The Role of the Senses in Food Choice and Energy Intake
From Measuring Perception to Understanding Ingestive Behaviour

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Overview

• How do we study the senses role in Food Choice?

• A Role for Sensory Perception in Food intake and Nutrition

• Sensory as a Bridge between Nutrition and Behaviour
  – Example 1: Something to Chew On
  – Example 2: When a Calorie is not a Calorie
  – Example 3: Sensory Epidemiology & the ‘taste’ of diets

• Future Challenges
  – How do we sustain liking in healthier products?
  – How do we communicate less calories and improved health?

Sensory Nutritional Science;
If its all about energy, we should explore what makes us eat what we eat

A Diet by Any Other Name Is Still About Energy

No difference across diets... participants lost 13 pounds at six months & maintained a 9 pound loss at two years. Participants also reduced their waistlines by 1 to 3 inches by the end of the study.

...and diet satisfaction were all similar across the four diets

...reduced-calorie diets, regardless of which macronutrients they emphasize, can help overweight and obese adults

POUNDS LOST Study: Preventing Overweight Using Novel Dietary Strategies

We Quantify the Intensity of Individual Sensations

Sensory Evaluation is a measurement science – we **Evoke, Measure, Analyse and Interpret**

Then Look for Relationships between Perception and Liking

**External Preference Mapping of Cheese Preferences**

A Role for Sensory in Food Intake and Nutrition
A Role for Sensory Factors in Energy Selection and Intake

We don’t just eat what we ‘like’ – We eat for a lot of other reasons For fullness, health, convenience......

Measuring liking and intensity may not be telling us what is really driving our food intake behaviours

Eating Behaviours (Satiation)
Eating Rate as a Target for Obesity Treatment


HAPIfork
Eat slowly. Lose weight. Feel great!
Vibro-tactile feedback during a meal to slow eating

SmartPlate
wireless interface that helps track your calorie intake

mando meter
Clinically proven weight changes by re-training eating rates within a meal

“Fun Feeder”
Specially designed plate to slow eating rate in obese dogs

Exploring the Eating Rate of Singaporean Foods

Application of Sensory Principals to Studying Eating Behaviours

Research report
Oral processing characteristics of solid savoury meal components, and relationship with food composition, sensory attributes and expected satiation
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ABSTRACT
Background: The modern food supply is often dominated by a large variety of energy dense, subtly textured foods that can be eaten quickly. Previous studies suggest that particular oral processing characteristics such as large bite size and lack of chewing activity contribute to the low satiating efficiency of these foods. To better design meals that promote greater feelings of satiation, we need an accurate picture of the oral processing characteristics of a range of solid food items that could be used to replace softer tex-

Differences in Eating Rate in the Food Environment

Viskaal-Van Dongen et al, Appetite, 2011

Natural variations in eating rate in Singapore

- There was a wide variation in eating rates across the foods (10-120 g/min) and within food categories.
- Different forms of rice ranged from 16.8 g/min to 120 g/min.

Natural Variations in Food Eating Rates in Singapore

Natural Variations in eating rate can be used to promote/reduce food intake

Using Natural Variations Eating Rates to Reduce Energy Intake in Singapore

Texture difference led to a 13% reduction in energy intake (difference - 93 kcals)

When a Calorie is not a Calorie

Example 2: Using Sensory properties to conceal calorie reductions

Question: If we maintain the sensory/hedonic properties of a food, can we reduce calories consumed in a food or beverage, without impacting later eating?

Study 1 Is there a dose-response relationship between calorie content and Re-bound hunger/energy compensation
Do we respond to differences in kcal content when meals taste the same?


How do we respond to differences in calorie content?

