

# Impact of Marijuana Use on the Teenage Brain: Reframing the Discussion

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I **do not** intend to discuss an unapproved/investigative use of a commercial product/device in my presentation.

# Learning Objectives

*At the conclusion of the presentation, participants should be able to:*

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- Describe the current evidence around the impact of cannabis on the neurobiology of the adolescent brain
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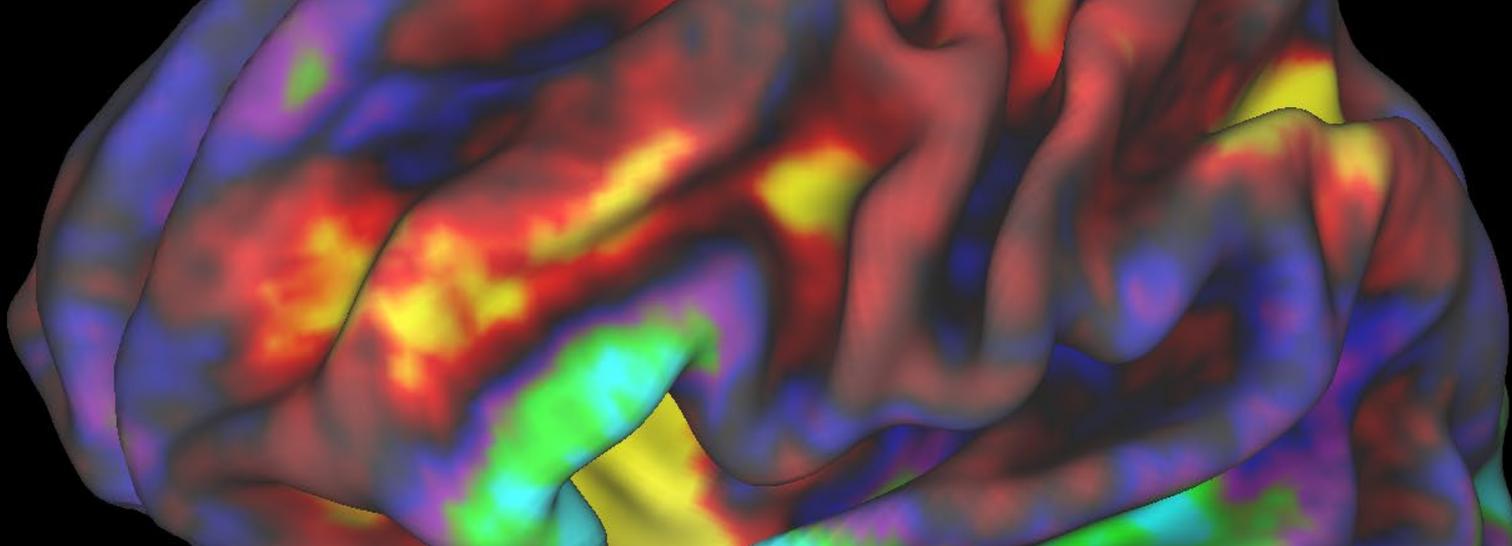


Image source: NIDA

# Neurobiology of the Adolescent Brain

# Adolescence

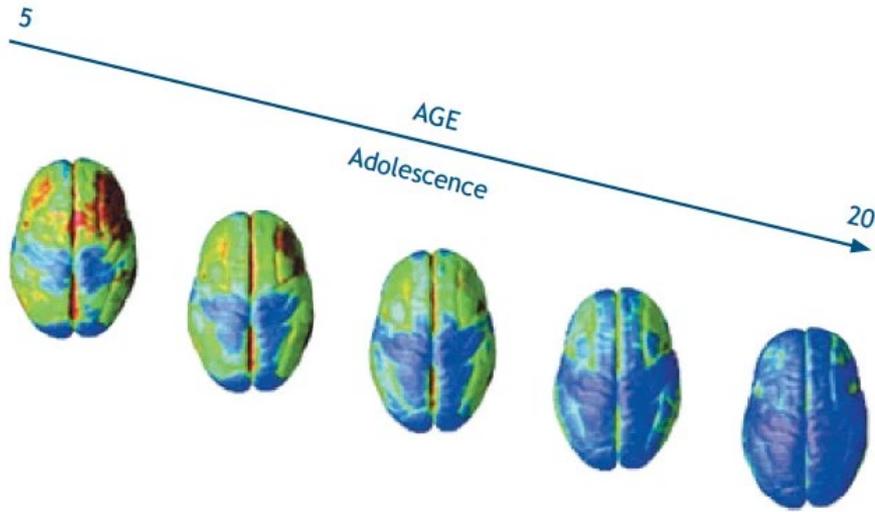
Derived from the Latin term

“*adolescere*”



“to grow up or to  
grow into maturity”

# Adolescence



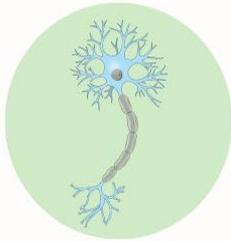
Marked by changes in

- Brain structure
- Function
- Connectivity

Gogtay et al. Dynamic mapping of human cortical development during childhood through early adulthood. *Proceedings of the National Academy of Sciences* May 2004, 101 (21) 8174-8179

# Changes in Brain Structure

## Gray Matter

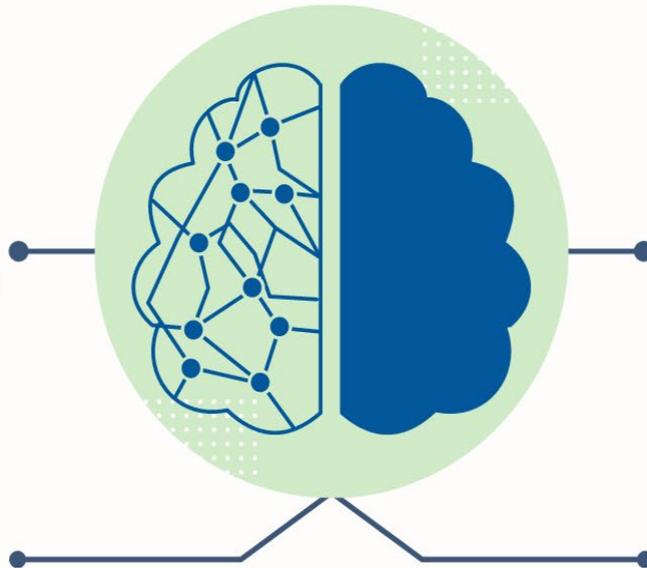


### Contains

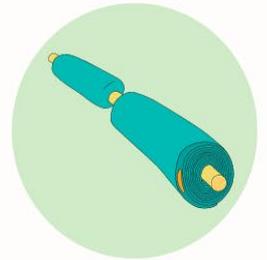
- Neural cell bodies
- Dendrites
- Synapses

