Drugs, Brain and Behavior

The Science of Addiction

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Presentation Objectives

☑ Understand what the scientific research says about drug addiction
☑ Dispel several myths and misunderstandings about drug addiction
☑ See what the research says about the effectiveness of drug addiction treatment
In just the last 10 years, advances in science have revolutionized our views about drug abuse and addiction, showing us that:

► abuse is a preventable behavior

► addiction is a treatable disease
Science can influence perceptions about the nature of illness and subsequently, change the way it is viewed and treated.

For instance, during the Renaissance Period, the root of psychosis and schizophrenia were considered to be witchcraft and demonic possession.

Therefore, treatment included *trepanation* - the boring of holes in the skull to release the *evil spirits*.

This illustration shows a colonial surgeon attempting a trepanation procedure, which required up to 60 minutes of constant drilling.
In the 19th century, some treatments were designed to induce fear. Spinning the patient until loss of consciousness occurred was thought to help rearrange the contents of the brain.

In the 1940’s “newer” techniques included insulin shock and frontal lobotomies.
Actually, the evidence is that schizophrenia is a biologically-based disease of the brain.

This evidence is supported by brain imaging showing precisely the wave of tissue destruction that takes place in the brain that is suffering from schizophrenia.
How we used to perceive and treat drug and alcohol addiction

In the past, society viewed drug addiction as a moral flaw. Popular "treatments" involved imprisonment, sentencing to asylums, and church-guided prayer.
Actually, the evidence is that drug addiction is a biologically-based disease of the brain.
Addiction is a Brain Disease

Prolonged Use Changes the Brain in Fundamental and Lasting Ways

“Healthy” Brain

“Cocaine Addict” Brain
used to be

down this is your brain on drugs.
Your Brain on Drugs Today

YELLOW shows places in brain where cocaine goes (striatum)

Science has added an important piece to the understanding of addiction
Even though there is the science, several common myths about addiction still persist, including:

• Addiction is a moral weakness
• You have to “hit rock bottom” to recover
• You have to want treatment for it to be successful
• Alcohol is not really a drug
• Drug abuse is more common among minorities
What is Drug Addiction?

Drug Addiction:
A compulsive need for continued use despite adverse consequences and an inordinate amount of time spent looking for, being under the influence of and/or recovering from the effects of drugs.
What is Drug Addiction?

A chronic and relapsing condition characterized by:

• compulsive drug seeking and use and,
• continued use despite harmful consequences

A brain disease because drugs change the brain – they change its structure and how it works.

The changes can be long lasting.

ASAM. 2004. NIDA. 2007
Addiction is a Chronic Illness Because:

✓ It has both a genetic and environmental basis influencing its development and manifestation

✓ Recovery from it is often a long-term process requiring repeated treatments

✓ Relapses can occur during or after successful treatment episodes

✓ Participation in self-help support programs during and following treatment can be helpful in sustaining long-term recovery
Why Do People Take Drugs in The First Place?

To feel good
To have novel: feelings sensations experiences AND to share them

To feel better
To lessen: anxiety worries fears depression hopelessness
Initially, A Person Takes A Drug Hoping to Change their Mood, Perception, or Emotional State

Translation---

...Hoping to Change their Brain
After Using Drugs For A While
A Person May Not Be Able To
Just Stop

Because . . .
Their Brains...

Get Rewired by Drug Use
Vulnerability
Why do some people become addicted while others do not?
We Know There’s a Big Genetic Contribution to Drug Abuse and Addiction…

…Overlapping with Environmental Influences that Help Make Addiction a Complex Disease.
IFH + high tolerance = 60%

IFH + low tolerance = 15%

Marc Schuckit. UCSD. 2002.
Do Drugs Cause Addiction?
Many drugs, but few with *abuse potential*

There are about 15,000,000 substances in the world.

However, of these only about 55,000 are available for human consumption.
Interestingly, of these 55,000 substances . . . only about 25 drugs have “abuse potential”
Drugs With Abuse Potential

✓ **Uppers:** CNS Stimulants. Amphetamine, methamphetamine, cocaine

✓ **Downers:** CNS Depressants. Alcohol, benzodiazepines (like valium, etc), barbiturates (like seconal, etc.), Inhalants, etc.

