



The impact of food and beverage characteristics on expectations of satiation, satiety and thirst



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ABSTRACT

The expected impact of a food or drink on appetite can influence decisions around eating and the actual experience of satiation and satiety post-consumption. This study explored the relationship between a product's anticipated sensory characteristics and its expected impact on feelings of hunger, fullness and thirst. Female participants ($n = 118$) evaluated 40 widely available food and beverage products (varying in physical characteristics, packaging, serving size and total energy content) for anticipated sensory characteristics, pleasantness and familiarity, alongside expected impact on immediate fullness, hunger after one hour and thirst both immediately and after one hour. Correlations revealed that the most caloric products and those anticipated to be creamier were expected to be more filling and hunger suppressing than the products with lower energy content and expected to be less creamy. Total energy was the best predictor of expected satiation and satiety. We observed that beverage products were expected to be similarly satiating as food products (including liquid, solid and semi-solids) with a similar total energy content and expected creaminess. On the other hand, products expected to be less salty and thick were expected to be most thirst-quenching, and these tended to be beverage products, regardless of their total energy content. These results are in line with emerging evidence suggesting that certain sensory cues associated with nutrients can be used to estimate the satiating power of other foods, including beverages. Beverages are expected to be uniquely thirst-quenching, but are not always expected to have a low satiety-value.

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1. Introduction

In an environment where food and drink is readily available, decisions about what and how much to consume will impact a person's ability to maintain a healthy body weight. An increasing amount of evidence suggests that beliefs about the potential satiating effect of a food are a key factor affecting energy intake and the experience of satiety (Brunstrom, Collingwood, & Rogers, 2010; Brunstrom & Shakeshaft, 2009; Cassidy, Considine, & Mattes, 2012; Wilkinson et al., 2012). Caloric beverages have been identified as having a particularly weak impact on satiety responses (Almiron-Roig et al., 2013; Flood-Obbagy & Rolls, 2009; Mattes, 2006a, 2006b; Mourao, Bressan, Campbell, & Mattes, 2007), possibly because they are not expected to be satiating (Mattes, 2005). The present study explores the anticipated

satiating effect of a range of commonly consumed beverages and ready-to-eat food products.

The anticipated satiating effect of a food is linked to our previous experience. Physiologically, the anticipation of nutrients (characterised by cephalic-phase neural and hormonal responses to food cues) is in-part learned from associations between the sensory characteristics of the food and its post ingestive effect (Booth, 1972; Woods, 1991, 2009). As a result the sight, smell and taste of that food come to trigger salivation and release of gastrointestinal and other hormones involved in subsequent nutrient processing. If consistent, these sensory-nutrient relationships may be expressed at a cognitive level as explicit expectations of satiation (the extent to which a food is expected to deliver fullness immediately) and satiety (the extent to which a food is expected to suppress hunger over time) for a given food (Blundell et al., 2010; Brunstrom, 2007).

Although our understanding of how explicit expectations of satiation and satiety are altered is limited (Hogenkamp, Brunstrom, Stafleu, Mars, & de Graaf, 2012; Hogenkamp, Mars, Stafleu, & de Graaf, 2012; Wilkinson & Brunstrom, 2009;

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Yeomans, McCrickerd, Brunstrom, & Chambers, 2014), the impact of these expectations on eating behaviour is now well documented: expectations are thought to guide both portion size selection and actual food intake (Brunstrom & Rogers, 2009; Brunstrom & Shakeshaft, 2009; Wilkinson et al., 2012), independent of perceived volume and liking (Brunstrom, Collingwood, et al., 2010), and alter our experience of satiety post-consumption (Brunstrom, Brown, Hinton, Rogers, & Fay, 2011; Cassady et al., 2012; Hogenkamp et al., 2013; McCrickerd, Chambers, & Yeomans, 2014). Perhaps the most consistent evidence that satiety expectations are learned with experience comes from research demonstrating that expectations of satiety increase with a food's rated familiarity (Brunstrom, Shakeshaft, & Alexander, 2010; Brunstrom, Shakeshaft, & Scott-Samuel, 2008; Hardman, McCrickerd, & Brunstrom, 2011). Yet what has been overlooked in these studies is that people can still generate expectations about the satiating effect of foods that they are unfamiliar with or which they have never eaten. The existence of expectations prior to consumption of unfamiliar foods suggests that these expectations are not simply a consequence of direct experience with a specific food, but may be guided by characteristics of the new product that show similarities to other known foods.

