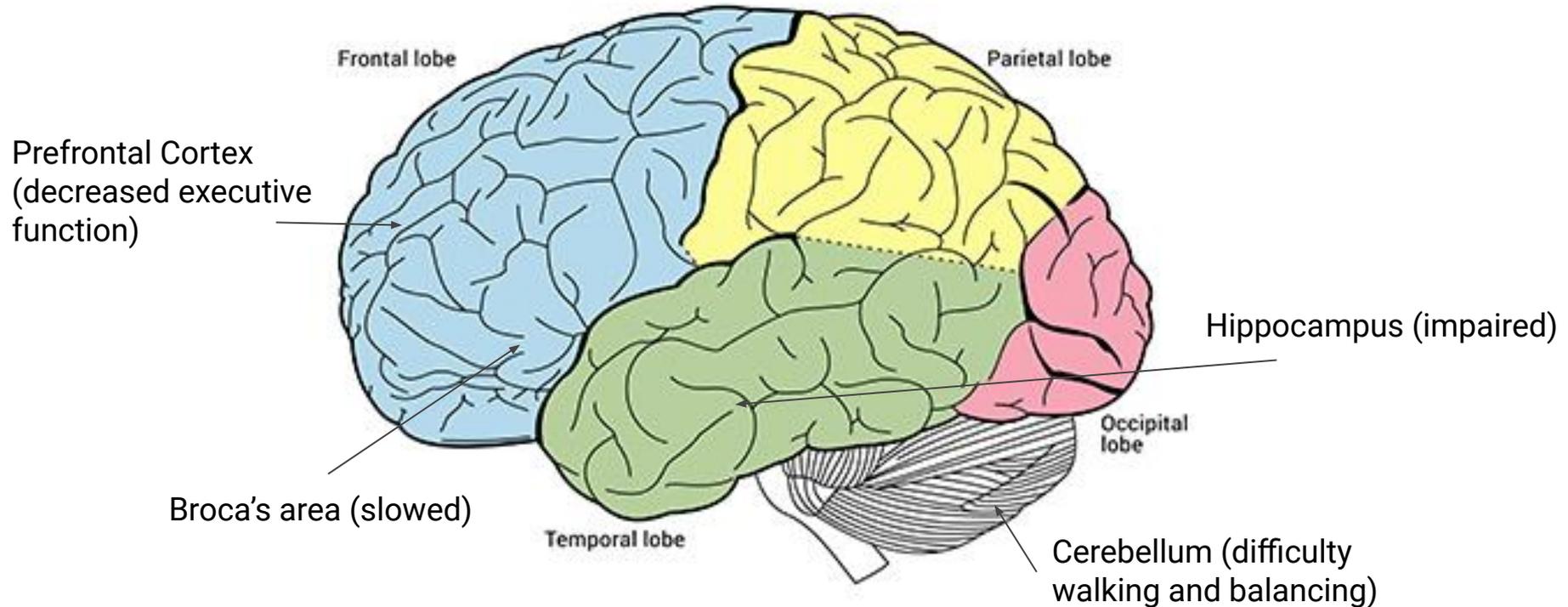
Brock Turner



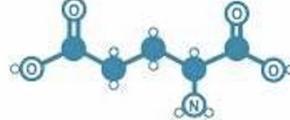
Chanel Miller



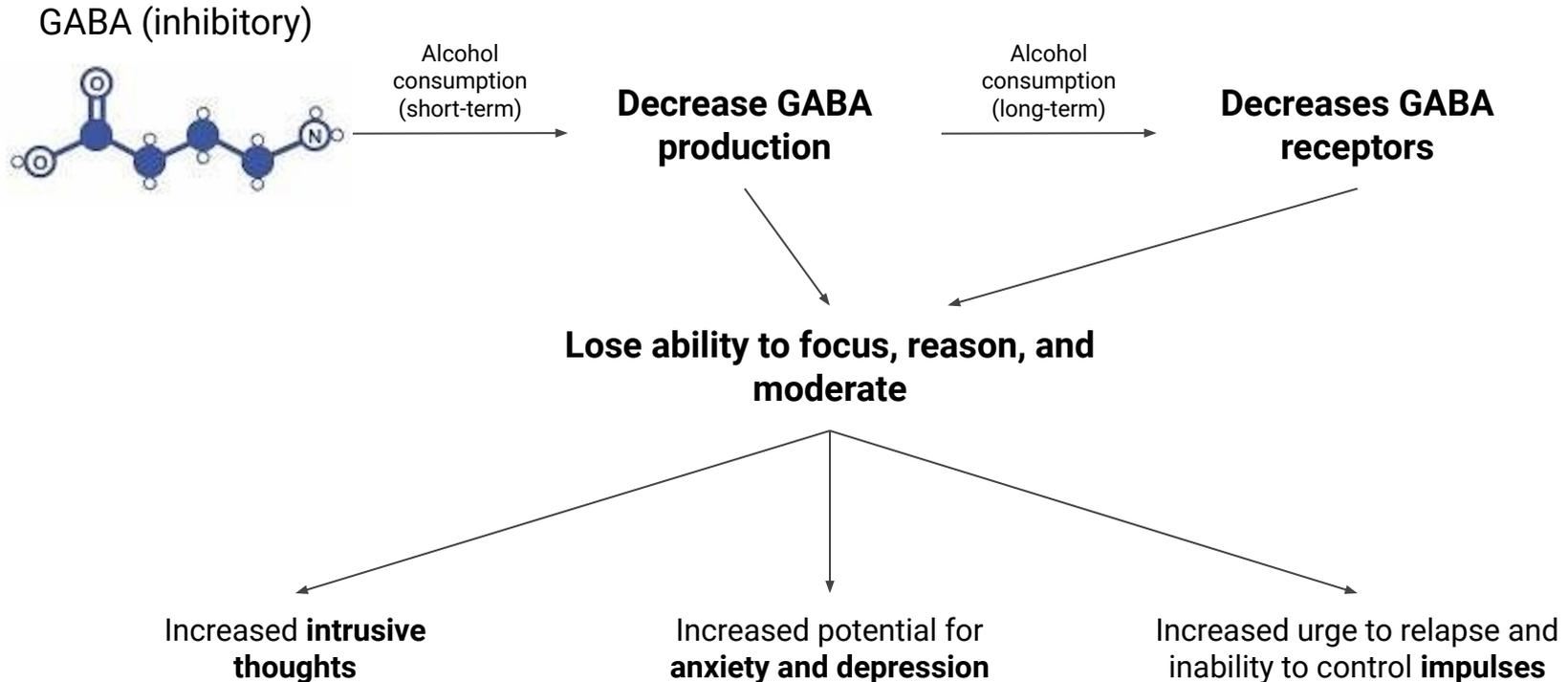
Alcohol intoxication causes global loss of function



