Is there evidence for altered reward system activity and food addiction in obese children and adolescents?

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www.eat.sbg.ac.at
Outline

• Subjective measures of food-addiction and data in youth
• Neural measures of ‘food addiction’: Models and conceptual problems
• Salzburg study on neural & behavioral responses to food in obese and healthy adolescents
• Outlook and questions
Why is it so difficult to control (over)eating?

Processed food is highly Available, Affordable & “Addictive”

Eating = self-regulation challenge in food-rich environments!
How can “food addiction” be measured?

Table 1 | Diagnostic criteria for substance dependence according to the DSM-IV.

1. Tolerance
2. Withdrawal symptoms
3. Taking the substance in larger amounts or over a longer period than was intended
4. Persistent desire or unsuccessful effort to cut down or control substance use
5. Spending much time obtaining or using the substance or recover from its effects
6. Giving up social, occupational, or recreational activities because of substance use
7. Continued substance use despite physical or psychological problems

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Meule, 2011, *Front Psychiatry*
# Yale Food Addiction Scale

**IN THE PAST 12 MONTHS:**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>Never</th>
<th>Once a month</th>
<th>2-4 times a month</th>
<th>2-3 times a week</th>
<th>4 or more times or daily</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>I find that when I start eating certain foods, I end up eating much more than planned</td>
<td></td>
<td></td>
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<tr>
<td>2.</td>
<td>I find myself continuing to consume certain foods even though I am no longer hungry</td>
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<tr>
<td>3.</td>
<td>I eat to the point where I feel physically ill</td>
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<tr>
<td>4.</td>
<td>Not eating certain types of food or cutting down on certain types of food is something I worry about</td>
<td>Large amounts</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>5.</td>
<td>I spend a lot of time feeling sluggish or fatigued from overeating</td>
<td></td>
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<tr>
<td>6.</td>
<td>I find myself constantly eating certain foods throughout the day</td>
<td></td>
<td></td>
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<tr>
<td>7.</td>
<td>I find that when certain foods are not available, I will go out of my way to obtain them. For example, I will drive to the store to purchase certain foods even though I have other options available to me at home.</td>
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<tr>
<td>8.</td>
<td>There have been times when I consumed certain foods so often or in such large quantities that I started to eat food instead of working, spending time with my family or friends, or engaging in other important activities or recreational activities I enjoy.</td>
<td>Time effort</td>
<td></td>
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<tr>
<td>9.</td>
<td>There have been times when I consumed certain foods so often or in such large quantities that I spent time dealing with negative feelings from overeating instead of working, spending time with my family or friends, or engaging in other important activities or recreational activities I enjoy.</td>
<td></td>
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<tr>
<td>10.</td>
<td>There have been times when I avoided professional or social situations where certain foods were available, because I was afraid I would overeat.</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>11.</td>
<td>There have been times when I avoided professional or social situations because I was not able to consume certain foods there.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12.</td>
<td>I have had withdrawal symptoms such as agitation, anxiety, or other physical symptoms when I cut down or stopped eating certain foods. (Please do NOT include withdrawal symptoms caused by cutting down on cafffeinated beverages such as soda pop, coffee, tea, energy drinks, etc.)</td>
<td></td>
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</tr>
<tr>
<td>13.</td>
<td>I have consumed certain foods to prevent feelings of anxiety, agitation, or other physical symptoms that were developing. (Please do NOT include consumption of cafffeinated beverages such as soda pop, coffee, tea, energy drinks, etc.)</td>
<td></td>
<td></td>
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<tr>
<td>14.</td>
<td>I have found that I have elevated desire for or urges to consume certain foods when I cut down or stop eating them.</td>
<td></td>
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<td></td>
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<tr>
<td>15.</td>
<td>My behavior with respect to food and eating causes significant distress.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16.</td>
<td>I experience significant problems in my ability to function effectively (daily routine, job/school, social activities, family activities, health difficulties) because of food and eating.</td>
<td></td>
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</tr>
</tbody>
</table>

Gearhardt et al., 2009, *Appetite*
Yale Food Addiction Scale

Food addiction diagnosis

3 + 1

• Withdrawal
• Tolerance
• Continued use despite problems
• Important activities given up
• Time effort
• Loss of control
• Unsuccessful attempts to cut down

• „My behavior with respect to food and eating causes a significant distress."

