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Associations between nutritional properties of food and consumer perceptions related to weight management.

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Abstract

Consumer perceptions of food (for example, how filling or healthy) influence eating behaviour and appetite control. Therefore approaches to understand the global nutritional attributes of foods that predict the strength of consumer perceptions are of academic and commercial interest. The current research describes the development of a flexible platform for systematically mapping the global nutritional attributes of foods (both objective and perceived) to consumer perceptions of those foods. The platform consists of a database of standardised UK food images (currently n = 300), linked to a catalogue of detailed perceptual, nutritional, sensory, cost, and psychological information ('nutritional attributes'). The platform also incorporates demographic and psychometric questionnaires to examine the importance of nutritional attributes on consumer perceptions within or between relevant target groups. In the current study, the platform was applied to a sample of dieting and non-dieting British men and women (n = 887) to examine the global attributes of a subset of foods (n = 75) and their association with successful weight management (i.e. supportive of weight loss, weight loss maintenance or prevention of weight gain). Generalised linear models identified energy density, cost (£/kcal), perceived energy content and satiating capacity as the main nutritional attributes underlying dieters' and non-dieters' perception of successful weight management food. Additionally, pleasantness, and desire not to (over) eat were uniquely associated with dieters' perception of food as good for weight management; pleasantness was positively associated with weight management and desire to eat was negatively associated with weight management. Therefore, global nutritional attributes of foods can predict and distinguish the extent consumers' perceive a food to be related to successful weight management. This platform will be extended to increase the variety of foods and specificity of nutritional attributes in the database suitable for a range of commercial, academic or clinical research applications.

Key words: Food perceptions; food images; successful weight management; dieters; consumer perceptions.

1 Introduction

Consumer perceptions of foods vary on a number of dimensions such as healthiness (Ross & Murphy, 1999), taste (Raghunathan, Naylor, & Hoyer, 2006), satiating capacity (Oakes, 2006) and freshness (Oakes & Slotterback, 2002). Such perceptions can influence food selection (Steptoe, Pollard, & Wardle, 1995) and energy intake (Buckland, Graham Finlayson, & Hetherington, 2013; Capaldi, Owens, & Privitera, 2006; Provencher, Polivy, & Herman, 2009). For instance, consuming preloads perceived as meals reduced young adults' subsequent test meal intake compared to consuming preloads perceived as snacks (Capaldi et al., 2006; Pliner & Zec, 2007). Perceptions about foods can also reduce food intake. Buckland, et al. (2013) found that eating food perceived to be congruent with weight loss goals reduced dieters' subsequent meal intake compared to an equi-caloric food associated with hedonic goals. As perceptions of food play a role in the choice and amount of food consumed, it could be valuable to systematically explore which common dimensions of foods contribute to the strength of consumer perceptions to facilitate healthy eating choices.

Existing research on food perceptions have mostly explored determinants of foods perceived as 'healthy'. Participants report perceived freshness (Oakes & Slotterback, 2002) and perceived fat content (Carels, Harper, & Konrad, 2006; Carels, Konrad, & Harper, 2007; Oakes & Slotterback, 2001a, 2002; Rizk & Treat, 2014) to be most important in their association with health. Two studies have also examined the perception that foods can influence weight loss. Participants reported that they perceive foods as strongly associated with weight loss if they are low in fat, low in energy content, high in satiating capacity and high in protein (Carels et al., 2006; Carels et al., 2007). However, such findings on the perception of weight loss foods are based on studies including only 16 foods (Carels et al. 2006; 2007) and the generalizability of these findings to a wider range of foods is currently unclear.

Perceptions about foods is an important issue given that governments are calling for consumers to focus on the proactive prevention of avoidable disease by taking more responsibility for their own health through the adoption of healthier lifestyles, improved diets, increased physical activity and managing their own weight (U.S. Department of Health and Human Services, 2010; HM Government, 2010). There is interest in developing and marketing functional foods to manage satiation, satiety and body weight (for example, Blundell, 2010). According to the EC guidance (EFSA Panel on Dietetic Products, 2012; European Parliament, 2006) claims relating to appetite and energy balance are classified as health claims if they refer to "slimming or weight control or a reduction in the sense of hunger or an increase in the sense of satiety or the reduction of the available energy from the diet" (European Parliament, 2006). The EC specifically notes that such claims need to be based on

scientific substantiation “by taking into account the totality of the available scientific data, and by weighing the evidence” (European Parliament, 2006). A systematic map of the global nutritional attributes of foods (both objective and perceived) in relation to consumer perceptions and experience of those foods could contribute to the evidence base for foods to manage satiation, satiety and body weight.