Alcohol creates loss of function by increasing GABA and Decreasing Glutamate

Neurotransmitter	Change	Effect
 <p>GABA</p>		Impaired cognition "Cognitive Myopia"
 <p>Glutamate</p>		Impaired cognition Unable to make memory

The brain tries to accommodate chronic alcohol use by reducing GABA (loosen the brake lines)

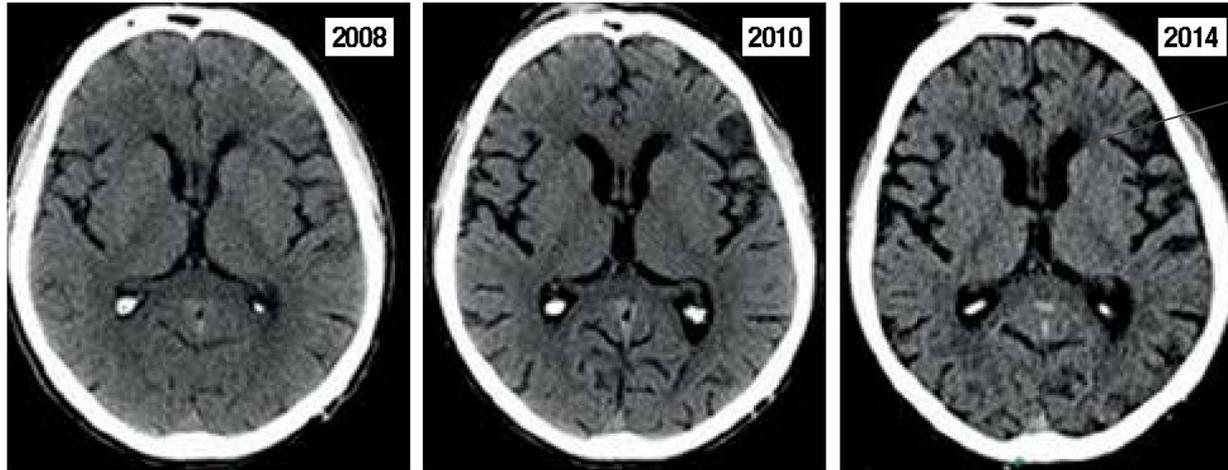


Loosening the brakes causes the brain to speed up

	Anxiety	Depression	Quality of Sleep	Judgment	Learning
Effect of having less GABA and more glutamate	Increased	Increased	Decreased quality	Clouded	Impaired



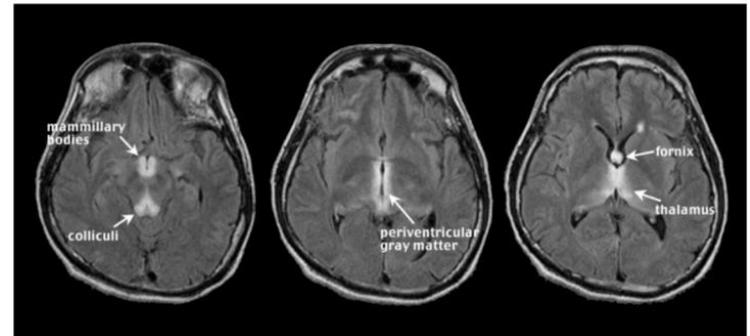
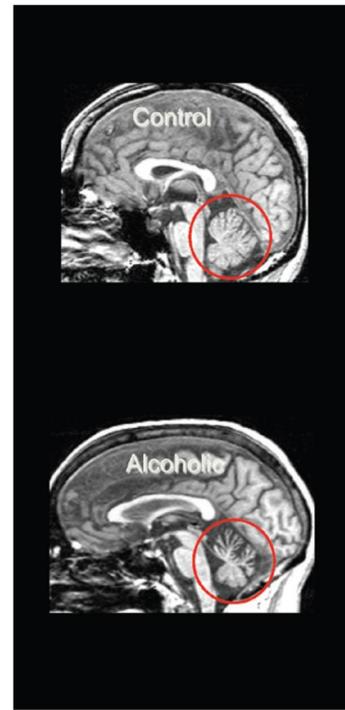
Chronic alcohol use shrinks the brain