• „I experience significant problems in my ability to function effectively because of food and eating."

Gearhardt et al., 2009, *Appetite*
“Food addiction” in obese adolescents

Prevalence: 38%

<table>
<thead>
<tr>
<th>Food addiction symptom</th>
<th>n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unsuccessful attempts to cut down consumption</td>
<td>47 (94%)</td>
</tr>
<tr>
<td>Tolerance</td>
<td>29 (58%)</td>
</tr>
<tr>
<td>Physical or psychological problems through eating</td>
<td>25 (50%)</td>
</tr>
<tr>
<td>Reduction of important activities</td>
<td>21 (42%)</td>
</tr>
<tr>
<td>Impairment or distress because of eating behaviour</td>
<td>20 (40%)</td>
</tr>
<tr>
<td>Lack of control over eating</td>
<td>17 (34%)</td>
</tr>
<tr>
<td>Increased time effort</td>
<td>17 (34%)</td>
</tr>
<tr>
<td>Withdrawal symptoms</td>
<td>13 (26%)</td>
</tr>
</tbody>
</table>

Table 2  Endorsement rates of food addiction symptoms in the current sample

Meule et al., 2015, *Eur Eat Disord Rev*
“Food addiction” in obese adolescents

<table>
<thead>
<tr>
<th></th>
<th>Food addiction (n = 19)</th>
<th>No food addiction (n = 31)</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
<td></td>
</tr>
<tr>
<td>Yale Food Addiction Scale</td>
<td>5.47</td>
<td>2.10</td>
<td>8.79</td>
<td>.001</td>
</tr>
<tr>
<td>(symptom count)</td>
<td>1.31</td>
<td>1.33</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td>16.79</td>
<td>16.32</td>
<td>0.87</td>
<td>ns</td>
</tr>
<tr>
<td>Body mass index (kg/m2)</td>
<td>35.98</td>
<td>37.30</td>
<td>0.73</td>
<td>ns</td>
</tr>
<tr>
<td>Standardized body mass index</td>
<td>2.20</td>
<td>2.31</td>
<td>0.94</td>
<td>ns</td>
</tr>
<tr>
<td>(zBMI)</td>
<td>0.38</td>
<td>0.44</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Food Cravings Questionnaire—Trait</td>
<td>145.47</td>
<td>85.00</td>
<td>8.74</td>
<td>.001</td>
</tr>
<tr>
<td>Eating Disorder Examination—Questionnaire</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Restraint</td>
<td>2.42</td>
<td>1.88</td>
<td>1.32</td>
<td>ns</td>
</tr>
<tr>
<td>Eating concern</td>
<td>3.08</td>
<td>1.32</td>
<td>5.54</td>
<td>.001</td>
</tr>
<tr>
<td>Weight concern</td>
<td>4.53</td>
<td>2.80</td>
<td>5.75</td>
<td>.001</td>
</tr>
<tr>
<td>Shape concern</td>
<td>4.87</td>
<td>3.20</td>
<td>4.68</td>
<td>.001</td>
</tr>
<tr>
<td>Binge days</td>
<td>3.92</td>
<td>1.29</td>
<td>2.43</td>
<td>.02</td>
</tr>
<tr>
<td>Center for Epidemiologic Studies Depression Scale</td>
<td>31.74</td>
<td>17.90</td>
<td>4.71</td>
<td>.001</td>
</tr>
<tr>
<td>Barratt Impulsiveness Scale—short form</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attentional impulsivity</td>
<td>13.42</td>
<td>9.77</td>
<td>4.62</td>
<td>.001</td>
</tr>
<tr>
<td>Motor impulsivity</td>
<td>12.79</td>
<td>10.61</td>
<td>2.54</td>
<td>.01</td>
</tr>
<tr>
<td>Nonplanning impulsivity</td>
<td>12.37</td>
<td>11.00</td>
<td>1.41</td>
<td>ns</td>
</tr>
</tbody>
</table>

Meule et al., 2015, Eur Eat Disord Rev
Non-linear relationship of food-addiction with BMI
Non-linear relationship of food-addiction with BMI

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Reward system activity in relation to eating and weight disorders: interpretative problems

1) Evidence for increased reward system activity: Meta analysis by Pursey et al., 2014
2) Evidence for decreased reward system activity: Geiger et al., 2009
Wang et al., 2001; de Weijer et al., 2012; Volkow et al., 2008

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Temporal trajectory?