Individual differences also seem to play an important role in the perception of foods. One example is gender (Oakes & Slotterback, 2001a; 2001c; Rappoport, Peters, Downey, McCann, & Huffcorzine, 1993; Slotterback & Oakes, 2000). Fat content tends to be more important to women than men in their perception of healthiness (Oakes & Slotterback, 2001a). Age can also influence food perceptions, with younger participants naming freshness and unprocessed attributes as important for healthiness, whereas older participants focus more on fat and energy content (Oakes & Slotterback, 2001b). Previous research also suggests that being on a weight management diet can affect how some foods are perceived. For example, when asked which dimensions affect the perception of weight loss foods, those on a diet were more likely to refer to low sugar (Carels, 2007), low energy, fat and sodium content (Oakes, 2006) compared to participants not dieting.

However, most research exploring food perceptions have relied on participants’ self-report of what factors determine their perceptions (For example, Carels et al. 2006; 2007; King, Herman, & Polivy, 1987; Oakes & Slotterback 2001; 2002). However, perceptions of an attribute of food (such as satiating capacity) are not always congruent with the objectively measured strength of the attribute (Green and Blundell, 1996).Furthermore, perceptions of food may be influenced by other sources of information, even if unknowingly. For example, Oakes (2006) found that protein content across a range of foods was associated with their perceived satiating capacity, yet open ended questions asking participants why they thought a food was high in satiating capacity failed to reveal this. Thus, it seems that the perception of foods is complex and can be influenced by cues outside consumers’ awareness (Cohen & Babey, 2012). Relying on consumers’ reports, about a limited range of foods, as most research has done, may not be sufficient to reveal the true combination of attributes that determine how a food is perceived. It is also important to note that the majority of previous studies have used names or written descriptions of foods to explore perceptions (for example, King et al. 1987; Oakes & Slotterback 2002). Yet, carefully prepared images of foods are likely to be more ecologically valid and may have different effects on how food perceptions are formed. Food images provide much richer information compared to words and as such they elicit physiological responses such as increased heart rate (Drobes et al. 2001) and psychological responses such as increased motivation to eat (Ouwehand & Papies, 2010). Images then are more likely to reflect the situation

(physiological and psychological) people will be in when they are forming food perceptions in in the real world. Furthermore, few studies have explored the role of branding, packaging and pricing on perceptions about foods (Cavanagh, Kruja & Forestell, 2014) and a flexible platform which allows these factors to be explored needs to be developed.

The current research describes the development of a platform to map the global attributes (nutritional, sensory, psychological) of a large range of systematically sampled foods onto consumer perceptions of those foods. Furthermore, because individual differences may affect food perceptions, the platform incorporates demographic and psychometric profiles of respondents to examine the importance of nutritional attributes on consumer perceptions between relevant groups (e.g. dieters and non-dieters). For the purposes of this paper, 'food perceptions' is used as a general term which can refer to sensory or cognitive perceptions and their associated meaning as held by consumers about foods.

In this initial demonstration, the platform was used to examine the global food attributes that determine the consumer perception of foods that promote successful weight management in a sample of dieting and non-dieting adults. The perception of foods associated with successful weight management is important in part because perception may assist dieters to meet diet-related goals by directing food choices and reducing energy intake (Buckland et al. 2013). Therefore, it was of interest to explore how the perception of foods may differ between dieters and non-dieters.

The objectives of this study were to: i) map nutritional attributes to consumer perceptions of a large database of food images; ii) examine which global attributes predict the perception of foods as supportive of successful weight management and; iii) test whether the perception of successful weight management foods differs according to current dieting status.

2 Methods

2.1 Food image database

Foods were sourced from a UK supermarket and were prepared, weighed (to nearest 0.1g) and photographed at the Human Appetite Research Unit, University of Leeds according to standardised operating procedures. To minimise the impact of packaging and branding on perceptions all foods were photographed without packaging or branding information.

The database for the present study consisted of 300 different foods comprising of snack and meal foods appropriate to different eating occasions (for example, breakfast, lunch, dinner) and formats (for example, entrees, desserts, snacks), presented as either single or compositional foods (for

example, salmon fillet with rice and vegetables). The foods varied on a number of other dimensions including taste (i.e. sweet, bland, savoury), energy content, macronutrient content, portion size (recommended serving/large serving) and cost (low/high).