Ventricles (gaps)
enlargened

Other Long-term Effects of Alcohol

- Walking problems
 - Progressive **muscle damage** caused by long-term alcohol abuse
 - **Wasting of cerebellum** can cause walking problems
- Wernicke's encephalopathy
 - Caused by damage to **thalamus** and **hypothalamus**
 - Symptoms include mental confusion, vision problems, coma, hypothermia, low blood pressure, lack of muscle coordination

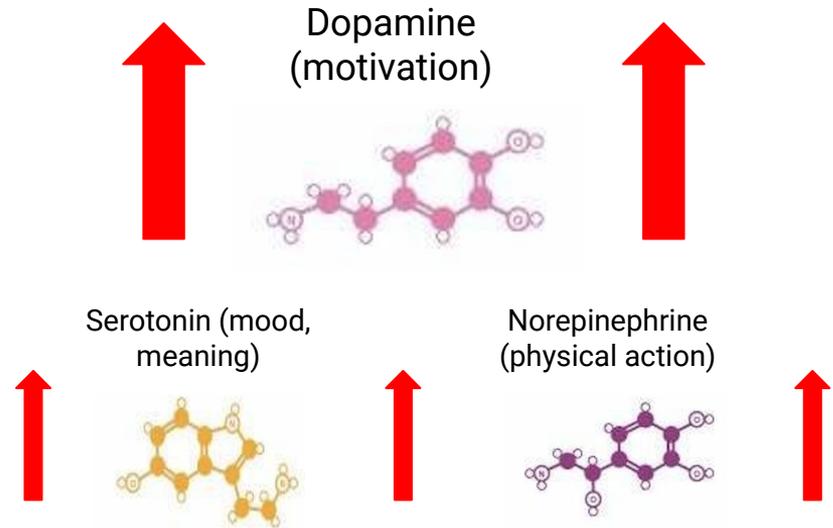
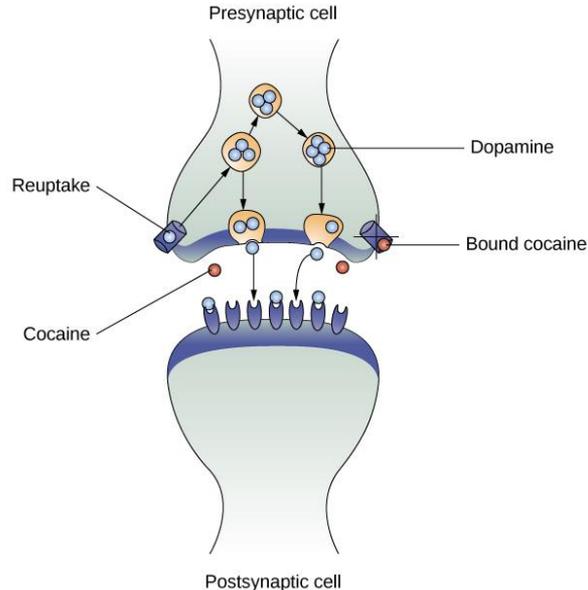




Brain response to stimulant use

Cocaine works by boosting neurotransmitter levels

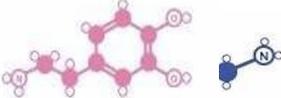
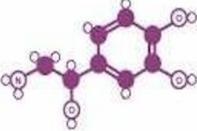
- Blocks reuptake of **dopamine**, **serotonin**, and **norepinephrine** by attaching to receptors → prolonged effect of these neurotransmitters (especially dopamine)



This boost in neurotransmitters leads to many positive effects

Neurotransmitter	Acute Change	Psychological Effect	Behavioral/Physical
Dopamine (motivation) 	Increase	Increased motivation	“I can get so much done”
Serotonin (mood, meaning) 	Increase	Euphoria	“I feel so great”
Norepinephrine (physical action) 	Increase	Hyperactivity Insomnia	“I have so much energy”

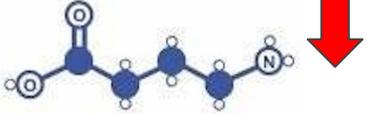
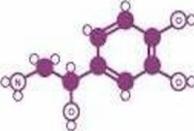
But the brain accommodates cocaine by reducing the release of neurotransmitters

Neurotransmitter	Chronic Change	Psychological Effect	Behavioral/Physical
Dopamine (motivation) 	Decrease	Loss of motivation	"I can't get anything done"
Serotonin (mood, meaning) 	Decrease	Depression	"My life is awful"
Norepinephrine (physical action) 	Decrease	Hypoactivity Hypersomnia	"I can't get out of bed"

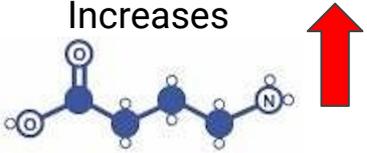


The Recovering Brain: Alcohol Detox

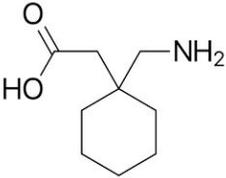
Stopping alcohol suddenly creates a dangerous storm