In line with this idea, a growing body of evidence now links satiety expectations to certain sensory characteristics: foods perceived to be thicker (Hogenkamp, Stafleu, Mars, Brunstrom, & de Graaf, 2011), chewier and saltier (Forde, van Kuijk, Thaler, de Graaf, & Martin, 2013) and heavier (Piqueras-Fiszman & Spence, 2012) were expected to be more satiating. Indeed, in a drink context McCrickerd, Chambers, Brunstrom, and Yeomans (2012) demonstrated that adding subtle thick and creamy sensory cues to a beverage (without affecting nutrient content) increased the expectation that the beverage would be filling and would suppress hunger to a greater extent than the same drink without these added characteristics. Previously, creamy textural cues have been associated with nutrient-rich foods (Bertenshaw, Lluch, & Yeomans, 2008, 2009, 2013), and it is possible that satiety-relevant sensory cues can be used to estimate the satiating power of other foods with similar sensory characteristics. This would support the view that oro-sensory taste and texture cues act as a nutrient sensor (Woods, 1991, 2009), directing eating behaviour to ensure the efficient consumption of nutrient rich or nutrient lacking foods.

The present study aimed to investigate the extent to which the anticipated taste and texture characteristics (such as thickness, creaminess, sweetness and saltiness) of a range of food and beverage products relate to their expected impact on appetite. Participants evaluated 40 images of ready-to-eat products consisting of a range of liquid (waters, soft drinks, fruit juices, soups), semi-solid (yoghurt, jelly, porridge) and solid (chocolate, crisps, apple etc.) foods and beverages, for their anticipated sensory characteristics and expected impact on feelings of hunger, fullness and thirst (four outcome expectations: *fullness immediately*, *hunger after one hour*, *thirst immediately* and *thirst after one hour*). Beverages were considered to be products designed to be drunk. The food and beverage items were selected to represent a wide range of sweet and savoury products and a mixture of raw, modified and highly processed foods readily available in the UK.

2. Method

2.1. Participants

One hundred and nineteen female students and staff from the University of Sussex were recruited to take part in a study investigating "the interaction between food products and mood". Participants had English as their first language, were mainly

younger adults (mean age 21 years, $SD \pm 3$, range 18–38 years) and had an average BMI of 23.5 kg/m^2 ($SD \pm 4.0$, range 17.0–37.2 kg/m^2). Participants had a mean dietary restraint score of 10 ($SD \pm 6$, range 0–21) and disinhibition score of 8 ($SD = 3.1$, range 2–16) as measured by the Three Factor Eating Questionnaire (TFEQ; Stunkard & Messick, 1985). The research was approved by the University of Sussex Life Science Research Ethics Board.

2.2. Design

The study was conducted using a correlational design, where all data were collected as continuous variables. Participants rated the expected sensory characteristics (*thick*, *hard*, *creamy*, *sweet*, *bitter*, *salty*, *pleasant*) of 40 food and drink products readily available in the UK, and also rated their anticipated effect of feelings of satiation, satiety and thirst: expected fullness immediately after consumption (*fullness immediately*); expected hunger one hour after consumption (*hunger +1*); expected thirst immediately after consumption (*thirst immediately*); expected thirst one hour after consumption (*thirst +1*). The total energy content (kcal) and serving size (g) of each depicted product was noted.

2.3. Procedure

Testing took place Monday–Friday between 9:00–11:00 and 14:00–17:00 and all participants gave written informed consent and were instructed not to eat or drink anything but water for two hours before taking part. Testing was conducted in air-conditioned testing cubicles using a Dell PC computer running Windows 7 with an 18-inch screen with a resolution of 1280×1024 . The experimental task was programmed and completed in MATLAB R20112b.

Participants began by completing a set of appetite ratings to record their appetitive state. They were then presented with an instruction page, informing them that they would be rating 40 food and drink products for a number of characteristics. At this point the experimenter was called to give an example of the types of questions they would be asked. Participants were instructed that they would need to imagine consuming the entire food or beverage product that was presented in each image, both inside and outside of its container if necessary, except for one item (rice cakes) where they were only instructed to imagine consuming the three presented next to the packet. Placed next to the computer screen was an example of the plate, bowl and glasses used in the images, and participants were instructed that they should refer to these to help them imagine the serving size presented. The picture-rating task involved participants viewing images of the 40 items, presented in a random order in the centre of a white screen. The participants were required to base all their evaluations on the images provided and were not given any additional information about the products (such as energy content). Eleven evaluations were made of each product: seven expected sensory characteristics and the four judgements of expected fullness immediately, hunger in one hour, and thirst both immediately and one hour later, all made using 100-point Visual Analogue Scales (VAS) and in randomised order. The first rating was presented two seconds after each image was displayed. Participants could answer the questions in their own time with the instruction "to complete the rating please move the cursor along the line to the point that best reflects your judgement, and right click", and once clicked the next question was presented. In order to discourage rapid responding, participants could only move on if they responded at least one second after the question was presented. Once complete, participants repeated the appetite ratings before filling out a paper version of the TFEQ. Height and weight were recorded prior to debriefing and receipt of £5 for taking part.

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