Foods were photographed in colour using a Sony NEX-F3 camera. All foods were photographed under laboratory controlled conditions such that light exposure, background, and image composition were controlled. Foods were arranged on a white plate (circumference: 21.5 cm) unless the food was a food typically served in a bowl (for example, soup or porridge). Foods typically eaten from a bowl were arranged in a glass bowl (circumference: 15.5 cm, height: 6 cm) and the glass bowl was placed in the centre of the white plate to ensure matched appearance between plated and bowled foods (see Figure 1). All images were edited to adjust for light, and to standardise image size and background using iPhoto (Apple Inc., California, USA). The dimensions of all photos were 1024 x 768 pixels (see Figure 2).

2.2 Nutritional attributes for the database

For each food in the database, nutritional information (including cost) was sourced from the UK Composition of Foods Database (Mc Cance & Widdowson, 1992; Finglas et al., 2015), the product manufacturer's nutritional information or a UK supermarket's nutritional information database. For the current study, the following nutritional information was obtained per 100g and per serving size presented per image: energy density (kcal/100g); protein; total fat; saturated fat; unsaturated fat; total carbohydrate; sugars; non-sugar carbohydrates; fibre; salt. Percentage energy (%) from protein, fat and carbohydrate were calculated per food item. Cost/kcal and per image (different portion sizes) was sourced from one of the largest supermarkets in the UK (http://www.sainsburys.co.uk[1]). Promotional offers were excluded from cost calculations.

2.3 Perceived attributes

For the purposes of the current research, 'perceived attributes' refers to the subjective ratings of foods based on 8 attributes. All foods in the database were scored on 8 attributes guided by previous research (Carels et al. 2006; King et al., 1987; Oakes, 2006). This was based on previous research which showed participants used several main attributes to categorise foods including eating enjoyment, sensory (for example, sweet or savoury) and nutritional attributes (King et al. 1987). Other research has shown that perceptions of healthiness and satiating capacity influence beliefs about a food's potential for weight management (Carels et al. 2006). Furthermore, individuals attempting to restrict food intake might be most vulnerable to overeat foods rated with high

[1] Costs were sourced January to May 2014.

enjoyment (Fedoroff, Polivy & Herman, 1997). Therefore, we were interested to examine whether there were any differences in the extent dieters and non-dieters perceived foods in terms of their potential for overconsumption. As such, the attributes included: pleasantness, taste (sweet, bland or savoury), perceived fat content, perceived energy content, association with successful weight management (referred to as successful weight management from here on), desire to (over) eat, perceived healthiness and perceived satiating capacity. Each attribute was assessed using a 7-point scale. Items and response scales are listed in Table 1.

In the platform, successful weight management foods were defined as *"foods that would be typically eaten as part of a successful diet aimed at weight loss, weight maintenance or prevention of weight (re-)gain."* This definition was developed to incorporate the multifaceted nature of weight management. Other studies exploring food perceptions about weight management have tended to focus on weight gain or weight loss (Carels et al., 2006; Carels et al., 2007) or general dieting (Sobal & Cassidy, 1987, 1990), therefore, a more inclusive term was used to encompass all aspects of weight management.

Online surveys were used to collect ratings of these attributes. Each food item was presented individually on screen with the questions assessing the 8 perceived attributes presented below (4 items on one webpage and another 4 items on a subsequent page with the image presented at the top of the screen). Foods were presented to participants in a fixed order per survey. This order was determined randomly in the design of each survey. To avoid fatiguing participants, each survey included 25 food images.

As the methodology used photos of foods rather than names of foods it was important to ensure that participants correctly recognised and rated the food presented. Therefore, alongside ratings of perceptual attributes, participants were required to name the food(s) presented in each image.

2.4 Individual differences, habitual consumption and motivational states

The online surveys were designed to collect individual differences and motivational states including: age, gender, self-reported height and weight, demographics and diet status. Current diet status was assessed using Lowe's (1993) method ("Are you currently on a diet?" with responses "yes, to lose weight", "yes, to avoid weight gain," "yes, to gain weight" and "no, I'm not currently dieting"). This categorical method has been shown to be a validated measure of current diet status (Lowe, 1993; Witt, Katterman, & Lowe, 2013). To assess motivational states, the surveys collected information on the time since participants last ate and obtained a rating of hunger ("How hungry do you feel right now?") using a 10-point rating scale (1 = 'not at all hungry' and 10 = 'extremely hungry'). To assess

whether participants regularly consumed each food, the database also included participants' frequency of consumption for each food (never, once a year, every few months, once a month, once a week and almost every day). Furthermore, the platform is equipped to address specific research questions pertaining to eating behaviour and psychometric traits. For example questionnaires can be included in the online surveys to examine how individual differences in personality traits affect perceptions of food.