Loss of inhibition	Storm of Stimulation	Outcomes
<p data-bbox="324 478 583 559">GABA Inhibition Plunges</p> 	<p data-bbox="865 412 1047 493">Glutamate (excitatory)</p>  <p data-bbox="826 679 1105 760">Norepinephrine (physical action)</p> 	<ul data-bbox="1263 395 1653 792" style="list-style-type: none">● Hallucinations● Seizures● Delirium Tremens ● Tremor (Shakes)● Hypertension● Racing heart beat● Sweating

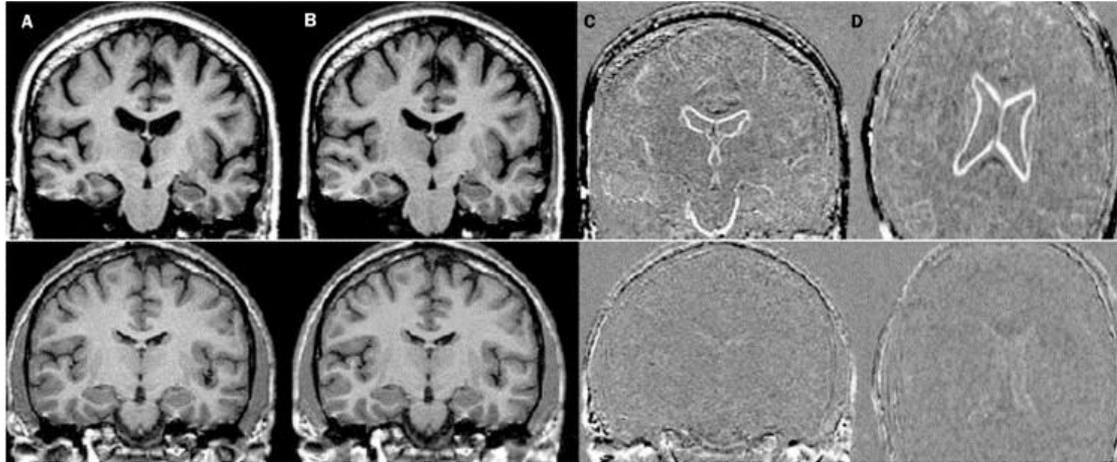
We can use benzos to detox, because it is like alcohol

Benzos activate GABA	The storm is calmed	Limitations
<p data-bbox="324 478 583 559">GABA Inhibition Increases</p>  <p>The diagram shows the chemical structure of GABA, a neurotransmitter. It consists of a four-carbon chain with a carboxyl group at one end and an amino group at the other. A red arrow points upwards from the structure, indicating an increase in GABA inhibition.</p>	<p data-bbox="865 412 1047 493">Glutamate (excitatory)</p>  <p>The diagram shows the chemical structure of Glutamate, an excitatory neurotransmitter. It consists of a five-carbon chain with a carboxyl group at one end and an amino group at the other. A red arrow points downwards from the structure, indicating a decrease in excitatory activity.</p> <p data-bbox="834 762 1105 843">Norepinephrine (physical action)</p>  <p>The diagram shows the chemical structure of Norepinephrine, a catecholamine neurotransmitter. It features a benzene ring with two hydroxyl groups and a side chain ending in an amine group. A red arrow points downwards from the structure, indicating a decrease in physical action.</p>	<ul data-bbox="1271 351 1715 926" style="list-style-type: none">● Benzos can cause delirium● If you miss a dose of benzos, the storm can break through● Some Heavy and chronic users may have lost receptors for benzos, so this cannot work for them

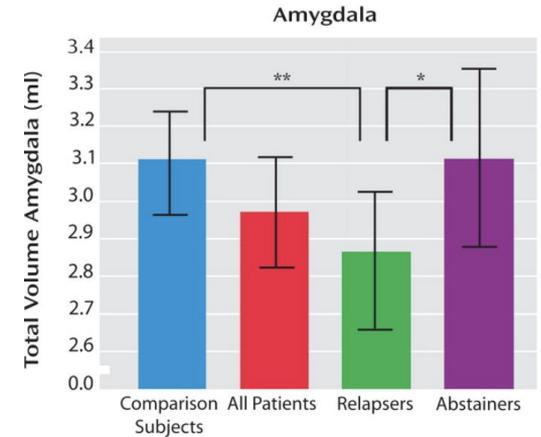
A better way to detox is to calm the storm directly

Two Medications	Reduce excitation	Benefits
<div data-bbox="336 361 562 539"></div> <p data-bbox="351 572 546 609">Gabapentin</p> <div data-bbox="247 661 653 869"></div> <p data-bbox="351 893 546 930">Guanfacine</p>	<p data-bbox="857 377 1049 463">Glutamate (excitatory)</p> <div data-bbox="832 481 1078 587"></div> <p data-bbox="1116 432 1174 536"></p> <p data-bbox="826 694 1103 779">Norepinephrine (physical action)</p> <div data-bbox="852 784 1051 915"></div> <p data-bbox="1116 694 1174 798"></p>	<ul data-bbox="1263 350 1644 749" style="list-style-type: none"><li data-bbox="1263 350 1644 388">● No risk of delirium<li data-bbox="1263 443 1644 607">● Non-narcotic medications are easier to dispense and administer<li data-bbox="1263 661 1644 749">● Calms the storm directly

Long-term recovery from alcohol leads to restoration of brain volume



Increase in volume in entire cerebral cortex



Increase in volume in amygdala



The Recovering Brain: Neuroscience of the 12 steps

Alcoholics Anonymous most effective path to alcohol abstinence

A Stanford researcher and two collaborators conducted an extensive review of Alcoholics Anonymous studies and found that the fellowship helps more people achieve sobriety than therapy does.

