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Redefining Drug Education: A Neuroscience-Based Class for High Schoolers

Talia Frost-Belansky

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Abstract

There is a desperate need to move beyond abstinence-only drug education for high schoolers to address rising overdose rates and acknowledge an industry targeting teenagers for highly potent drugs. Neuroscience offers students insight into how drugs affect the dopaminergic reward system and can alter the ability for endogenous systems to modulate essential functions. I created a lesson plan titled, "The Neuroscience of Addiction" for a class at Sehome High School. The presentation addresses the role of dopamine in addiction, the discrepancy between drug policy and scientific understanding, how potency affects tolerance, how motivation for drug seeking evolves overtime, ways that long-term drug use alters the brain, etc. Additionally, I compiled a list of lesson plan objectives and created a facilitator guide to accompany the presentation. I surveyed high schoolers' perceptions of drugs and found that the majority are aware of the risks associate with a variety of drugs

Introduction

Drug related deaths among adolescents rose 109% from 2019 to 2021 and continues to increase alongside the upsurge in synthetic opioids (Tanz, 2022). Illicitly manufactured fentanyls (IMFs) are 100 times more potent than natural opioids like morphine and contributed to 84% of drug overdoses in people aged 10-19. Opioid overdoses are reversible using competitive opioid antagonists like naloxone and naltrexone. Given that two thirds of adolescent drug overdoses include bystanders, it is clear that there is need for increased education on treating overdoses and the risks associated with highly potent synthetic drugs.

High school drug curriculums like Drug Abuse Resistance Education (DARE) and "Just Say No" utilize an abstinence only approach which has failed to instill safer drug practices in youth (Pan & Bai, 2009). There is an urgent need to move beyond fear-based education that spreads misleading information about the effects of drugs on the body and move towards a safety-first approach (Machado do Vale et al., 2022). This includes providing a scientific understanding of the role of potency in the risk of addiction and overdoses and promoting harm reduction strategies such as drug testing and naloxone training. Teenagers are at the forefront of

an industry advertising highly potent drugs, such as nicotine vapes and concentrated synthetic THC products. Just as abstinence-only sex education fails to reduce unwanted pregnancy, the spread of sexually transmitted viruses and sexual harassment… abstinence-only drug education fails to offer useful tools for informed decision making about safe drug use (Ott & Santelli, 2007).

High school drug use will continue despite preventative initiatives aimed to instill fear about the dangers of drug use. As overdose rates increase alongside widespread access to highly potent and addictive compounds, a new approach is desperately needed. Teenagers make choices about drug use based on the *perceived* risk of that drug; therefore, it is our job to provide accurate harm reduction information grounded in neuroscience principles of pharmacodynamics, pharmacokinetics, addiction, and risk of overdose.

Methods

I created and presented a leson titled, "The Neuroscience of Addiction," to a study hall class at Sehome High School in April of 2023 (see external pdf link). For a detailed facilitator guide, see Appendix A. The class included students from grades 9-12 and the lesson lasted around one hour, with an additional 30 minutes for surveys and questions. I gave students an anonymous pre-survey assessing their perceptions of drug use before the lesson and an identical post-survey immediately after the presentation with an additional question asking for 1-3 things they learned (Appendix B, results in Appendix C).

Lesson Plan Objectives:

- Demonstrate how drug policy and science are often NOT in agreement using a historical lens (The legality of a drug does not correspond to its relative harm to the user and/or others)
- Increase awareness of misleading drug advertisements targeted towards young people (i.e., vaping is marketed as a "safer alternative to smoking")
- Explain the role of dopamine as it relates to reward prediction error, association learning, and motivation to seek out a reward

- Describe how drug related stimuli can eventually drive drug seeking and craving in the absence of the drug itself
- Demonstrate how potency affects the risk for addiction, tolerance, and overdose
- Analyze how drugs affect endogenous systems, which disrupt the body's ability to maintain homeostasis (and how potency plays a role)
- Describe how long-term drug use leads to cell and molecular changes that underly tolerance
- Describe how long-term drug use leads to association learning that underly tolerance and the risk of overdose
- Demonstrate how expectation and setting and can influence the experience of a high and the risk of overdose
- Describe how drug use is initially driven by "liking" the drug, but overtime it increasingly becomes driven by "wanting" the drug in order to avoid withdrawal symptoms (motivation for drug use is independent of liking the drug)

Future Directions

The goal of this project is to redefine drug education for young adults to include harm reduction information using principles of neuroscience. I developed a presentation that I hope can be reused and revised as needed. Here is a list of future objectives that I was unable to include but are essential for drug education:

Future Harm Reduction Objectives to Include:

- How using multiple drugs at once can have compounding effects and increase the risk of overdose (specific drug combinations to avoid)
- How to use fentanyl testing strips
- How to test drugs for purity (i.e., at-home drug test kits)
- How to recognize and treat an opioid overdose

Note about surveys: Post-survey responses were taken immediately following my presentation, I urge future presenters to wait at least one week before the follow-up to more

accurately assess the extent to which the presentation altered students' perceptions. Another tip: ensure that surveys are anonymous but keep track of which pre- and post-surveys correspond to the same participant in order to conduct a within subject analysis (I did not do this).

