Who controls the food we eat?

Jeff Brunstrom
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Who controls the food we eat?

Meal size

Cognition

Dietary learning

Obesity

Flavour preference

Food choice

Appetite control
Portion sizes are getting larger

<table>
<thead>
<tr>
<th>Food Item</th>
<th>FDA</th>
<th>USDA</th>
</tr>
</thead>
<tbody>
<tr>
<td>White bread</td>
<td>-44</td>
<td>0</td>
</tr>
<tr>
<td>Beer</td>
<td>28</td>
<td>93</td>
</tr>
<tr>
<td>Soda</td>
<td>35</td>
<td>103</td>
</tr>
<tr>
<td>Hamburger, chain restaurant</td>
<td>112</td>
<td></td>
</tr>
<tr>
<td>Pizza slice, independent store</td>
<td>42</td>
<td></td>
</tr>
<tr>
<td>French fries, chain restaurant</td>
<td>168</td>
<td></td>
</tr>
<tr>
<td>Bagel, independent store</td>
<td>195</td>
<td>195</td>
</tr>
<tr>
<td>Steak</td>
<td>224</td>
<td></td>
</tr>
<tr>
<td>Muffin</td>
<td>225</td>
<td>333</td>
</tr>
<tr>
<td>Cooked pasta</td>
<td>190</td>
<td>480</td>
</tr>
<tr>
<td>Chocolate chip cookie</td>
<td>263</td>
<td>700</td>
</tr>
</tbody>
</table>

Difference in portion size, %

The Contribution of Expanding Portion Sizes to the US Obesity Epidemic

Lisa R. Young, PhD, RD, and Marion Nestle, PhD, MPH
Psychological/physiological controls are overwhelmed

Despite consuming 73% more, participants in the ‘self refilling’ condition did not believe they had consumed more, nor did they perceive themselves as more sated than those eating from normal bowls.
Understanding overconsumption

Obesogenic environment

Foods are more palatable?

Portion sizes are larger
Young & Nestle (2002)

Foods are cheaper & more readily available

‘Hidden calories’
Innate responses to basic tastes

**Sweet taste** – lip smacking and tongue protrusion

**Bitter** – negative or aversive gapes – retraction of lips ‘scrinching’ of brows and muscles around the eyes.

**Sour taste** (citric acid) & **salt** – facial grimaces (less intense) between polar extremes of sweet and bitter.
Flavour-nutrient learning

Robust conditioned flavor preference produced by intragastric starch infusions in rats


ANTHONY SOLAFANI AND JEFFREY W. NISSENBAUM
Department of Psychology, Brooklyn College and the Graduate School, The City University of New York, Brooklyn, New York 11210
Does dietary learning occur outside awareness?

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Received 9 April 2003
Available online 17 June 2004

Dietary learning in humans: Directions for future research

Jeffrey M. Brunstrom*

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Learned Influences on Appetite, Food Choice, and Intake: Evidence in Human Beings

E. L. Gibson and J. M. Brunstrom
FIGURE 1  Energy density versus 4 to 5-year-old children’s preference scores for fruit and vegetables ($R^2 = 0.42$; $r(21) = 0.65$, $p < 0.001$, one tail). Preference scores were averaged from mother’s ratings for their children ($N = 228–416$, depending on the number eating the food). Controlling for protein or sugar content (vegetables only) did not remove the correlation. With permission from Gibson and Wardle (2003).
Flavour-nutrient learning in restrained and unrestrained eaters, *Physiology & Behavior*, 90, 133-141.

Day 1  Chocolate/high energy
Day 2  Mandarin/low energy
Day 3  Chocolate/high energy
Day 4  Mandarin/low energy
Day 5  Chocolate/high energy
Day 6  Mandarin/low energy

High = 1182 kJ
Low = 227 kJ

Day 7  Chocolate/medium energy
Day 8  Mandarin/medium energy
(a) Liking

N = 44
(a) Unrestrained eaters (n = 21)

(b) Restrained eaters (n = 23)

[Graphs showing liking ratings for low energy and high energy food across different pairs of trials for unrestrained and restrained eaters.]
Impaired ‘adaptive’ memory in restrained eaters

Foraging memory

Danielle Ferriday PhD thesis, Bristol, 2012
Impaired learning?