### Changes

- Synaptogenesis- synapse formation



## White Matter



### Contains

- Myelin

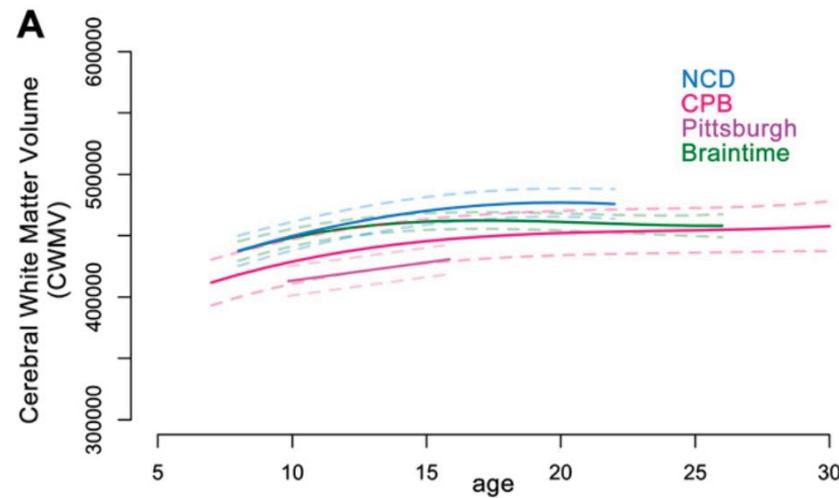
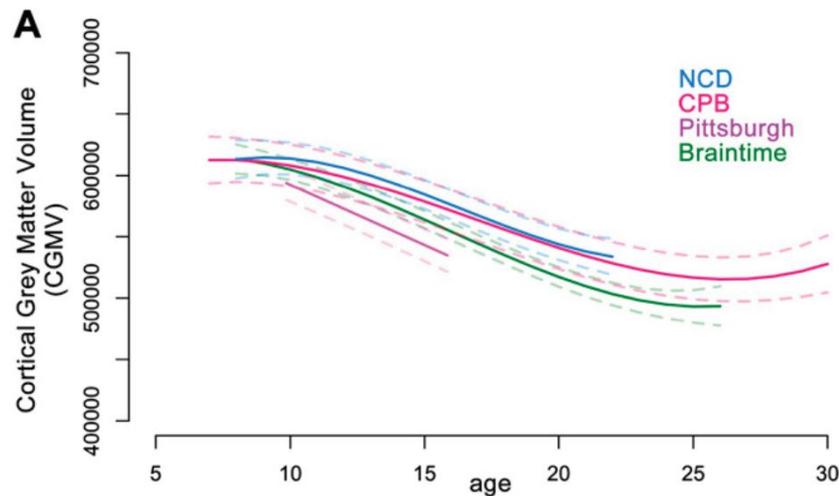
### Changes

- Increased myelination

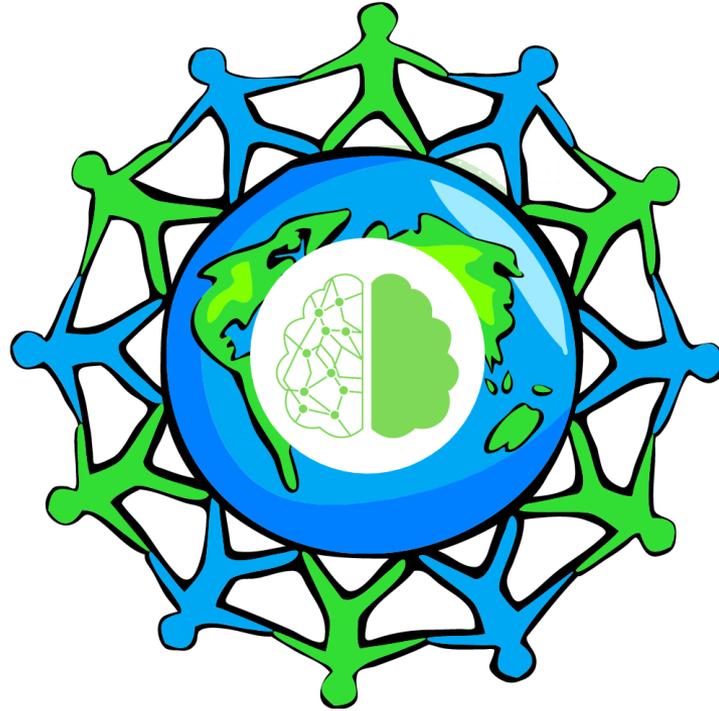
# Changes in cortical gray- and white-matter volume, ages 5 to 30

CPB = NIH Child Psychiatry Branch (NIMH)  
NCD = Neurocognitive Development (University of Oslo)  
Pittsburgh = University of Pittsburgh  
Braintime = Leiden University.

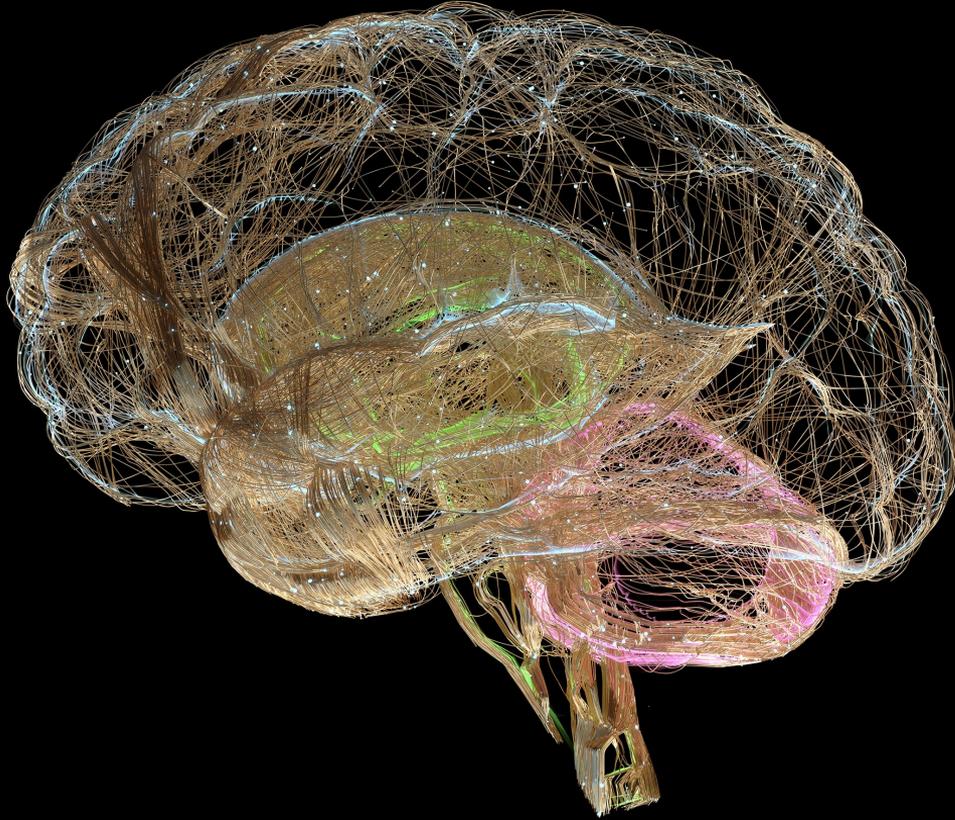
Mills, et al. (2016). Structural brain development between childhood and adulthood: Convergence across four longitudinal samples. *Neuroimage*, 141, 273–281.