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Appendix A

Facilitator guide

1. **Title slide**
    a. Introduce yourself and the title of the talk, “The Neuroscience of Addiction”
    b. Goal: I want to give you all the information you need to make informed decisions. There is a lot of misleading information and stigma around drug use that make it hard to determine what are the actual risks are. We as young people are the target of many addicting substances and it is up to only yourself to determine what risks are worth taking
    c. Remember to avoid fear-tactics and always reassure students that you know they are smart and aware of risks
2. **Slide 2 – Historical Context**
    a. Objective: Understand how drug policy and science are often NOT in agreement using a historical lens (The legality of a drug does not correspond to its relative harm to the user and/or others)
    b. Increase awareness of misleading drug advertisements targeted towards young people (i.e., vaping is marketed as a “safer alternative to smoking”)
3. **Slide 3 – Dopamine**
    a. Objective: Explain the role of dopamine as it relates to reward prediction error, association learning, and motivation to seek out a reward
    b. Question: “What do you think of when you hear dopamine?”
    c. Dopamine is often thought of as the “feel good” neurotransmitter, but that’s not entirely accurate. It is involved in motivation -> effortful behavior during goal pursuit
    d. If something caused a large dopamine release, that tells your brain its important, so you remember the events that led to that reward, and you will be more motivated to do it again in the future
    e. Dopamine is related to movement -> the motivation to actually go and get what you want
4. **Slide 4 – Dopamine cnt.**

    a. When dopamine goes below baseline following a peak, it often feels uncomfortable and we seek that thing out that gave us the peak, this creates a cycle
    b. Dopamine is like a wave pool, there are waves of increases and decreases that then return to baseline. If the wave is too steep or there are many peaks in a row, the water will slosh out of the pool and the baseline will be lower
    c. Drugs can alter our baseline dopamine level
5. **Slide 5 – Homeostasis**
    a. Objective: Analyze how drugs affect endogenous systems, which disrupt the body's ability to maintain homeostasis (and how potency plays a role)
    b. Question: Ask if the class if they know what homeostasis means
    c. Homeostasis = equilibrium = balance out the effects of the surges/drops in dopamine
6. **Slide 6 – Initial drug use**
    a. Drug seeking is initially driven by liking the drug
    b. Relate this to dopamine -> reward prediction error, association learning, and motivation
7. **Slide 7 – Repeated drug us**
    a. Objective: Describe how long-term drug use leads to cell and molecular changes that underly tolerance
    b. Objective: Describe how long-term drug use leads to association learning that underly tolerance and the risk of overdose
    c. These changes reduce pleasure associated with drug use and cause the user to need more of the drug to achieve the desire effects
    d. Tolerance occurs as a combination of biological changes that influence how much our body is affected by a substance, and due to the anticipation of a reward from environmental cues that prepare our body for the rise in dopamine. Our body compensates for this expected change by trying to counteract it -> this diminishes the effect and more of the substance is needed to reach the initial high.
8. **Slide 8 – Association Learning**

a. Objective: Describe how drug related stimuli can eventually drive drug seeking and craving in the absence of the drug itself
b. Use vaping in the bathroom with a certain person as an example for how who, what, where stimuli becomes associated with the drug and leads to craving in the absence of the drug itself
c. Not only does the spike in dopamine from related stimuli lead to craving, it also functions to prepare the brain for the increase in dopamine its expecting. Your brain tries to counteract this effect and eventually it will take more nicotine to produce the increase in dopamine that initially made you continue vaping

9. **Slide 9 – Environment and tolerance**
    a. Demonstrate how expectation and setting and can influence the experience of a high and the risk of overdose
    b. Objective: Describe how long-term drug use leads to association learning that underly tolerance and the risk of overdose
    c. The brain is always trying to maintain equilibrium, essentially tries to counteract the effect of the drug
10. **Slide 10 – The importance of setting**
    a. Objective:
    b. Give an example that if they always smoke weed in their basement at home, their brains will begin to anticipate and prepare for the effects of the drug, but they may have a completely different experience if they do the exact same amount at a friend's house or at a party surrounded by different people.
11. **Slide 11 – Compulsive drug taking**
    a. Once tolerance is increased, you have to take more of the drug to reach the same effect
    b. The brain undergoes changes from chronic high dose drug exposure
    c. Question: Ask if anyone has heard of the prefrontal cortex?
    d. Explain how changes in the brain eventually affect the prefrontal cortex which impairs executive functioning, decision making, value comparisons
12. **Slide 12 – Eventual effects of drug use**

a. Objective: Describe how drug use is initially driven by “liking” the drug, but overtime it increasingly becomes driven by “wanting” the drug in order to avoid withdrawal symptoms (motivation for drug use is independent of liking the drug)
b. Drug use continues in the absence of liking the drug itself, it becomes a way to avoid the negative consequences associated with withdrawal

