The legalization of marijuana controversy: the brain's perspective

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Introduction

Canada has the highest rate of youth marijuana use in the developed world with 28% of children aged 11-15 and 47% of 18-19 year olds having used cannabis in the past year. Further, marijuana is the most common illicit drug in North America. Past brain imaging research has shown that both prenatal exposure to marijuana and teen use can alter the brain's development and negatively impact the neurophysiological basis of executive functioning. Executive functioning includes such essential cognitive tasks as decision-making, planning, organizing, working memory and goal-directed behaviours, which are primarily controlled by the frontal cortex of the brain.

A critical period in neuro-maturation occurs during adolescence during which the developing brain is particularly vulnerable to the harmful effects of regular marijuana use. The objective of the present study is to examine fMRI blood oxygen level-dependent response (BOLD) among current adolescent marijuana users and non-using controls during the 2-Back working memory task to better understand the impact of regular marijuana use on working memory.

Methodology

Participants age from 19 to 21 year olds and are all from the OPPS (Ottawa Prenatal Prospective Study). The OPPS is an ongoing longitudinal investigation initiated in 1978, with the primary objective of examining the effects of "soft" prenatal drug exposure on offspring. Children were followed from infancy to young adulthood and detailed information has been collected on their prenatal drug exposure, current and past drug use, cognitive/behavioural performance, and over 4,000 lifestyle variables.

This study imaged 10 marijuana users and 14 non-using controls while they performed the 2-Back working memory task. Regular marijuana use is defined as at least 1 joint per week for at least 3 years. fMRI blood oxygen level-dependent response was examined and reaction times for each response and errors of both commission and omission were recorded. All imaging took place at The Ottawa Hospital (General campus) using the 1.5 Tesla Siemens Magnetom Symphony MR scanner.

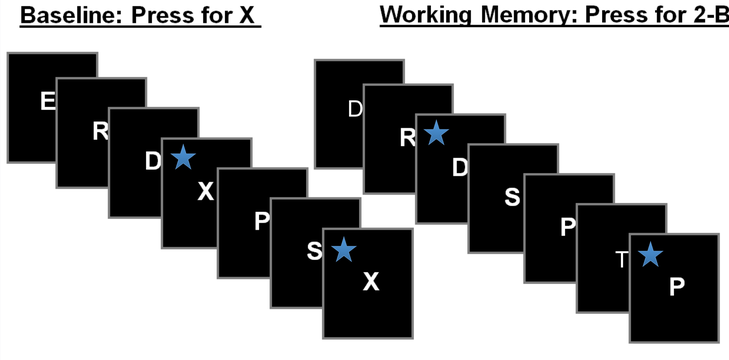


Figure 1. Example of the 2 conditions presented during the N-Back Task. Letters were presented sequentially. Each box containing a letter represents a screen presented to the participants. The diagram illustrates with a star (not present in the real task) the letter presentations that would require a button press according to the task directions.

Results

Fixed effects group analyses revealed a similar pattern of activation during the 2-Back working memory task for both groups of participants, demonstrating that the task was activating the expected brain regions including the dorsolateral prefrontal cortex. There were no significant performance differences between marijuana users and non-using controls on reaction time and errors of both commission and omission. Despite similar task performance, marijuana users had significantly greater activation in several prefrontal regions, including the superior medial prefrontal gyri, the inferior frontal gyri, and the left middle temporal gyrus – all contributing to the executive function of working memory. The increased activations of these brain regions postulate that the brain is working harder (expending more energy and glucose) in order to complete the presented 2-Back task, compared to the non-user group. Regions typically not associated with working memory (particularly the right superior occipital gyrus) were, in fact, activated in the marijuana user group, suggesting that the brain may be engaging in compensatory strategies in order to complete the task. These results suggest that marijuana use leads to altered neurocognitive functioning during the 2-Back working memory task.