# The Adolescent Brain is Designed to Adapt to the Environment



# Two Key Neurodevelopmental Processes

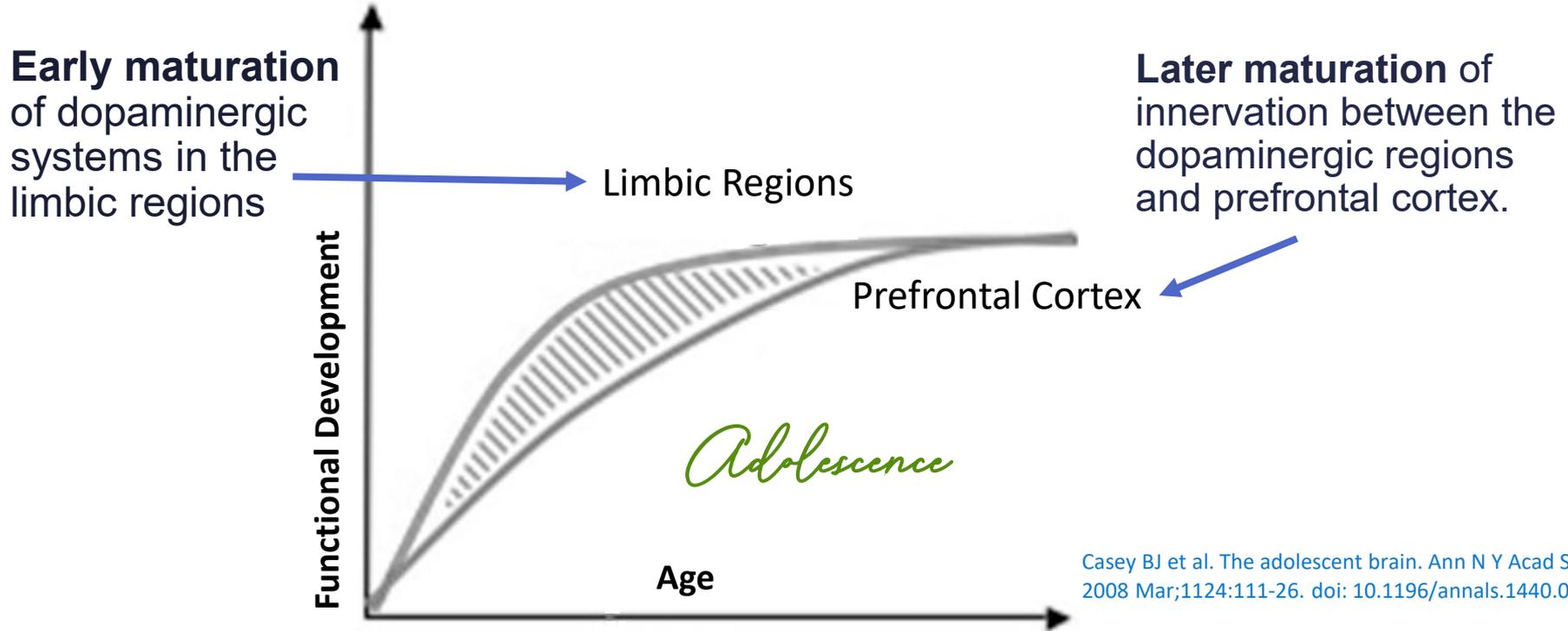


1. Maturation of the prefrontal cortex
2. Improved connectivity between the cortical and subcortical regions

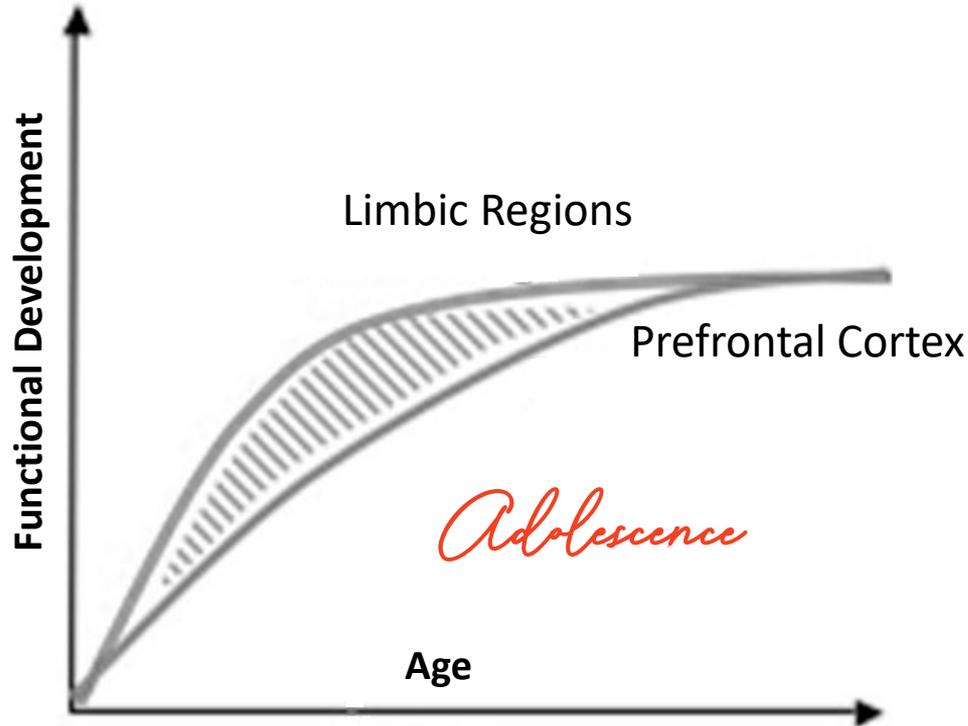
From: NASEM 2019. *The Promise of Adolescence: Realizing Opportunity for All Youth*.

Image source: Microsoft Stock Image

# Asynchronous development



# Asynchronous development leads to:



- Heightened limbic response to threats and rewards
- Propensity to explore new things and take risks
- The development of the cognitive, social, and emotional skills for adulthood

# Changes in Cognition with Prefrontal Cortex Maturation



- ↑ Working memory
- ↑ Inhibitory control
- ↑ Abstract reasoning

From: NASEM 2019. *The Promise of Adolescence: Realizing Opportunity for All Youth*.  
Image source: Microsoft Stock Image

# Changes in Cognition

Complex problem-solving skills  
Creativity  
Deep Learning



From: NASEM 2019. *The Promise of Adolescence: Realizing Opportunity for All Youth*.  
Image source: Microsoft Stock Image

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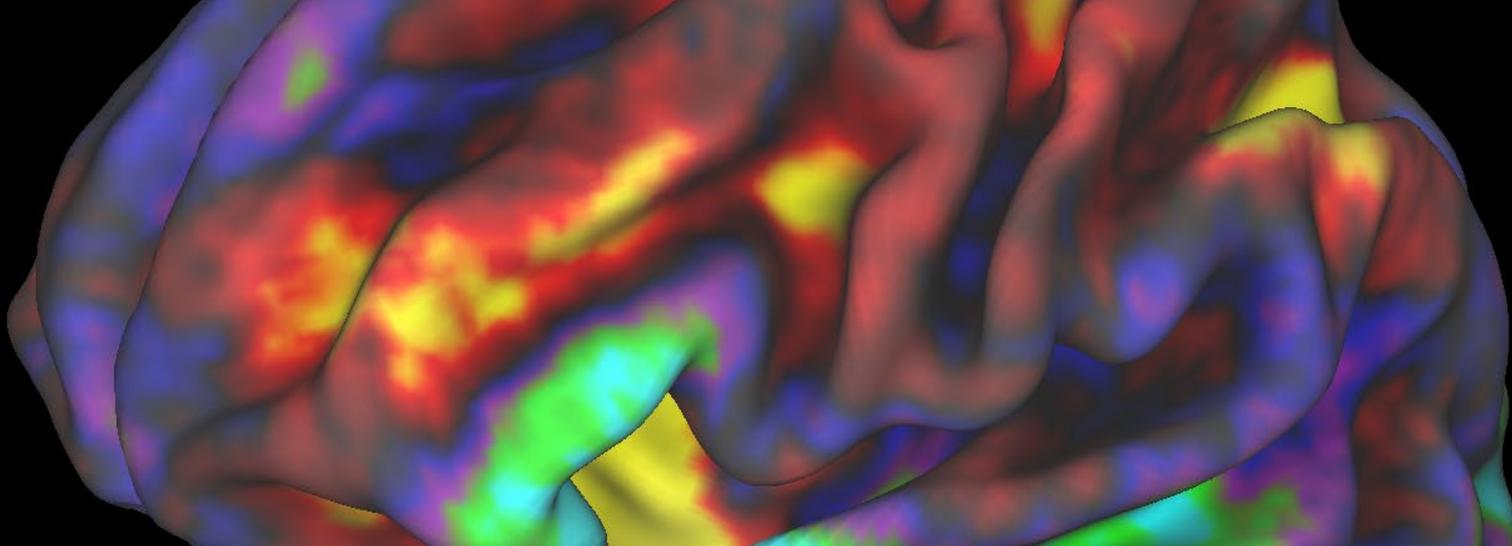


