Measuring the effects of prenatal marijuana exposure on response inhibition using fMRI

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Introduction

The purpose of this experiment was to investigate the lasting prenatal effects of marijuana exposure on response inhibition as measured by performing the block design Go/No-Go task while having neural activity measured by functional magnetic resonance imaging (fMRI). It has been previously shown that 18 to 22 year olds exposed to marijuana prenatally show greater activity in the bilateral prefrontal cortex and right pre-motor cortex during response inhibition. This finding was seen in participants who are a part of the Ottawa Prenatal Prospective Study (OPPS) (Smith, Fried, Hogan & Cameron, 2004). In this experiment it was sought out to determine if the effects of being prenatally exposed to marijuana, regarding response inhibition as seen in Smith et. al. (2004), continued past the age of 22 using participants from the OPPS at age 28-32. The importance of these results are to show if the effects of prenatal exposure to marijuana on neurophysiological functioning, regarding response inhibition, remain in early adulthood.

Methods

A total of 9 participants were scanned 5 of which were exposed to marijuana prenatally and 4 of those who were not. Each participant spoke English as their first language and was at least 28 years of age at the time of testing. All participants were raised in middle class homes with married parents of which none had been diagnosed with an Axis I diagnosis from the DSM – IV at the time of pregnancy. Each participant was scanned in a 1.5-T Siemens MR scanner while laying flat on their back with their head in a standard head holder to keep from moving. While in the scanner each participant performed a block design Go/No-Go response inhibition task. The participants observed a screen through a mirror on the head holder and were instructed to respond using their right index finger on a fiber-optic response pad. There were two conditions for the task. In the press for X condition participants were instructed to press for every presentation of X and to refrain from pressing for all other letters. In the press for all but X participants were instructed to press for all letters presented except for X. For both conditions 50% of the letters were X and 50% were other letters from the alphabet. Each condition was separated by a rest period and there were four trials for each condition always starting with the press for X condition. Post imaging analysis was performed using SPM8.

Results

Two-sample t-tests revealed significant differences in neural activity between those exposed to marijuana prenatally compared to those who were not. Prenatally exposed participants showed significantly less activity than non-exposed participants in the anterior cingulate gyrus, superior frontal gyrus, post central gyrus and the culmen of the cerebellum, all of which were lateralized to the right side of the brain as presented in Figure 1. In addition, the prenatally exposed participants had significantly greater activity than non-exposed participants in the superior temporal gyrus, and posterior cerebellum, again all lateralized to the right side of the brain as seen in Figure 2.

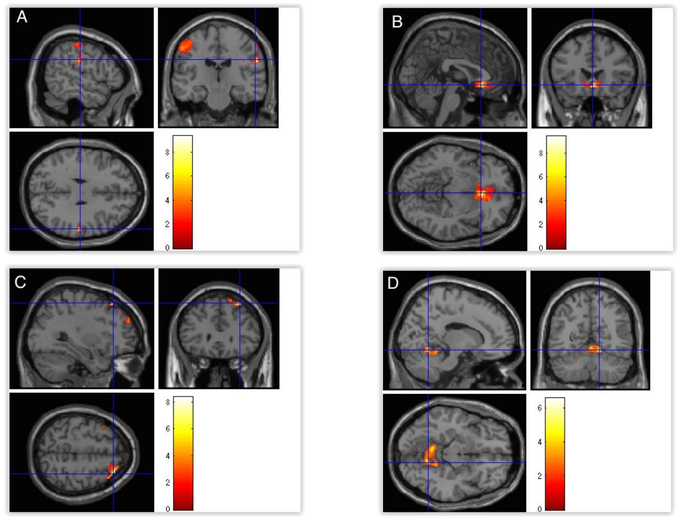

Fig.1 – Regions with larger activity observed in those not exposed to marijuana prenatally (A) Regional activity difference in post central gyrus *x,y,z*= 50, -30, 58 (MNI coordinates); z=3.80; and P=0.001. (B) Regional activity difference in anterior cingulate gyrus *x,y,z*= 2, 22, -8 (MNI coordinates); z=4.16 and P=0.003. (C) Regional activity difference in superior frontal gyrus *x,y,z*= 16, 46, 52 (MNI coordinates); z=3.27 and P=0.034. (D) Regional activity difference in culmen *x,y,z*= 14, -58, -12 (MNI coordinates); z=3.61 and P=0.041.

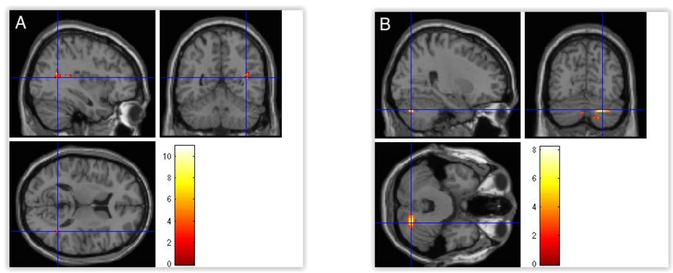

Fig.2 – Regions with larger activity observed in those exposed to marijuana prenatally. (A) Regional activity difference in the superior temporal gyrus *x,y,z*= 38, -54, 12 (MNI coordinates); z=4.38; and P=0.001. (B) Regional activity difference for uvula *x,y,z*= 26, -72, -32 (MNI coordinates); z=3.95; and P=0.039. Regional activity differences for the pyramis and cerebellar tonsils were excluded due to their images being practically identical to that of the uvula.

Discussion

The regions of the brain where group differences were observed in this study coincide with areas involved in response inhibition. Reduced activity in the anterior cingulate gyrus, as well as the superior frontal gyrus and post central gyrus, suggest deficits in response inhibition and response selection, both involved in tasks such as the Go/No-Go task (Liddle, Kiehl, & Smith, 2001). The decreased activity in the anterior cerebellum (culmen) is in concordance with previous findings from Smith et. al. (2004) which showed a negative relationship between anterior cerebellar activity and prenatal marijuana exposure. The areas with increased cerebellar activity (pryamis, uvula, and cerebellar tonsil) for those prenatally exposed could provide evidence for a possible compensatory effect as cerebellar activity has been linked with this type of response inhibition task. This difference in cerebellar activity could be explained by the large density of cannabinoid receptors found in the developing brain (Glass, Faull, & Dragunow, 1997) especially in the cerebellum. It is not improbable that prenatal marijuana exposure could have an altering effect on cerebellar development causing differences in regional activity that are still visible in early adulthood. The lateralization component proves interesting as the task is letter based, thus one would hypothesize more left side recruitment. This decreased activity in the anterior cingulate, superior frontal, and post central gyri yet increased activity in the superior temporal gyrus and cerebellum, all on the right side, for those prenatally exposed could be evidence of a different neural network being used to compensate for the difficulty of the task as compared to those not prenatally exposed. Regardless of the mechanism for the differences these results provide neurophysiological evidence that the effects of prenatal marijuana exposure do last into early adulthood.

Conclusion

Response inhibition is required for many types of executive functioning tasks. Significantly altered neural activity is still observable in prenatally exposed participants from the OPPS at the ages of 28-32 during a response inhibition task. This study provides neurophysiological evidence to support a possible compensatory effect still observed into early adulthood for those exposed to marijuana prenatally when performing a response inhibition task. These results highlight the importance of education for women of childbearing years, particularly given the current move towards policy changes with the drug in Canada .

References

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