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The effect of genotypical and phenotypical variation in taste sensitivity on liking of ice cream and dietary fat intake

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ABSTRACT

Emerging evidence suggests fat can be perceived as a taste. G-protein coupled receptors as well as *CD36*, a fatty acid translocase, have been proposed to be involved in fat perception. Therefore, differences in number of receptors and genotype of *CD36* have both been proposed to influence inter-individual fat taste perception. Fungiform papillae density (FPD) and PROP taster status are phenotypes related to receptor number. Previous authors have proposed an association between such phenotypes and *CA6* (gustin) genotype, because the latter influences receptor cell proliferation. The effect of these factors on fat perception, preference and intake, requires further investigation. Therefore, the main aim of this study was to investigate the effects of taste sensitivity, including both genotypic and phenotypic variation, on liking of ice cream and dietary fat intake. Participants (n = 136) age 18–55 years were recruited in the UK. Hedonic liking results demonstrated that liking for ice cream was significantly affected by the fat content of the sample, and by demographic factors (gender, ethnicity, age) but not by the consumers *CD36 rs1761667* or *CA6 rs2274333* genotype, PROP taster status nor FPD. However, categorising taste sensitivity from participant responses to salt taste alone (rather than to salt and PROP) found significant differences, with low salt perceivers liking the high fat (20%) ice cream substantially more than medium- and high salt perceivers. This indicated that increased taste sensitivity reduced liking of high fat. Cluster analysis highlighted that one group of consumers (18%) liked higher fat ice cream, whereas another (30%) liked lower fat ice cream compared to the 52% of consumers that liked ice cream regardless of fat content. There was a significant association between these groups and salt taste sensitivity. Concerning recorded dietary intake, the high-fat liker group were found to have substantially higher dairy product consumption compared to high-fat dislikers. Fat intake as a percentage of total energy intake was significantly related to *CA6* genotype, however the minor allele frequency at *rs2274333* is too low to draw firm conclusions within this study population.

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1. Introduction

Overconsumption of energy dense foods, particularly high fat foods, and specifically foods high in saturated fats and free sugars, is a major cause of the obesity epidemic (Nasser, 2001; Mela, 2001; WHO, 2013, 2015). Sensory perception and preferences for these nutrients may contribute to such overconsumption and, hence, it is important to understand and quantify the extent of inter-individual differences.

Fat perception is multi-sensorial, comprising texture, aroma and taste (Schiffman, Graham, Sattely-Miller, & Warwick, 1998; Le Calvé et al., 2015). The textural aspects of fat are perceived as mouthfeel sensations by trigeminal nerves wrapped around papillae (Whitehead, Beeman, & Kinsella, 1985; Whitehead & Kachele, 1994; Essick, Chopra, Guest, & McGlone, 2003). Greater fungiform papillae density (FPD) can increase fat texture sensitivity and those with lower FPD may be less sensitive to the texture of fat (Essick et al., 2003; Nachtsheim & Schlich, 2013). Hayes and Duffy (2007) also suggested that subjects with a higher FP count gave higher creaminess rating to milk-cream mixtures. Additionally, Hayes, Sullivan, and Duffy (2010) suggested that subjects with higher FPD had lower preference for high-fat, salty foods. Nachtsheim and Schlich (2014) demonstrated that subjects with lower fungiform papillae counts had higher consumption of high fat milk and spreads than high fungiform papillae counts subjects. Recently, results from Running, Craig, and Mattes (2015) demonstrated that medium- and long chain non-esterified fatty acid (NEFA) were perceived as a unique taste sensation, separate

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from the other five basic tastes (sweet, bitter, sour, salty and umami).

PROP taster status is widely used as a marker of taste acuity. Individuals are commonly classified into three different PROP taster status groups: supertasters, medium-tasters and nontasters, according to their relative sensitivity to PROP and sodium chloride (Tepper, Christensen, & Cao, 2001). A number of studies suggest that PROP tasters (supertaster and medium-tasters) are not only more sensitive to PROP solutions, but also perceive higher bitter intensity from various foods, such as wine (Pickering, Simunkova, & DiBattista, 2004), caffeinated coffee (Drewnowski, Henderson, Levine, & Hann, 1999) and grapefruit juice (Drewnowski, Henderson, & Shore, 1997), as well as to differences in the perception of sweeteners in soft drinks (Zhao & Tepper, 2007). In addition, authors such as Tepper (2008) have reviewed the role of PROP sensitivity in food choice and nutritional intake. Studies have also suggested that PROP sensitivity is positively associated with fat perception (Tepper & Nurse 1997, 1998; Hayes & Duffy, 2007; Nachtsheim & Schlich, 2013). Hayes and Duffy (2007) found subjects with higher intensity ratings towards the bitter-tasting substance PROP gave higher creaminess ratings to high fat cream. It also has been reported that preference for food with varied fat contents is influenced by PROP taster status. Anliker, Bartoshuk, Ferris, and Hooks (1991) found that PROP tasters preferred whole milk significantly more than non-tasters, however, tasters had a significantly lower preference for cheese. Tepper and Nurse (1997) demonstrated that oiliness and fat ratings were both significantly higher in PROP taster groups compared to nontasters for salad dressings of either 10% or 40% fat. Moreover, they found that nontasters preferred the higher fat sample. However, Yackinous and Guinard (2001) found that PROP taster status was not related to fat perception in a range of foods (crisps, chocolate drink, milk pudding and mashed potatoes).