March 11, 2020



Stanford
MEDICINE

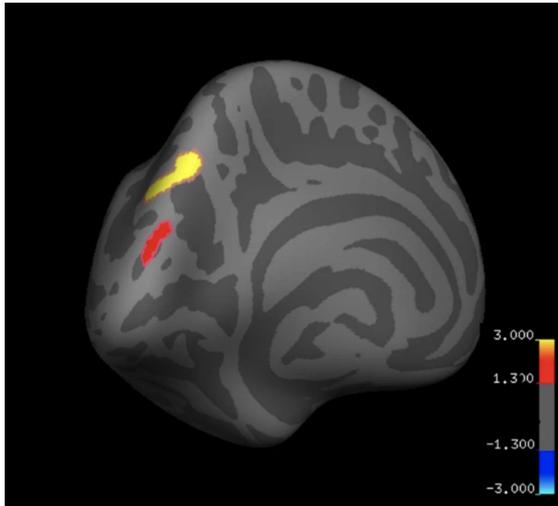
News Center

The 12 Steps empowers and challenges us to gain new expertise

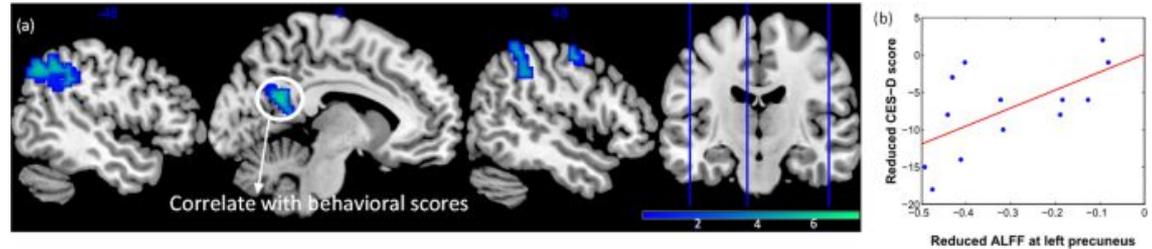
1. We admitted we were **powerless** over alcohol—that our lives had become unmanageable.
2. Came to **believe** that a Power greater than ourselves could restore us to sanity.
3. Made a **decision** to turn our will and our lives over to the care of God as we understood Him.
4. Made a searching and fearless **moral inventory** of ourselves.
5. **Admitted** to God, to ourselves, and to another human being the exact nature of our wrongs.
6. Were entirely ready to have God remove all these **defects of character**.
7. Humbly asked Him to **remove our shortcomings**.
8. **Made a list** of all persons we had harmed, and became willing to make amends to them all.
9. **Made direct amends** to such people wherever possible, except when to do so would injure them or others.
10. Continued to take **personal inventory** and when we were wrong **promptly admitted** it.
11. Sought through **prayer and meditation** to improve our conscious contact with God as we understood Him, praying only for knowledge of His will for us and the power to carry that out.
12. Having had a spiritual awakening as the result of these steps, we tried to **carry this message** to alcoholics, and to practice these principles in all our affairs.

Prayer and Meditation strengthens the brain

40 days of mindfulness meditation training in novices created healthy brain changes

