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Research report

Effects of meal variety on expected satiation: Evidence for a 'perceived volume' heuristic ☆

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ABSTRACT

Meal variety has been shown to increase energy intake in humans by an average of 29%. Historically, research exploring the mechanism underlying this effect has focused on physiological and psychological processes that terminate a meal (e.g., sensory-specific satiety). We sought to explore whether meal variety stimulates intake by influencing pre-meal planning. We know that individuals use prior experience with a food to estimate the extent to which it will deliver fullness. These 'expected satiation' judgments may be straightforward when only one meal component needs to be considered, but it remains unclear how prospective satiation is estimated when a meal comprises multiple items. We hypothesised that people simplify the task by using a heuristic, or 'cognitive shortcut.' Specifically, as within-meal variety increases, expected satiation tends to be based on the perceived volume of food(s) rather than on prior experience. In each trial, participants ($N = 68$) were shown a plate of food with six buffet food items. Across trials the number of different foods varied in the range one to six. In separate tasks, the participants provided an estimate of their combined expected satiation and volume. When meal variety was high, judgments of perceived volume and expected satiation 'converged.' This is consistent with a common underlying response strategy. By contrast, the low variety meals produced dissociable responses, suggesting that judgments of expected satiation were not governed solely by perceived volume. This evidence for a 'volume heuristic' was especially clear in people who were less familiar with the meal items. Together, these results are important because they expose a novel process by which meal variety might increase food intake in humans.

Introduction

The 'variety effect' describes the increases in amount of food consumed when animals (Morrison, 1974; Rogers & Blundell, 1984; Rolls, Van Duijvenvoorde, & Rowe, 1983) and humans (Bellisle & Le Magnen, 1981; Rolls et al., 1981) are exposed to multiple foods with different sensory characteristics (taste, texture, odour, and appearance). The effects of food variety on energy intake are substantial and can occur both within a single meal and across meals (Remick, Polivy, & Pliner, 2009). In non-human animals, exposure to a variety of foods increases intake by roughly 25% (McCrory, Burke, & Roberts, 2012). In humans this figure is estimated at 29% (McCrory et al., 2012).

Research investigating the effects of meal variety has tended to concentrate on the physiological and psychological processes that promote meal termination (e.g., sensory-specific satiety (Brondel et al., 2009; Raynor & Epstein, 2001; Rolls et al., 1981; Rolls, Van Duijvenvoorde, & Rolls, 1984). However, recent research suggests that meal size is very often planned, and therefore determined, in advance of eating (Fay et al., 2011; Hinton et al., 2013). A very good predictor of self-selected portion size (kcal) is the extent to which a food is expected to deliver fullness (Brunstrom, 2011; Brunstrom & Rogers, 2009; Wilkinson et al., 2012). This 'expected satiation' differs considerably across foods (up to a six fold difference) and is not based solely on a food's physical size (its 'perceived volume') (Brunstrom, Collingwood, & Rogers, 2010; Brunstrom, Shakeshaft, & Scott-Samuel, 2008; Brunstrom & Shakeshaft, 2009). Instead, the satiation that a food is expected to deliver increases with familiarity and with previous experience of eating it to fullness – a finding that is referred to as 'expected-satiation drift' (Brunstrom, 2011; Brunstrom, Shakeshaft, & Alexander, 2010; Hardman, McCrickerd, & Brunstrom, 2011; Irvine, Brunstrom, Gee, & Rogers, 2013). Recently, effects of variety have been explored in the context of meal planning (Wilkinson, Hinton, Fay, Rogers, & Brunstrom, 2013). Across

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Table 1
Macronutrient composition (g) of the six test foods.

Food type	Kcal	Carbohydrate (g)	Protein (g)	Fat (g)	Fibre (g)	Weight (g)	Energy density (kcal/g)
Sausage rolls	56.0	4.7	1.3	3.6	0.4	15.5	3.6
Cocktail sausages	53.2	2.7	2.2	3.7	0.5	20.0	2.7
Vol-au-vents	57.5	6.4	0.8	3.1	0.4	20.0	2.9
Scotch eggs	55.0	3.7	1.9	3.6	0.7	20.0	2.8
Cheese & pineapple	50.8	0.7	2.9	4.0	0.0	15.5	3.3
Salmon & cream cheese blinis	53.3	5.2	5.8	1.0	0.2	38.5	1.4

two studies, participants selected more food for a second course when it differed in its sensory characteristics from the first course. Here, we explored the prospect that meal variety influences energy intake by moderating beliefs about the satiating capacity of a meal *before* it begins.

