MPI
Marijuana
Prevention
Initiative
San Diego County

MPI Literature Review - Marijuana's effects on the adolescent brain

General Summary:

- **Marijuana use appears to have a significant effect on adolescents' brain structure and development. In particular, heavy marijuana use is associated with attention, memory, and planning problems as well as slower brain-processing power. Users may perform some tasks as well as non-users, but they typically require more brain processing power to perform the tasks. They also experience more difficulties in exercising inhibition.**
- **During late adolescence, young people's brains begin to shrink and prune gray matter. Marijuana use appears to hinder this natural pruning process, which causes sections of adolescent users' brains to be abnormally sized. Particularly among female adolescent users, these larger sections are associated with symptoms of depression and anxiety.**
- **Marijuana appears to affect the brain even after adolescents stop using it for 1 month. However, it is uncertain whether the effects persist beyond 3 months of abstinence.**

Citation	Summary/ Notes
Tapert et al. (2007). Functional MRI of inhibitory processing in abstinent adolescent marijuana users. *Psychopharmacology*.	- **Research Question:** Do brain abnormalities persist after adolescents stop using marijuana? Do adolescents continue to face problems with exercising inhibition after they stop using marijuana? - **Method:** Participants were adolescents between 16- 18 years old. Sixteen were marijuana users with at least 60 lifetime episodes of cannabis use and limited histories of other drug use. Seventeen were non-marijuana users. The participants were asked to complete a go/no go task after a 4-week period of marijuana abstinence. The go/no go task required participants to watch a screen flashing various shapes intermittently. Participants would press a button every time they saw a shape that was not square. This allowed researchers to gauge the young people's ability to stop themselves from responding to something. Researchers examined participants' brain-processing during the task through fMRI scans. - **Results:** Users and non-users performed equally well on the test. However, marijuana users needed more brain-processing power to complete the task than non-users. The most abnormal results were among older adolescents who were using MJ for short periods of time (though it may be helpful to keep in mind that there were only 16 MJ users). Tapert et al. suggest that long-term users' brains may have developed ways to adapt to marijuana use, and so

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	their brains responded more like the non-using control group. By contrast, the short duration users' brains may not have developed the ability to adapt to cannabis use. - **Implications:** The effects of marijuana use persist even after teens stopped using the drug for a month. By using marijuana, young people may need to devote more brain-power to inhibiting responses. It's essential for young people to have inhibitory control in school, work, and social relationships. Those who require more brain-power to inhibit responses may be less successful in transitioning to adulthood. It may also be more difficult for these young people to stop using other substances. - **Interesting References**: They refer to some research that finds that MJ use is associated with decreased attention, learning, and memory among young people.

Bava et al (2009). Altered white matter microstructure in adolescent substance users. Psychiatry Research: Neuroimaging	- **Research Question:** How does early marijuana and alcohol use affect the brain's white matter?
	  - White matter transmits signals from one region of the brain to another and therefore acts as a channel of communication between different regions of the brain. It affects how the brain learns and dysfunctions (according to a quick search on "white matter" from Wikipedia).
	- **Method:** Using Diffusion tensor imaging (DTI), they examined the differences in white matter among 36 marijuana and alcohol users' brains and in 36 non-users' brains (ages 16-19). They compared brain images to see where abnormalities exist in users.
	- **Results:** Adolescent marijuana and alcohol users exhibited abnormal white matter. Users exhibited lower FA (fractional anisotropy—this might concern the brain's ability to send direct signals; lower levels indicate more diffused signals). In some cases, it appears that the users' brains adapted to abnormalities in certain sections of white matter by using other neural pathways.
	- **Implications:** Findings reveal abnormalities within brain circuits that are responsible for complex cognitive, motor, and sensory processing.
	  - Given that marijuana users are often heavy alcohol users, it's important to

	study the two substances' combined effects. - **Interesting References:** They refer to several studies that suggest that, compared to non-users, marijuana users use different neural networks to complete tasks. This may occur because users have lower-caliber white brain matter than non-users.
Jacobus et al. (2009). Functional consequences of marijuana use in adolescents. *Pharmacology, Biochemistry and Behavior.*	- **Research Question:** [THIS IS A LIT REVIEW] How does marijuana use affect adolescents' neuropsychological functioning, brain structure, brain function, and sleep? - **Method:** They review several studies and summarize conclusions. - **Results:** Adolescents who use marijuana have disadvantaged attention, learning, and processing speed. Users have some subtle abnormalities in brain structure and generally require more brain processing to complete tasks (though they can perform tasks as well as non-users). They also have problems with sleeping. Some abnormalities persist after a month of marijuana abstinence, but many abnormalities may stop after 3 months of abstinence. - **Implications:** Adolescent MJ users may be at increased risk for impaired brain functioning. Use may therefore hurt school performance (by making it more difficult to remember information), impair driving, and provoke risky decision-making. - **Interesting References:** - In one study, marijuana onset before age 17 was associated with impaired