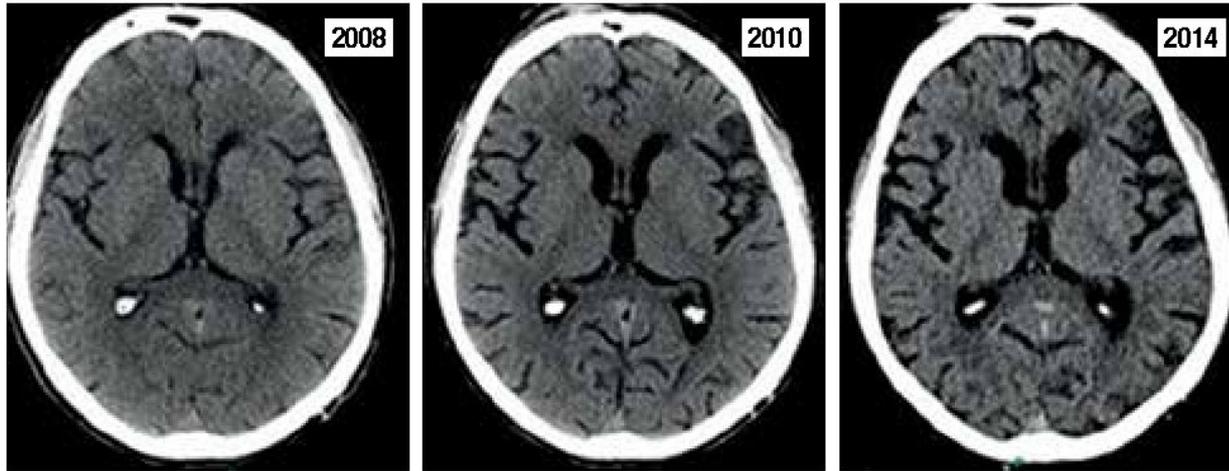


Increases in cortical thickness

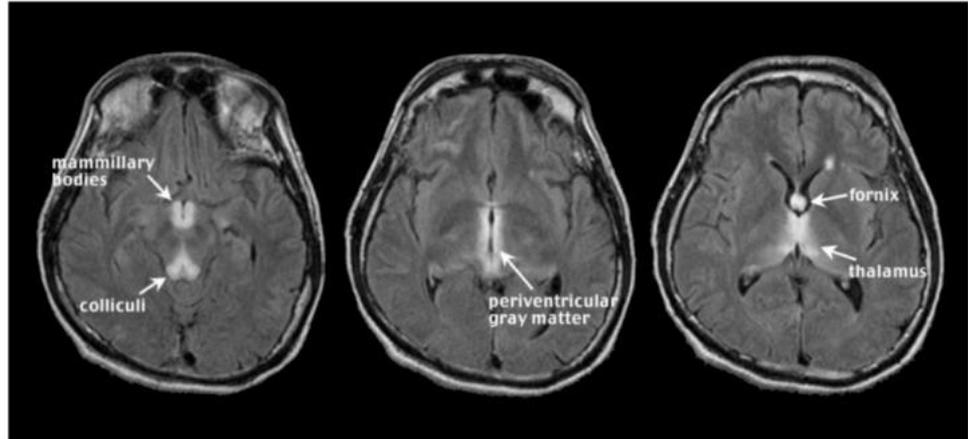


Structural changes associated with functional changes (reduction of depression score)

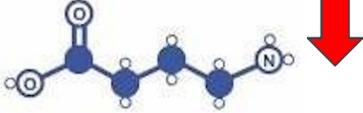
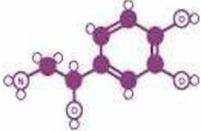
Neuroscience helps us understand Powerlessness



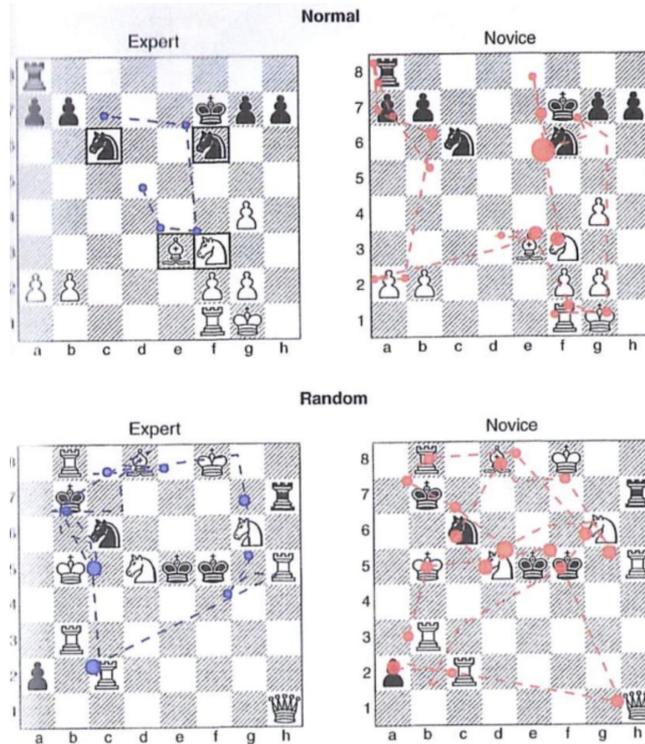
Neuroscience helps us understand Powerlessness



