The Neurophysiology of Alcohol Addiction

A Story for Clients and Clinicians working with any stage of recovery

Created by Louis Forouhar-Graff, Institute of Living/ Hartford Hospital Psychiatry Resident PGY2
The brain – a personified view
(Equipped with cup and string communication technology)
Meet the brain – beginning with ...

TEAM FRONTAL LOBE

- The frontal lobe, and the cortex more generally, gives the capacity to use past experience and knowledge to make sense of current behavior and guide future responses.
**Donna Lee the dIPFC (dorsolateral prefrontal cortex)**
- “The decider”
- Draws attention, actively selects an area of focus
- Controls attention
- Used for sustained organization of behavior to solve complex goals

**Ollie the OFC (Orbital Frontal Cortex)**
- The “value man”
- Works closely with Donna Lee the dIPFC
- Represents value of possible expected outcomes or stimuli
- Can flexibly assign value to environmental stimuli
- Guides behavior based on this expected value

**Andy the ACC (Anterior Cingulate Cortex)**
- “Manager of Conflict Resolution”
- A middle man between action and emotion
- Detects errors in tasks, modulates behavior accordingly
- Anticipates task
- Connects task and motivation
Archie the Amygdala
• “The Emotion Guy”
• Ties emotion to memory
• Consolidates memory
• Can governs actions with non-reflective conditioned impulses, (usually in moments of crisis or stress)

Elizabeth the Entorhinal Cortex
• “The Memory Hub”
• Optimization of Memory during sleep
• Her and Archie are married (close in proximity and closely connected)

Vinnie the VTA (Ventral Tegmental Area)
• “The Natural ‘Dope’ aka dopamine dealer”
• A key center for eliciting reward and pleasure
• He may also be dealing endocannabanoids, we’re not sure.

Ned the Nucleus Accumbens
• “The traffic cop”
• The first interface between the limbic system, the frontal cortex and the motor system.
• Relevant information processed to influence initiation of behavior
• Loves ‘dope’ aka dopamine

and continuing with…
THE REST OF THE GANG
• “The traffic cop”
• The first interface between the limbic system, the frontal cortex and the motor system.
• Relevant information processed to influence initiation of behavior
• Loves ‘dope’ aka dopamine
The End of Innocence

- They all lived happily together... until...

- Vinnie the VTA got an outside dealer. Whoa!!!! (Alcohol leads to less inhibition of dopamine release from the VTA a.k.a. more dopamine around. It also leads to release of endorphins, which further stimulate the VTA)

- Ned the Nucleus Accumbens is given dope by Vinnie, and he also gets it directly from alcohol himself. Also (in a wild plot twist), he is somehow getting endorphins (opioids) from alcohol. The details of how are still under investigation.
THE BRAIN’S IN THE GAME

• Donna Lee the dIPFC focuses attention on alcohol
• Ollie the OFC places value on that bottle of beer
• Andy the ACC mediates between all the players and makes sure the beer gets to the system as planned
• Vinnie the VTA works his hardest to meet the increased demand for dope
• Ned the Nucleus Accumbens is loving the increased stimulation. Problem is, he’s running out of receptor cash. He’s got less and less receptors by the day, so he can’t receive as much dope.
• Archie’s the Amygdala’s feeling a little numb but remembers the good times... he thinks
• Elizabeth the Entorhinal Cortex is restless, and having a tough time doing her job

A CYCLE BEGINS

Abstinence

Substance Use

Withdrawal (acute or sub acute)

WITHDRAWL

• Each withdrawal, even if it is sub-acute, puts a stress on the system. Archie the Amygdala doesn’t like the stress. He’s getting more and more anxious about it. He tells Elizabeth the Entorhinal Cortex to remember the feeling, so as to not repeat it.
Archie the Amygdala’s Plan

Who needs the withdrawal? Life is better without it. Just KEEP THE GOOD STUFF COMING. He attempts a system override. He begins negotiations with Vinnie the VTA and Ned the Nucleus Accumbens. Both are pretty tired of the heavy dealing but Archie insists. They go along for the ride.

“WHOA” says Team Cortex, “Enough is Enough”

Andy the ACC? Donna Lee the dIPFC? Ollie the OFC? What happened!??
Alcohol’s effect on the brain

- At levels of BAL .250 and higher, alcohol begins to create:
  - Dark cell degeneration (a shrunken neuron cell body leading to death)
  - The inhibition of brain neural stem cell proliferation and neurogenesis
  - Reduced size and length of the branches of neuronal dendrites
  - Eventually – reduced size and function of the brain
Enough is Enough – Recovery Begins with Drugs, Hugs and Higher Power Tugs

DRUGS (The helpful kind):
• Exercise - involves stimulation of brain reward circuit served by dopamine; exercise helps suppress cravings by activating that circuit and enhancing endorphins; rates of drug abstinence are higher if exercise is substituted for the drug.
• Nutrition – you are what you eat. Nutrition is an evolving science in how to use your food as a fuel.
• Sleep – uninterrupted by alcohol = beginning of rebuilding the brain
• Naltrexone – decreases the amount of alcohol one uses = less brain damage. Also significantly elevates the activity of the OFC during decision making.
• Campral – increasing abstinence = brain begins to regenerate
• Antabuse – increasing abstinence = brain begins to regenerate

HUGS (Deep holes require helping hands climb out).
• Inpatient rehabilitation – get stable, get motivated.
• Long term treatment centers – 90 days to restart the brain. The longer you stay, the greater your success
• AA – Higher attendance leads to abstinence though mechanisms such as learning to share feelings (amygdala training), positive role models (motivation and healthy frontal lobe modeling), less environmental cues (allows frontal OFC time to find new things of value besides alcohol, etc.)
• Therapy – Increase motivation, decision making, behavioral regulation, awareness of thought patterns.

HIGHER POWER TUGS (Towards Health):
• Grace... the scourge of the scientific method. Moments such as this are difficult to catch, and difficult to quantify.
• Spirituality: SPECT scans of individuals (Tibetan monks, Franciscan nuns) at the peak of spiritual awareness show a sharp reduction in activity of the orientation association area (OAA) in posterior superior parietal lobe, which draws a sharp distinction between the individual and the rest of the universe through the senses (studied using animal models). Moment such as this may facilitate health.
• Meditation:
  • Focus meditation can activate slow oscillation of alpha (relaxation, network communication) or theta (active movements, REM sleep) rhythms.
  • State of being meditation (specifically compassion) shown to create high amplitude gamma waves (attention, working memory, learning, conscious perception)
The brain – back on track

Epilogue

- Ollie the OFC went on naltrexone
- Donna Lee the dIPFC is in work retraining
- Archie the Amygdala is being treated for PTSD
- Elizabeth the Entorhinal Cortex has been referred for a sleep study
- Vinnie the VTA is in a “dealing appropriately” weekly webinar
- Ned the Nucleus Accumbens was put back on the traffic duty beat after a suspicious stint on the narcotics enforcement team
- Andy the ACC is in conflict resolution training
References

• Moon YJ. Effects of Persimmon-vinegar on Lipid Metabolism and Alcohol Clearance in Chronic Alcohol-fed Rats. J Med Food 2008; March 11(1): 38-45
• Spanagel R. Alcoholism: A systems approach from molecular physiology to Addictive Behavior. Physiol Rev 2009 (89): 649-705