Evaluating the expected satiation of a single food may be relatively simple. However, with greater meal variety (e.g., at a buffet or in a multi-component meal), the task of integrating separate expectations becomes increasingly complex. Researchers have long recognised that humans respond to decision complexity (or uncertainty) by using heuristics or 'cognitive shortcuts' (*e.g.,* Payne, 1976; Payne, Bettman, & Johnson, 1988; Russo & Dosher, 1983; Tversky & Kahneman, 1974). A heuristic represents a simplified rule or principle that provides a quick resolution that may not be optimal. For example, purchasing a car is a complex decision. Rather than focusing on all attributes (e.g., fuel efficiency, top speed, reliability), a prospective owner may simplify the task by focusing on a single feature (e.g., fuel efficiency). Heuristics of this kind have also been shown to be used in dietary decision making. For example, Piqueras-Fiszman and Spence (2012) added weights to the base of a plastic white bowl and showed that the weight of a food can affect its expected satiety. This was the case even after controlling for all other variables (volume, visual cues, etc). For other examples of dietary heuristic use, see Scheibehenne, Miesler, and Todd (2007) and Schulte-Mecklenbeck, Sohn, de Bellis, Martin, and Hertwig (2013).

It remains unclear how prospective satiation is estimated when the underlying decision is complicated by the concurrent presentation of multiple food items (e.g., multi-item meals). However, we know that when children are unfamiliar with a food, they tend to use its perceived volume in a portion-selection task that requires them to match its expected satiation to that of another food (Hardman et al., 2011). Similarly, we reasoned that adults might also default to this strategy (a volume-based heuristic) when they are presented with complex multi-item meals.

To test this hypothesis, participants provided separate estimates of expected satiation and physical size (perceived volume) for plates of buffet foods. The amount of meal variety depicted in each plate was systematically manipulated. These data enabled us to calculate the difference between responses based on expected satiation and responses based on perceived volume at different levels of meal variety. We anticipated a smaller difference between these responses with increased meal variety.

A second aim was to establish whether food familiarity moderates the use of this volume heuristic. As we have already noted, when instructed to assess the expected satiation of an unfamiliar food, children rely on perceived volume (Hardman et al., 2011). In our study, we anticipated that unfamiliarity might play a similar role and that it might work in combination with meal variety to further encourage the use of a volume heuristic.

Methods

Participants

An opportunity sample of 68 participants (36 women and 32 men) assisted with this study. Vegetarians and vegans were excluded together with anyone who declared a food allergy or intolerance. In addition, we excluded anyone who had suffered from an eating disorder in the last six months. Ethical approval was granted by the University of Bristol Faculty of Science Human Research Ethics Committee.

Stimuli

Six 'test' foods were selected that are commonly served at a cold buffet meal in the UK. Here we refer to a cold buffet as a table of several different types of food that are self-served and often selected in a variety of small portions, and which tend to be consumed at a party or social gathering. Specifically, we selected 'sausage rolls,' 'cocktail sausages,' 'vol-au-vents,' 'scotch eggs,' 'cheese & pineapple,' and 'salmon & cream cheese blinis.' The macronutrient composition of each food is shown in Table 1. Each contained approximately 55 kcal (±4.2 kcal).

In each image, six test foods were arranged in isolated equally spaced positions on a 255-mm diameter white plate. Particular care was taken to ensure the lighting and viewing angle remained constant across images. Meal variety was manipulated by altering the number of different test foods on the plate. At the lowest level of meal variety, six portions of the same test food were presented. The highest level of variety comprised six different test foods. See Fig. 1 for examples. A systematic clockwise rotation method was used to

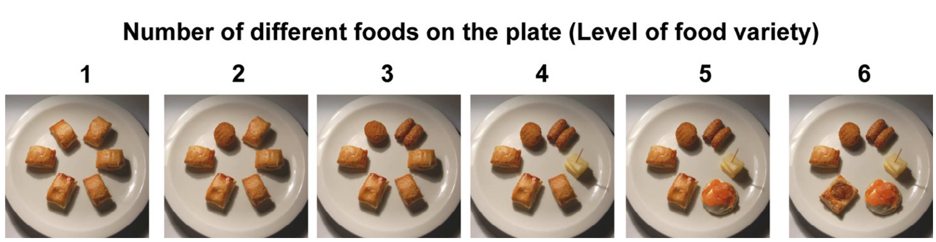

Fig. 1. Examples of stimuli with different levels of meal variety (1–6). Level 1 has the lowest meal variety (all of the foods the same) and level 6 has the highest (six different test foods on the plate). From left to right, the stimuli match image numbers 1, 7, 13, 19, 25, and 31 in Table 2.