Post-Prandial Brain Response to High-Calorie Visual Food Cues is Greater in Obese vs. Lean Children

Ellen A Schur¹, Susan J Melhorn¹, Kelley Scholz²,³, Mary Rosalynn De Leon¹, Maya Rowland², Gabrielle D’Ambrosio³, Elizabeth Aylward³, Brain E Saelens², Christian L Roth³

¹University of Washington, Dept. of Medicine; ²Seattle Children’s Research Institute, Center for Child Health, Behavior and Development; ³Seattle Children’s Research Institute, Center for Integrative Brain Research.

*Authors have no conflicts of interest to report.
The growing childhood obesity epidemic highlights the need to identify underlying neurobiological mechanisms.

We used functional magnetic resonance imaging (fMRI) to characterize brain responses to visual food cues before and after a meal in obese and normal weight children.

We investigated the hypothesis that in critical satiety-related brain regions, obese children do not reduce activation by high-calorie food cues after eating relative to normal weight children, indicative of a blunted central satiety response.
Methods

<table>
<thead>
<tr>
<th></th>
<th>Normal Weight</th>
<th>Obese</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>21</td>
<td>34</td>
</tr>
<tr>
<td>Female (%)</td>
<td>48%</td>
<td>41%</td>
</tr>
<tr>
<td>Age (y)</td>
<td>10.4±0.9</td>
<td>10.6±0.8</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>16.9±1.3</td>
<td>28.5±6.6</td>
</tr>
<tr>
<td>BMI (%tile)</td>
<td>46±18</td>
<td>98±1.1</td>
</tr>
<tr>
<td>BMI (z-score)</td>
<td>-0.11±0.47</td>
<td>2.16±0.30</td>
</tr>
</tbody>
</table>

**Study Visit.** Fasting participants received meals based on their estimated daily caloric needs (Breakfast 10%; Test meal 33%) and underwent 2 fMRI scans.
Subjective hunger and fullness rating.
All meals significantly suppressed hunger and increased fullness in both groups, but the degree of change did not differ between groups. Gray bars indicate fMRI and arrows represent the 3 meals. *P<0.01 significant meal-induced changes.
**Visual Food cues.** Representative images of easily recognizable high-calorie foods, low-calorie foods, and objects.
Region of interest (ROI)-specific voxel-wise activation maps (high- vs. low-calorie food images)

Color scales provide Z-values of functional activation.
After a meal, brain activation to images of high-calorie food was higher in obese compared to normal weight children.
Brain activation to images of high-calorie food was higher in obese compared to normal weight children:
- Before a meal in the ventral striatum, and
- After a meal in the medial orbitofrontal cortex

Overall activation was higher in obese children in ventral and dorsal striatum.
Across all subjects post-meal global brain activation was positively associated with BMI z-score. In regional analyses, significant associations with BMI z-score and brain activation were present in the insula and dorsal striatum.
Objective Satiety. Obese children consumed more calories at the ad libitum buffet, but their consumption based on estimated daily caloric need and macronutrient choice was not different. **P<0.0001 vs. normal weight.
CONCLUSIONS

• Post-prandial brain response to high-calorie visual food cues was greater in obese compared to normal weight children despite similar subjective satiety responses by visual analog scales.

• Central satiety responses using fMRI may be less susceptible to confounding factors (e.g., social desirability bias) than subjective measures.

• The fMRI studies provide new insights into the neurobiological basis of child obesity and obesogenic eating behaviors.

• The greater activation by palatable food cues after eating detected by fMRI in brain regions that regulate reward and appetite in obese children could indicate a blunted central satiety response.
CONCLUSIONS II

• This difference in a central mechanism could underlie some of the challenges of weight management in obese children.

• Clinical recommendations and interventions based on behavioral strategies for weight management in children need to consider that obese children may have a different central satiety response compared to normal weight children.

• Future treatment trials need to test if greater activation by high-calorie food cues in obese children is reversible with weight loss.