3 Research study: Applying the platform to assess perception of food for successful weight management in dieters and non-dieters

3.1 Participants

Surveys were distributed using Survey Monkey (SurveyMonkey Inc., Palo Alto, California, USA, www.surveymonkey.com). Responses were collected from January – July 2014. Across the 3 surveys, there were 887 participants (survey 1, n = 347; survey 2, n = 327 and survey 3, n = 213). The majority of the sample were females (87%, n = 770). Participants' age ranged from 18-76 years (*M*: 32.63 ±SEM: 0.42 years). Of the sample, 50% were either employed full time or part-time, 40% were students and 10% were either unemployed or were stay at home parents. The sample was recruited via email (43%, n = 383), online forums (18%, n = 163), social network sites (for example, Facebook) (3%, n = 26), online classified websites (3%, n = 25), word of mouth (2%, n = 14) and 31% (n = 276) did not indicate the source of recruitment. The survey was completed to entirety by 72% of the sample (n = 634; females n = 565)[2]. Of those that dropped out, 80% completed ratings for at least 12 food items. Responses from participants who did not complete the survey were included up to the point of attrition.

Of the sample, 329 participants indicated they were on a diet to either lose weight or avoid weight gain (to lose weight n = 280; avoid weight gain n = 46; undisclosed n = 3). Dieters had a higher BMI compared to non-dieters (dieters: 27.57 ± SEM 0.36 kg/m²; non-dieters: 23.00 ±SEM 0.18 kg/m², t(493.10) = 11.32, $p < .001$) and dieters were significantly older compared to non-dieters (dieters: 36.93 ± 0.76; non-dieters: 30.08 ± 0.46, t(593.92) = 7.73, $p < 001$).

Upon completion of the survey participants were entered in to a prize draw to win £100 shopping vouchers. Ethical approval for the study was granted by the University of Leeds Institute of Psychological Sciences ethics committee.

[2] A series of independent t-tests revealed no differences between completers and non-completers in terms of age, BMI, time since last ate and hunger ratings [largest t: t(484.47) = -.18, $p = ns$].

3.2 Procedure

From the total database of food images, 75 foods were selected for inclusion across 3 online surveys (25 foods per survey). These foods were selected to ensure similar distributions of sweet, savoury and bland foods, of low and high fat foods and to be suitable for different eating occasions.

The recruitment advert presented a direct web link to one survey. After consenting to take part in the survey, participants indicated their age, gender, self-reported height and weight, diet status (Lowe, 1993), demographics, indicated time since the last eating episode and rated hunger following the standardised assessment of the methodology. Participants were then shown an image of the first food item, were asked to name the food, indicate frequency of consumption and rate the perceptual attributes. Next, the second food item appeared on a new page and participants repeated the ratings. This process was repeated for all 25 food items. Once participants had completed ratings for all 25 foods they were asked to indicate where they heard about the survey, indicated nationality and indicated whether they wished to be part of the prize draw. The survey took a mean time of 27 minutes and 11 seconds to complete.

3.3 Data analysis

Statistical analyses were performed using IBM SPSS for windows (Chicago, Illinois, Version 21). Data are expressed as mean ± SD unless otherwise stated. Independent samples t-tests were used for group comparisons for each of the participant characteristics and to compare whether completers differed to non-completers on participant characteristics. Descriptive analyses on perceptual ratings of successful weight management were conducted. Perceptual ratings were only included in the analysis if participants correctly identified the foods (of the 75 foods, 74 were correctly identified by over 75% of the sample[3]). To retain as many responses as possible correct generic food descriptions were accepted. For example, if strawberries were described as “berries” responses were included in the analysis. If more specific descriptions were given which were incorrect, responses were excluded (for example, if milk chocolate was described as “plain chocolate”). Spelling mistakes (provided the word was decipherable) did not affect acceptability. Indecipherable responses were excluded.

Bivariate correlations were conducted to explore the relationships between global nutritional attributes and perceptions across all foods in the sample. Next stepwise regressions were conducted to examine which attributes or combination of attributes most strongly predicted successful weight management scores (as rated in the online surveys) in dieters and non-dieters. Separate models were tested firstly for objective nutritional attributes e.g. energy density, percentage protein, fat,

[3] One food (yoghurt coated cereal bar) was correctly identified by 51% of the sample.

