



Research report

Does modifying the thick texture and creamy flavour of a drink change portion size selection and intake? ☆



Keri McCrickerd*, Lucy Chambers, Martin R. Yeomans

School of Psychology, Pevensey Building, University of Sussex, Brighton BN1 9QH, UK

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ABSTRACT

Previous research indicates that a drink's sensory characteristics can influence appetite regulation. Enhancing the thick and creamy sensory characteristics of a drink generated expectations of satiety and improved its actual satiating effects. Expectations about food also play an important role in decisions about intake, in which case enhancing the thick and creamy characteristics of a drink might also result in smaller portion size selection. In the current study forty-eight participants (24 female) completed four test days where they came into the laboratory for a fixed-portion breakfast, returning two hours later for a mid-morning drink, which they could serve themselves and consume as much as they liked. Over the test days, participants consumed an iso-energetic drink in four sensory contexts: thin and low-creamy; thin and high-creamy; thick and low-creamy; thick and high-creamy. Results indicated that participants consumed less of the thick drinks, but that this was only true of the female participants; male participants consumed the same amount of the four drinks regardless of sensory context. The addition of creamy flavour did not affect intake but the thicker drinks were associated with an increase in *perceived* creaminess. Despite differences in intake, hunger and fullness ratings did not differ across male and female participants and were not affected by the drinks sensory characteristics. The vast majority of participants consumed all of the drink they served themselves indicating that differences in intake reflected portion size decisions. These findings suggest women will select smaller portions of a drink when its sensory characteristics indicate that it will be satiating.

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Introduction

Energy-containing drinks are reported to have a weaker satiety value than energy-matched 'foods', such as solid and semi-solid items and liquid soups (Hulshof, Degraaf, & Weststrate, 1993; Mattes, 2005; Mattes, 2006a; Mourao, Bressan, Campbell, & Mattes, 2007; Tournier & Louis-Sylvestre, 1991). Oro-sensory characteristics of foods are important for the development of satiety (Cecil, Francis, & Read, 1998; Cecil, Francis, & Read, 1999),

triggering learned salivatory and gastrointestinal cephalic phase responses which are thought to aid the digestion of nutrients and enhance the experience of satiety (Mattes, 1997; Mattes, 2006b; Woods, 1991). Evidence that energy consumed in liquid form elicits a weak cephalic phase response (Teff, 2010; Teff, Devine, & Engelman, 1995) suggests that the strength of associations formed between a drink's sensory characteristics and its post-ingestive effect is weak; possibly because they are consumed fast, and this reduced oral exposure time may limit the strength of its oro-sensory signal and subsequent learning (Mars, Hogenkamp, Gosses, Stafleu, & De Graaf, 2009). As a result, energy consumed as a drink may not be *expected* to be satiating, and the potential for these expectations to influence decisions about consumption is the focus of the present study.

Recent research from our laboratory supports the idea that the sensory characteristics of a drink can limit its satiety value: drinks varying in thick texture and creamy flavour were expected to have different satiating effects (McCrickerd, Chambers, Brunstrom, & Yeomans, 2012). The thicker drinks were expected to be more filling (expected satiety) and to suppress hunger to a greater extent (expected satiety) than thin versions, regardless of their actual energy content. The addition of creamy flavours did not affect

Abbreviations: mPa s, millipascal-second; s^{-1} , reciprocal seconds; mm s^{-1} , millimetres per second; MTM2, Mini-Traction-Machine tribometer.

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* Corresponding author.

E-mail address: k.mccrickerd@sussex.ac.uk (K. McCrickerd).

expected satiety but did enhance the expectation that the drinks would be filling, presumably because perceived creaminess has both textural (thickness and smoothness) and flavour (dairy, vanilla and sweet) attributes (de Wijk, Terpstra, Janssen, & Prinz, 2006; Kirkmeyer & Tepper, 2005) typically associated with nutrients. Indeed, energy compensation following a drink preload was improved by modifying its creamy texture and flavour to better signify the presence of the nutrients (Bertenshaw, Luch, & Yeomans, 2013; Yeomans & Chambers, 2011). This fits with the Satiety Cascade Model (Blundell, Rogers, & Hill, 1987), which proposes that early cognitive and sensory information is integrated with later post-ingestive and post-absorptive signals to suppress appetite after an eating episode. However, the Satiety Cascade also predicts that sensory characteristics and beliefs about the satiety value of food strongly influence satiation (the process of ending a meal or eating episode) and therefore the amount people eat (Blundell et al., 2010; Blundell et al., 1987; Brunstrom, 2011). So if a person expects a drink to be filling because it is thick and creamy, as our previous research suggests, they may select a smaller portion size and/or consume less of that drink.

