Delay discounting, food reward, and eating in the absence of hunger

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Background

- Obesity is major modifiable risk factor that is highly resistant to behavioral treatment

- High-quality behavioral trials: 5-9% WL at 1 year
  (Dansinger et al, 2007; Franz et al, 2007)
  - Need more basic behavioral research on processes that influence eating behavior (and weight control)
  - Translate findings into new approaches to prevention and treatment

Why do people overeat?
Neurobehavioral model


**INPUT**
- Weight loss, cost, etc.
- Palatable food cues
- GI and adipocyte hormones

**BRAIN**
- Prefrontal cortex
- Mesolimbic DA system
- Hypothalamus

**MOTIVATION**
- Inhibitory control
- Food reward
- Homeostatic hunger

**BEHAVIOR**
- Eating behavior
- Food acquisition
- Selective attention to food

Feedback
Reward × inhibitory control?
Does the interaction between food reward sensitivity and inhibitory control predict overeating?
Hypotheses

1. Association between sensitivity to food reward and palatable food intake will be moderated by inhibitory control
   - Higher sensitivity to food reward $\rightarrow$ greater intake given low inhibitory control
   - No association in context of high inhibitory control

2. No associations with bland food intake
Theory-driven design

**INPUT**
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- Palatable food cues

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**BEHAVIOR**
- Eating behavior
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**OATMEAL PRELOAD**
- Delay discounting task
- Power of food scale (Lowe et al., 2009)
- Laboratory taste test
## Participants (N=62 women)

<table>
<thead>
<tr>
<th></th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age (18 – 45 y)</strong></td>
<td>31.0</td>
<td>7.7</td>
</tr>
<tr>
<td><strong>BMI (25.0 – 39.9 kg/m²)</strong></td>
<td>31.5</td>
<td>3.4</td>
</tr>
<tr>
<td><strong>N</strong></td>
<td><strong>%</strong></td>
<td></td>
</tr>
<tr>
<td>Ethnicity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black/African-American</td>
<td>20</td>
<td>32.3</td>
</tr>
<tr>
<td>Hispanic</td>
<td>13</td>
<td>21.0</td>
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<tr>
<td>Non-Hispanic, White</td>
<td>23</td>
<td>37.1</td>
</tr>
<tr>
<td>Other/Multi-ethnic</td>
<td>6</td>
<td>9.6</td>
</tr>
<tr>
<td>Education level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High school or GED</td>
<td>2</td>
<td>3.2</td>
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<tr>
<td>Some college</td>
<td>27</td>
<td>43.5</td>
</tr>
<tr>
<td>4-year degree</td>
<td>25</td>
<td>40.3</td>
</tr>
<tr>
<td>Masters or doctorate</td>
<td>8</td>
<td>12.9</td>
</tr>
<tr>
<td>Household income (USD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$0-$14,999</td>
<td>8</td>
<td>12.9</td>
</tr>
<tr>
<td>$15,000-$29,999</td>
<td>11</td>
<td>17.7</td>
</tr>
<tr>
<td>$30,000-$44,999</td>
<td>14</td>
<td>22.6</td>
</tr>
<tr>
<td>$45,000-$59,999</td>
<td>11</td>
<td>17.7</td>
</tr>
<tr>
<td>$60,000 and above</td>
<td>18</td>
<td>29.1</td>
</tr>
</tbody>
</table>
Procedures

1. Survey measures
   - Power of Food Scale (Lowe et al., 2009)
     • 15 items, Cronbach α=.92

2. Oatmeal preload (consumed: M=164.7 g)
3. Delay Discounting task (next slide)
4. Taste test:

<table>
<thead>
<tr>
<th></th>
<th>Presented (g, kcal)</th>
<th>Energy density (kcal/g)</th>
<th>Palatability 0-100 scale, M (SD)</th>
<th>Consumed kcal, M (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Palatable items</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potato chips</td>
<td>50.0, 268.0</td>
<td>5.4</td>
<td>68.0 (23.5)</td>
<td>62.6 (51.8)</td>
</tr>
<tr>
<td>Salted peanuts</td>
<td>150.0, 910.5</td>
<td>6.1</td>
<td>56.4 (27.4)</td>
<td>59.6 (67.0)</td>
</tr>
<tr>
<td>Chocolate kisses</td>
<td>90.0, 439.2</td>
<td>4.9</td>
<td>78.5 (18.9)</td>
<td>70.1 (63.4)</td>
</tr>
<tr>
<td>Raisins</td>
<td>100.0, 325.0</td>
<td>3.3</td>
<td>60.3 (26.5)</td>
<td>36.9 (38.9)</td>
</tr>
<tr>
<td>Bland items</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soup crackers</td>
<td>65.0, 273.0</td>
<td>4.2</td>
<td>51.8 (22.5)</td>
<td>20.0 (22.6)</td>
</tr>
<tr>
<td>Regular Cheerios</td>
<td>45.0, 165.6</td>
<td>3.7</td>
<td>42.4 (21.7)</td>
<td>6.0 (14.8)</td>
</tr>
</tbody>
</table>

“Eat slowly until comfortably full”
Delay Discounting (1)

• Degree to which rewards lose their influence on behavior at increasing delays
  – $100 now, or $120 in 6 months
  – Palatable food now vs. long-term weight loss benefits

• Individual differences in DD linked with:
  – Addiction, smoking, compulsive gambling (Reynolds, 2006)
  – Obesity in women (Weller, 2008)

• DD is a facet of impulsivity
  – Reduced (PFC) inhibition of (mesolimbic) reward
    (Bickel et al, 2007; Tanaka et al, 2004; McClure et al, 2004; Hariri et al, 2006)
Delay Discounting (2)

Which would you prefer?