Image source: NIDA

# Cannabis and the Developing Teen Brain



***“We are still very much at the forefront of beginning to understand how cannabis impacts adolescent through adult cognitive health and broader psychosocial functioning.”***

*National Academies of Science, Engineering and Medicine: The Health Effects of Cannabis and Cannabinoids: The Current State of Evidence and Recommendations for Research, 2017*

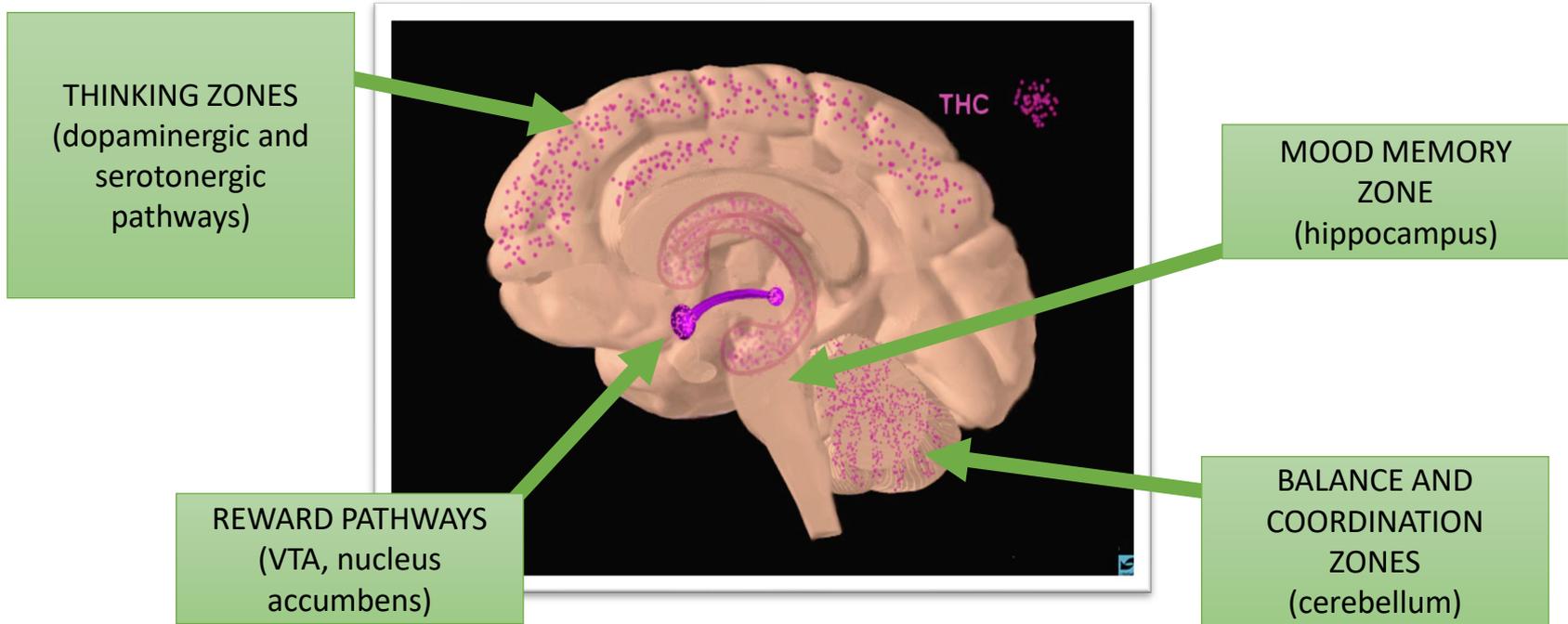
# Endocannabinoid System

- Regulates and controls level and activity of most of the other neurotransmitters
- Essential for maintaining homeostasis
- Components
  - Endogenous cannabinoids
  - Cannabinoid Type 1 & 2 receptors
  - Enzymes

# Cannabis and Cannabinoids

- A plant that contains cannabinoids
- 2 most common cannabinoids
  - Tetrahydrocannabinol (delta-9-THC)
  - Cannabidiol

# Endocannabinoid receptors present throughout the brain



# Cannabis Exposure & Brain Morphometry

- Neuroimaging studies have had mixed findings with either:
  - Functional and structural alterations in frontoparietal, frontolimbic, frontostriatal, and cerebellar regions
  - No group differences
- Some studies have found neural alterations precede the initiation of cannabis

Lichenstein SD, et al. Systematic review of structural and functional neuroimaging studies of cannabis use in adolescence and emerging adulthood: evidence from 90 studies and 9441 participants. *Neuropsychopharmacology*. 2022 Apr;47(5):1000-1028.

# Acute Cognitive Effects

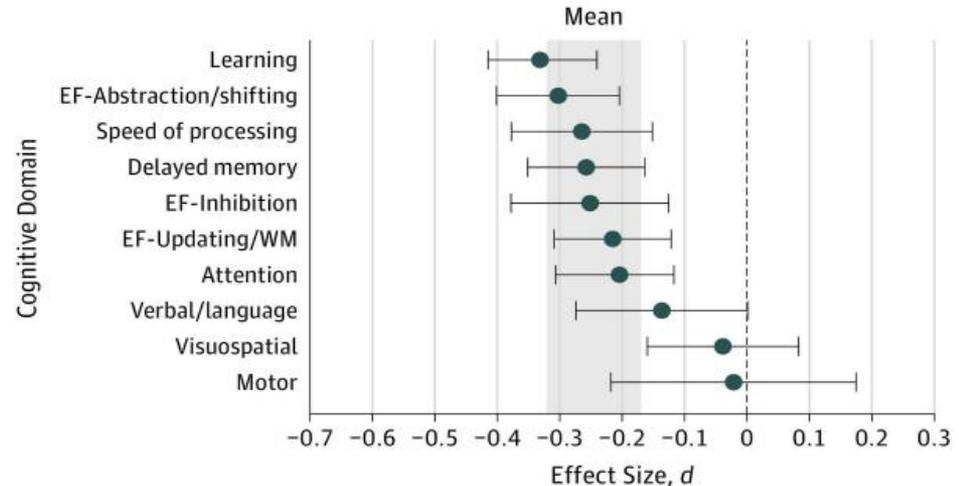
JAMA Psychiatry | [Original Investigation](#)

## Association of Cannabis With Cognitive Functioning in Adolescents and Young Adults A Systematic Review and Meta-analysis

J. Cobb Scott, PhD; Samantha T. Slorniak, MD; Jason D. Jones, PhD; Adon F. G. Rosen, BS; Tyler M. Moore, PhD; Ruben C. Gur, PhD

- **Meta-analysis of 69 studies of adolescents and young adults with heavy cannabis use**
- **Main finding:** “Statistically significant but small cognitive effects associated with heavy/frequent cannabis use.”

