BioEd℠

THE LEARNING BRAIN

Brain Chemistry
Teacher's Guide

Drugs, Risks and the Nervous System

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Free, related neuroscience education resources and online versions of these lessons are available at www.bioedonline.org/.

BCM® Baylor College of Medicine

Second edition. First edition published 2003.
Printed in the United States of America

ISBN: 978-1-888997-45-3

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Teacher Resources from the Center for Educational Outreach at Baylor College of Medicine.

Development of The Learning Brain and BrainLink® educational materials was supported, in part, by funds from the National Institutes of Health, Science Education Partnership Award grant number R25RR13454, and the NIH Blueprint for Neuroscience Research Science Education Award, National Institute on Drug Abuse and NIH Office of the Director, grant number 5R25DA033006. The opinions, findings and conclusions expressed in this publication are solely those of the authors and do not necessarily reflect the views of Baylor College of Medicine or the funding agencies.

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Acknowledgments

This project at Baylor College of Medicine has benefited from the vision and expertise of scientists and educators in a wide range of specialties. Our heartfelt appreciation goes to David Eagleman, PhD, Assistant Professor, Department of Neuroscience, William Thomson, PhD, Professor of Family and Community Medicine, and C. Michael Fordis, MD, Senior Associate Dean and Director of the Center for Collaborative and Interactive Technologies at Baylor College of Medicine, who have lent their support and expertise to the project. We also express our gratitude to Marsha Lakes Matyas, PhD, Education Officer of the American Physiological Society, who led field tests of this unit in the Washington, D.C. area.

Members of the original steering committee provided much valued vision and inspiration that shaped the project's initial direction and design: Terry Contant, PhD, Barbara Foots, MS, Anne Hayman, PhD, Judith Livingston, MEd, Christina Meyers, PhD, Kathleen Philbin, PhD, Carolyn Sumners, EdD, and Katherine Taber, PhD. We also acknowledge the invaluable contributions of Leslie Miller, PhD, and Judith Dresden, MS, who originally led the BrainLink project.

Several colleagues helped to guide the production of this book. In particular, we wish to thank Michael Levy and Sara Copeland Shalin of the Division of Neurosciences, Baylor College of Medicine; David Heller, BS, Middle School Education, Carolina Biological Supply Company; and Eric Chudler, PhD, University of Washington.

We are especially grateful to the many classroom teachers in the Houston area who participated in the field tests of these materials and provided invaluable feedback.

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NIH Blueprint for Neuroscience Research

SEPA SCIENCE EDUCATION PARTNERSHIP AWARD
Supported by the National Institutes of Health

NIDA NATIONAL INSTITUTE ON DRUG ABUSE
National Institutes of Health
U.S. Department of Health and Human Services

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Page 2: MRI image of brains and source material courtesy of National Institute on Drug Abuse, NIH, and Volkow ND, Chang L, Wang GJ, Fowler JS, Franceschi D, Sedler M, Gatley SJ, Miller E, Hitzemann R, Ding YS, and Logan J. Loss of dopamine transporters in methamphetamine abusers recovers with protracted abstinence. *J Neurosci* 21(23): 9414-9418, 2001.

Overview

Students will estimate risks associated with different events and compare their estimates to the real probabilities.

Drugs, Risks and the Nervous System

People perceive risks differently, depending on the nature of the risk and their individual experiences. Risk perceptions are strongly influenced by issues of choice and control; risks often seem "riskier" to people if they have not voluntarily chosen to bear them. Conversely, people are more willing to accept or ignore risks that they choose voluntarily, especially if the immediate benefit seems to outweigh the potential for negative outcomes much later in time. In the case of chemical substances that affect the brain, the risks can be very high indeed.

Unit Links

Legacy of Lost Canyon
Chapter 10

Brain Chemistry Explorations
"How Risky Is It?" p. 8
"Careers for NeuroExplorers," p. 6

It is important to note that most people begin to use brain-altering chemicals voluntarily. Over time, however, the brain and body may adapt to the effects of a chemical. This can create a new "normal" state, adjusted to the presence of the introduced substance. This adaptation may lead to a physical dependence on the substance, such that the individual requires the chemical to function normally.

For example, more than 80 percent of the current US population chooses to consume the stimulant caffeine in coffee and/or cola drinks because of its taste and/or perceived enhancement of mental and physical performance. Eventually, most caffeine consumers develop a dependence on its stimulating effects and experience mild withdrawal symptoms, such as sleepiness and headaches, when they do not have caffeine. Other chemicals have more dramatic effects on the brain and body, affecting the brain's natural reward centers, which are responsible for generating feelings of pleasure or well-being. However, feelings of euphoria, comfort or pleasure often decrease or disappear after the first few uses of the substance.