carbohydrate and cost; and secondly for perceived attributes e.g. satiating capacity, energy content and taste. Given the known effect of age on consumer perceptions of foods (Oakes & Slotterback, 2001b), age was examined as a covariate in all models generated. Since no *a priori* hypotheses had been made to determine the order of entry of the nutritional attributes, a stepwise method of entry was used for each analysis. To check for the presence of statistical outliers that might unduly influence the relationship between variables, the residual statistics were examined. A standardised residual of less than -3 or greater than +3 SD was used to indicate that an observation was a statistical outlier. Furthermore, Cook's Distance scores were also calculated, with a score of greater than 1 taken to indicate that an observation unduly influenced the model. To check for multicollinearity between predictor variables, the variance inflation factor (VIF) and tolerance statistics were calculated. Multicollinearity was assumed if the VIF statistic was greater than 10, and the tolerance value below 0.2 (Tabachnick and Fidell, 2007). In model 2 (perceived global attributes), healthiness violated the assumptions of multicollinearity due to overlap with rated energy content (r = .96) and weight management (r =.99) and was excluded from the model (tolerance: 0.10; VIF statistic: 10.26)[4]. All remaining nutritional attribute variables were statistically correlated with perceived ratings of successful weight management which indicated that the data was suitably correlated with the dependent variable for examination through multiple linear regression to be reliably undertaken. For all analyses, alpha was set at $p < .05$.

4 Results

4.1 Descriptive statistics

Scores for successful weight management ranged from 1.3 to 6.7 (*M*: 3.35 ± 0.20) across foods. Foods scoring highest in successful weight management were salad (*M*: 6.6 ± 1.1), broccoli (*M*: 6.26 ± 1.3), green pepper (*M*: 6.18 ± 1.4), apple (*M*: 6.04 ± 1.3) and carrots (*M*: 6.03 ± 1.8). Foods scoring lowest in successful weight management were chocolate (*M*: 1.3 ± 0.8), pastry (*M*: 1.4 ± 1.0), onion rings (*M*: 1.4 ± 1.0), doughnuts (*M*: 1.4 ± 0.1) and fruit flavoured candy (*M*: 1.4 ± 1.1).

4.2 Relationships between nutritional attributes and successful weight management scores

Table 2 displays correlations between nutritional and perceived attributes of foods for the full sample. In terms of objective nutritional attributes, foods supporting successful weight management the most were positively associated with percentage protein and cost (£/kcal) and negatively associated with energy density and percentage fat. Percentage carbohydrate was not significantly associated with weight management scores.

[4] This did not differ between dieters and non-dieters.

For perceived attributes, foods rated as supporting successful weight management most were associated with lower energy content, lower fat content and lower desire to (over) eat compared to those scoring low on associations with weight management. Pleasantness, taste and satiating capacity were not associated with successful weight management.

4.3 Predictors of successful weight management scores for dieters and non-dieters

Results of multi-level modelling showed that for model 1 (objective nutritional attributes), energy density and cost were the strongest predictor of successful weight management scores for non-dieters [$R^2 = .60$, $F(2, 74) = 53.01$, $p < .001$] and dieters [$R^2 = .66$, $F(2, 74) = 68.23$, $p < .001$]. Foods perceived to support successful weight management the most were associated with lower energy density. This model accounted for 60% and 66% of the variation in non-dieters' and dieters' perceptions of successful weight management foods respectively (see Table 3).

For model 2 (perceived nutritional attributes) perceived energy content and satiating capacity significantly contributed to successful weight management scores for non-dieters ($R^2 = .96$, $F(2, 72) = 951.77$, $p <.001$) (see Table 3). For dieters, perceived energy content and satiating capacity were also important, however, pleasantness and desire to (over) eat also predicted successful weight management scores ($R^2 = .96$, $F(4, 70) = 417.77$, $p < 001$) (see Table 4). Foods perceived to support successful weight management the most scored high in pleasantness and satiating capacity and low in energy content and desire to (over) eat.

5 Discussion

The current research describes the development of a flexible platform for systematically mapping the global nutritional attributes of foods (both objective and perceived) to consumer perceptions of those foods. The database currently comprises of 300 foods, each linked to a detailed catalogue of nutritional, sensory, psychological and perceptual information. The platform can also be used to assess individual differences in food perceptions as demonstrated by the application of the platform to explore dieters' and non-dieters' perceptions of successful weight management for a restricted sample of foods.

In the sample tested, salads, fruits and vegetables were rated most strongly as associated with successful weight management whilst chocolate, pastries, doughnuts and sweets scored lowest. These findings confirm previous studies showing that salads, fruits and vegetables are the types of foods perceived to be most associated with dieting and weight loss constructs (Carels et al., 2006; Carels et al., 2007; Sobal & Cassidy, 1987, 1990). The current research confirms and extends these findings using a more inclusive definition of weight management. Thus, rather than just weight loss

and dieting, the perceptions explored in the current study apply to weight loss, weight loss maintenance and prevention of weight regain.