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	reaction time on a task of visual scanning and attention. - Another study suggests that early onset is linked to decreases in verbal memory, IQ, and fluency. - There are other studies that suggest that marijuana dependent adolescents had problems with verbal and non-verbal memory; yet the trend improved after the young people stopped using marijuana for 6 weeks. - Those who start using marijuana at earlier ages are more susceptible to cannabis' toxic long term effects on brain development. - Chronic marijuana use may disrupt mood. - It's uncertain whether changes in brain structure among marijuana-using adolescents persists into adulthood. - Compared to adult marijuana users, teens may be more resilient against marijuana's effects on their sleep cycles.
Jacobus et al. (2011) Altered cerebral blood flow and neurocognitive correlates in adolescent cannabis users. *Psychopharmacology*.	- **Research Question:** How does marijuana use affect cerebral blood flow (CBF) in adolescents? - Abnormalities in cerebral blood flow may contribute to pathological changes in the brain. - **Method:** The study compared brain scans of 23 heavy adolescent marijuana users (with more than 200 lifetime use episodes) to those of 23 controls (with limited substance exposure). Participants' brains were scanned at the beginning of the study (baseline) and then after 4 weeks of marijuana abstinence. Participants were between 15-18 years old. - **Results:** At baseline, marijuana users had less blood flow in four regions of the brain and more blood flow in one region. When controlling for heavy drinking and smoking, marijuana use had no effect on the region where it was associated with higher blood flow. There were no differences between users' and non-users' cerebral blood flow (CBF) after 4 weeks of marijuana abstinence. - **Implications:** Adequate CBF is critical for brain developmental processes that continue into late adolescence. The abnormal blood flow in marijuana users may contribute to or underlie changes in bran activation, neuropsychological performance, and mood. Results suggest that marijuana use may alter

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<td>patterns of healthy neurodevelopment in adolescents. Both neural tissue and neural signaling may be damaged by marijuana use. However, it appears that young people can recover from abnormal blood flow by abstaining from marijuana use.
- Interesting References: Most studies report an increase in CBF immediately after the subject uses marijuana. High CBF rates are typically associated with decreased cognitive performance.</td>
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<td>McQueeny et al. (2011). Gender effects on amygdala morphometry in adolescent marijuana users. Behavioural Brain Research.</td>
<td>- Research Question: How does marijuana use affect the size of the adolescents' amygdala? How does the size of the amygdala affect the anxiety/ depression symptoms?
- The amygdala section of the brain processes memory and emotional responses (according to a Wikipedia search on "amygdala").
- Methods: Participants included 35 chronic marijuana users and 47 non-users between the ages of 16-19 years old. Data on substance use, anxiety/ depression symptoms, and brain scans were collected after a 28-day abstinence period.
- Results:
- Female marijuana users had larger right amygdalas and more anxiety/ depression symptoms than non-users. Among the female MJ users, large right amygdalas were associated with anxiety/ depression. Among others (female non-users and males), smaller right amygdalas were associate with anxiety/ depression symptoms.
- Overall, being a MJ user was associated with worse mood/ anxiety symptoms.
<table>
<tr><th></th><th>Female No MJ</th><th>Female MJ</th><th>Male No MJ</th><th>Male MJ</th></tr>
<tr><td>Amygdala Size</td><td>Normal</td><td>Larger right amygdala than control females</td><td>Normal</td><td>Normal</td></tr>
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	<table><tr><td>Anxiety/ Depression Symptoms</td><td>Normal</td><td>More than control females</td><td>Normal</td><td>Normal</td></tr></table>
	- **Implications:** Brains typically shrink as adolescents mature into adulthood. The results suggest that marijuana exposure during adolescence may impair the typical brain pruning phase that occurs during adolescence. This is particularly problematic among girls. Marijuana effects during adolescence may leave teenage girls particularly vulnerable to brain damage. Interventions targeting teen marijuana use may reduce risks for developing substance abuse disorders or symptoms of anxiety/ depression.
	- **Interesting References:**
	  - Adolescent females who abuse substances experience the negative consequences of drug use earlier than their male peers.
	  - Subclinical depression symptoms have been reported in conjunction with reduced white matter in teen marijuana users.

