

<b>Institution:</b> University of Bristol		
<b>Unit of Assessment:</b> 4) Psychology, Psychiatry and Neuroscience		
<b>Title of case study:</b> Bristol Satiety Toolkit used by global food manufacturing industry to support product reformulation		
<b>Period when the underpinning research was undertaken:</b> 2005 - 2016		
<b>Details of staff conducting the underpinning research from the submitting unit:</b>		
<b>Name(s):</b>  Jeff Brunstrom Dani Ferriday	<b>Role(s) (e.g. job title):</b>  Professor of Experimental Psychology Lecturer in Experimental Psychology	<b>Period(s) employed by submitting HEI:</b> 03/2005 - present 10/2006 - present
<b>Period when the claimed impact occurred:</b> 1 <sup>st</sup> August 2013 - 2020		
<b>Is this case study continued from a case study submitted in 2014?</b> No		

## 1. Summary of the impact

Obesity is major global health concern and food product reformulation is a core mitigation strategy. Novel methodology, developed at the University of Bristol, has been important in supporting product reformulation across the multi-billion-pound food manufacturer sector, by quantifying the extent to which foods are expected to stave off hunger (expected satiety) and deliver fullness (expected satiation). The 'Bristol Satiety Toolkit' has been used in product reformulation initiatives to reduce calorie intake by nine food manufacturers, including global leaders Nestlé, Mars Wrigley and Unilever. The toolkit was successfully used by Nestlé to reformulate ready meals commercialized under the global Lean Cuisine brand which is worth 30% of Nestlé's USD 2.6 billion prepared food sales in the USA.

## 2. Underpinning research

Since 1975, obesity has nearly tripled globally, leading to increases in a range of noncommunicable diseases, such as cardiovascular disease, type 2 diabetes, osteoarthritis, and some cancers. Living in an 'obesogenic environment', one that promotes overeating, is often proposed as a driver of the global obesity crisis. In the UK and elsewhere, a core mitigation strategy has been voluntary or mandated commercial food 'reformulation' – the redesign of products in ways that reduce calorie intake. Research carried out by the University of Bristol (UoB) Nutrition and Behaviour Unit has been key in supporting product reformulation. Work by Prof Brunstrom and Dr Ferriday seeks to understand our interaction with our food environment, how certain foods and meals promote overeating and why certain individuals are more likely to eat in excess.

Prior experience with a food influences the extent to which it promotes fullness (satiation) after it has been consumed. Prof Jeff Brunstrom was interested in these learned controls of food intake and reasoned that evidence for learning might be exposed in beliefs about appropriate portion size before a meal begins. To explore this idea, his research group developed psychophysical methods that quantify the **expected satiation** (anticipated fullness) and **expected satiety** (anticipated relief from hunger) of commonly consumed foods. Using bespoke software, consumers were able to morph the size of a food on a screen. In so doing, it was possible to obtain precise estimates of expected satiety and satiation and, in turn, identify specific product reformulations (e.g., reductions in portion size, calories or fat) that ensure consumer acceptance is preserved. This work, funded by food manufacturer Kraft Foods [i], represented the first of its

kind and it demonstrated that: a) humans form and can express these expectations; b) they can be precisely quantified and importantly, c) that product reformulation is acceptable to consumers [1].

BBSRC funding [ii] to further progress these methods enabled Brunstrom, working with Ferriday, to develop a portion-selection tool that can be used to animate the presentation of different food portions on a computer screen. This work also showed that expected satiety and satiation influence meal size [2,3] and that they are learned and can be manipulated over time [1 and ii]. In 2012, Brunstrom and Ferriday applied these methods in two BBSRC projects, 50% funded by Nestlé [iii and iv], demonstrating that these expectations can be affected by modern food processing methods and eating rate [4].

Extending this research, Brunstrom and Ferriday showed that tools for assessing expected satiety and expected satiation can also be used to explore the effects of repeated exposure to 'processed' foods [5]. A key finding was that these expectations play a major role in food choice [2]. This discovery formed the basis of involvement in an EU-FP7 project (Nudge-it) [v] and led to publications demonstrating the relative importance of satiety expectations alongside other predictors of food choice. This was achieved by developing a 'consumer expectations toolbox' that incorporates other measures (e.g., healthiness and palatability) alongside assessments of expected satiety and expected satiation [6].

Together, this research and the novel methodologies comprise the 'Bristol Satiety Toolkit'. A further application of the toolkit has been to understand individual differences in dietary behaviour. For example, and in combination with neuroimaging, these methods have shown differences in underlying drivers of portion selection in people with obesity and in patients with anorexia nervosa.