Flavour-nutrient associations are learned

Individuals differ in their ability to learn
What about learning and the control of meal size?
CONSIDERED SATIETY IN THE RAT

D. A. BOOTH

University of Sussex, Brighton, England
The conditioned satiating effect of orosensory stimuli

John D. Davis a,*, Gerard P. Smith b

Physiology & Behavior 97 (2009) 293–303


Looking in the wrong place?
Consumer attitudes and temporal dynamics

“…for many participants the amount they ate was guided mainly by portion size and, to a lesser extent, by an internal satiety cue … it seemed that the decisional moment regarding the amount they ate was ahead of eating. At purchase, when deciding whether or not to open a package, or during cooking, participants found it easier to regulate the amount they ate than once it was served.”

Willemijn Vermeer et al. (2010) Health Education Research, 25, 109-120
Portion size influences meal size


Meal planning is commonplace

What determines real-world meal size? Evidence for pre-meal planning

Stephanie H. Fay, Danielle Ferriday, Elanor C. Hinton, Nicholas G. Shakeshaft, Peter J. Rogers, Jeffrey M. Brunstrom

School of Experimental Psychology, University of Bristol, 12a Priory Road, Bristol, BS8 1TU England, UK

Computer-based assessments of expected satiety predict behavioural measures of portion-size selection and food intake

Laura L. Wilkinson, Elanor C. Hinton, Stephanie H. Fay, Danielle Ferriday, Peter J. Rogers, Jeffrey M. Brunstrom

Nutrition and Behaviour Unit, School of Experimental Psychology, University of Bristol, 12a Priory Road, Bristol BS8 1TU, UK

Using photography in 'The Restaurant of the Future': A useful way to assess portion selection and plate cleaning

Elanor C. Hinton, Jeffrey M. Brunstrom, Stephanie H. Fay, Laura L. Wilkinson, Danielle Ferriday, Peter J. Rogers, Rene de Wijk

School of Experimental Psychology, University of Bristol, 12a Priory Road, Bristol BS8 1TU, UK
Food & Behaviour Research, Dept. of Consumer Science & Intelligent Systems, J.J. Roos 72, 6700 AA Wageningen, The Netherlands
How are decisions about portion size made?
Introducing expected satiety and expected satiation

Expected satiety:
The extent to which foods differ in the satiety they are expected to confer when compared on a calorie-for-calorie basis.

Expected satiation:
The extent to which foods differ in the fullness they are expected to confer when compared on a calorie-for-calorie basis.
Method of adjustment

Match the food on the right to the food on the left

Standard
Margherita pizza

Comparison
Chicken tikka masala
Other observations

- Extremely good discrimination
- Demonstrated in other labs and in foods that are similar
- Participants find the task extremely easy
Excellent predictors of self-selected ‘ideal’ portions

Research report
Measuring affective (liking) and non-affective (expected satiety) determinants of portion size and food reward
Jeffrey M. Brunstrom*, Nicholas G. Shakeshaft
Department of Experimental Psychology, University of Bristol, 12a Priory Road, Bristol BS8 1TU, United Kingdom

How Many Calories Are on Our Plate? Expected Fullness, Not Liking, Determines Meal-size Selection
Jeffrey M. Brunstrom¹ and Peter J. Rogers¹
Challenging assumptions about the control of meal size

Fig. 1. Relationships (Pearson’s) between meal-size predictors and actual meal intake. Strong and weak associations are indicated by wide and narrow arrows, respectively.

Computer-based assessments of expected satiety predict behavioural measures of portion-size selection and food intake

Laura L. Wilkinson *, Elanor C. Hinton, Stephanie H. Fay, Danielle Ferriday, Peter J. Rogers, Jeffrey M. Brunstrom

Nutrition and Behaviour Unit, School of Experimental Psychology, University of Bristol, 12a Priory Road, Bristol BS8 1TU, UK
Translation and application

- **Expected Satiety**
  - Expected satiety
  - Expected satiation
  - Tolerance (max portion)

- **Expected Reward**
  - Preference
  - Purchasing behaviour
  - Willingness to work