### Mean Weighted Effect Sizes for Each Neurocognitive Test Domain



# IQ

## Persistent cannabis users show neuropsychological decline from childhood to midlife

Madeline H. Meier<sup>a,b,1</sup>, Avshalom Caspi<sup>a,b,c,d,e</sup>, Antony Ambler<sup>a,f</sup>, HonaLee Harrington<sup>b,c,d</sup>, Renate Houts<sup>b,c,d</sup>, Richard S. E. Keefe<sup>d</sup>, Kay McDonald<sup>f</sup>, Aimee Ward<sup>f</sup>, Richie Poulton<sup>f</sup>, and Terrie E. Moffitt<sup>a,b,c,d,e</sup>

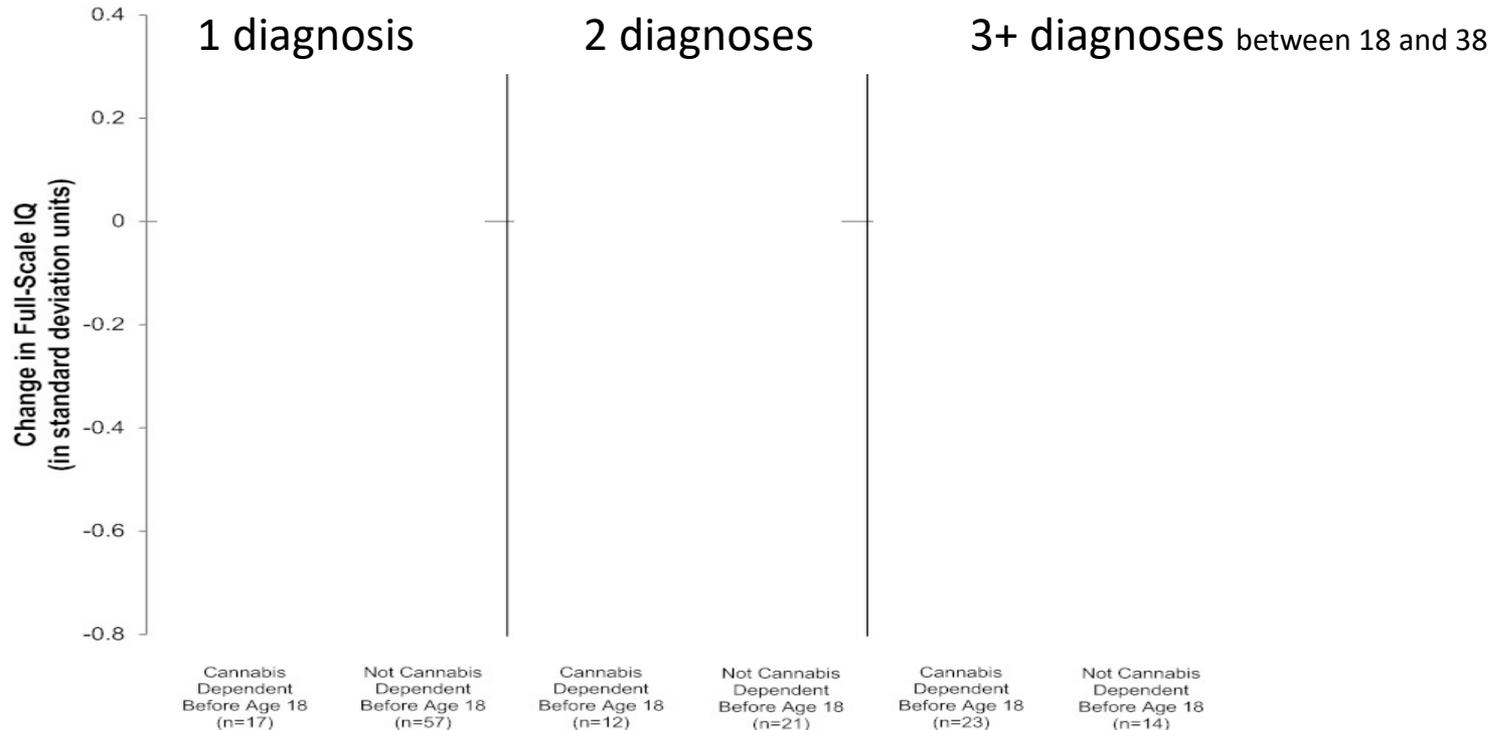
<sup>a</sup>Duke Transdisciplinary Prevention Research Center, Center for Child and Family Policy, <sup>b</sup>Department of Psychology and Neuroscience, and <sup>1</sup>Institute for Genome Sciences and Policy, Duke University, Durham, NC 27708; <sup>d</sup>Department of Psychiatry and Behavioral Sciences, Duke University Medical Center, Durham, NC 27710; <sup>e</sup>Social, Genetic, and Developmental Psychiatry Centre, Institute of Psychiatry, King's College London, London SE5 8AF, United Kingdom; and <sup>f</sup>Dunedin Multidisciplinary Health and Development Research Unit, Department of Preventive and Social Medicine, School of Medicine, University of Otago, Dunedin 9054, New Zealand

Edited by Michael I. Posner, University of Oregon, Eugene, OR, and approved July 30, 2012 (received for review April 23, 2012)

- New Zealand birth cohort followed from age 3 to 38
- IQ tested at age 7-13
- IQ again tested at age 38
- Followed them at ages 18, 21, 26, 32, and 38

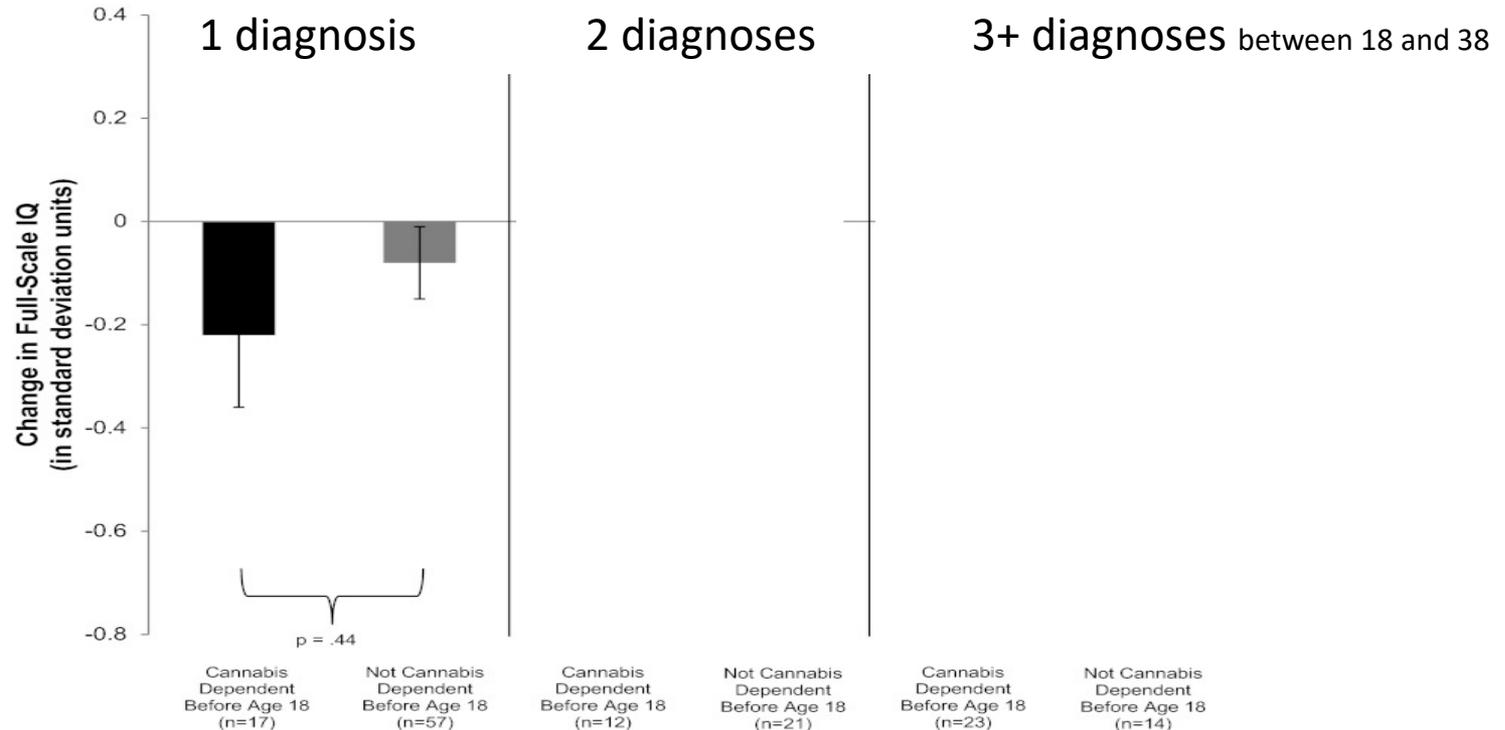
# Cannabis dependence onset in adolescence and IQ