Drugs that act on areas of the brain related to sensations of pleasure are sometimes used inappropriately by people. Unfortunately, continued drug use actually changes the way the brain works. In some cases, it can cause permanent changes in the structure and function of the brain. This is the biological basis of addiction.

Many mind-altering chemicals abused by children and adults in the US lead to permanent changes in the brain that lead to addiction, and also may cause damage to other parts of the body. Marijuana use can alter memory regions of the brain and affect coordination and the senses in

Concepts

- Perception of risk is affected by issues of personal choice and control.
- Many chemicals influence the function of the nervous system.
- Health risks associated with tobacco, alcohol and other drugs of abuse often are underestimated.

Science & Math Skills

Predicting, sorting and classifying, comparing, sequencing, inferring and understanding probability

Time

Preparation: 10 minutes
Class: 45 minutes

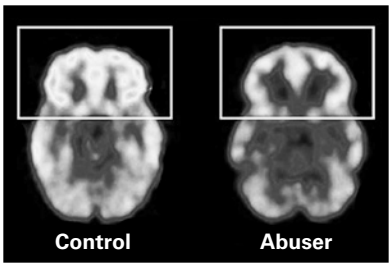
Adolescents and Risky Behavior

Adolescents commonly take more risks than younger children and adults do, but not because they are attracted to danger. Rather, adolescents are simply more willing than other age groups to accept risks when consequences are unknown. A recent study showed that when risks are precisely stated, adolescents avoid them as much—if not more—than adults do.

Chemicals for Better Health

Studies on how chemical messengers work within the nervous system hold promise for unraveling many basic questions about the actions of drugs and the causes of some diseases. Almost all drugs that influence the way the brain works do so by altering the transmission of chemical messages. This influence can have important medical applications for the treatment of severe pain or illnesses such as schizophrenia or depression. Some medicines used to treat depression, for example, act on chemical messengers involved in regulating sleep and body temperature. Morphine, a potent pain medication, mimics the effects of a natural chemical messenger found in brain pathways involved in minimizing pain and producing a sense of well-being.

Seeing Addiction in the Brain



Drug addiction compromises the brain circuits involved in processing reward and punishment, and in exerting control over one's actions. The MRI scans above show what happens in the brain when drugs are abused. On the left is a scan of a normal brain. Notice the bright areas of activity. The scan on the right is of a person who is abusing cocaine. The large dark areas show the loss of neuronal activity. This loss can be reversed if an abuser stops taking the drug.

the short term. Heroin changes the way nerve cells in the brain receive and process messages. Inhalants, which are taken up by fatty tissue in the body, damage or destroy the fat-containing myelin sheath on nerve cell axons and disrupt nervous system communications, sometimes permanently. LSD can contribute to the development of chronic mental disorders. Alcohol, which depresses physical and mental abilities, damages many tissues throughout the body, including the liver and the brain. Alcohol also is a major contributing factor to automobile accidents because it affects coordination and judgment. Nicotine, a stimulant in tobacco, is a very addictive substance that can damage the circulatory system. However, the greatest health risk from smoking comes from other compounds in cigarette and cigar smoke that are linked to development of lung and other cancers.

MATERIALS

Per Group of Students (See Setup)

- Roll of clear tape, 0.5 in.

Per Student

- Pair of scissors
- Sheet of paper, 8.5 in. x 11 in.
- Copy of "What Are the Odds?" and "The Risks Are Real" student pages

SETUP

Make photocopies of the student pages (one set for each per student). Begin with a class discussion, followed by students working in groups of four to complete the activity.

PROCEDURE

1. Begin with a class discussion of the previous activity in which students simulated the effects of chemicals on neuron signaling. Ask, *What are examples of substances that change the way the brain works or how a person feels?* Give students time to think of some of the most common examples, such as alcohol, coffee and soft drinks with caffeine, cigarettes (nicotine), marijuana, inhalants ("sniffing" glue, paint or aerosols), etc.
2. Follow by asking, *Do you think people evaluate possible health risks when they take a substance that affects the brain? Why or why not? Do you think they should?*
3. Tell students that one way to quantify risk is to state it as a probability that something will occur. For example, when students rolled a die in Activity 4, they had a one in six chance of rolling a "two" on any given toss because the die has six sides. Explain that by studying how frequently events have happened in the past, scientists and statisticians have been able to calculate the risk of many different types of occurrences.
4. Give each group of students a copy of the "What Are the Odds?" page and have them read all of the statements. Have students cut the statements into strips (so that they can be rearranged easily). Next,

Volkow ND, Chang L, Wang GJ, Fowler JS, Franceschi D, Sedler M, Gatley SJ, Miller E, Hitzemann R, Ding YS, and Logan J. Loss of dopamine transporters in methamphetamine abusers recovers with protracted abstinence. J Neurosci 21(23): 9414-9418, 2001.

have students discuss within their groups how likely it is that each event will occur.