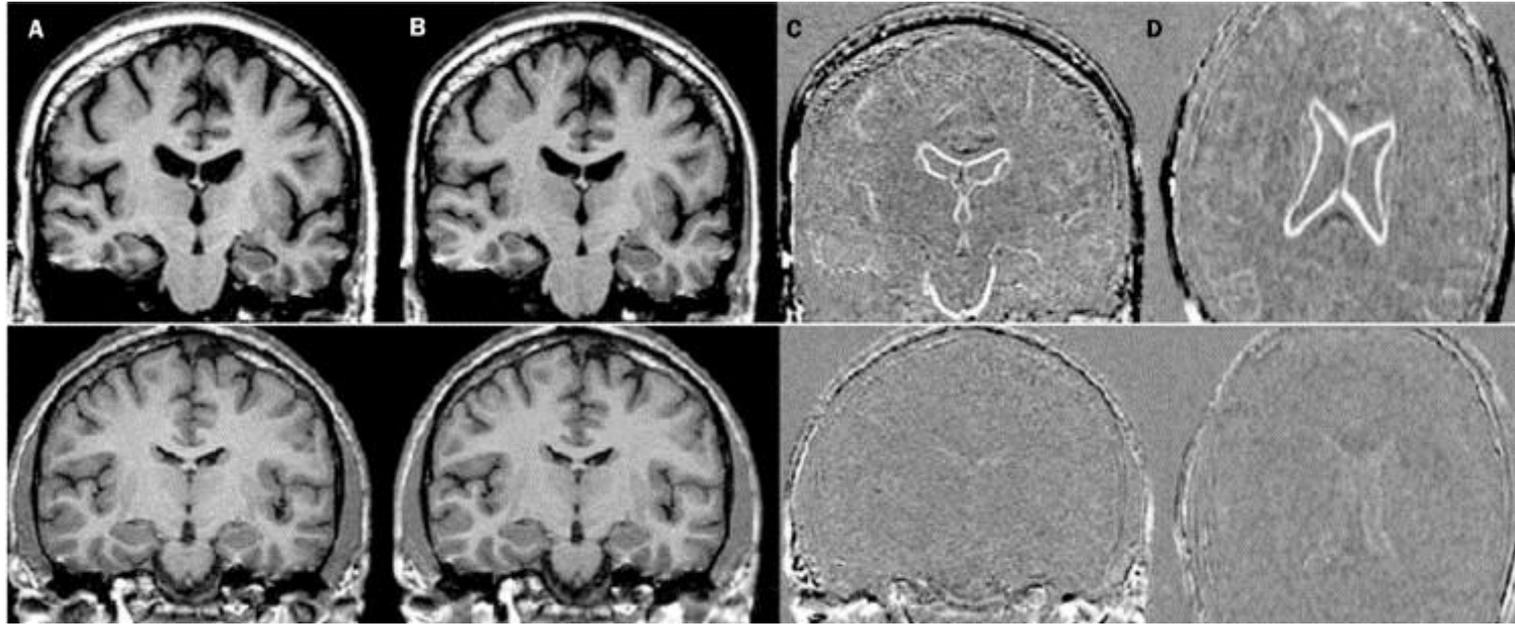
Neuroscience helps us understand Powerlessness

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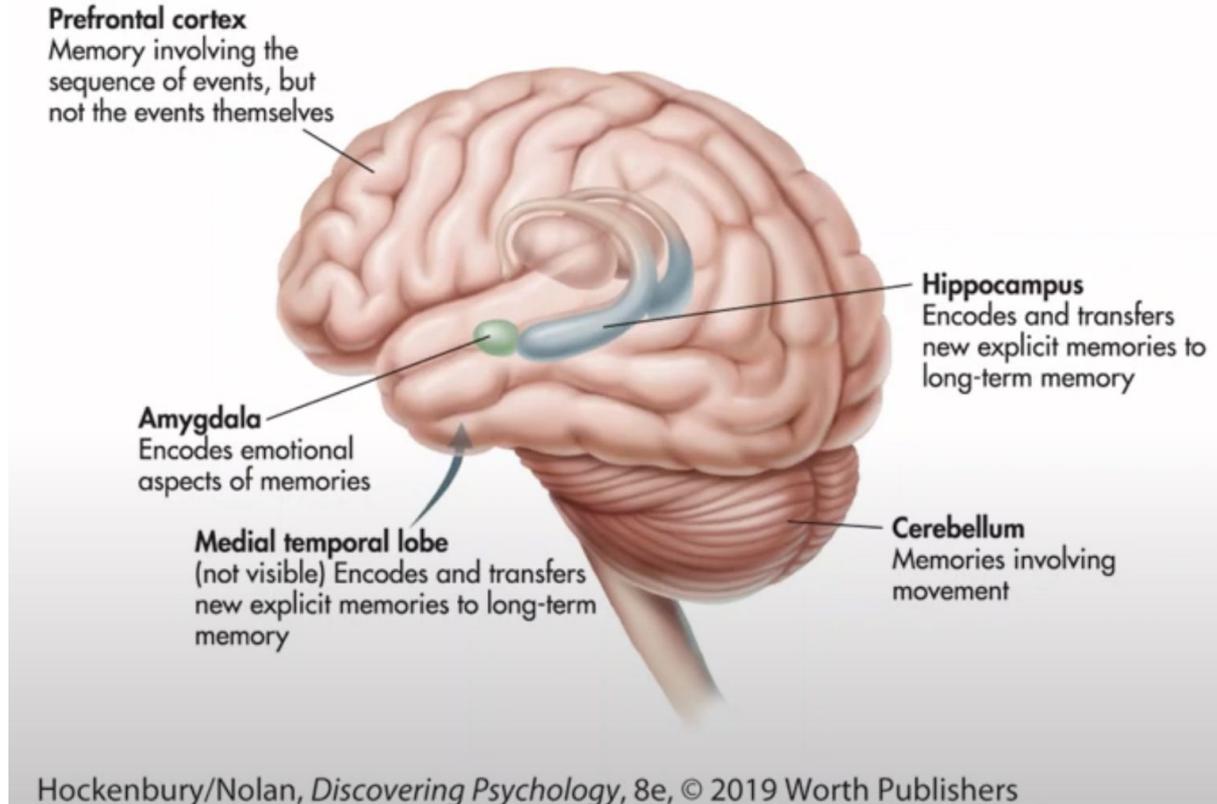
Neuroscience helps us understand Powerlessness



