A calorie is not a calorie; how taste, texture and energy density affect satiation and energy intake

Obesity meeting Dublin November 2016, Kees de Graaf
Which food is more satiating? Why?
Large series of (40 – 50) studies on effects taste, smell on satiation; move beyond the effect of palatability

- PhD theses of Weijzen, Zijlstra, Ruijschop, Griffioen-Roose, Hogenkamp, Viskaal-van Dongen, Bolhuis, Wanders, and Ramaekers.

Effect of taste on food intake

- Taste system is focused on sensing nutrients
  - Sweet → carbohydrates
  - Umami → proteins
  - Fat → fat
  - Salt → minerals and fluid balance
  - Sour and bitter → bad for us

- Exposure to taste is highly dependent on texture → slower food leads to longer oro-sensory exposure to taste → earlier satiation, higher, longer satiety
Eating rate (g/min)

range: 4 – 630 g/min

Soup and satiety

Mattes, 2005; Physiol Behav, 83, 739-47
Consuming 1 kg grape juice / grapes

2 kilos of grapes

1 kilo juiced into grape puree  |  1 kilo divided into 100 gr batches
Effect of magnitude of exposure to taste on satiation.

N = 55 Subjects, within subjects design
Subject consumed ad libitum tomato soup from tube; tomato soup delivered by a peristaltic pump, constant eating rate

Exposure time in Long = 24 s/min
Exposure time in Short = 12 s/min

<table>
<thead>
<tr>
<th>TABLE 1</th>
<th>Sodium concentrations and sensory characteristics of LS and HS soups$^1,2$</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>LS soup</td>
</tr>
<tr>
<td>Sodium, mg/100 g soup</td>
<td>146 ± 49</td>
</tr>
<tr>
<td>RTI saltiness intensity,$^3$ mm</td>
<td>−14 ± 15</td>
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<tr>
<td>Saltiness intensity,$^4$ mm</td>
<td>31 ± 17</td>
</tr>
<tr>
<td>Overall flavor intensity,$^4$ mm</td>
<td>43 ± 19</td>
</tr>
<tr>
<td>Pleasantness,$^3,4$ mm</td>
<td>53 ± 19</td>
</tr>
</tbody>
</table>

High salt soup was similar in palatability to low salt soup; salt concentration varied by factor 4. Determined on individual basis

Bolhuis et al, J Nutr 2011
Effect of magnitude of sensory exposure to taste on satiation

Both Longer Oral Sensory Exposure to and Higher Intensity of Saltiness Decrease Ad Libitum Food Intake in Healthy Normal-Weight Men¹–³

Dieuwerke P. Bolhuis,⁴ Catriona M. M. Lakemond,⁴ Rene A. de Wijk,⁶ Pieternel A. Luning,⁴ and Cees de Graaf⁵

Exposure time in Long = 24 s/min
Exposure time in Short = 12 s/min

Bite-size (exposure time): $P<0.001$ (≈30%)

Salt intensity: $P=0.002$ (≈9%)

Bolhuis et al, J Nutr 2011
• 50 Ss → lunch wit hamburger and rice salad, either hard or soft version of it → ad libitum intake
• Assessment of energy intake compensation throughout the remainder of the day
- Harder foods → lower food energy intake
- No energy intake compensation

Figure 1. Food intake at lunch of soft and hard foods, n=50 (means + SD). Total is the sum of hamburger and rice salad in either soft or hard versions.

doi:10.1371/journal.pone.0093370.g001

Figure 2. Energy intake at lunch and dinner, n=50 (means and SD).

doi:10.1371/journal.pone.0093370.g002

Bolhuis et al, 2014; Effect of hardness on energy intake, PLOS-one
Harder foods $\rightarrow$ lower bite size, more chews/g, longer oral residence/g

Figure 3. Differences in oral processing characteristics of soft and hard foods, n = 36 (means and SD); bite size (g) (A), oral residence duration (s/g) (B) and chews (no of chews/g) (C). doi:10.1371/journal.pone.0093370.g003
Oro-sensory exposure to taste determines satiation

- It is the magnitude of oro-sensory exposure to taste, that determines satiation!

- Taste is a nutrient sensor

- Taste signals the energy that comes into the body to the brain and the gut; with liquids / fast foods this system is bypassed → overeating

- Harder, chewier foods → lower intake
Lowering energy density lowers energy intake

**FIGURE 1.** Cumulative (A) food and beverage intake and (B) energy intake over 2 d in 26 preschool-age children who were served foods and beverages that were lower in energy density at breakfast, lunch, and afternoon snack. ↓, Meals that were not varied in energy density (ie, dinner and evening snack). There was no effect of energy density on the cumulative weight of food and beverages consumed over 2 d. There was a significant effect of energy density on cumulative energy intake starting at breakfast on day 1 and accumulating over the course of 2 d when assessed by a mixed linear model (P < 0.01).

Leahy, Birch & Rolls, Am J Clin Nutr 2008
Do we respond to differences in kcal content when meals taste the same?

How do we respond to differences in calorie content?

Little or no compensation for “missing” or “added” calories

Sensory-matched meals promote positive / negative energy balance

Discussion

- Food supply with **soft, energy dense** foods promotes energy overconsumption → obesity

- Not sugar, fat perse → texture, energy density

- Basic mechanism is lack of responsiveness to energy density, and bypassing system of taste

- Fast, liquid foods → no sensing → energy overconsumption
Thank you for your attention

Questions?