Change in full-scale IQ (in SD units) from childhood (ages 17-13) to adulthood (age 38)



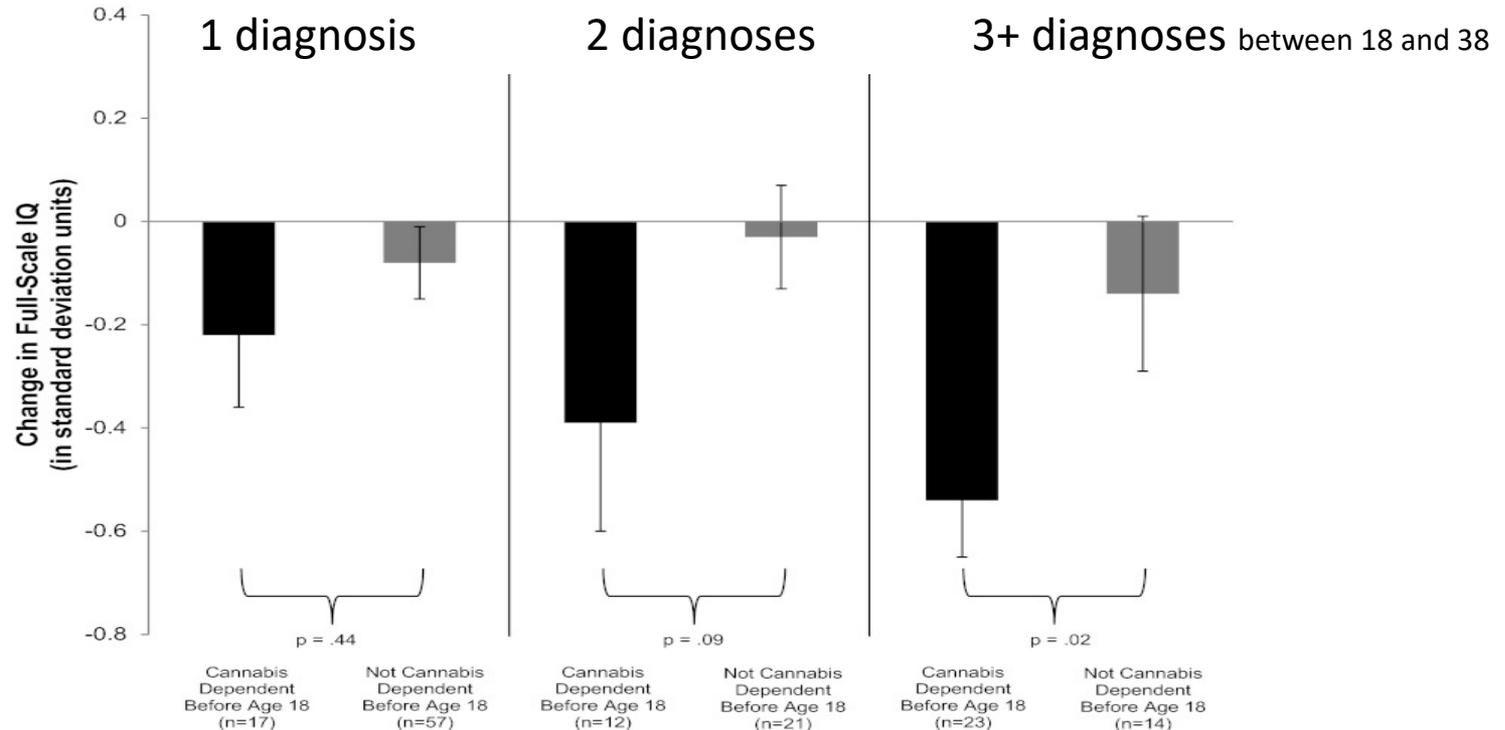
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# Cannabis and Risk of Psychosis

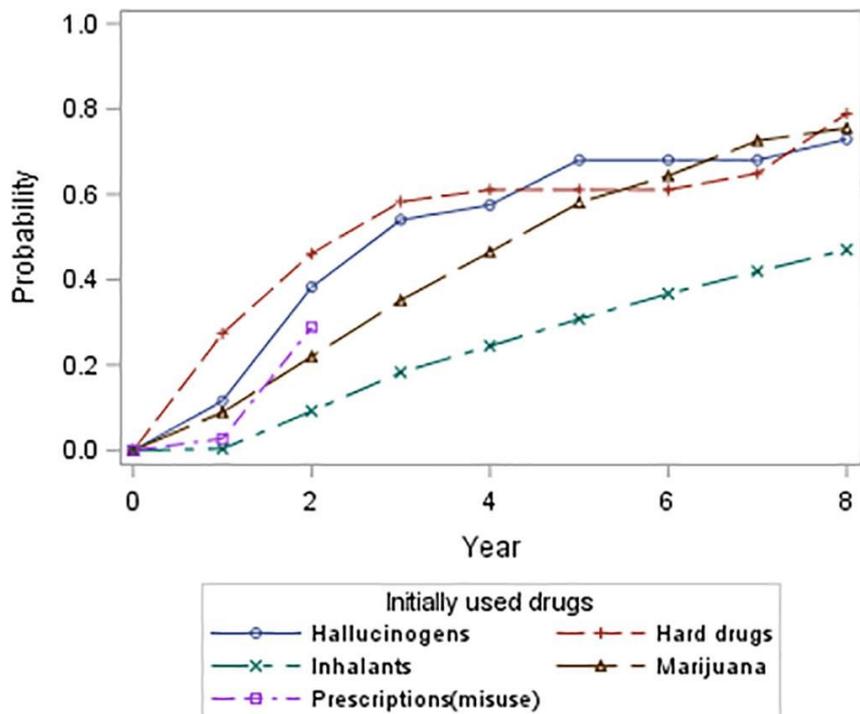
- “A 4-fold increase in risk for the heaviest users and a 2-fold increase for the average cannabis user in comparison to nonusers.”
  - In both cohort and cross-sectional studies
  - With broad definition of psychosis or narrow diagnosis of psychotic disorder

# Cannabis and Adult Mental health

- Positive Associations with
  - Suicidal thoughts among heavy cannabis users
  - Greater symptoms among those with bipolar disorder who use cannabis frequently
- No Association with
  - Developing anxiety, depression, PTSD

National Academies of Sciences, Engineering, and Medicine. 2017. *The health effects of cannabis and cannabinoids: The current state of evidence and recommendations for research*. Washington, DC: The National Academies Press. doi: 10.17226/24625.