$40 right now

or

$100 in 365 days

161 choice trials
23 hypothetical $ rewards
7 delay intervals

Calculated:
1. Indifference points at each delay (Mitchell, 1999)
2. Area under discounting curve (AUCDD) (Myerson et al, 2001)
Preliminary analyses

• Identified covariates
  – Lower education, greater discounting \((r=.32, \ p=.01)\)
  – Higher BMI, greater palatable food intake \((r=.34, \ p<.01)\)
    • BMI unrelated to bland food intake, PFS scores, or \(AUC_{DD}\)
  – Oatmeal preload consumed

• Palatability ratings
  – Higher for palatable vs. bland items, \(M=65.8 \ vs. \ 47.1\)
  – Unrelated to BMI, PFS, or \(AUC_{DD}\)
Primary findings

• Bland food intake
  – No interaction or main effects of PFS and AUC_{DD}

• Palatable food intake
  – PFS*AUC_{DD} interaction (t=-2.06, p=.04, η^2=.04)
  – No effect of PFS at high inhibitory control (±1SD AUC_{DD})
    • β=-.07, t=-.44, p=.66, η^2=.00
  – Effect of PFS at low inhibitory control (±1SD AUC_{DD})
    • β=.46, t=2.58, p=.01, η^2=.07
Interpretation

• Among overweight and obese women, food reward sensitivity predicts palatable food intake in the absence of homeostatic hunger only in the context of low inhibitory control

• No effects with bland food intake

• Consistent with our neurobehavioral model

• Consistent with other studies
Research report
Delay discounting moderates the effect of food reinforcement on energy intake among non-obese women

Brandi Y. Rollins a, Kelly K. Dearing b, Leonard H. Epstein b,c,*

Self-Control in Decision-Making Involves Modulation of the vmPFC Valuation System
Todd A. Hare, 1,4 Colin F. Camerer, 1,2 Antonio Rangel 1,2

Control Yourself or Just Eat What You Like? Weight Gain Over a Year Is Predicted by an Interactive Effect of Response Inhibition and Implicit Preference for Snack Foods
Chantal Nederkoorn and Katrijn Houben
Maastricht University
Wilhelm Hofmann
University of Würzburg and University of Amsterdam
Anne Roefs and Anita Janson
Maastricht University

Body mass correlates inversely with inhibitory control in response to food among adolescent girls: An fMRI study
Laura Batterink a,*, Sonja Yokum b, Eric Stice b
Limitations

• Excluded men, BMI<25, BMI>40
• Is inhibitory control reflected in a discounting task with hypothetical monetary rewards?
  – Yes, but we need better measures of inhibitory control in context of food rewards
• Laboratory eating task = naturalistic eating behavior?
Implications

• Further research
  – Seek better understanding of inhibitory control
    • Behavioral manifestations and neural mechanisms
  – Prediction of diet adherence (primary aim of project)

• Understand obesity as a neurobehavioral syndrome, not a character flaw or a deficiency of “willpower”

• Develop better interventions
  – Simultaneously ↓ food reward and ↑ inhibitory control
  – How?
Inhibiting Food Reward: Delay Discounting, Food Reward Sensitivity, and Palatable Food Intake in Overweight and Obese Women

Bradley M. Appelhans, Kathleen Woolf, Sherry L. Pagoto, Kristin L. Schneider, Matthew C. Whited, and Rebecca Lieberman

Overseating is believed to result when the appetitive motivation to consume palatable food exceeds an individual’s capacity for inhibitory control of eating. This hypothesis was supported in recent studies involving predominantly normal weight women, but has not been tested in obese populations. The current study tested the interaction between food reward sensitivity and inhibitory control in predicting palatable food intakes among energy-regulate overweight and obese women (N = 82). Sensitivity to palatable food reward was measured with the Power of Food Scale. Inhibitory control was assessed with a computerized choice task that captures the tendency to discount large delayed rewards relative to smaller immediate rewards. Participants completed an eating in the absence of hunger protocol in which homeostatic energy needs were eliminated with a bland preload of plain oatmeal, followed by a bogus laboratory taste test of palatable and bland snacks. The interaction between food reward sensitivity and inhibitory control was a significant predictor of palatable food intake in regression analyses controlling for BMI and the amount of preload consumed. Probing this interaction indicated that higher food reward sensitivity predicted greater palatable food intake at low levels of inhibitory control, but was not associated with intake at high levels of inhibitory control. As expected, no associations were found in a similar regression analysis predicting intake of bland foods. Findings support a neurobehavioral model of eating behavior in which sensitivity to palatable food reward drives overseating only when accompanied by insufficient inhibitory control. Strengthening inhibitory control could enhance weight management programs.
Thanks to ...

Collaborators
Kathleen Woolf, PhD, RD (NYU)
Sherry Pagoto, PhD (UMASS)
Kristin Schneider, PhD (UMASS)
Matthew Whited, PhD (UMASS)
Rebecca Liebman, MPH (Rush)

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Research subjects!
Sources

• Rollins BY, Dearing KK, Epstein LH. Delay discounting moderates the effect of food reinforcement on energy intake among non-obese women. *Appetite* 2010;55;420-425.