Early phase

Voluntary consumption

Habitual consumption

Compulsive consumption

Tolerance?

Late phase

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Mismatch between expectancy and reward?

Anticipatory phase  consumatory phase  Compensatory behavior

Volkow et al., 2011, Stice et al, 2008
The moderating role of self control/impulsivity

Low self control

High self control

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Role of individual differences and obesity in neural food cue processing

Societal stigma, dieting experiences, parental restraint

Exposure to hyper palatable foods

Restricted eating

Food craving

Impulsivity

Top-down self-control

Bottom-up appetitive drive

P300 ERP Amplitude

0 100 200 300 400 500 time

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Literature review: food cue reactivity

- Obese children/youth: less delay discounting (Davis et al., 2004, Nederkoorn et al., 2006)
- Obese adults: (state dependent?) attentional biases regarding high calorie foods (reviewed in Roefs et al., 2015)
- Obese youth: Attentional bias predicts weight gain post-treatment (Werthman, Jansen, et al., 2015)
- Obese children: Decreased liking ratings, increased consumption (smell-taste-triggered) (Jansen et al., 2003)
- fMRI: generally less activity in control regions in children/youth relative to adults (non-obese subjects, van Meer et al, 2015)
- Obese children: hyperactivation to food pictures in brain networks linked to motivation, reward and cognitive control (Bruce et al., 2010)
- Implicit evaluations regarding high calorie food images: inconsistent findings (Craeynest et al., 2005, 2007, 2008)
Literature review: ERPs and moderators

Adults

• P300 not modulated by hunger in obese women compared to controls (Nijs, Murris et al., 2010) but enhanced in external eaters (Nijs et al. 2008)

• *Dietary restraint* associated with counter-regulatory eating behavior and enhanced reward system responses (e.g. Coletta et al., 2009).

• *Food addiction/craving*:
  - correlates positively with reward circuitry activity in response to food cues
  - correlates negatively with inhibitory regions in response to food intake (Gearhardt et al., 2011)

Children

• In children (7-11y), visual attention to food cues correlates
  - negatively with BMI
  - positively with parental restraint (Hill et al., 2013).
Hypotheses

• Food cue reactivity moderately enhanced in obese youth

• Moderation by restraint, impulsivity, food craving

• Early (P100) versus late (P300) effects?

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Sample

~70 boys and girls with obesity >97%
~50 boys and girls with healthy weight (3-89%)
Age 10-18 years

Procedure

Hunger rating

SC-IAT
Unpleasant pleasant chocolate

Picture Rating/Viewing

Geschmacks-test
Unexpected findings

- **Hunger** reported to be *lower* in obese children (hunger independent from time since last meal)
- **Implicit associations** with chocolate *not different* from controls
- **Liking** ratings of high calorie foods *lower* in obese kids
- **Selection** of high calorie foods for consumption *lower* in obese kids
- So: reduced reward system response in obese kids?
- **Social desirability?** *(Swanson, Rudman & Greenwald, 2001)*
- Or: subtle differences and modulation by moderators?
Differential influence of food craving on selection in both groups

Reward sensitive subgroup?
Impulsivity not different between groups but ......

- Motor impulsivity
- Non-planning impulsivity
- Attentional impulsivity
- Perceived self-regulatory success in dieting
- Standardized body mass index

...certain constellations of aspects of impulsivity determine perc. dieting success which in turn predicts BMI

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• **P1:** The more impulsive, the more early attention for food
• **P3:**
  Obese: *More* late attention when restrained
  Healthy: *Less* late attention when restrained
• Paradox effect in obese, result of thought suppression?

Hofmann, …… Blechert (in preparation)
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Future directions

• BMI not the most sensible DV/IV!
• Self-regulation/impulsivity plays a role
• Eating behavior plays a role (craving, restraint, perc. dieting success)
• Eating behavior is sensitive to life style interventions
• Thus eating behavior = DV & IV
• Thought suppression/restraint is a crucial target

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