When assessing which nutritional attributes (objective and perceived) were important in determining the perception of successful weight management foods, several attributes were identified. For objective attributes, low energy density, low fat (%) and high protein (%) were associated with foods scoring high in successful weight management. Of these, energy density and cost were the strongest predictors of successful weight management perceptions for both dieters and non-dieters. Thus, foods scoring high in the successful weight management attribute were associated with a low energy density and higher cost. For perceived attributes, lower perceived energy content, lower perceived fat content and lower desire to (over) eat were associated with higher scores for successful weight management foods. Of these, perceived energy content and satiating capacity were the strongest predictors of successful weight management foods for non-dieters. Interestingly, perceived energy content and satiating capacity were also important for dieters but additional attributes were also identified. Specifically, pleasantness and desire to (over) eat were significant predictors in the model. Such that, for dieters, successful weight management foods were *positively* associated with pleasantness, but *negatively* associated with desire to (over) eat. These findings suggest that for dieters, foods perceived as supportive of successful weight management are perceived to be more pleasant but are also inversely associated with a hedonic element that leads to a desire to over eat. This finding is relevant given that perceived assessments of liking and wanting for food tend to co-vary, while in restrained eaters there is evidence for dissociation in these processes, particularly for high energy dense food (Finlayson & Dalton, 2012). Restrained eating and dieting are independent constructs (Lowe, 1993), however, there is conceptual overlap, and this study on dieters supports similar findings to those found in restrained eaters.

These findings are important because they demonstrate that perceptual processes underlying the categorisation of foods as successful for weight management differ between dieters and non-dieters. Previous research has indicated that dieters identify different attributes as important in the perception of weight loss foods compared to non-dieters. For example, dieters tend to be more likely to describe the low sugar content (Carels et al., 2007), low energy, fat and sodium content compared to non-dieters (Oakes & Slotterback, 2002).

This study demonstrates that for dieters, the discrimination between finding a food pleasant but not leading to overconsumption is important in the perception of successful weight management foods, whereas, for non-dieters these attributes are less important. These differences between groups may

be due to dieters' greater experience and knowledge of successful weight management foods. Indeed, other research suggests individuals scoring high in measures of restrained eating have more knowledge generally about foods as evidenced with high restrained eaters using more dimensions to describe foods compared to low restrained eaters (King et al. 1987). This research suggests that in addition to high restrained eaters, dieters may also have a wider base of knowledge and experiences about foods compared to non-dieters.

One application of these findings is that important nutritional attributes can be recommended for the formulation or promotion of foods and diets used in weight management programs. Further research is underway to test the translation of consumer perceptions identified by the platform to situations of actual eating behaviour. Indeed, one of our future objectives is to understand when and why participants' expectations about foods do not correspond with objective measures of food intake. For example, Green and Blundell (1996) showed participants consumed more sweet foods compared to savoury, despite rating sweet foods as more filling. Thus, the correspondence between subjective ratings and actual eating behaviour needs to be examined.

Furthermore, it is important to note that the findings presented in this paper are specific to the foods used and the sample tested, and these may not generalise to other foods and samples. One limitation of the sample is that most participants were female and therefore the results may not be representative of males perceptions about food. Future work aims to extend these findings by extending the platform to larger samples, incorporating different cultures, and increasing the coverage of foods and meal compositions to account for a greater proportion of the food environment.

This platform is in the early stages of development but the current research demonstrates its potential application to many research questions in a number of domains. For example, future work may apply the platform to improve understanding about the determinants of perceived satiating capacity. This has relevance considering the potential consumer benefits of satiety enhancing foods (Hetherington et al., 2013). Furthermore, research might examine food perceptions under different environmental and physiological conditions, such as how packaging or branding (Cavanagh et al. 2014), portion size (Piqueras-Fiszman, Harrar, Alcaide, & Spence, 2011) or nutritional status (Cabanac, 1979; Frank et al. 2010) affects food perceptions.

This platform has relevance to academic and commercial interests: From an academic perspective this platform can be used to identify key nutritional attributes which influence food choice and food intake (for example, healthiness, satiating capacity, and support for weight management). Upon

identification, these attributes provide targets for manipulation or intervention and their effects on eating behaviour can be evaluated. From a commercial perspective, this platform can inform the (re)formulation and marketing of food products to target these satiety enhancing attributes. For example, a specific 'target' food can be introduced into the database to examine how it is perceived by consumers and how it compares to competitor products. Furthermore, the idea of tailored nutrition for specific consumer groups is receiving growing interest (Gibney & Walsh, 2013) and optimising product lines as informed by the platform could be received favourably by consumers.