✓ **All-arounders:** Hallucinogens. LSD, mescaline, MDMA (XTC), psilocybin (magic mushrooms), PCP, etc.

✓ **Pain Killers:** Opioids. Heroin, codeine, morphine, vicodin, fentanyl, Oxycontin, etc.
Why do some drugs have abuse potential and others do not?
100 years ago not much was known about drugs and abuse potential.
Prior to the 1950’s, not much was known about the brain/behavior link, let alone the addictive nature of drugs.
In the late 1800s, Coca Cola actually did not contain small amounts of cocaine – but a lot of caffeine. It was like the *Starbucks* of the time.
Even 50 years ago, not much was known about drugs and abuse potential.
Research in the 1970’s began to investigate the nature of addiction.

From the 1990’s, dramatic advances were made about the biobehavioral basis of addictions and improved treatment methods based on scientific research.
Behaviors that result in the experience of release from a biological tension (i.e. eating) make us feel good.

This “feel good” response is registered in a certain part of the brain.
Behaviors experienced as pleasurable are processed in certain areas of the brain called the **brain reward pathway**.

The fancy name for this brain area is called the **mesocorticolimbic** pathway.
Natural Rewards

The brain's reward pathway is necessary for survival since it motivates important activities such as food seeking and eating, mating, and parenting.

- Food
- Water
- Sex
- Nurturing
Natural Rewards Elevate Pleasure

Di Chiara et al., Neuroscience, 1999.

Drugs and alcohol effect the same areas in the brain’s reward pathway . . .

. . . But in a way that is dangerous and potentially fatal!
Effects of Drugs on Brain Reward Pathways

**Amphetamine**
- Graph shows % of basal release over time after amphetamine administration.
- Graph includes curves for DA, DOPAC, and HVA.

**Cocaine**
- Graph shows % of basal release over time after cocaine administration.
- Graph includes curves for DA, DOPAC, and HVA.

**Nicotine**
- Graph shows % of basal release over time after nicotine administration.
- Curves are for Accumbens and Caudate.

**Morphine**
- Graph shows % of basal release over time after morphine administration.
- Curves are for Accumbens.
- Doses (mg/kg) indicated: 0.5, 1.0, 2.5, 10.

*Di Chiara and Imperato, PNAS, 1988*
If taking drugs make people feel good or better, what’s the problem?
Repeated use of drugs and alcohol saturate the brain’s reward pathway to the point that:

- the person becomes conditioned to the intense level of drug-induced pleasure,
- the normal level of natural rewards are no longer experienced as very pleasurable, and
- after chronic use, the brain’s reward pathway becomes drained so that nothing is pleasurable – not even the drugs!
Drugs impair the brain’s chemical balance and therefore affect mood, thought & behavior.

△ = The brain’s own “feel good” chemicals (dopamine)

★ = Drugs of abuse increase dopamine action
Repeated drug use impacts the brain by reducing available dopamine and other brain chemicals.

With repeated exposure to drugs, brain dopamine becomes reduced and behavior becomes unstable.
Withdrawal occurs when drugs have depleted critical brain chemicals needed for emotional health & balance.

When the drug is gone, there’s not enough brain dopamine. Why is this important? What is the function of dopamine?
NEWS FLASH!!!

All Brains Are Actually Not Alike!

Brains actually differ from person to person!
What if a person has genetically determined low dopamine activity? How might drugs be experienced?

△ = Brain dopamine level

★ = Drugs of abuse
Dopamine D2 Receptors are Lower in Addiction

**Reward Circuits**

- **Control**
- **Addicted**

**Drug Abuser**
**Non-Drug Abuser**

Cocaine
Meth
Alcohol
Heroin

DA D2 Receptor Availability

- **Cocaine**
- **Meth**
- **Alcohol**
- **Heroin**
DA Receptors and the Response to Methylphenidate (MP)

As a group, subjects with low receptor levels found MP pleasant while those with high levels found MP unpleasant.