13. **Slide 13 – OPTIONAL**
    a. This is a graph demonstrating drug seeking motivated by liking vs wanting, the same effect you’ve explained in slides 6-12
14. **Slide 14 – The role of potency**
    a. Objective: Demonstrate how potency affects the risk for addiction, tolerance, and overdose
    b. Increased potency -> bigger dopamine release -> larger high -> increased abuse potential
    c. Potency can increase the speed and severity of the development of addiction
15. **Slide 15 – Nicotine**
    a. Objective: Increase awareness of misleading drug advertisements targeted towards young people (i.e., vaping is marketed as a “safer alternative to smoking”)
    b. Remind students that drugs work because there are endogenous systems that they can act on. For nicotine it’s acetylcholine and for cannabis it’s the endocannabinoid system
    c. Vaping contains highly potent nicotine
    d. Vaping makes it easier to consume more nicotine and more frequently (free base vs salt-based protonated)
    e. Nicotine binds to nAchRs and desensitizes receptors, in order to maintain homeostasis your brain adds more receptors
    f. Vaping advertised as a way to stop smoking, but the pharmacokinetics do not support this -> the absorption rate of nicotine is not any less than smoking cigarettes
16. **Slide 16 – Marijuana**
    a. THC binds to CB1 receptors which modulate the endocannabinoid system

b. Endocannabinoid system has many functions! Roles in mood, memory, anxiety, appetite, sleep, pain modulation, etc.
c. Marijuana products have increasingly more THC, this leads to faster tolerance

17. **Slide 17 – CB1 Receptors**
    a. Objective: Describe how long-term drug use leads to cell and molecular changes that underly tolerance
18. **Slide 18 – Overall harm of selected drugs**
    a. Objective: Demonstrate how drug policy and science are often NOT in agreement using a historical lens (The legality of a drug does not correspond to its relative harm to the user and/or others)
    b. Multicriteria analysis of selected drugs conducted in the UK
    c. Harm to users: mortality, dependence, impairment of mental functioning, injury
    d. Harm to others: loss of relationships, crime, environmental damage, family adversities, economic cost, international damage
19. **Slide 19 – OPTIONAL**
20. **Slide 20 – OPTIONAL**
    a. Same data as slide 18 but broken up into different criteria
21. **Slide 21-23 – OPTIONAL**
    a. If students are interested in the history of the War on Drugs and its impact on potency, mass incarceration, and overdose rates these slides provide a brief overview

Appendix B

Pre-Survey:

To what degree do you agree or disagree with the following statements? There is no one "correct" answer!

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Whether a drug is legal or illegal determines if it is safe for me to use					
There are safe levels of some drugs					
I am likely to try a drug if my friends do					
Nicotine has harmful risks associated with its use					
Marijuana (THC) has harmful risks associated with its use					
Alcohol has harmful risks associated with its use					
Opioids (fentanyl, heroin, morphine, etc.) have harmful risks associated with their use					
I feel comfortable discussing the risks of drug use with my parents or teachers					
I am confident that I understand how drugs affect my brain and body					

Post-Survey:

To what degree do you agree or disagree with the following statements? There is no one "correct" answer!

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Whether a drug is legal or illegal determines if it is safe for me to use					
There are safe levels of some drugs					
I am likely to try a drug if my friends do					
Nicotine has harmful risks associated with its use					
Marijuana (THC) has harmful risks associated with its use					
Alcohol has harmful risks associated with its use					
Opioids (fentanyl, heroin, morphine, etc.) have harmful risks associated with their use					
I feel comfortable discussing the risks of drug use with my parents or teachers					
I am confident that I understand how drugs affect my brain and body					

What are 1-3 things you learned today?

_____

_____

_____

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Appendix C

Survey responses

Pre-survey	**Mean**	**Standard Error**
Whether a drug is legal or illegal determines if it is safe for me to use	2.125	0.1933
There are safe levels of some drugs	3.667	0.1966
I am likely to try a drug if my friends do	2.500	0.2025
Nicotine has harmful risks associated with its use	4.333	0.1554
Marijuana (THC) has harmful risks associated with its use	3.875	0.2025
Alcohol has harmful risks associated with its use	4.208	0.1994
Opioids (fentanyl, heroin, morphine, etc.) have harmful risks associated with their use	4.625	0.1320
I feel comfortable discussing the risks of drug use with my parents or teachers	3.792	0.1901
I am confident that I understand how drugs affect my brain and body	3.625	0.1787
Post-survey		
Whether a drug is legal or illegal determines if it is safe for me to use	1.955	0.2415
There are safe levels of some drugs	3.500	0.1946
I am likely to try a drug if my friends do	2.409	0.2432
Nicotine has harmful risks associated with its use	4.136	0.2111
Marijuana (THC) has harmful risks associated with its use	3.909	0.2071
Alcohol has harmful risks associated with its use	4.136	0.2399
Opioids (fentanyl, heroin, morphine, etc.) have harmful risks associated with their use	4.409	0.2148
I feel comfortable discussing the risks of drug use with my parents or teachers	3.682	0.2407
I am confident that I understand how drugs affect my brain and body	3.955	0.1916