Sex, Drugs, and Rock ‘n Roll: The Biology of Addiction

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Disclosure

- Dr. Mays is not on any drug advisory boards, paid for doing drug research, or otherwise employed, funded, or consciously influenced by the pharmaceutical industry or any other corporate entity.
- No off label uses of medications will be discussed unless mentioned in the handout and by the presenter.
- No funny business.
Love

• The human experience of “love” involves three distinct biological/emotional experiences:
  – Sex/Lust
  – Romantic Love
  – Devotion
Sex/Lust

• “An intolerable neuronal itch.” (WH Auden)
• Doesn’t need to be focused on any one individual.
• Testosterone, dopamine, vasopressin, and oxytocin are brain chemicals involved in the sexual response.
  – Vasopressin: supports the pair-bond between the sexual partners, may induce the male to become aggressive towards other males.
  – Oxytocin (tend and befriend): may increase sexual excitement, bonding, feelings of love and empathy, nurturing of children, calming (testosterone may block this effect, estrogen increase it)
Romantic Love

• “Love consists of underestimating the differences between one woman and another.” (GB Shaw)

• We focus intense energy, experience wild mood swings, see special meaning around the beloved. We experience craving, withdrawal. It is a desire for emotional, not just physical contact. It is wanting and obsessing. It deactivates threat detection in the amygdala and right prefrontal cortex (oxytocin?)

• It is not an emotion. It is a dopamine-based drive, affecting the same brain regions as cocaine. It is one of the most powerful brain systems, more powerful than the sex drive. We kill and die for it.
Attachment, Devotion

- Facilitated by oxytocin and vasopressin
- Characterizes couples who have been together for many years. Couples who are older are less likely to divorce than younger couples.

- These three mind states (lust, romantic love, and devotion) are not necessarily directed toward the same person, although it makes things simpler when they are.
Oxytocin

- Found only in mammals, baseline levels are close to zero, half life is 3 minutes.
- Seems to facilitate empathy, trust, and generosity
- 5% of the population do not show increases of oxytocin with stimuli – they tend to be greedy, less honest – look psychopathic
- People who have been abused do not show oxytocin increases.
Oxytocin

• High stress, testosterone inhibits oxytocin. (Testosterone makes a person more likely to spend money to punish others, rather than generously giving it away.)

• Hugging, dancing, massage all increase oxytocin, as does getting a phone call from mom.

- Drug Use
- Firearms
- Infection
- Alcohol
- Smoking
Legal Responsibility

• Are people who voluntarily use drugs responsible for the consequences of their actions? There is a well documented association of substance abuse and crime (70% of violent crime, marital violence, child abuse.)

• The assumption of criminal law is that a person has the ability to distinguish between lawful and unlawful behavior, and has the freedom to act on this knowledge.
Legal responsibility

• Generally it is agreed that a person who is intoxicated is not insane. Therefore, he/she is responsible.

• Some states allow for “diminished capacity” as a partial defense where there was not a specific intent to commit a crime.

• But do some people understand the rules of behavior yet are unable to follow them?
Wisconsin Criminal Responsibility

• In Wisconsin law, the issues of guilt and responsibility are determined by two separate court proceedings. For the criminal responsibility proceeding: "A person is not responsible for criminal conduct if at the time of such conduct as a result of mental disease or defect he lacked substantial capacity either to appreciate the wrongfulness of his conduct, or conform his conduct to the requirements of the law." Antisocial personality is not considered a mental disease, nor is substance dependence.
Impulsivity

• A predisposition toward rapid, unplanned reactions to internal or external stimuli without regard to negative consequences to oneself or others. It is not poor judgment. It is no judgment.

• Normal brain mechanisms over the first 0.5 seconds enables the brain to screen behavior before it enters conscious awareness. (It takes 0.2 seconds for a stimulus to produce an expression on the human face. It takes >0.4 seconds to recognize an internal emotion.) Impulsive people lack this response.
Impulsivity

• What you are impulsive about is determined by exposure in your environment, to a certain extent. You may be impulsive about shopping, gambling, sexual activity, violence, etc.

• The causes of impulsivity are complex and involve biological, developmental, psychosocial, and cultural factors.

• Impulsivity is an important component of bipolar disorder, borderline personality disorder, autism, PTSD, ADHD, AODA problems, OCD, etc. Addiction and impulsivity frequently co-occur. The precise nature of the association is not certain.
Four Facets of Impulsivity

• 1) Urgency: the tendency to give in to strong impulses in the face of intense negative emotions. High in suicide ideators and attempters, borderline personality disorder, eating disorders.
• 2) Lack of perseverance: individuals are not able to persist in a task when they get frustrated, bored, or tired. High in antisocial personality, some ADHD
Four Facets of Impulsivity

• 3) Lack of premeditation: the inability to think through the consequences of behavior before acting. Seen in suicide attempters rather than suicide ideators.