No compensation for “missing” or “added” calories

Sensory-matched meals promote positive / negative energy balance

Sensory Properties Conceal Energy Addition or Removal

Participants consumed fewer calories on low energy soymilk days while more calories on high energy soymilk days

Study 2 What happens when you added or removed 200kcal from a beverage?

n = 29, males, randomised crossover study
Test soymilk pre-load before ad-lib lunch

‘Sensory Epidemiology’

Example 3: The Taste of Diets
The Taste of Diets: Understanding what motivates change in dietary behaviour

Sensory Mapping of 377 Different Foods
Lease et al 2016, FQAP

Exploring Taste-Diet Relationships (237 foods)
van Lagerveld et al 2017

Linking Perception Intensity to Dietary Intakes

People who frequently consume sweet things (LNCS and Natural sugars) – tend to show a preference for sweeter beverages when tested in the laboratory (higher content of sugar)

This is the same across sugars and non-nutritive sweeteners
Maher and Duizer (2007), J. Food Science.

Sensory Epidemiology: Dietary Data is Sensory Data

- We can link dietary data with ‘sensory’ data for new insights into what, when and why people eat what they eat?

- By combining perceptual measures with dietary intakes, it is possible to explore food (sensory) sources of calories, meal pattern behaviours and the role of specific sensations – such hardness or sweetness in the diet

Tracking Changes in the Early Diet (Sensory and Nutrition)

- A sharper rise in sweets in Mexico, but ~90% consuming in both countries by age 2.
- Sweetened beverages drive the increase, especially in Mexico - 78% by age 2 vs. 46% in USA.

Percent ages 0-47 months consuming any sweet

<table>
<thead>
<tr>
<th>Age in months</th>
<th>USA</th>
<th>Mexico</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5</td>
<td>1.8</td>
<td></td>
</tr>
<tr>
<td>6-8</td>
<td>9.7</td>
<td>43</td>
</tr>
<tr>
<td>9-11</td>
<td>43</td>
<td>43</td>
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<tr>
<td>12-23</td>
<td>72</td>
<td>75</td>
</tr>
<tr>
<td>24-47</td>
<td>85</td>
<td>87</td>
</tr>
</tbody>
</table>

Percent ages 24-47 months consuming different sweets

<table>
<thead>
<tr>
<th>Sweets</th>
<th>USA</th>
<th>Mexico</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cakes, pies, cookies</td>
<td>50</td>
<td>28</td>
</tr>
<tr>
<td>Candy</td>
<td>26</td>
<td>26</td>
</tr>
<tr>
<td>Ice Cream</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>Sweetened beverages</td>
<td>46</td>
<td>78</td>
</tr>
</tbody>
</table>

Slide courtesy of Dr. Kathleen Reidy, Dr. Denise Deming,
Future Challenges: Communicating health and Pleasure

How do you communicate feeling full to someone who is trying to control their energy intake?

Tobler-Wrong?

The past (170g)
The present (150g)

Now with less (Salt, sugar, fat calories...) – but still that great taste!

Conclusions: Sensory and Ingestive Behaviour

• A Foods Sensory Properties have a functional role in what and how much we eat
  – Many of our food decisions are passive and habitual
  – We are not accurate at detecting changes in the energy content of the foods / meals we eat
  – We eat in response to our food environment and sensory cues guide these behaviours

• Profiling the sensory properties of (un)healthy diets is central to defining nutritional behaviours for better health

• The future challenge remains how we achieve ‘healthy’ for health conflicted consumers
When companies design reduced energy foods to help manage energy intake, their key considerations are often.....

The Sensory Ingestive Behaviour Lab

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Thank You

What happens when you add / remove 200kcal in Soy Milk?

Energy density manipulated with Malto-dextrin and texture flavour and colour matched with small quantities of Xanthan gum, colouring and almond flavour

- Dose response study (kcal up as well as down)
- Realistic food system (matched for sensory & volume)
- Drinks matched for flavour and viscosity
- Served as a pre-lunch drink

Viscosity well matched at in-mouth shear rates

How do we respond to differences in calorie content?