So far research has demonstrated that increasing the viscosity of a liquid did result in decreased *ad libitum* consumption, but whether this reduction is based on the belief that a thicker product would be more filling is less clear. Hogenkamp, Mars, Stafleu, and de Graaf (2012) provided participants with 1000 g portions of a custard product as either a lemon-flavoured liquid or a meringue-flavoured and “caramel” coloured semi-solid, both to be consumed from a large bowl with a spoon. Participants expected the thicker custard to be most filling and consumed approximately 30% less of that custard compared to the thin version. However, because the colour and flavour were not matched across the thick and thin versions, the extent to which differences in intake can be attributed to viscosity alone is limited. In a drink context, Zijlstra, Mars, de Wijk, Westerterp-Plantenga, and de Graaf (2008) found similar reductions in intake of an iso-energetic semi-solid chocolate milk compared to a less viscous liquid version, which were presented in 1.5 l opaque cartons and frequently replaced so the serving could not be finished. The researchers suggest this was due to a difference in eating rate between the products because when eating rate was standardised participants consumed a similar amount of the thick and thin versions. Indeed, *ad libitum* consumption from a ‘bottomless’ portion is a good measure of satiation, but is likely to emphasize the role of factors such as eating rate, stomach distension and appetitive sensations, whilst limiting the opportunity for participants to plan, see and adjust the amount of food they consume based on visual and olfactory cues and pre-existing expectations about its satiating effects. Instead, expectations held about the satiating value of foods are an important determinant of self-selected portion size (Wilkinson et al., 2012) and portion size decisions are a regular feature of everyday eating behaviour, alongside consuming all of the food selected (Fay et al., 2011).

The present study aimed to extend the previous findings that thick texture and creamy flavours can modify expectations and enhance satiety, by determining whether such sensory manipulations also influence actual self-selected intake of a drink and assessing the relative contribution of satiety-relevant texture and flavour cues. Participants were able to select the amount of a drink to consume across four different sensory contexts identical to those used in our previous research (McCrickerd et al., 2012): thin and low-creamy flavour; thin and high-creamy flavour; thick and low-creamy flavour; thick and high-creamy flavour. It was predicted that participants would consume less of the thicker drinks than the thinner ones, as thick texture generates strong expectations of satiety, and that the addition of a creamy flavours would have more

subtle effects on intake. A secondary prediction was that the self-served drink would be consumed in its entirety.

Methods and materials

Participants

Forty-eight participants (24 female) completed the study “investigating the effect of breakfast on mood and alertness”. Participants were recruited from a volunteer database of staff and students at the University of Sussex. Participants were selected to be non-smokers, not currently dieting or diagnosed with an eating disorder, without allergies or aversions to any of the test food ingredients and not taking prescription medication. On average, participants were 20.8 years (range = 18–52 years, $SD = 5.3$), with a BMI of 22.5 kg/m² (range = 18–30 kg/m², $SD = 2.8$) and mean dietary restraint score of 7.1 for males (range = 1–16, $SD = 4.4$) and 6.7 for females (range = 1–15, $SD = 3.8$), measured using the Three Factor Eating Questionnaire (TFEQ; Stunkard & Messick, 1985). Male and female participants did not differ in age, restraint and BMI. The research was approved by the University of Sussex Life Science Research Ethics Board.

Design

A three-factor mixed design was used to assess the effect of drink texture (thin vs. thick) and the addition of creamy flavours (low-creamy vs. high-creamy) on the self-selected consumption of a fruit drink, controlling for participant gender. Based on our previous finding that texture (effect size $r = 0.90$) and flavour (effect size $r = 0.74$) of a drink (repeated measures) influenced how filling it was expected to be (McCrickerd et al., 2012) a sample size calculation was conducted, which indicated that for the smallest effect size of interest (creamy flavour) a total of 8 participants would be needed. However, it was assumed that the effect of these expectations on actual self-selected intake would be smaller, therefore based on a medium effect size ($r = 0.30$) a second calculation suggested a sample of 44 participants (22 males and females), which was taken to 48 to counterbalance drink order across males and females.

Standard breakfast

On each test day all participants consumed a breakfast of cereal (“Crunchy Nut Cornflakes”, Kellogg’s, UK: males 80 g, females 60 g), semi-skimmed milk (Sainsbury’s, UK: males 200 g, females 160 g) and orange juice (Sainsbury’s, UK: males 200 g, females 200 g). The breakfast provided the males with 540 kcal (2259 kJ) and the females with 440 kcal (1841 kJ), approximately 22% of an adults daily average recommended energy intake.

Test drinks

The test drinks were based on the low energy versions of a fruit drink described in a previous study from our laboratory (McCrickerd et al., 2012), formulated and prepared in the Ingestive Behaviour Unit at the University of Sussex. One hundred grams of the fruit drink base contained 23 kcal (96 kJ) and consisted of 31 g of fresh mango, peach and papaya fruit juice (Tropicana Products, Inc.), 17 g 0.1% fat fromage frais (Sainsbury’s UK), 41 g of water and 11 g of peach flavoured diluting drink (Robinsons from Britvic, UK). The drinks were prepared in four sensory contexts varying in thick texture (thin vs. thick) and creamy flavours (low-creamy vs. high-creamy): thin/low-creamy; thin/high-creamy; thick/low-creamy; thick/high-creamy. Small quantities

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