Despite the potential applications of the platform, this work is in its early stages and there are some limitations which need to be addressed in subsequent research. Ratings were collected based on responses to images of foods and expectations may differ when encountering real foods. Subsequent laboratory work will test the correspondence between ratings to food images and ratings to actual foods. Additionally, the portion size of foods used in images could be improved. In the current study, portion sizes were judged by two independent raters to provide an amount of food which covered the majority of the plate. However, a more uniform standardisation of portion size across foods would be useful to confirm appropriate portion sizes. The food images also used generic food items with no packaging. Although this served to control for the influence of food packaging on ratings, in the real world food products tend to be encountered in packaging and the effect packaging has on perceptions needs to be confirmed. Furthermore, while the use of online surveys in the current study meant a relatively large range of foods and relatively large sample of respondents could be examined, additional in-depth information from qualitative interviews with consumers could also be important (Furst, Connors, Bisogni, Sobal & Falk, 1996; Furst, Connors, Sobal , Bisogni, & Falk, 2000). Findings from both quantitative and qualitative research should be compared to draw clear conclusions about food perceptions.

In conclusion, this research represents the initial proof-of-concept for a platform for mapping the global nutritional attributes of foods to consumer perceptions of those foods. The platform is being extended in terms of the food database and the precision and detail of its associated information. Promisingly, the platform can be modified and tailored to address specific research questions and as such offers a flexible and sustainable approach to examine consumer perceptions of food.

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Table 1. Perceptual attributes assessed, items and response scales

Attribute	Item	Response scale
Pleasantness	"How pleasant does this food typically taste?"	1 = not at all pleasant; 7 = extremely pleasant
Taste (sweet/bland/savoury)	"Is this food sweet, savoury or bland tasting?"	1 = sweet;' 4 = 'bland'; 7 = 'savoury'[a]
Fat	"Is this food low or high in fat?"	1= 'low fat;' 7 = 'high fat'
Energy content	"Is this food low or high in calories?"	1 = 'low calorie;' 7 = 'high calorie'
Successful weight management	"To what extent do you associate this food with successful weight management (e.g. weight loss, weight maintenance, prevention of weight regain?)"	1 = 'not at all associated' 7 = 'extremely associated'
Desire to (over) eat	"To what extent do you associate this food with eating too much because of how desirable or pleasurable the food is?"	1 = 'not at all associated;' 7 = 'extremely associated'
Healthiness	"To what extent do you think this food is healthy?"	1 = 'not at all healthy;' 7 = 'extremely healthy'
Satiating capacity	"Generally, how filling do you consider this food to be?"	1= 'not at all filling;' 7 = 'extremely filling'

[a] "Responses were coded as either sweet <4 or savoury>4."

Table 2. Correlations between nutritional and perceptual attributes of 75 foods, rated by the full sample (n = 887).

	1	2	3	4	5	6	7	8	9	10	11	12
1. Successful WM[a]	-	-	-	-	-	-	-	-	-	-	-	-
2. Energy density (kcal/100g)	-.77***	-	-	-	-	-	-	-	-	-	-	-
3. Protein (%)	.29*	-.29*	-	-	-	-	-	-	-	-	-	-
4. Carbohydrate (%)	.18	-.19	-.48***	-	-	-	-	-	-	-	-	-
5. Fat (%)	-.44***	.46***	-.07	-.81***	-	-	-	-	-	-	-	-
6. Cost (£/kcal)	.59***	-.56***	.39**	.05	-.56***	-	-	-	-	-	-	-
7. Perceived energy content	-.97***	.78***	-.25*	-.28*	.53***	.61***	-	-	-	-	-	-
8. Perceived fat	-.91***	.75***	-.16	-.48***	.71***	.56***	.95***	-	-	-	-	-
9. Taste[b]	.02	-.09	.42***	-.42***	.23*	.07	-.01	.14	-	-	-	-
10. Pleasantness	-.10	.07	-.14	-.07	.14	.02	.17	.14	-.33**	-	-	-
11. Desire to (over) eat	-.86***	.70***	-.33**	-.13	.40***	-.44**	.86***	.78***	-.20	.49***	-	-
12. Satiating capacity	-.14	-.06	.29*	-.47***	.35**	-.18	.25*	.35**	.40***	.21	.04	-

Note.

[a]WM = weight management

[b] Taste was coded as '0 = sweet' and '1 = savoury.'

*p<.05

**p<.01

***p<.001

Table 3. Stepwise regression for objective nutritional attributes predicting successful weight management food scores for dieters and non-dieters (n = 887).