Figure 2. Superior Medial Prefrontal Gyri

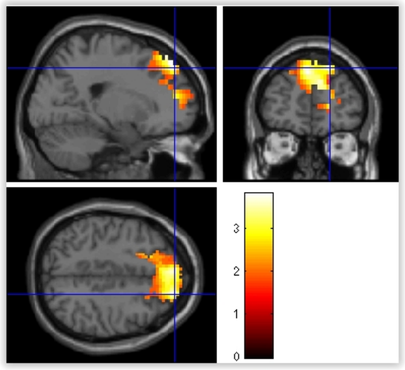


Figure 3. Inferior Frontal Gyrus

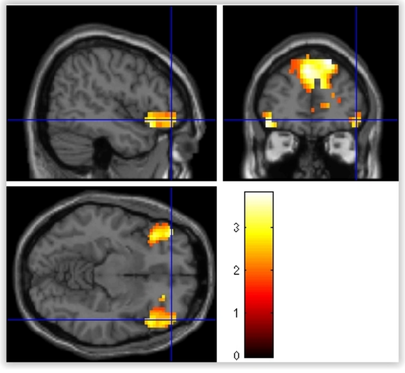


Figure 6. Brain activations where marijuana users show significantly more activity than non-users.

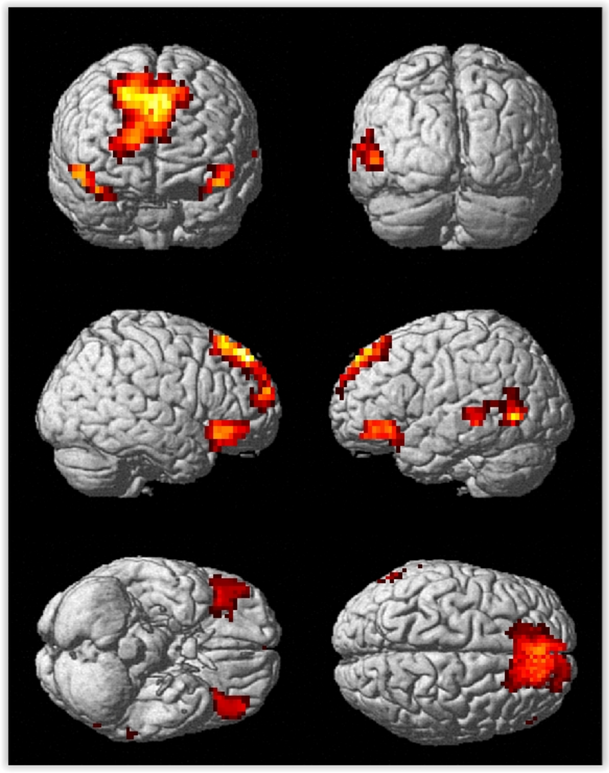


Figure 4. Left Middle Temporal Gyrus

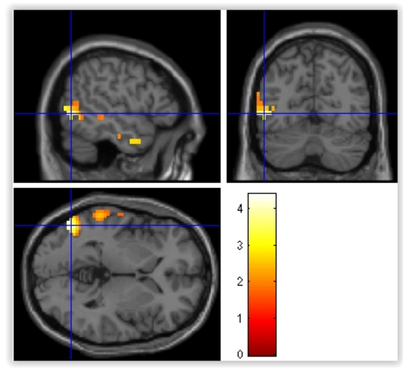
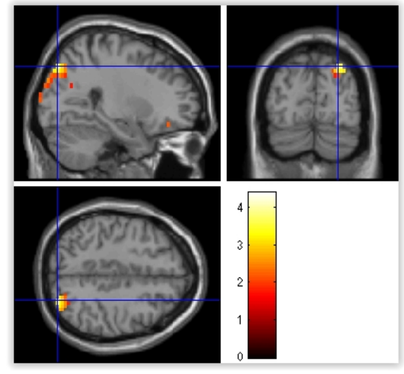


Figure 5. Right Superior Occipital Gyrus



Conclusion

The present study examined fMRI brain activity among current marijuana users and non-using controls, from the OPPS, during the 2-Back working memory task. The results provide further evidence that regular marijuana use significantly impacts neural activity during working memory. Challenged with a harder task than the 2-Back working memory task, current marijuana users may not be able to compensate and performance may suffer. Support for this hypothesis can be derived from several neurocognitive studies that used more difficult tasks and found performance deficits among marijuana users compared to controls. This significant impact of marijuana on brain functioning at such a young age is important for future neural development and should be widely acknowledged and discussed in an attempt to reduce the possible long-term detrimental effects that early use may have on the brain. Indeed, given the policy changes expected in the summer of 2018, which will legalize marijuana in Canada, it is essential that we fully understand the impact of cannabis on the brain, specifically on the developing brain of adolescents and its long-term effects.

Acknowledgments

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