Sobriety is essential for moving through the steps

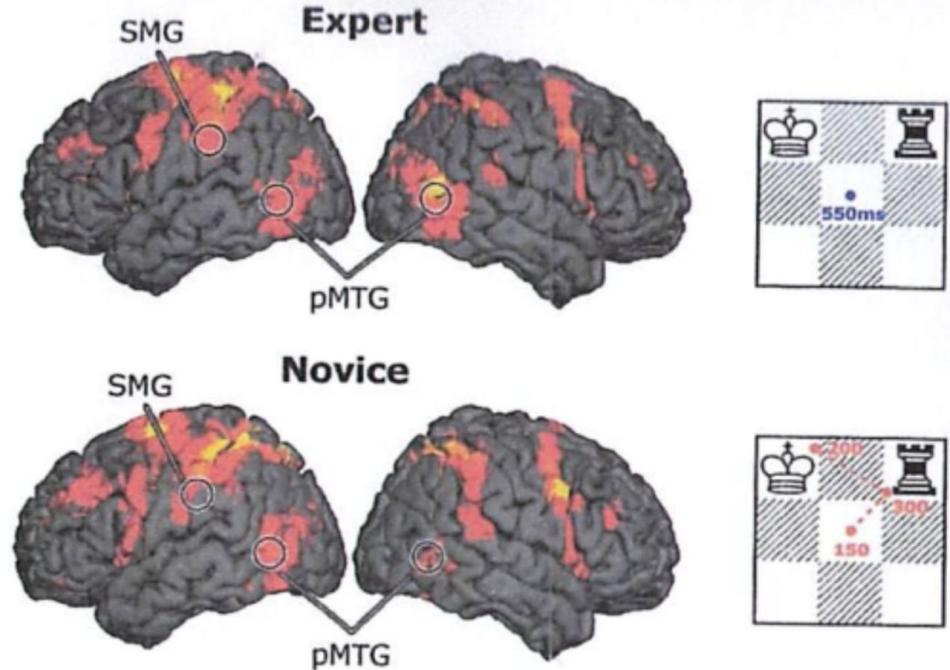
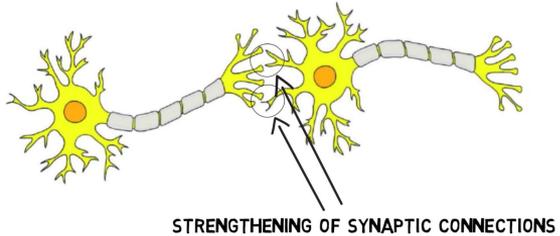


A healthy brain is able to learn - create new memories

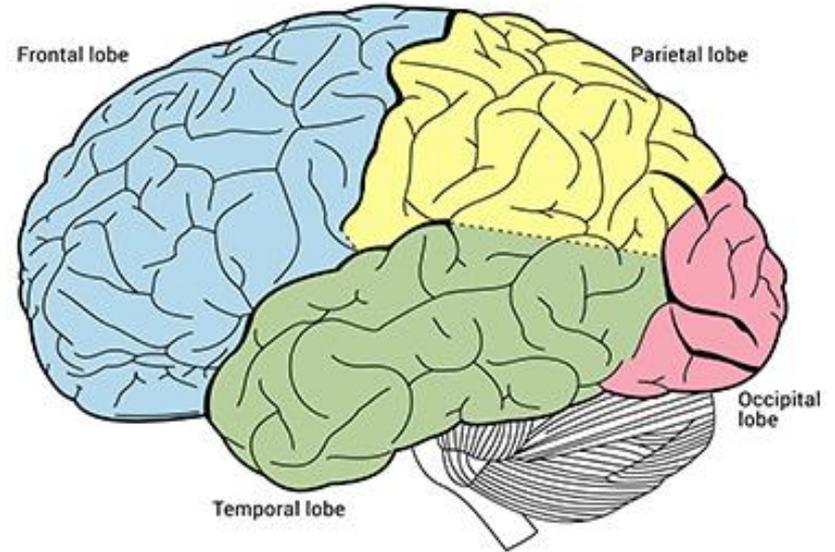
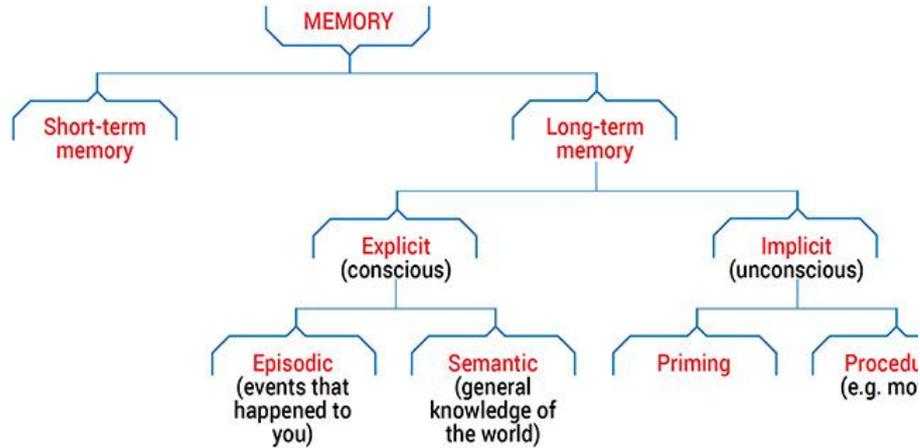


A healthy brain is able to learn - create new memories

LONG-TERM POTENTIATION (LTP)



A healthy brain in a healthy group creates powerful memories, which leads to expertise



A healthy brain, in a healthy group creates powerful memories, which leads to being an expert in recovery



Discussion and Open Q&A

Sources

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