### 3. References to the research

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- [1] **Brunstrom JM**, Shakeshaft NG, Scott-Samuel NE. (2008). Measuring 'expected satiety' in a range of common foods using a method of constant stimuli. *Appetite*, 51(3), 604-614. DOI: [10.1016/j.appet.2008.04.017](https://doi.org/10.1016/j.appet.2008.04.017)
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- [4] **Ferriday D**, Bosworth ML, Godinot N, Martin N, Forde CG, Van Den Heuvel E, Appleton SL, Mercer Moss FJ, Rogers PJ, **Brunstrom JM**. (2016). Variation in the Oral Processing of Everyday Meals Is Associated with Fullness and Meal Size; A Potential Nudge to Reduce Energy Intake? *Nutrients*, 8(5), 315. DOI: [10.3390/nu8050315](https://doi.org/10.3390/nu8050315)
- [5] O'Sullivan HL, Alexander E, **Ferriday D**, **Brunstrom JM**. (2010). Effects of repeated exposure on liking for a reduced-energy-dense food. *American Journal of Clinical Nutrition*, 91(6), 1584-1589. DOI: [10.3945/ajcn.2009.28863](https://doi.org/10.3945/ajcn.2009.28863)
- [6] **Brunstrom JM**, Jarvstad A, Griggs RL, Potter C, Evans NR, Martin AA., Brooks JCW, Rogers PJ. (2016). Large portions encourage the selection of palatable rather than filling foods. *The Journal of Nutrition*, 146(10), 2117-2123. DOI: [10.3945/jn.116.235184](https://doi.org/10.3945/jn.116.235184)

## Impact case study (REF3)

Grant Funding:

- [i] **Brunstrom JM**, Strategies for successful portion reformulation, Kraft Foods, 2005 – 2006, GBP42,000
- [ii] **Brunstrom JM**, [Understanding decisions about portion size: The key to acceptable foods that reduce energy intake?](#), BBSRC, 2009 – 2012, GBP376,251
- [iii] **Brunstrom JM**, [Does flavour-nutrient inconsistency compromise energy regulation in humans?](#), BBSRC, 2012 – 2015, GBP416,657
- [iv] **Brunstrom, JM**, [Understanding eating topography: The key to reducing energy intake in humans?](#), BBSRC LINK, 2012 – 2016, GBP203,144
- [v] **Brunstrom JM**, Nudge-it project – Deconstructing food choice: a role for sensory, nutrient and satiety reward, EU-FP7, 2013 - 2018, GBP7,400,000

**4. Details of the impact**

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Food product reformulation is often complex, because lower-calorie ingredients affect shelf life and impact consumer acceptability. One option is to simply reduce portion size. However, this approach is only suited to pre-portioned foods and portion reduction has the potential to undermine brand reputation due to low consumer acceptability.

Research and methodology developed by Brunstrom and Ferriday, the 'Bristol Satiety Toolkit' [including 1-6], has enabled international food industry leaders to estimate and compare the likely impact of reformulations on consumer expected satiation, satiety and product acceptability. The toolkit has been applied to a broad range of savoury, sweet, main meal and snack foods, including sugary products which are a key target for public health mitigation, as well as retailer own brand products. Industry investment and collaboration over 13 years, has enabled food manufacturers to address public health concerns while maintaining product integrity. UoB research has changed practice in this multi-billion-pound industry.

**Informing food industry strategy, operations and practices****i) Nestlé**

Nestlé is the world's leading nutrition, health and wellness company. A longstanding collaboration (2007 onwards) between the Nestlé Research Centre (NRC) and Prof Brunstrom, has supported the development of the Bristol Satiety Toolkit.

The Head of Behaviour & Perception Group and Head of Consumer Science at the NRC acknowledges that one of their key challenges has been to; *'understand consumer beliefs about food, and in particular, the satiety and satiation that consumers expect their products to confer'* [A]. Methods developed by UoB, have allowed Nestlé's researchers to meet this challenge and explore ways to reduce portion size without impacting consumer satisfaction [Bi, ii], as well as assess changes in the physical dimensions of a food offering [C]. These industry studies [Bi, ii, C], particularly have drawn on the UoB approach [2], citing this in their own methodology as well as drawing on the wider Bristol Satiety Toolkit (including [1,3]).

Importantly, the NRC have confirmed the role of UoB methods in changing their Research and Development operations for well-known products and brands: *'As a direct consequence [of UoB methods], we have assessed the expected satiation of several of our product lines, including ready meals commercialized under the Lean Cuisine brand. With these tools we have been able to explore ways to enhance expected satiation and to propose guidelines for the reformulation of our*

*products for enhancing satiation (fullness)*' [A]. The Lean Cuisine brand constitutes 30% of Nestlé's USD2.6 billion USA prepared food sales (data from 2017) [Aii].

The NRC have also expanded this area of product development to understand brain responses (using EEG) to portion sizes [D], in doing so, citing methods developed in collaboration with UoB [2]. In total, seven industry studies from the NRC, examining up to 19 commercially available meals, as well as gummy candy and ice cream products, cite the Bristol Satiety Toolkit [G].