Q. Do we respond the same way to the same amount of energy when it is added vs when it is taken away?

A. Participants consumed fewer calories on low energy soymilk days while more calories on high energy soymilk days

McCrickerd, K., Salleh, N. B., & Forde, C. G. (2016). Removing energy from a beverage influences later food intake more than the same energy addition. Appetite, 105, 549-556.
Sensory Quality (what) & Intensity (how strong) Influences Intake

McCrickerd and Forde (2016) Obesity Reviews (Open access)

CNRC: From Food to Function and Health

1 Sensory and Cognitive Influences
   - Sensory perception
   - Mastication / Oral processing
   - Texture cues to change eating rate

2 Metabolic Impact of food intake
   - Glycaemia / Glucose metabolism
   - Lipid metabolism
   - Brown Adipose Tissue activation
   - Cardio-metabolic risk factors

3 Impact of food on BC and Metabolic Health
   - Partitioning of energy metabolism
   - Changes in BC after weight loss
   - Impact of weight change on metabolism
   - Insulin sensitivity after weight loss

Why do we respond differently to Energy Content Differences?

No differences in hunger responses above a certain energy intake level (300 kcal?) = Is there A Calorie Threshold?

de Graaf & Hulshof, Appetite 1996
Faster Eaters and Energy Intake at Meals (Singapore)

3 trials, consistent meal in each, 4 x replicates of eating rate (g/min) per individual

Study 1 (Rice porridge)

- N = 60 consumed rice porridge for breakfast x 4 days

Study 2 (fried rice)

- N = 27 consumed fried rice for lunch x 4 days

Study 3 (fried rice)

- N = 25 consumed fried rice for lunch x 4 days

Intake (kcal)

Eating Rate (g/min)

McCrickerd, Tey, Chia-Ming and Forde (2016) (Under review)

Rapid Profiling / Napping / etc...

Multi-dimensional scaling Sorting / Napping Flash Profiling....

A Role for Taste in Dietary Behaviour

- Texture Analysis
- Time intensity techniques
- Progressive Profiling (Jack and Piggott 1996)
- Temporal Dominance Sensations (Schlich et al)

Temporal Techniques
What does Sensory Innovation look like?

Moving from hedonics to emotions...
Liking is no longer enough...

Better Measurements, better reproducibility....(eg: Panels)

Going beyond Sensory Properties to Function
Example - Satiety Panels (Mondelez)
Sensory Nutritional Science

Application of Descriptive Analysis to Understand the Taste of Diets

Descriptive Analysis and the Application to understand the taste of diets (Lease et al 2016)

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Texture</td>
<td>The degree to which the diet feels soft, hard, or somewhere in between.</td>
</tr>
<tr>
<td>Moistness</td>
<td>The overall moisture content of the diet.</td>
</tr>
<tr>
<td>Appearance</td>
<td>The overall visual appearance of the diet.</td>
</tr>
<tr>
<td>Flavor</td>
<td>The overall flavor of the diet.</td>
</tr>
<tr>
<td>Overall Impression</td>
<td>The overall impression of the diet.</td>
</tr>
</tbody>
</table>

Table 1: Sensory vocabulary used in sensory descriptive evaluation of RTT foods.

<table>
<thead>
<tr>
<th>Diet</th>
<th>Texture</th>
<th>Moistness</th>
<th>Appearance</th>
<th>Flavor</th>
<th>Overall Impression</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calorie Control</td>
<td>Soft</td>
<td>Moist</td>
<td>Good</td>
<td>Sweet</td>
<td>Mild</td>
</tr>
<tr>
<td>Regular</td>
<td>Hard</td>
<td>Dry</td>
<td>Poor</td>
<td>Salty</td>
<td>Strong</td>
</tr>
</tbody>
</table>

Slowing Eating Rate and Reducing Intake for Obese Dogs!

“Fun Feeder™”

Lease et al 2016, FQAP