Users of ‘diet’ drinks who think that sweetness is calories

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Abstract

We present the first experiment that was based on a novel analysis of the mental processes of choice. Sensed material characteristics such as the sweetness of a drink and symbolic attributes such as the source of sweetness stated on the label are put into the same units of influence on the response. Most users of low-calorie drinks thought about the energy in a drink quite differently from the way they decided how sweet and how low in calories they liked the drink to be. Also the female diet drink users thought about energy content differently from most of the male users of sugar drinks. In both groups’ ratings of likelihood of choice and in sugar drink users’ estimates of energy content, sweetness and labelled calories were usually treated as separate stimuli or ideas. In contrast, some female diet drink users treated sweetness and perceived calories as the same, whereas no male sugar drink user did. Such findings illustrate how this approach spans the gap between sensory perception and conceptual knowledge.

Introduction

This brief report presents the earliest analysis of the mental processes by which the cultural role of a symbol on a food or drink item interacts with biological sensing of one of that item’s material constituents. The symbol was the brand name of a low-calorie sweetener, contrasted in implied energy content with the word “sugar.” The constituent was sucrose at varied levels that were sensed by taste alone. The decision processes of some young people who used diet drinks were contrasted with the thinking of others who avoided such drinks in favour of sugar-containing (sub)brands.

The general issue

Putting a brand name or other label on a product has long been known to alter its sensory assessment, price tolerance and other quantitative responses (Elder & Krishna, 2010; Vickers, 1993; Wansink et al., 2004, 2005). Conversely, dislike of the textures and flavours of food products and beverages lowered in contents of fats, sugars and salt is notorious for changing reactions to pack labels that make such nutrient contents into health claims. Indeed, “palatable” and “unhealthy” can be almost synonymous (Booth, 1988b; Chandon & Wansink, 2007; Raghunathan et al., 2006; Rozin et al., 1999). Yet there has been remarkably little direct investigation of such mental interactions between conceptual and sensory influences on appetite as they are seen in individuals' choices among foods and drinks.

One reason for this gap in research is the view that sensory data are totally separate from preference data. As a result, sensed product formulations are not coordinated effectively to marketing concepts, despite recent efforts to build better connections (Moskowitz, Beckley & Resurreccion, 2006). Nevertheless, that presupposition was disproved, and the business development gap bridged in principle, during the 1980s when sensory preferences were first measured psychophysically. The difference between sensory intensity and sensory preference shown to be merely in the mental task given to the assessor, i.e. in the wordings of the anchors used in the ratings (Booth, Thompson & Shahedian, 1983; Conner & Booth, 1988; Conner et al., 1986, 1988a,b; McBride & Booth, 1986).

A related reason for the neglect of interactions between ideas marketed in brands, labels and straplines and the sensing of the material product has been the view -- widely held in fundamental psychology as well as in commercial research -- that verbal concepts and non-verbal symbols are in a separate cognitive realm from sensory processes (Barsalou, 2008). However, that research in the 1980s on an individual’s taste preference in a full sensory, social and somatic context also provided the basis for a universal metric of sensory and conceptual influences on preference (Booth & Freeman, 1993). A scale in units of
objective discriminative performance can be constructed from raw data on a conceptualised cultural attribute using the traditional calculation of discriminations between levels of sensed material constituents (e.g., McBride, 1983). Discriminations between disparities in amount of a feature (including its presence versus its absence) are measured monadically (on one sample of the food or drink at a time) because each discrimination is between the test stimulus in the context as perceived by the assessor and her or his personally learnt norm for that object and situation (Booth & Freeman, 1993, 1995).

**This example**

The first quantitative comparison of the influences on choice of a sensed material factor and a culturally communicated factor was published by Freeman *et al.* (1993). The first norm-based discrimination scaling of this pair of sensory and conceptual factors was calculated for doctoral thesis purposes (Freeman, 1996) and presented orally at a Food Choice Conference (Freeman & Booth, 1993a) and a meeting of the Canadian Society for Brain, Behaviour and Cognitive Science with the Experimental Psychology Society (Freeman & Booth, 1993b). The findings at that time are published for the first time here.