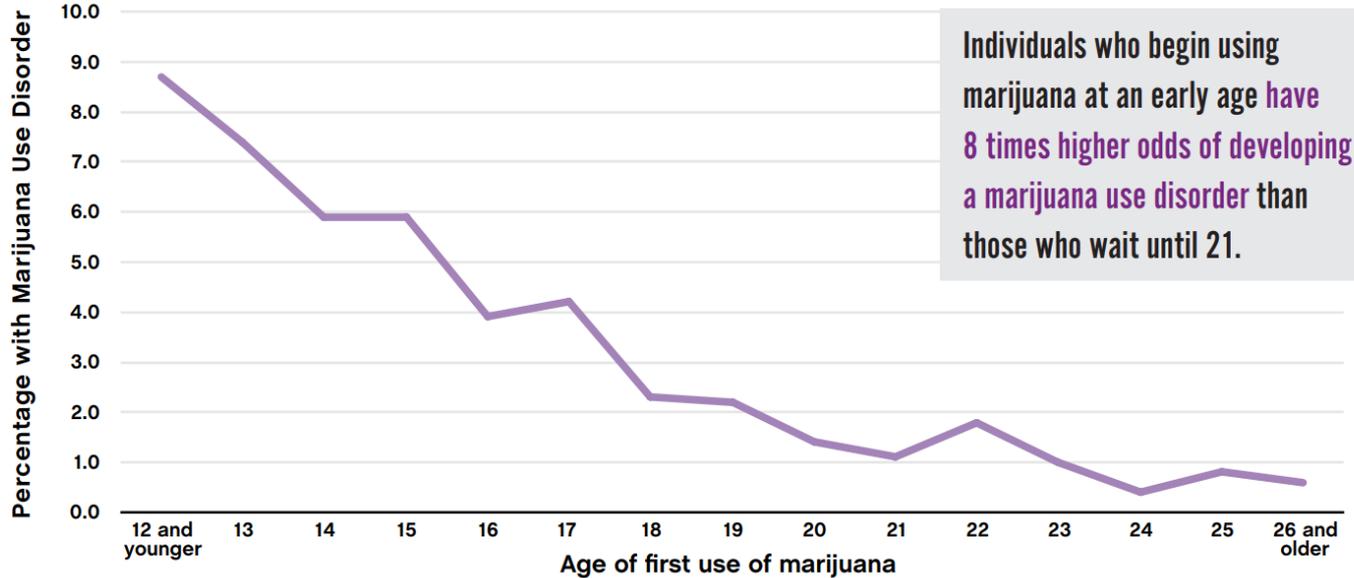
# Age of Cannabis Use Initiation & Risk of Other Drug Use



**70%** of adolescents who start using cannabis in adolescence will use another illicit drug 6 years later.

Zhang S, et al. Adolescent drug use initiation and transition into other drugs: A retrospective longitudinal examination across race/ethnicity. *Addict Behav.* 2021 Feb;113:106679. doi: 10.1016/j.addbeh.2020.106679. Epub 2020 Sep 25

## Likelihood of marijuana use disorder as a function of age at first use of marijuana



Source: Analysis of 2018 data from the National Survey on Drug Use and Health

Although teenagers engaging in harmful behaviors are in the minority, recent statistics show that the proportion of those who do so, especially with regard to substance use, remains high.<sup>12</sup>

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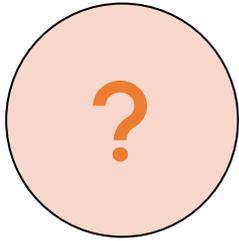
# Counseling Patients

The healthiest thing for you and your brain is to not use any marijuana.

# Main messages

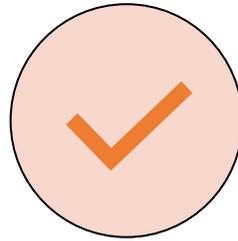
- Marijuana is not a benign drug
  - Alters brain development.
  - Interferes with learning and memory
  - Increases risk of developing addiction and psychosis.

# Strategies for Effective Counseling



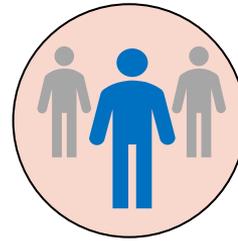
**ASK**

Permission



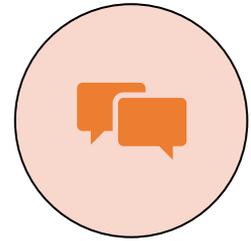
**ACKNOWLEDGE**

Their beliefs



**PERSONALIZE**

The information



**MOTIVATE**

Them to  
consider a  
change

At this time in your life,  
your brain is growing to  
become FASTER and more  
EFFICIENT.

Marijuana affects how  
FAST and EFFICIENT it  
can be.



I know all that, but it helps me...

think, concentrate, stay calm, pay  
attention...



## ACKNOWLEDGE

Their beliefs

**I hear** what you are saying, that it helps you concentrate.

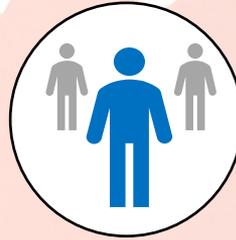
Tell me more about that...



I think its great **you want to concentrate so you can do your homework...**

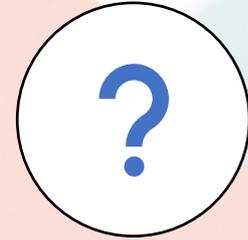
Its tricky because marijuana may help your concentration, but on the other hand we know that it affects the speed and efficiency of your brain. I'm worried that, in the end, it won't help with school....

**Is it OK if I share some other strategies you might consider...**



**PERSONALIZE**

The information



**ASK**

Permission



Marijuana can be addictive,  
especially in young people.

I'm not addicted to it



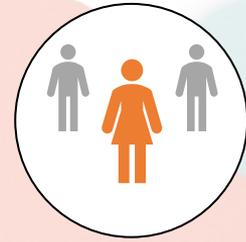
**I hear** you.

“I know **you said that you need it to sleep**. Needing something might be a sign that you are developing a craving. Cravings are signs that your brain wiring might be changing and you may start developing an addiction.”



**ACKNOWLEDGE**

*Their beliefs*

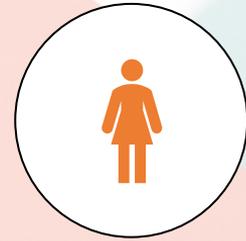


**PERSONALIZE**

*The information*



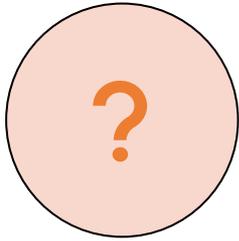
I think in your case, you have to be very careful. Because of your dad's history, your brain may be more likely to develop an addiction than other people who do not have the same history as you.”



