Cortical Thickness and Subcortical Volumetric Differences Associated with Marijuana Use

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Background

With recent legalization of medical or recreational marijuana (MJ) use in the US, it is expected that the prevalence of MJ use and abuse will increase. Understanding the effects of MJ, particularly on the maturing brain, therefore remains an important public health endeavor. Given ongoing brain maturation during adolescence that lasts into early adulthood, MJ use during this developmental stage may therefore confer greater neurobiological consequences.

The endocannabinoid system is broadly distributed throughout the CNS and is viewed as a modulatory brain system affecting multiple synapses. CB1 receptors are found in high concentrations in association cortices (frontal and occipito-temporal), as well as in subcortical regions including the hippocampus, amygdala, thalamus, pallidum and cerebellar cortex (Glass et al, 1997). The endocannabinoid system has been implicated in modulating cognition, memory, motivation, and emotional processing (Huber and Knutson, 2010). In this study, structural differences in the cortical thickness and subcortical volumes were examined in young adult MJ users relative to non-users.

Methods

Participants: 15 marijuana users (MJ; 2 females) and 15 non-using controls (NC; 2 females) were included. Ages ranged between 18-30 years old. The study protocol was approved by the McLean Hospital IRB. All participants were free of Axis I diagnoses (except for MJ abuse), neurological illness and severe medical problems.

Clinical Variables: Profile of Mood States (POMS; McNair et al., 1971), the Barratt Impulsiveness Scale (BIS-11, Patton et al., 1995), and the Positive Affect/Negative Affect Schedule (PANAS; Watson et al., 1988).

Structural MR Imaging: High-resolution anatomical images were obtained on a 3.0 Tesla Siemens Trio at the McLean Imaging Center, using the following parameters: 128 slices, 2562 matrix, echo time (TE)=2.7ms; repetition time (TR)=2100ms; inversion time (TI)=1100ms; flip=12°.

Cortical Thickness (CT) and Subcortical Volumetric Processing and Analysis: Cortical surface reconstruction and thickness estimates were performed using Freesurfer (http://surfer.nmr.mgh.harvard.edu). Statistical comparisons of whole-brain surface maps were conducted using the Freesurfer analysis suite to compare CT between groups. Surface maps in each hemisphere were defined by statistical thresholds of $p = 0.01$, and were smoothed to a full-width half-maximum (FWHM) level of 10. A priori regions of interest (ROI) analyses of cortical thickness, based on prior studies of MJ and NC groups, included the ACC, PCC, and dLPFC. A priori ROI analyses of subcortical volumes included thalamus, pallidum, cerebellar cortex and amygdala. Analyses of subcortical volumes included intracranial volume as covariate.

Demographic and Clinical Data

<table>
<thead>
<tr>
<th>Variable</th>
<th>NC</th>
<th>MJ</th>
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<tbody>
<tr>
<td>Age</td>
<td>22.5 ± 0.9</td>
<td>24.8 ± 0.9</td>
</tr>
<tr>
<td>Education</td>
<td>15.1 ± 0.5</td>
<td>14.0 ± 0.4</td>
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<tr>
<td>No. Drinks/week</td>
<td>3.85 ± 3.8</td>
<td>4.92 ± 3.9</td>
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<tr>
<td>Age at onset</td>
<td>16.7 ± 0.5</td>
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<tr>
<td>Use duration (years)</td>
<td>5.6 ± 0.8</td>
<td></td>
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<tr>
<td>Lifetime Smokes</td>
<td>300 ± 502</td>
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<tr>
<td>THC/Creat (mg/ml)</td>
<td>249 ± 99.7</td>
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BIS motor

Motor performance (19.0 ± 1.3 vs. 23.4 ± 1.2; $F_{(1,29)}=4.312, p=0.05$)

BIS non-planning

Non-planning measure (23.0 ± 1.2 vs. 28.1 ± 1.1; $F_{(1,29)}=3.83, p=0.05$)

BIS total

Total score (58.0 ± 2.79 vs. 69.9 ± 2.89; $F_{(1,29)}=7.179, p<0.01$)

Results

CT was greater in NC than MJ users in R fusiform gyrus (RFG).

RFG thickness was not correlated with age of MJ use onset, duration of use, THC:creatinine ratio, or lifetime use in MJ users.

Imaging Data

CT was greater in NC than MJ users in R fusiform gyrus (RFG). CT was greater in NC than MJ users in R fusiform gyrus (RFG).

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Data from this study suggests neuroanatomical substrates fusiform gyrus and thalamus, that may be neurobiologically vulnerable to MJ exposure, leading to deficits in areas of cognition mediated by these regions.

Discussion

The fusiform gyrus has been implicated in visual attention and representation, by combining object specific information to aid in forming unified leading to deficits in areas of cognition mediated by these regions.

CB1 receptors are also expressed in thalamus and have been implicated, among other roles, in modulating visual information sent to cortex by maintaining stimuli salience (DaSilva et al, 2011). Previous studies have shown that MJ users allocate attentional resources differently from non-users across a variety of attentional domains (Kempel et al., 2003), including visual attention (Vivas et al, 2012).

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