• 4) Sensation seeking: preference for excitement and stimulation. Seen in antisocial personality.
Impulsivity

• Children are by nature impulsive, and most will gradually learn to control their impulses and defer gratification.
Impulsivity: Summary

• Impulsivity is behavior that manifests itself as rapid, unplanned action.
• Impulsivity can be measured in the laboratory, as well as observed in people’s histories.
• Some people are consistently impulsive (trait), and others are impulsive in only in certain situations (state).
• Impulsivity shows itself differently depending on the circumstances - sensation seeking, risk taking, extroversion.
Impulsivity: Summary

- Being impulsive is not a choice that people make. People are impulsive to different degrees, and are born that way.
- But people can make choices that help them manage their impulsivity. People can make choices about their habitual behaviors, and probably their addictions.
Obsessive Compulsive Disorder

• A syndrome characterized by obsessions, compulsions, and doubting

• “I see that the door is locked and the stove is turned off, but I don’t get the feeling of certainty that it’s so.”
Obsessions

• Experienced internally as thoughts, impulses, or images. All of us have some intrusive thoughts. (In fact, OCD seems to merge closely with normal human behavior.) When they are disruptive, and the client recognizes them as irrational and actively resists them, they may reflect the disorder. Obsessional ideas are different from depressive ruminations in that they are not about guilt or self-criticism, and are more specific than the worries of GAD.
Compulsions

- Repetitive behaviors or purposeful mental acts that can be observed by others, which clients feel driven to perform. They are ritualized behavior patterns or mental rituals that provide relief from the anxiety caused by the obsession. They do not bring about pleasure. They often have no relationship to the obsession or the anxiety they relieve.
Compulsions

- Checking 63%
- Cleaning/washing 50%
- Counting 36%
- Need to ask or confess 31%
- Ordering/arranging 28%
- Hoarding/collecting 18%
- Multiple 46%
Impulsivity vs. Compulsivity

• Both are unable to refrain from repetitive behaviors.

• The driving force behind compulsive actions is to reduce anxiety.

• The driving force behind impulsive actions is to obtain arousal and gratification.

• Impulsive disorders are more ego-syntonic. Compulsive more ego-dystonic.
Addictions: History

• Social foundations
• Neurobiological foundations
• Some behaviors have begun to be considered equivalent to addiction
  – Salience
  – Withdrawal symptoms
  – Tolerance
  – Relapse
  – Mood effects
Addiction

- Presently, “loss of control” is a primary criterion of addiction. This loss of control neutralizes any economic valuation of the subject, producing an alteration in salience, and finally, loss of choices for the person.
- Addictions involve continued behavioral engagement despite adverse consequences - they are disorders of misdirected motivation and impaired self-control.
- Addicted individuals tend to select preferentially small immediate rewards over larger delayed ones (delay discounting).
Three Phenomena Modulating Addiction

• Vulnerability
  – Sustained exposure to addicting drugs
  – Gene, environment, behavior interactions

• Motivational shift
  – Pleasure to craving

• Aberrant learning
  – Move to reflexive, rather than planned decisions
The Biology in a Nutshell

• The brain registers all pleasures the same way: by the release of dopamine in the nucleus accumbens. The likelihood that the use of a drug or participation in an activity will lead to addiction is linked to the speed with which it promotes dopamine release and the reliability of that release.

• Dopamine not only causes the experience of pleasure, but plays a key role in learning and memory.
The Biology in a Nutshell

• Dopamine interacts with glutamate to take over the brain’s system of reward-related learning. The reward circuit includes areas involved in motivation and memory.

• Addictive drugs can release 10x the amount of dopamine that natural rewards do and do it more reliably. Brain receptors become overwhelmed, producing less dopamine and dopamine receptors.
The Biology in a Nutshell

• Dopamine has less impact on the reward centers. The substance causes less pleasure. Compulsion takes over as the memory of the pleasure and the need to recreate it persists in spite of the decrease. Environmental cues receive more salience.

• 60% of people will relapse when they try to give up their substance, similar to relapse with hypertension and asthma.
Salience: From Recreation to Addiction

- The circuitry of motivational salience is activated by money in pathological gamblers, food in binge eaters, sexual stimuli in sexual compulsives, drug related cues in addicts.
- The change is from dopamine based behavior in the NAcc to glutamate based behavior from the cerebral cortex.
- At this point, enduring cellular changes have occurred. Often, these changes become greater with increasing periods of withdrawal!!
Impulsivity vs. Compulsivity vs. Addiction

• Impulse control disorders are motivated by positive reinforcement: feeling tension and arousal, acting, receiving gratification, experiencing guilt, starting the cycle over.