**PERSONALIZE**

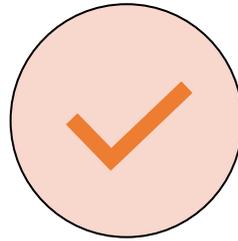
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# Strategies for Effective Counseling



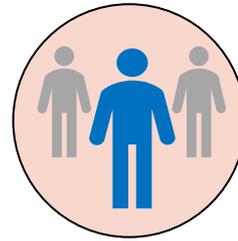
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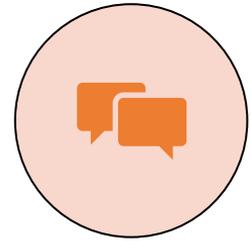
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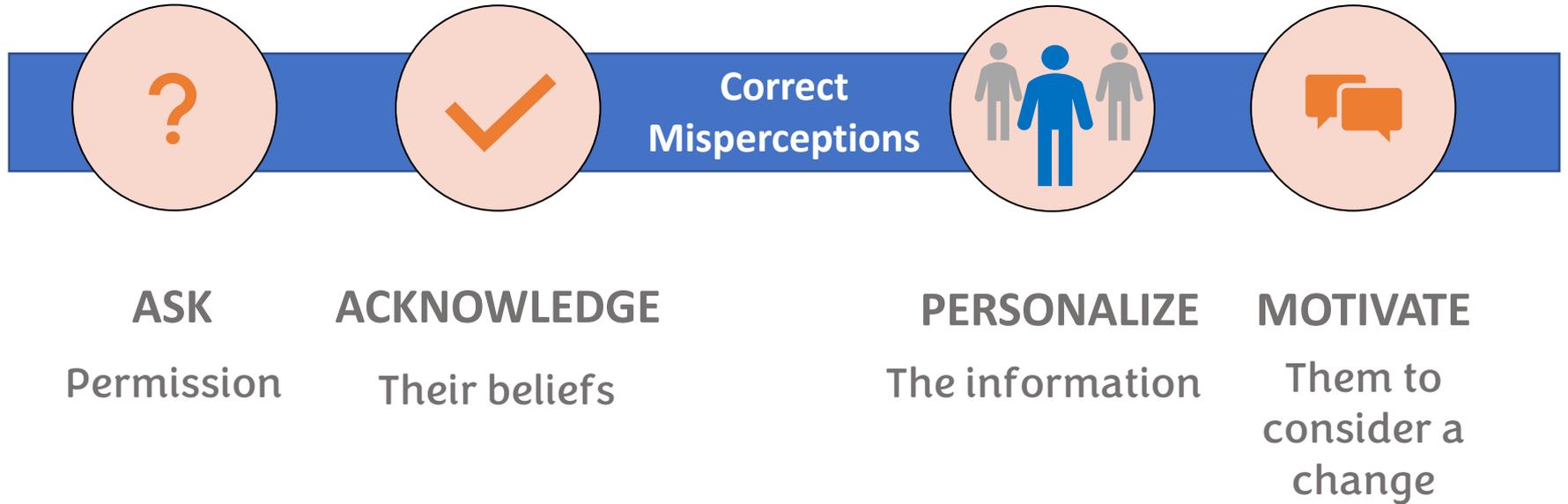
The information



**MOTIVATE**

Them to  
consider a  
change

# Strategies for Effective Counseling



# Share The Facts

- **The drug supply is contaminated with fentanyl**
  - You can't see it or smell it, but very small amounts can kill you
- **Marijuana can make you sick**
  - It is very easy to overconsume edibles
- **Cannabis is not legal for those under age 21**
  - In many states, there are harsh penalties for young drivers who are impaired

# Summary

- **Adolescence is a period of learning, exploration and growth**
- **Cannabis and cannabinoids adversely impact the brain's ability to grow, learn, and explore.**
- **Counseling Strategies include**
  - **Asking permission**
  - **Acknowledging Beliefs**
  - **Personalizing the Information**
  - **Motivating a change**
  - **Correcting misperceptions**



# Changes you may wish to make in practice:

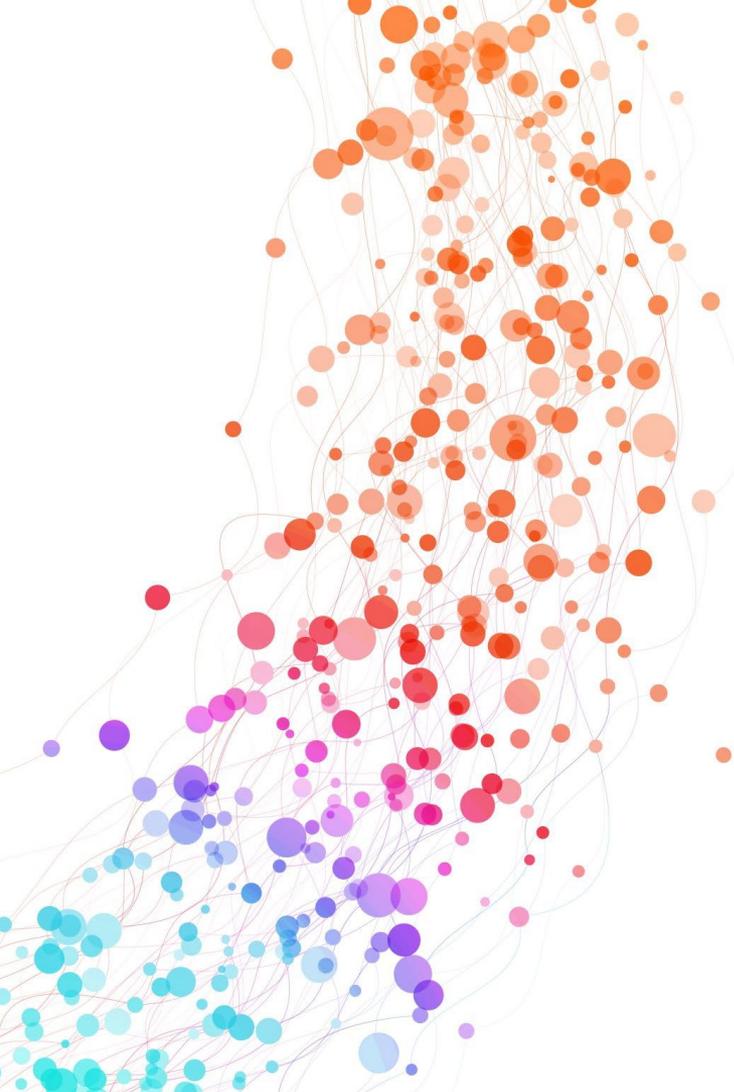
1. Counsel adolescent patients about the growing speed and efficiency of their brains.
2. When counseling about the adverse effects of cannabis:
  - **Ask permission**
  - **Acknowledge Beliefs**
  - **Personalize the Information**
  - **Motivate a change**
  - **Correct common misperceptions**

# References

For more information on this subject, see the following publications:

Ryan SA, Ammerman SD et al. COMMITTEE ON SUBSTANCE USE AND PREVENTION, Counseling Parents and Teens About Marijuana Use in the Era of Legalization of Marijuana. *Pediatrics* March 2017; 139 (3): e20164069. 10.1542/peds.2016-4069

National Academies of Sciences, Engineering, and Medicine 2019. *The Promise of Adolescence: Realizing Opportunity for All Youth*. Washington, DC: The National Academies Press. <https://doi.org/10.17226/25388>.



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