Results from this experiment without discrimination scaling (Freeman *et al.*, 1993, Figure 7) indicated that some users of “diet” drinks wanted more from a low-calorie sweetener than replacement of sugar’s sweetness without its energy: their ideal levels for calories in the sweetener were below zero, i.e. negative – that is, they hoped that the sweetener somehow burns off energy. Here we extend that preliminary evidence by diagnoses of each assessor’s thought processes while deciding how much they liked each variant of a drink and how many calories it contained. These characterisations of mentation were calculated from the raw data by individualised norm-relative multiple discrimination scaling (also known as personal cognition) in its initial version, described in full by Booth and Freeman (1993). Those calculations determined if the tasted sugar concentration and the viewed sweetener calories label were processed mentally together (as the same signal) or separately (as different signals; Booth, 2008). This first version of normed discrimination analysis also made a three-way distinction among the levels of information processing. Low-level sensory processing was modelled as directly driven by the gustatory or visual stimulation. Prediction of responses by discrimination-scaled ratings of sweetness or calories represented control by those concepts learnt from the culture. Deeper in the mind than either of these is descriptive processing, either as the sweetness of sugar or as the calories at 10% in the branded intense sweetener and at 100% in the energy-rich bulk sweetener, sucrose (table sugar).
Method

Participants

A total of 145 young people volunteered to evaluate samples of a familiar orange-flavoured drink, 83 female and 62 male. The majority (n = 125) were 16-17-year-old visitors to the School of Psychology during the University’s Open Days in March 1992. The others (n = 20) were undergraduates in other disciplines, mostly aged 18-21.

After giving informed consent, volunteers wrote down the extent to which they used soft drinks containing low-calorie sweeteners. The women were more likely than the men always to choose a low-calorie drink (33% versus 6%) and less likely never to drink one (25% versus 58%), $\chi^2(2) = 21.4$, $p < 0.001$. Therefore, to reduce irrelevant diversity within each category, this paper focuses on the female users and the male avoiders of ‘diet’ drinks.

Drinks to be tested

Unsweetened orange flavouring supplied by Mars Limited Four Square, Basingstoke, was made up in mains water (used in the vending machines stocked by Four Square) and sucrose added to a final concentration of 2.0, 2.8, 3.9, 5.4, 7.6, 10.6, 14.9, 20.9 or 29.2 g per 100 ml of the drink (ratios between concentrations of approximately 1.4). Previous testing of these drinks by assessors in this age range indicated that this range and ratio of sucrose concentrations covered variations among individuals in most preferred sweetness and tolerance of deviations from it.

The flavoured solutions of sucrose were prepared in the morning of the day of use and kept at room temperature until needed. Samples of 25 ml were presented in plain white plastic catering cups, labelled pseudorandomly with either a letter from A to I and the word “sugar” or R to Z and “NutraSweet,” the brand name of the low-calorie table sweetener aspartame in maltodextrin. Samples A and R contained 7.6 g of sucrose in 100 ml, a similar level to that vended.

Layouts for ratings

Quantitative judgments were written on one page per sample, with the letter code inserted by the experimenter just before the assessor tasted that drink. First, the assessors indicated whether the sample was too sweet or not sweet enough. Next they marked a position on a 75-mm vertical line with “I’d ALWAYS choose a drink like this” written at the top (scored as zero distance from ideal) and “I’d NEVER choose a drink like this” at the bottom of the line (scored as 100). Samples were selected to avoid any rating close to this just-rejected point (beyond which a worse drink should be rated).
Assessors then marked a position on a 150-mm horizontal line with “not at all sweet” at the left-hand end (scored as minus 50) and “as sweet as my most familiar orange drink” above a hatch mark at the middle of the line (scored as zero). Finally, they rated the drink on an identical line from “zero calories” (-50) to “same calories as my most familiar drink” (0) and beyond.

Procedure

Participants who had indicated that they never used low-calorie drinks were started with the sugar-labelled, usual-sweetness sample, A. The others started with the same solution labelled “NutraSweet,” sample R. That minimised centring bias (Poulton, 1979).

Subsequent samples were selected to equate the number of ratings on either side of the assessor’s usual sweetness and calories and to distribute them as evenly as possible within an upper limit of eight samples, minimising range and frequency biases.

Normed discrimination measurement

The 50% discrimination and the norm points of always chosen (ideal) or usual sweetness or calories were calculated for each stimulus by each response (Booth, 1988c; Conner et al., 1988a,b). The ideal point for sucrose for each assessor was taken as the estimate accounting for the greater variance from sweetness or choice ratings.