Adapted from Volkow et al., Am. J. Psychiatry, 1999.
Neuroscience Research and Brain Imaging Technology
Science shows that …

prolonged drug use changes the brain in fundamental and long-lasting ways
Drugs Have Long-term Consequences
Normal images in different color scales: Mid-Thalamic plane

Transaxial

Sagittal

Coronal

Brigham & Women's Hospital

Harvard Medical School
Methamphetamine

Brigham & Women's Hospital  Harvard Medical School
A critical part of addictions treatment is the prevention of relapse behaviors.

Drug craving behaviors are triggered by a conditioned response of the nervous system when re-exposed to an environmental cue it has associated with drug use.

And . . . this conditioned response can last a lifetime.
The Memory of Drugs

Front of Brain

Amygdala not lit up

Back of Brain

Nature Video

Amygdala activated

Cocaine Video
Conditioned Response

• Pavlov’s Dogs
  Meat  ➔  Mouth Waters
  Meat + Bell  ➔  Mouth Waters
  Bell  ➔  Mouth Waters

• Stanford’s Cats
  Food  ➔  pacing for food
  Sound of can opener + food  ➔  pacing for food
  Sound of can opener  ➔  pacing for food

• Addiction
  Drug  ➔  Craving
  Drug + Trigger  ➔  Craving
  Trigger  ➔  Craving
A Conditioned Response
Brain activity changes in response to cocaine-related cues – from normal to craving behaviors (elapsed time)

Composite slide – N=23, cocaine addicted men with min. 6 years clean and sober.

Childress. 2003.
Memories Appear to Be A Critical Part of Addiction

“"Its about people, places and things…”"
Is continued drug abuse a voluntary behavior?
The initial decision to use drugs is mostly voluntary. However, when drug abuse takes over, self control becomes seriously impaired.

Brain imaging studies show physical changes in areas of the brain critical to judgment, decision making and self control. These changes alter the way the brain works.
What’s Being Done About All of This?
What does the Science say about the best ways to TREAT drug addiction?
Facts of Addiction Treatment

• Substance abuse is a preventable behavior
• Addiction is a brain disease that is treatable
• A chronic disorder requiring multiple strategies and multiple episodes of intervention
• Treatment works in the long run
• Treatment is cost-effective

Scientific research has identified some of the fundamental principles that are important in drug addiction treatment
Matching Treatment to Individual’s Needs

- No single treatment is appropriate for all individuals
- Effective treatment attends to multiple needs of the individual, not just his/her drug use
- Treatment must address medical, psychological, social, vocational, and legal problems
Medications can be an important element of treatment for many patients, especially when combined with counseling and other behavioral therapies.

- Alcohol: Naltrexone, Disulfiram, Acamprosate, Odansetron
- Opiates: Methadone, Buprenorphine, Naltrexone,
- Nicotine: Nicotine replacement (gum, patches, spray), Zyban, Chantix
- Stimulants: None to date (3 in development)
Duration of Treatment

• Depends on patient problem/needs
• Less than 90 days is of limited/no effectiveness for residential/outpatient setting
• A minimum of 12 months is required for methadone maintenance
• Longer treatment is often indicated
Motivation to Enter/Sustain Treatment

- Effective treatment need not be voluntary
- Sanctions/enticements (family, employer, criminal justice system) can increase treatment entry and retention
- Treatment outcomes are similar for those who enter treatment under legal pressure vs voluntary
HIV/AIDS, Hepatitis and Other Infectious Diseases

- Drug treatment is disease prevention
- Drug treatment reduces likelihood of HIV infection by 6 fold in injecting drug users
- Drug treatment presents opportunities for screening, counseling and referral
Self-Help and Drug Addiction Treatment

• Compliments and extends treatment efforts, but are not treatment

• Most commonly used models include 12-Step (AA, NA) and Smart recovery

• Most treatment programs encourage self-help participation during/after treatment
Treatment works!
And in Santa Clara County,
visit us at

www.sccdad.org
Thank You!