The effects of prenatal marijuana exposure on brain structural volume

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Introduction

The upcoming legislation regarding the legalization of marijuana will expand the availability of this drug to a greater number of people. Understanding the long term consequences of prenatal exposure to marijuana is vital in understanding the effects on the brain. This is imperative as a growing number of women are using marijuana for morning sickness as well as for pleasure.

Canada has one of the highest rates of youth marijuana use in the developed world. This high rate of use has led to numerous teens becoming apathetic, unmotivated and perform poorly leading to a decrease chance of future life successes. As there is considerable confusion surrounding the long term effects of marijuana use, especially during the developmental years, this study seeks to provide empirical evidence of the significant long term effects on brain volume, cognition and brain function. This study is one of the first to use an innovative methodology, magnetic resonance imaging (MRI), a longitudinal study design and a multifactorial approach to study the change in brain structure and volume that occurs with marijuana use.

This study investigates the effects on the brain post prenatal marijuana exposure. A group of 31 individuals from the Ottawa Prenatal Prospective Study (OPPS) were scanned in which 16 were prenatally exposed to marijuana and 15 had no exposure. These brain scans were examined using voxel-based morphometry (VBM). Global grey and white matter volumes were analyzed and compared between the two groups to assess the effects of prenatal exposure on the brain. This approach allowed for a focal analysis of the long term effects of prenatal marijuana exposure on brain anatomy.

Methods

Participants:

- 31 participants recruited from Ottawa Prenatal Prospective Study (OPPS)
- 16 had prenatal marijuana exposure- 15 had no prenatal marijuana exposure

Procedure:

- Marijuana habits of participants were followed since participants were teenagers
- Participants had been tested since birth through the OPPS
- Structural and Functional MRI was performed using a 1.5 Tesla Siemens Magnetom Symphony MR scanner at the Ottawa Hospital (General campus) – only structural presented here
- Structural MRI was examined with a T1 weighted 3D FLASH (Fast Low Angle Shot) sequence (TR/TE 629/15 ms, flip angle 90°, FOV 187 × 250 mm2 , 256 x 192 matrix, slice thickness 5 mm, 27 axial slices, bandwidth 62.5 kHz)
- Voxel-based morphometry (VBM8 with SPM8) was used to examine the T1 scans
- Images were segmented into grey and white matter and CSF
- Two-sample t-tests were used to compute and co-vary the global difference and specific regional changes in grey and white matter volumes, accounting for potentially confounding variables (for e.g. current marijuana use)
- This approach allows for a focal analysis of the brain anatomy and the impact of prenatal marijuana on long term brain health.

Results

This experiment produced results in providing various brain scans of participants that allowed for a further analysis of the white and grey matter of the two test groups. These brain scans allowed for a comparison between the individuals with prenatal exposure to marijuana to the individuals who lacked this exposure. From these analysis it was shown that there were differences between these two groups. As Figure 1 and Figure 2 depict these are areas that showed the most difference in brain matter volume between the two test groups.

Figure 1: Grey Matter – Cerebellum and Postcentral Gyrus

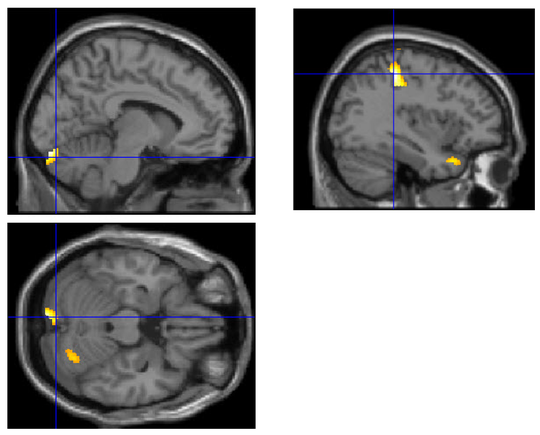
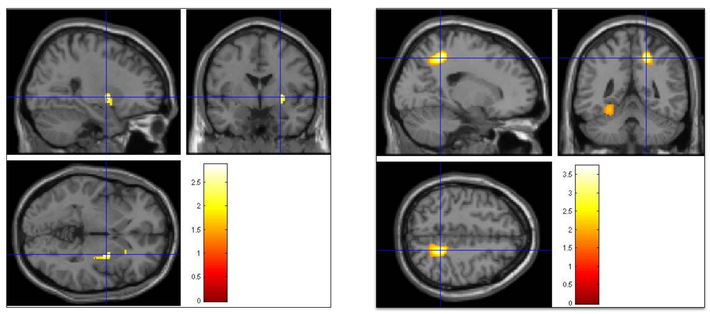


Figure 2: White Matter – Putamen and Superior Parietal Lobule (SPL)



- Prenatally exposed showed smaller grey matter volume compared to non-prenatally exposed.
- Prenatally exposed group also showed larger white matter volume
- Brain areas with most difference in volume between the two test groups:
  - Putamen (localized to right side) involved in a very complex feedback loop that prepares and aids in movement
  - Precentral gyrus- motor strip, primary motor area; controls the voluntary movements of skeletal muscles
  - Precuneus- wide spectrum of highly integrated tasks, including visuo-spatial imagery, episodic memory retrieval and self-processing operations, namely first-person perspective taking
  - Superior parietal lobule including Postcentral gyrus- spatial orientation, and receives visual and sensory input from one's hand; involved in parietal lobe functions of sensation, perception and the integration of sensory input.

Conclusions

Based on the results of this study, it was observed that prenatal marijuana exposure did have an effect on brain anatomy in terms of global grey and white matter volume. As hypothesized, the prenatally exposed individuals did have a difference in their grey matter volume compared to those who did not experience prenatal exposure to marijuana. It is interesting that the main areas of difference all have a role in movement, sensation and cognition.

These results are important because they yield some interesting effects on the brain of individuals who have experienced prenatal exposure to marijuana. These insights will benefit future research and will allow for proper guidelines and legislations to be put in place for marijuana use, especially pregnant women. These results are also a great foundation to further explore the effects on the developing brain in terms of structure, volume and function.

To extend this research further, it would be interesting to analyze the data in terms of the confounding variables and examine the relationship between the brain structure of those individuals who are still using marijuana, those who have never used marijuana and those individuals who previously used but have since quit. Additionally, it would be interesting to further explore the reasons behind why the differences in the putamen were localized to the right side. Furthermore, exploring the differences in total brain volume between prenatally exposed and those with no prenatal exposure would be intriguing. One last expansion would be to test the differences in voluntary movement, visuospatial imagery and self processing operations between these two groups to further examine the long term extent of prenatal exposure to marijuana.

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Acknowledgments

I would like to thank my supervisor, Andra Smith for all the support, guidance and assistance throughout this project. I would also like to thank the University of Ottawa UROP for providing this opportunity.

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