5. Students should rank the events numerically, from most likely to occur to least likely. The number "1" should be given to the most likely event. Have students place the strips in order of likelihood from most risk (top) to least risk (bottom). You may want to provide tape and a separate sheet on which students can arrange and secure their strips.

   Note. Tell students that some items have the same odds.

6. Discuss students' predictions briefly by asking which events they placed at the tops and bottoms of their lists. Let each group share some of its predictions and the reasoning behind the choices. Allow student groups to rethink or revise their predictions based on the discussion.
7. Distribute a copy of "The Risks Are Real" page to each group and ask students to compare their predictions to the actual risk calculations.
8. Conclude by discussing the actual risks as compared to students' predictions. Ask guiding questions such as, *Which ranking surprised you the most? Which were you able to predict most accurately? Do you think you or any of your friends might be ignoring long-term risks because you are making choices based on short-term benefits?*

Abuse or Addiction?

There is a difference between drug abuse and drug addiction. Drug abuse involves any illicit use of a substance, including nonmedical use of prescription drugs. Drug addiction is a chronic, relapsing disease characterized by compulsive drug seeking and use despite harmful consequences, as well as neurochemical and molecular changes in the brain.

People abuse drugs for many reasons. Sometimes, it is because drugs produce feelings of pleasure, or because they remove feelings of stress and emotional pain.

Over time, the body can become "used" to a drug, causing severe withdrawal symptoms when the substance is removed. People who are physically dependent on a drug continue to use it to avoid the pain of withdrawal, not because they derive any pleasure from the experience.

Historical and Cultural Drug Use

Anthropologists have uncovered ancient uses of mind-altering substances for medicinal and ritualistic purposes in cultures around the world.

The use of the substances in ritualistic practices was strictly controlled by community leaders and involved plant-based medicines that were less refined and often less potent than many of the drugs used today.

What Are the Odds?

Read the statements below. Cut the statements into strips and place the events in order from most likely (top) to least likely to occur (bottom). Rank the statements numerically, assigning "1" to the most likely event. Keep in mind that some items are equally likely, so they will share the same number.

Being born left-handed

Living to the age of 116 years

Being killed by a shark

Picking all 5 winning numbers in a lottery (total of 49 numbers)

Quitting smoking successfully without any help

Becoming addicted to caffeine if you regularly drink caffeinated coffee, tea or soft drinks (such as cola)

Being electrocuted

Becoming a professional basketball player if you play basketball in high school

Becoming addicted to nicotine if you smoke cigarettes

Being involved in an alcohol-related car accident

Having poor driving skills after smoking one marijuana cigarette

Being killed by falling out of bed

Permanently damaging the myelin sheath on nerve cells in the brain by "sniffing" paint or glue

Dying from influenza (the flu)

Being pressured by a friend to smoke or use alcohol

Having a fatal accident while playing sports

Becoming dependent on crack or cocaine, if injected

Dying of a smoking-related illness if you start smoking as a teenager

The Risks Are Real

These are the real odds for the events you ranked, from most likely to occur to least likely. Compare the odds to your rankings. Surprised?

1.	Having poor driving skills after smoking one marijuana cigarette	1 in 1
2.	Becoming addicted to caffeine if you regularly drink caffeinated coffee, tea or soft drinks (such as cola)	1 in 1.25
3.	Becoming addicted to nicotine if you smoke cigarettes	1 in 2
3.	Permanently damaging the myelin sheath on nerve cells in the brain by "sniffing" paint or glue	1 in 2
4.	Being pressured by a friend to smoke or use alcohol	1 in 3
4.	Being involved in an alcohol-related car accident	1 in 3
4.	Dying of a smoking-related illness if you start smoking as a teenager	1 in 3
5.	Becoming dependent on crack or cocaine, if injected	1 in 4
6.	Being born left-handed	1 in 10
7.	Quitting smoking successfully without any help	1 in 10
8.	Dying from influenza (the flu)	1 in 5,000
9.	Becoming a professional basketball player if you play basketball in high school	1 in 10,000
10.	Having a fatal accident while playing sports	1 in 25,000
11.	Being electrocuted	1 in 350,000
12.	Picking all 5 winning numbers in a lottery (total of 49 numbers)	1 in 1,953,393
13.	Being killed by falling out of bed	1 in 2 million
14.	Being killed by a shark	1 in 300 million
15.	Living to the age of 116 years	1 in 2 billion

Compiled from public domain statistics made available by the National Institutes of Health, Center for Substance Abuse Prevention, National Clearing House for Alcohol and Drug Information, American Cancer Society, CareerQuest and Dartmouth University.