Cueing satiety: the use of labels and sensory characteristics to signal nutrient content

Martin R Yeomans

School of Psychology
Traditional bio-nutritional model of satiety

• Ingestion of nutrients lead to multiple signals from gut to brain that suppress appetite
• Large amount of data show this to be true
• But it is not enough....
Actual satiety integrates cognitive and orosensory stimuli with nutrient-derived signals.
Chambers et al, TIFS 2015. Adapted from Blundell et al, 1987
Measuring satiety expectations

1. **Calorie matching.** Participants select the portion of a standard food needed to suppress their hunger as much as they expect the sample they are testing. Imagine consuming the whole bottle of sample X. How much pasta would you need to eat to feel as full as you would after drinking this product?

2. **Satiety rating.** VAS ratings of:
   - How full would you feel immediately after consuming this product?
   - How hungry would you expect to feel one hour after consuming this product?
Sensory enhancement of satiety

Satiety-relevant *sensory* and *cognitive* characteristics

Nutritional content

Overnight fast

180 min Delay

Ratings of *appetite* and *sensory evaluations*
Expectations generated by sensory experience enhance nutrient-induced satiety

- Six preload drinks consumed 30 minutes before lunch
- Drinks combined 3 levels of sensory characteristics (low, medium and high satiety expectation) & 2 levels of energy

Yeomans & Chambers, AJCN, 2011
Changes in rated appetite

Change in rated hunger

Low Sensory

Medium Sensory

High Sensory

Change in rated fullness

Low sensory

Medium sensory

High sensory
Understanding expectations
(McCrickerd et al., 2015, FQP)

• Consumers presented with pictures of package and portion for 40 well known UK snack and drink products
• For each product, they rated 4 key satiety/thirst expectations & expectations about sensory aspects
• Multiple regression modeling then explored factors (sensory, nutrition etc) best predicting satiety/thirst expectations.
McCrickerd, Lensing & Yeomans, (FQP 2015)
Imagine you have just consumed ALL of the product. How FULL would you feel IMMEDIATELY after?

Not at all ———— Ex...
Expectations of **fullness immediately** and **hunger one hour** after consuming all of the product

**Creaminess**

- Fullness $r = 0.350$, Hunger $r = -0.359$
- Total energy content
  - Fullness $r = 0.671$, Hunger $r = -0.701$

Expectations of **thirst immediately** and **one hour after** consuming all of the product

**Thick/Hard**

- Immediately $r = 0.765$, +1 hour $r = 0.663$

**Salty**

- Immediately $r = 0.670$, +1 hour $r = 0.689$
Other sensory cues?

• Thickness and creaminess may be associated with satiety because of past learning
• But other sensory cues may predict particular nutritive effects
• For example, umami taste may have evolved as a way of predicting the presence of protein
Umami as a satiety cue
(Masic & Yeomans, 2013)

Hunger recovered more slowly after consuming a fixed portion of a protein-rich soup with added MSG than without: the effect seemed specific to the presence of protein.

![Graphs showing change in hunger rating over time for control, protein, and carbohydrate conditions with and without MSG.](image)

* indicates significant difference.
MSG enhances protein-induced compensatory eating

When participants ate a 2-course lunch 45 minutes after consuming these same 6 soups, MSG increased satiety.
Sensory/cognitive or post-ingestive effects?

- Studies so far demonstrate consumers have satiety-relevant expectations driven by cues such as orosensory thickness, creaminess or Umami.
- BUT they ingest the whole product: can we be sure this is not some subtle post-ingestive effect of the added ingredients (e.g. tara gum, MSG, etc.)?
Engineering expectations...

Varying oil drop size in oil-fat emulsions without altering fat content changes both sensory experience and consequent satiety expectations (Lett et al. 2016)
Small droplet sized lead to greater satiety (Lett et al, 2015)

Participants (n=34) consumed a test meal 20 minutes after consuming isocaloric oil/water emulsions varying in droplet size only (2 or 50 µm)
Believing is experiencing:

Volunteers drank low and high energy versions of drinks in one of 4 conditions:

- Low Sensory, no label
- Low Sensory, Thirst Quenching
- Low Sensory, Hunger Reducing
- High Sensory

![Graph showing total lunch intake (%)](chart)
Memory and eating:

Series of studies by Higgs et al. using healthy participants e.g.:

Participants asked to think about:
- LUNCH EATEN TODAY
- LUNCH EATEN YESTERDAY
- ANYTHING THEY LIKE (CONTROL)

Bogus taste test
SNACK FOOD INTAKE MEASURED

<table>
<thead>
<tr>
<th></th>
<th>Snack intake</th>
<th>Liking of snacks</th>
</tr>
</thead>
<tbody>
<tr>
<td>LUNCH EATEN TODAY</td>
<td>24 grams*</td>
<td>64</td>
</tr>
<tr>
<td>LUNCH EATEN YESTERDAY</td>
<td>48 grams</td>
<td>62</td>
</tr>
<tr>
<td>CONTROL</td>
<td>44 grams</td>
<td>60</td>
</tr>
</tbody>
</table>
Does memory modify response to sensory satiety cues?

- Combining our sensory manipulation with Higgs’ memory method
- Participants consumed either the HELS or HEHS drink combined with memory manipulation

Day 1: consume standard drink (lemonade) mid-morning

Day 2: standard preload test with either HELS or HEHS drink

**Memory manipulation:**
Just before test meal recall EITHER the drink from Day 2 or Day 1
Separate sensory and memory effects

- Less consumed when asked to recall the drink they had consumed earlier relative to the previous day
- Less consumed after HEHS than HELS
Optimising foods for satiety

Expected satiety must be congruent with actual satiety

Consumer’s previous experience

Consumer’s eating motivations

Nutrient content

Sensory characteristics

Expected satiety must be congruent with actual satiety
Effective design for satiety

1. Match expectations to nutrition
2. If product has significant levels of nutrients, build in features that ensure consumers have appropriate expectations
   a. Suggestive labels
   b. Appropriate sensory characteristics
   c. Possibly manipulate physical food structure
Summary

• Both explicit (label) information and sensory experience generate expectations about satiety that modify the response to ingested nutrients

• Hidden nutrients lead to poor appetite regulation: the key is signal-honesty

• Reduced energy products could be counter-productive

• But increased knowledge of sensory-nutrient interactions offer novel pathways to future product development
Acknowledgements

**Research Fellow**
Dr Lucy Chambers

**DPhil students**
Keri McCrickerd
Una Masic
Aaron Lett

**Collaborators**
Harvey Ells
Ken Woodward
Martin Wickham
Roberta Re

IFF and Firmenich for flavours, Cerestar for ingredients

BBSRC, Unilever, Mars UK, Danone, Leatherhead and Ajinomoto for funding