More recent studies have revealed that fat can be detected as a taste when both mouthfeel and aroma are masked (Mattes, 2009). Animal (Gilbertson, Liu, Kim, Burks, & Hansen, 2005) and human (Mattes, 2009; Chale-Rush, Burgess, & Mattes, 2007; Newman & Keast, 2013; Haryono, Sprajcer, & Keast, 2014; Keast & Costanzo, 2015; Running et al., 2015) studies have suggested that fat might be the sixth basic taste sensation and some researchers have found that genotype can influence perception of fat taste. *CD36* is responsible for transporting fatty acids and the presence of different single nucleotide polymorphisms (SNPs) of *CD36* may influence fat perception (Laugerette et al., 2005; Abumrad, 2005). Keller (2012) found that individuals with *CD36* A/A genotype (at *rs1761667*) rated salad dressing as creamier than either those with A/G or G/G genotype. Recently, Mrizak et al. (2015) also reported that obese Tunisian women with *CD36* A/A genotype had significantly higher oleic acid detection thresholds. Regarding *CD36* genotype and fat preference, Keller (2012) found that the A/A subjects showed higher preference for added fats, oils and spreads, using data from participants' self-report food questionnaires.

Gustin (Carbonic anhydrase VI (*CA6*)) has been reported to affect the maintenance and development of taste buds (Henkin, Martin, & Agarwal, 1999). More recently, studies found that the polymorphism *rs2274333* strongly associated with fungiform papillae density, where individuals with the G/G genotype had lower FPD (Melis et al., 2013; Barbarossa et al., 2015). Moreover, Melis et al. (2013) found that individuals with A/A genotype were more likely to be PROP supertasters, whereas those with G/G were more frequently PROP nontasters. As discussed before, fat perception has been reported to associate with papillae density and PROP taster status. Moreover, considering the role of gustin in fungiform papillae development and its close association with PROP sensitivity (Padiglia et al., 2010; Calo et al., 2011; Melis et al., 2013), gustin may plausibly play a role in fat perception.

Previous research has investigated the relationship between different dietary patterns and risk of obesity. Work since the 1980's (Drewnowski, 1985; Miller, Lindeman, Wallace, & Niederpruem, 1990; Salbe, DelParigi, Pratley, Drewnowski, & Tataranni, 2004; Deglaire et al., 2015) has shown that obese people tend to prefer high-fat food and have higher fat consumption. However, it is also known that cognitive control of eating behaviour plays an important role in dietary intake and BMI (Tepper & Ullrich, 2002; Harden, Corfe, Richardson, Dettmar, & Paxman, 2009) and this should be accounted for in any study of diet. A number of questionnaires are used to assess eating behaviour traits. The Three-Factor Eating Questionnaire (TFEQ) (Stunkard & Messick, 1985) is the most widely used to measure cognitive restraint, disinhibition and hunger in adults. The results from previous research suggested that women with low restraint and high disinhibition scores tend to have higher BMI (Dykes, Brunner, Martikainen, & Wardle, 2004).

In summary, fat preference and intake are not only influenced by taste perceptions and preferences, but also by demographic factors, such as gender, age and eating behaviour. However, it remains unclear to what degree genetic and phenotypic measurements of fat taste perception influence the liking of fat in foods and dietary fat intake. Therefore, the main aims of this study were to investigate how variations in taste sensitivity influenced the liking of ice cream samples with a range of fat levels, and to investigate any association between taste sensitivity and dietary fat intake.

2. Materials and methods

2.1. Subjects

Healthy adults aged 18–55 years, were recruited by advertisement within and around the University of Reading, UK. The subjects included in this study are the same cohort used in a study of vegetable perception and liking previously reported (Shen, Kennedy, & Methven, 2016). Exclusion criteria were: smokers, pregnancy, relevant food allergies, major medical conditions and medication used that could impact on taste perception. The study was given a favourable opinion to proceed by the University of Reading Ethics committee (study number 12/04).

2.2. Study design

Participants attended two separate study days (visit 1 and visit 2), which were up to two weeks apart, with each visit lasting one hour. In the first visit, participants were asked to complete the study consent form and pre-study questionnaires, and a buccal cell swab was collected. Anthropometric measurements and FPD measurements were also completed in this visit. Between visit 1 and 2, participants were asked to complete a Food Frequency Questionnaire (FFQ), 3-day food diary and Three Factor Eating Questionnaire (TFEQ). During visit 2, they rated their liking for a range of ice cream samples, and completed a suprathreshold PROP sensitivity test. All tasting sections were performed in sensory booths in University of Reading with room temperature controlled to 22 ± 1 °C.

2.3. Phenotypical measurements

2.3.1. Suprathreshold test

A suprathreshold test was used to classify PROP taster status of the participants. Using the method described by Tepper et al. (2001) in which both the perceived intensity of bitterness from PROP (0.000032 M, 0.00032 M, 0.0032 M) and saltiness from sodium chloride (0.01 M, 0.1 M, 1 M) are rated on a Labelled

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