Medina et al. (2010). Abnormal cerebellar morphometry in abstinent adolescent marijuana users. *Psychiatry Research: Neuroimaging*.	- **Research Question:** How does prior marijuana use affect cerebellar volume in abstinent users (those who were chronic users, but have abstained for 1 month)? - The cerebellum is the part of the brain associated with motor control. It can also be involved in cognitive functions like language and attention (according to a Wikipedia article on the cerebellum). The study therefore aims to examine how marijuana affects the size of the cerebellum—and particularly the vermis lobe, a section of the cerebellum. - **Method:** Participants included 16 marijuana users and 16 non-users, aged 16-18 years old. Marijuana users had more than 60 lifetime experiences with marijuana, a past month experience, less than 25 lifetime uses of another drug, and were not heavy alcohol users. The control group had less than 5 experiences with marijuana. Researchers performed a brain scan on the participants and collected their neuropsychological and drug use history after a 28-day monitored abstinence period.

	- **Results:** Users had significantly larger vermis volumes. Larger vermis volumes were associated with poorer executive functions (planning, memory, attention, multi-tasking, etc).
	- **Implications:** The results suggest that chronic MJ exposure interrupts the gray matter pruning process that occurs in adolescence. As young people's brains mature and develop, they prune gray matter. The larger size of the MJ users' vermis lobes suggests that the pruning process may not be occurring normally. In other studies, abnormal vermis volumes have been found in patients with multiple episodes of depression. Other studies also link larger vermis lobes to attention deficit disorders.
	- **Interesting References:**
	  - It's important not to generalize findings from adult studies to youth. The endocannabinoid continues to develop during adolescence. So, studies that indicate that MJ use does not affect adult brains are not generalizable to young people's brains. That's why it's important for researchers to focus on youth separately.
	  - In adolescents, chronic MJ exposure has been associated with slower psychomotor processing speed and poorer executive functioning.

Medina et al. (2007). Neuropsychological functioning in adolescent marijuana users: Subtle deficits detectable after a month of abstinence. *Journal of the International Neuropsychological Society.*	- **Research Question:** How does past marijuana use affect neuropsychological functioning (attention, memory, planning and sequencing ability, and psychomotor speed) in abstinent users? - **Method:** Participants included 31 marijuana users and 34 controls, ages 16-18 years old. Neuropsychological assessments were conducted after a 28-day abstinence period. - **Results:** Higher lifetime MJ use was associated with poorer complex attention and verbal story memory. Controlling for depressive symptoms and alcohol use, abstinent MJ users had poorer psychomotor speed, complex attention, sequencing ability, and verbal story memory than non-users. - **Implications:** Results indicate that marijuana continues to affect adolescent brains even after a month of abstinence. Medina et al. suggest that MJ's effects persist because MJ affects adolescents' brain development. The study also has implications for young people's performance in school. Young people

	who use marijuana may miss information presented in class due to poorer processing speed, attention, and working memory. The study lends further evidence to research that suggests that marijuana use is associated with poorer attention, memory, and sequencing ability. - **Interesting References:** - Compared to other polydrug users (non-MJ), MJ users in a treatment program demonstrated short-term memory challenges after 6 weeks of abstinence.
Schweinsberg et al. (2010). The Influence of Recency of Use on fMRI Response During Spatial Working Memory in Adolescent Marijuana Users. *Journal of Psychoactive Drugs*.	- **Research Question:** Does the adolescent brain recover from marijuana use after a period of abstinence? - **Method:** Participants included 13 recent MJ users (2-7 day abstinence), 13 abstinent users (27-60 day abstinence), and 18 non-using controls, aged 15-18 years old. They performed two spatial working memory (SWM) tasks during an fMRI. During the task, participants watched line drawings presented in one of 8 locations on a computer screen. Participants pressed a button every time they saw a repeated image in the same place as it was earlier. Participants were also asked to press a button every time a figure appeared with a dot over it. - **Results:** Compared to teens who had abstained from MJ for 27 days, heavy marijuana users (with 2-7 day abstinence) demonstrated greater brain response in certain areas of the brain. Non-users did not demonstrate any significant response in these areas of the brain. The higher brain activity among MJ users indicates that users may recruit other areas of the brain to maintain performance levels. Heavy MJ users also demonstrated higher insula response, which may suggest that they need more effort to exercise inhibition. The higher level of insula response among heavy MJ users may also indicate that it is more difficult for these individuals to avoid relapsing into substance abuse. - **Implications:** The difference between abstinent and current MJ users suggests that sustained abstinence may be associated with improved memory responses. However, given that there was more brain activity in the abstinent

	group than the control group, MJ's effects appear to persist even after a month of abstinence.