marijuana and the teen brain

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in this talk

what is marijuana?

the brain on marijuana

is the teen brain special?

current research
what is marijuana?

- cannabis sativa plant
- leaves, stems flowers
- delta-9-tetrahydrocannabinol = Δ⁹-THC
- main psychoactive ingredient
Δ⁹-THC is the main psychoactive ingredient

Δ⁹-THC activates cannabinoid₁ (CB₁) receptor in the brain.

CB₁ is expressed at high levels in many brain areas.

Two endogenous brain lipids have been identified as CB₁ ligands.
endocannabinoids – ligands for CB₁

- N-arachidonylethanolamine
- Anandamide (AEA)
  - arachidonate-derived neuroactive lipids
- 2-arachidonoylglycerol
- 2-AG
what areas of the brain process marijuana?

- hypothalamus
- basal ganglia
- ventral striatum
- amygdala
- brainstem
- cortex
- hippocampus
- cerebellum
motor controlled planning

initiation of actions

termination of actions

habit pathway

motor controlled planning

initiation of actions

termination of actions

habit pathway
prediction

reward

addiction?

[Diagram of brain showing hypothalamus, basal ganglia, ventral striatum, amygdala, hippocampus, cortex, cerebellum, and brainstem]
anxiety
emotion
fear

- hypothalamus
- basal ganglia
- ventral striatum
- amygdala
- cortex
- hippocampus
- cerebellum
- brainstem
vomiting reflex

pain sensation

sympathetic nervous system reactions
The brain contains various regions such as the hypothalamus, basal ganglia, ventral striatum, amygdala, and brainstem. The cortex, hippocampus, and cerebellum are also highlighted. The diagram outlines:

- **Cognitive Functions**: Higher cognitive functions
- **Sensation Perception**: Sensation and perception
- **Judgment and Pleasure**: Judgment and pleasure
memory formation
learning: facts
sequences
places
hypothalamus
basal ganglia
ventral striatum
amygdala
brainstem
cortex
hippocampus
cerebellum

motor control
coordination
motor learning
doubles risk of car accident - DUI
Three Types of Implicit Learning

- Habituation
- Sensitization
- Classical Conditioning
Most simple form of learning

Initial response to stimuli:
very defensive -

Repeated exposure to stimuli:
Response is muted - Eventually ignored.

Purpose:
Animal needs to learn which stimuli to safely ignore

Eliminates inappropriate or exaggerated defense responses

Important for:
Organizing perception
Sensitization – mirror image of habituation

After a noxious stimulus

the sensitized animal respond more strongly to all stimuli.

Purpose:
Instead of ignoring a stimulus – it is a form of learned fear. Survival.

It teaches the animal to attend and respond more vigorously to almost any stimulus

Konrad Lorenz: “An earthworm that has just avoided being eaten by a blackbird ... is indeed well advised to respond with a considerably lowered threshold to similar stimuli because it is almost certain that the bird will still be nearby for the next few seconds.”
Aversive Classical Conditioning

A neutral stimulus must always precede the aversive stimulus – that way the animal will come to predict it.

Pavlov: shock a dog’s paw. The shock caused the animal to raise and withdraw its leg – a fear response.

Pavlov found that after several trials in which he paired the shock with a bell – first sounding the bell then the shock – the dog would withdraw his paw whenever the bell sounded.

Classical conditioning an association is formed between a pair of stimuli that occur in rapid sequence.

Teaches the animal to associate an unpleasant stimulus with a stimulus that ordinarily elicits no response.
Synaptic strength is not fixed – it can be altered in different ways by different patterns of activity.
Cellular basis of learning and memory

- Learning changes neural responsiveness
- Enhanced functioning of existing neural circuits or the establishment of new ones.
Changes in synaptic efficiency:

1. Normal synapse
2. Increase in release probability
3. Increase in number of release sites
4. Increase in number of vesicles
5. Increase in receptor sensitivity
6. Increase in the number of receptors
7. Increase in number of dendritic spines

PRE-SYNAPTIC

POST-SYNAPTIC

active receptor
hyper-sensitive receptor
silent receptor
synaptic vesicle
released
How do endocannabinoids affect synaptic transmission?

Pre-synaptic

Post-synaptic

Voltage-dependent Ca++ channels open & Ca++ enters the terminal.

Xmtr is released from synaptic vesicle

Xmtr binds to receptor and the channel opens.

Post-synaptic depolarization opens voltage-dependent Ca++ channels → which activates endocannabinoid synthesis.
endocannabinoid signaling is critical during development
what now?

- hypothalamus
- basal ganglia
- ventral striatum
- amygdala
- brainstem
- cortex
- hippocampus
- cerebellum