- **Memory**
  - Portion size
  - Colour
  - Sensory characteristics

- **Ideal portion**
Applications

- Effects of an acute exercise on appetite
- Prognostic tool to assess severity of anorexia nervosa
- Obese-lean differences (New York Obesity Centre)
- Post-operative responses to gastric band and RYGB
- NIH obesity intervention programme
- Effects of sleep deprivation on food choice and energy intake
- Expected satiety and ‘eating topography’
Conclusion 2

Expected satiety/satiation can be measured

Expected satiety/satiation play an important role in meal planning
Research report

Perceived volume, expected satiation, and the energy content of self-selected meals

Jeffrey M. Brunstrom a,b,*, Jane Collingwood a, Peter J. Rogers a

*University of Bristol, England, UK
Department of Experimental Psychology, University of Bristol, 12a Priory Road, Bristol BS8 1TU, UK

Research report

The ‘variety effect’ is anticipated in meal planning

Laura L. Wilkinson *, Elanor C. Hinton, Stephanie H. Fay, Peter J. Rogers, Jeffrey M. Brunstrom

Nutrition and Behaviour Unit, School of Experimental Psychology, University of Bristol, 12a Priory Road, Bristol, BS8 1TU, UK

The weight of the container influences expected satiety, perceived density, and subsequent expected fullness

Betina Piqueras-Fiszman a,b,*, Charles Spence b

a Department of Engineering Projects, Universitat Politècnica de València, Camino de Vera s/n, 46022, Valencia, Spain
b Department of Experimental Psychology, University of Oxford, South Parks Road, Oxford OX1 3UD, UK
What about learning?

The typical 21-year old has consumed 21,000 meals
Familiarity increases expectations


$F[3,54] = 4.67, p = .006$

Figure 1: Thumbnails of the 40 foods used as stimuli in Experiments 5 - 7. Each photograph depicts the recommended serving size of a product with the median energy density for its food category.
Eat to fullness increases expected satiation

\[ F_{1,11825} = 3032.35, \ p < 0.001 \]
Expected-satiation drift

“We expect novel foods to confer relatively little satiation until experience teaches us otherwise”

Conclusion 3

Expectations are learned
Memory for portion size influences satiety

Rozin, P., et al. (1998). What causes humans to begin and end a meal? A role for memory for what has been eaten, as evidenced by a study of multiple meal eating in amnesic patients. Psychological Science, 9, 392-396.


Dissociating ‘actual’ and ‘perceived’ amounts consumed

Participants are tested in one of four conditions:

<table>
<thead>
<tr>
<th>See 500ml/eat 300ml</th>
<th>See 500ml/eat 500ml</th>
</tr>
</thead>
<tbody>
<tr>
<td>See 300ml/eat 300ml</td>
<td>See 300ml/eat 500ml</td>
</tr>
</tbody>
</table>

Episodic Memory and Appetite Regulation in Humans
Brunstrom et al., 2012
Actual amount
(F(1,95)=5.57, p<.02)

Perceived amount
(F(1,95)=5.78, p<.02)

Perceived amount
(F(1,95)=4.1, p<.047)

ns
Effects of distraction on intake at a subsequent meal

Playing a computer game during lunch affects fullness, memory for lunch, and later snack intake\textsuperscript{1,2}

Rose E Oldham-Cooper, Charlotte A Hardman, Charlotte E Nicoll, Peter J Rogers, and Jeffrey M Brunstrom


Focusing on food during lunch enhances lunch memory and decreases later snack intake

Suzanne Higgs, Jessica E. Donohoe *

School of Psychology, University of Birmingham, Edgbaston, Birmingham, West Midlands, England B15 2TT, United Kingdom
Expectations influence actual satiety

(a) Change in hunger

(b) Change in fullness

‘Expected satiety’ changes hunger and fullness in the inter-meal interval

Jeffrey M. Brunstrom *, Steven Brown, Elanor C. Hinton, Peter J. Rogers, Stephanie H. Fay

Department of Experimental Psychology, University of Bristol, 12a Priory Road, Bristol BS8 1TL, United Kingdom
Labelling influences actual satiety


“Seeing is believing; Labelling a product as ‘highly satiating’ promotes sustained increases in both expected and actual satiety.”
Portion size and meal planning are important, both before and after a meal.
Conclusion 1