• Compulsive disorders are motivated by negative reinforcement: anxiety and stress, repetitive behavior, relief, focusing on the obsession, starting the cycle over.

• Collapse both of these to get the 3 stages of addiction: 1) preoccupation (OCD)/anticipation (ICD) 2) binge/intoxication 3) withdrawal/ negative reinforcement
Obesity

• Many people who are overweight crave food, lose control over eating, and experience negative health effects but don’t lose weight. They tend to eat when stressed, and relapse after gaining weight. Is this an addiction? What is the addictive chemical (e.g. nicotine, alcohol, amphetamine, THC...)?
“Behavioral” Addictions?

- Although traditionally addiction has been viewed as solely due to ingesting a chemical, evidence supports links between impulsive behaviors and substance-based addictions.

- Clinical and epidemiological
  - Repetitive behavior despite adverse consequences
  - Loss of control over the behavior
  - Pleasure during the behavior
  - Tolerance, withdrawal, craving, and relapse
  - Impairment in life functioning
  - Comorbidity: (they are probably syndromes)
  - Begins in adolescence
The behaviors exist on a continuum, with many individuals having some behavior, some individuals not having the behavior at all, and a few having a great deal of difficulty. And in some, perhaps those with a biological vulnerability, there will end up being such a loss of control that there will be a significant amount of distress and functional impairment.
Humans and Music

• Humans were constructing music making tools 35,000 years ago.

• Neurology patients, after a stroke or disease, who are unable to initiate the movement of walking, can dance when music is played. Patient’s with Parkinson’s disease, who are unable to put on their glasses, have been known to play the piano beautifully for hours.
Music Therapy

• Musicians with Tourette’s Disorder can remain free of tics while they play. Patients with aphasia who have lost language are able to speak words if they sing them.

• Music can lower blood pressure, reduce anxiety and pain, increase energy, and ease depression. People have been self-medicating with music for thousands of years.
What Causes that Thrill?

• Music elicits strong emotions. Listening to favorite music causes dopamine to be released in the nucleus accumbens.

• The intense pleasure response we get when listening to some music causes skin orgasms: goosebumps. Robert Zatore has listed a number of musical moments that elicit this phenomenon in subjects.
My (Partial) List

- Samuel Barber: Adagio for Strings
- Beethoven: Symphony #9, last movement
- Brahms: Second Piano Concerto, second movement
- Josh Grobin/Charlotte Church: The Prayer
- Puccini: O mio babbino caro
- Rachmaninov: Rhapsody on a Theme of Paganini
- Hermann: Theme from Vertigo
- Any song by Nancy LaMott
Musical Emotion

• Naïve listeners who have never heard Western music can identify certain passages as sad, happy or scary, the same as Western listeners.

• Autistic children can do this as well, even though they are unable to perceive emotions in other people. Newborns prefer music to speech.

• Part of the power of music is its effect on the motor parts of the brain. People will unconsciously sway together to music.
What is it about Rock ‘N Roll?

• It’s the beat, stupid.
  – Melody
  – Harmony
  – Rhythm (the heart of rock ‘n roll, it is a waist down phenomenon)

• Backbeat or offbeat – 1 2 3 4
  – Jumpy, jerky – may be particularly sexual
The religious experience

• Is there a spiritual center in the brain?
• Brain scans during meditation show decreased activity in the parietal lobe (sense of position, spatial orientation) and increase in the right prefrontal cortex (concentration.)
• Nuns recalling emotionally powerful religious experiences showed increased activity in the caudate nucleus (learning, memory, falling in love) and the insula (body sensations, social emotions.)
God and the Brain

• Several studies have shown that people who have prayed or meditated for many years have more brain tissue in their frontal lobes (associated with attention and reward) than those who do not pray or meditate.

• fMRI cans show that when people talk to God, they use the same brain areas that they use to talk to any person. The same is true when they think about God. It is the same as thinking about any other thing.
God and the brain

• Believers are more likely to have higher levels of dopamine. They are more likely to see words and faces on a screen when there is just noise. (Skeptics often do not see words and faces when they are present!)

• When skeptics are given dopamine, they also see words and faces in scrambled patterns.
The Religious experience

- Dopamine is released in various parts of the brain during prayer and meditation.

- There is no single spot for religious experience in the brain, rather an extensive neural network.
Sir Charles Sheriden

“The central nervous system is like an enchanted loom where millions of flashing shuttles weave a dissolving pattern, always a meaningful pattern, but never an abiding one...”