Non-dieters				Dieters			
Attribute	B	SE B	β	Attribute	B	SE B	β
Energy density	-0.01	0.01	-0.75***	Energy density	-0.01	0.01	-0.78***
Cost	58.53	23.0	.23*	Cost	59.16	19.58	.25**

Note

Adjusted R^2 = .58 for non-dieters; Adjusted R^2 = .65 for dieters.

Energy density: kcal/100g.

Cost: £/kcal.

*p<.05.

***p<.001.

Table 4. Stepwise regressions for perceptual nutritional attributes predicting successful weight management food scores for dieters and non-dieters (n = 887).

Non-dieters				Dieters			
Attribute	B	SE B	β	Attribute	B	SE B	β
Energy content	-1.06	0.03	-1.01***	Energy content	-.72	.06	-.80***
Satiating capacity	.21	0.04	.12***	Satiating capacity	.09	.05	.05
				Pleasant	.43	.11	.17***
				Desire to (over)eat	-.36	.12	-.24**

Note.

Adjusted R^2 = .96 for non-dieters; Adjusted R^2 = .96 for dieters.

**p<.01.

***p<.001.

Figure 1. Image example of foods photographed on a plate (white toast) or bowl (porridge).

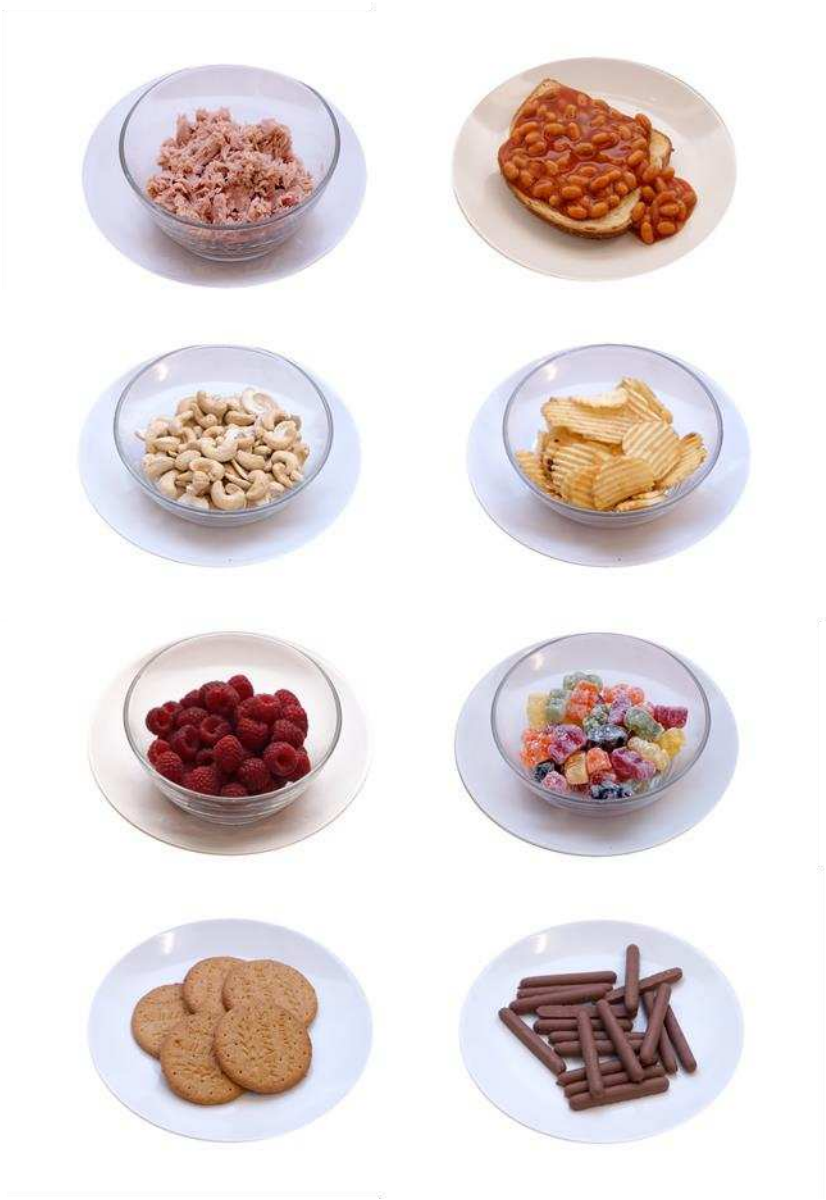

Figure 2. Examples of foods in the database.