Flavour-nutrient associations can be learned

Individuals differ in their ability to learn

Conclusion 2

Expected satiety/satiation can be measured

Expected satiety/satiation play an important role in meal planning

Conclusion 3

Expectations are learned

Conclusion 4

Portion size and meal planning are important, both before and after a meal!
Current preoccupations
1. Should we increase expected satiety/satiation?
Consumer Expectations Toolbox

**Expected Satiety**
- Expected satiety
- Expected satiation
- Tolerance (max portion)

**Expected Reward**
- Preference
- Purchasing behaviour
- Willingness to work

**Memory**
- Portion size
- Colour
- Sensory characteristics

**Ideal portion**
Eating to fullness

50% of ideal

N = 60

110% of ideal

N = 60
Study 1 & 2 – Follow-up at 4/5 months
Is fullness rewarding?


The relationship between food reward and satiation revisited

Anthony Sclafani*, Karen Ackroff
Physiology & Behavior 82 (2004) 89–95

Review
Flavour–nutrient learning in humans: An elusive phenomenon?

Martin R. Yeomans *
School of Psychology, University of Sussex, Brighton, BN1 9QH, UK

Physiology & Behavior 106 (2012) 345–355
2. Reducing energy density?
Expected satiety and expected satiation

**Standard formulation**
567 kcal (141 kcal/100g)

**Reduced energy formulation**
374 (84 kcal/100g)
Liking is diminished in ‘reduced energy’ group

Effects of repeated exposure on liking for a reduced-energy-dense food$^{1-3}$

*Hayley L O’Sullivan, Erin Alexander, Danielle Ferriday, and Jeffrey M Brunstrom*

American Journal of Clinical Nutrition 91, 1584-9
The ‘missing calories effect’

Learned Avoidance of Flavors Signaling Reduction in a Nutrient

Robert A. Boakes, Ben Colagiuri, and Michelle Mahon
University of Sydney

Flavor avoidance learning based on missing calories but not on palatability reduction

Robert A. Boakes • Angela E. Patterson •
Dorothy W. S. Kwok
SUPERNORMAL STIMULUS
(Oystercatcher Egg)

Konrad Lorenz
‘Supernormal foods’?
FP7 KBBE.2013.2.2-01: New technologies to study brain function in relation to eating behaviour

“Deconstructing food choice: a role for sensory, nutrient, and satiety reward”
3. Inconsistent flavour-nutrient associations

Examined the effects of varying the predictive relationship between sweet taste and the caloric consequences of eating.

Inconsistency causes loss of ability to use orosensory cues to predict caloric content and this contributes to over-eating and obesity.
1. Cumulative body weight gain across 5 weeks exposure to sweet predictive, sweet nonpredictive, or predictive control diets. Error bars represent standard error. *$p < .05$.
• Environmental variability - foods are available in many different varieties, which differ substantially in energy content.

501 kcal 1107 kcal 1909 kcal
Is it likely that you have eaten a SAINSBURY'S PEPPERONI pizza within the last year?

Some examples are shown below.
Key Findings ($N = 199$):

- Average pizza energy content = 1209 kcal ($SD = 170$; range 721 to 1909).
- Average interquartile range* = 271 kcal ($SD = 143$) (range 0 to 594).
Two-session laboratory study ($N = 66$).

Key outcome measure: Compensation index (COMPX) = difference in test meal energy intake divided by the energy content of the preload.
Predictors of COMPX:

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Standardised Beta coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inconsistent F-N associations</td>
<td>-.26*</td>
</tr>
<tr>
<td>Average pizza energy content</td>
<td>.27*</td>
</tr>
<tr>
<td>Confidence</td>
<td>.16</td>
</tr>
<tr>
<td>Loss aversion</td>
<td>-.15</td>
</tr>
<tr>
<td>Confidence x Loss aversion</td>
<td>.25*</td>
</tr>
</tbody>
</table>

* $p < .05$

Model accounted for 21% of the variance [$F(5, 61) = 3.0, p = .018$]
Samburu tribe of Northern Kenya
Who controls the food we eat? - Conclusions

Mindless eating is an unhelpful concept
Learning and memory are important
Does our food environment impair dietary learning?

Have we been conditioned to ‘crave’ ‘supernormal foods?’

What individual differences exist? Can this tell us something about a susceptibility to over consumption?