## ii) Mars Wrigley

Leading manufacturer of confectionary treats and snacks, Mars Wrigley, has also *'followed the work of Professor Brunstrom'* [E] and in 2019, a new project leveraged UoB expertise to understand the impact of product reformulation [E]. A Mars Wrigley senior research scientist highlights how this has been incorporated into their product development processes; *'With this partnership we have developed ways to model and predict the potential effects of portion reduction on expected satiety and consumer choice.'*

They also highlight the benefit for their company; *'This work is very important to us because it can help guide us to the most effective solutions in reducing calorie density while maintaining consumer satisfaction and enjoyment'* [E].

## iii) Wider commercial adoption application

A scoping review of published literature (detailed methodology and complete output list provided in [G]), revealed that since 1<sup>st</sup> August 2013, 33 publications directly or indirectly supported by the food industry, have drawn on the UoB methodology and 19 of these outputs directly cited the Bristol Satiety Toolkit [including 1-6] [G]. Three studies were undertaken by multinational consumer goods company Unilever and include an independent validation and application of aspects of the UoB framework [F]. The 19 studies identified, applied the Bristol Satiety Toolkit to a wide range of both savoury and sweet, main meal and snack foods, including fruit juice, yoghurt and confectionary products [G], which are a key target of public health sugar reduction strategies. The breadth of products shows the relevance of the UoB methodology across the food industry.



**Figure 1:** Summary of scoping review data [G]. Text size indicates relative frequency (actual frequency in brackets) of food industry manufacturers (=9) and commercial innovation (=1), which draw on (=33) and directly cite (=19) the Bristol Satiety Toolkit (some studies funded by more than one food manufacturer).

### Industry collaboration and investment

Studies identified by the scoping review [G] made use of funding from BBSRC DRINC (Diet and Health Research Industry Club), a collaboration between industry (14 company members) and academic research to deliver enhanced health benefits for consumers. This collaboration included major food manufacturers (e.g., Coca Cola, Nestlé) and retailers (e.g. Sainsburys, Marks and Spencer) along with a GBP22 million budget, highlighting the importance of this area to the food industry. Brunstrom and Ferriday collaborated on four of these studies [G] which cited the Bristol Satiety Toolkit and included investigation of portion size in own brand meals from Sainsburys and Asda.

Two new multidisciplinary collaborative projects [Hii-iii], part of the 'Priming Food Partnerships' between academic and industry partners, centre around the Bristol Satiety Toolkit [1-3]. Using UoB methods, one of these projects is generating multidisciplinary approaches to developing high-protein foods for healthy ageing, and the other is investigating the effects of reduced-fat reformulations on feelings of 'fullness'. Together, these projects are financed by 13 different food manufacturers including Pladis, Nestlé, Unilever, Pepsico, and Premier Foods [Hi - iii]. This continued investment and collaboration further demonstrates the value of the Bristol Satiety Toolkit for industry.

### 5. Sources to corroborate the impact

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- [A] i) Nestlé Research Centre (2016). Corroborating Statement – Head of Behaviour & Perception Group and Head of Consumer Science  
 ii) Nestlé (2017). Nestlé in the USA & Frozen Meals Performance
- [B] i) Labbe *et al.* (2017). Influence of BMI and dietary restraint on self-selected portions of prepared meals in US women. *Appetite*, 111, 203–207. DOI:[10.1016/j.appet.2016.11.004](https://doi.org/10.1016/j.appet.2016.11.004)  
 ii) Labbe *et al.* (2018). Right Sizing: Sensory-Based Product Design Is a Promising Strategy to Nudge Consumers toward Healthier Portions. *Nutrients*, 10, 1544. DOI:[10.3390/nu10101544](https://doi.org/10.3390/nu10101544)
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- [E] Mars Wrigley (2020). Corroborating Statement – Senior Research Scientist
- [F] Bultmann *et al.* (2015). High satiety expectations of a first course promote selection of less energy in a main course picture task. *Appetite*, 87, 236–243. DOI:[10.1016/j.appet.2014.12.218](https://doi.org/10.1016/j.appet.2014.12.218)
- [G] UoB (2020). Scoping Review Data.
- [H] i) BBSRC (2017). [Priming Food Partnerships: Addressing challenges faced by the UK's food and drink industry](#)  
 ii) Stevenson *et al.* (2018). Protein for Life: Towards a focussed dietary framework for healthy ageing. *Nutr. Bull.* 43, 97–102. DOI:[10.1111/nbu.12312](https://doi.org/10.1111/nbu.12312)  
 iii) Yeomans *et al.* (2019). The Mouth-Gut-Brain model: An interdisciplinary approach to facilitate reformulation of reduced fat products. *Nutr. Bull.* 44, 241–248. DOI:[10.1111/nbu.12392](https://doi.org/10.1111/nbu.12392)