In accord with Booth and Freeman (1993), 18 types of cognitive integration into either choice or calories were measured, nine interactions of three processes for each of the two stimuli, each at a dimensionality of one or two. The three processes were: (direct) stimulation by label or sucrose; the concepts behind calories and sweetness responses; and the (indirect) description of a stimulus by a concept. Processes operating over the same channel (unidimensionality, 1D) were identified by addition of discrimination distances from norm. Distinct processes in separate channels (2D) were estimated as their orthogonal combination in the square root of the sum of the squares of the distances. One integrative model accounting for the most variance in the individual’s choice ratings was identified in 112 of the participants. The others tied.

Statistical analyses

Groups were compared by ANOVA in the variances in rated choice explained by label, sugar level or 1D vs. 2D integration. Distributions of counts in 2 x 2 contingency tables were evaluated by Fisher’s Exact Probability test (two tailed).
Results

Conceptualised and sensed influences on choice

Professed users and avoiders of drinks containing low-calorie sweeteners differed in proportions of some of the ways of deciding which combination of label and sweetness they most preferred in the orange-flavoured drink (Figure 1, upper panels).

Figure 1 here

The biggest difference between the groups in individuals’ thinking about choices was in the prevalences of the mental interaction between the strength of sweetness stimulated by the sucrose in the drink (STIMulation, Figure 1) and the concept of “sugar” or the low-calorie sweetener brand “NutraSweet” viewed on the label of each sample of drink (CONcept in Figure 1). This integration into choice always treated the calories concept and the sweet taste as distinct influences (2D in Figure 1). A fifth of the (male) avoiders of diet drinks (upper right-hand panel of Figure 1) used this cognitive process, whereas none of the (female) users did (upper left-hand panel), $p < 0.03$. All six of these 2D stimulatory and conceptual processors among the diet-drink avoiders had an ideal point for energy in the sweetener that was below the median for all assessors ($p < 0.02$ by sign test). Thus it seems that this subset of the male users of sugar drinks were influenced by the sweet taste of the sugar, but were not attracted by the thought of the energy that they would get from sugar.

In contrast to that sucrose-sensing mentation in choices by some avoiders of diet drinks, more users than avoiders of diet drinks (left-hand upper panel, Figure 1) decided how much they liked a sample in terms of the concept of sweetness (CON), rather than its taste, and by processing that concept separately from their describing (DESC) the range from “NutraSweet” to “sugar” as a variation in calories. On possibility that could be investigated is that these assessors were trading off their liking for sweetness against their fear of being fattened by the energy in sugar.

Conceptual and sensory processes in the attribution of calories

The prevalences of different mental processes in users and avoiders of low-calorie drinks differed more sharply in the calories judged to be in each variant of the drink than it did in the strengths of the disposition to choose a variant. Processing of information about the sweetener label and the sweet taste over the same channel (a single scale, 1D) during estimation of energy content occurred in the great majority of users of diet drinks (83%) but only a large minority of the avoiders (44%), $p < 0.01$ between groups (lower panels, Figure 1). That is, more users of diet drinks treated sweetness as inherently calorific than did users of sugar drinks.
The prevalences of some particular cognitive processes threw more light on this difference. Among those who judged calories on a single channel (1D), more users than avoiders of diet drinks combined the concept of sweetness (back row of columns in the lower panels of Figure 1) with either the concept also of a sweetener calorie label (second column from right) or the sight (STIM) of the brand name NutraSweet or the word sugar (far left-hand column), two-tailed exact $p < 0.01$. In the latter process, the idea of calories might have an implicit influence on the judgment, rather than that meaning of the symbols coming into awareness.

This general line of interpretation of the 1D integration was supported specifically by the finding for five of the users of diet drinks. They judged drink energy contents by conceptualising the label and the taste as the same (label CON-1D with CON sucrose, left-hand lower panel, Figure 1) whereas no avoider did (right-hand lower panel), $p < 0.015$. These young women treated the idea of sweetness as the same as the idea of calories.

However, other diet drink users treated calories and sweetness the same when judging calories (left-hand lower panel, Figure 1) much less than often when they were deciding whether or not to consume an orange drink (left-hand upper panel), $p < 0.0001$. That contrast of performance indicates that those young women’s explicit thinking about calories when judging drink energy content did not extend to the way that they decided choice. There was a numerical difference in the same direction among diet drink avoiders, although it was not reliable, $p = 0.16$. If some (male) users of sugar drinks thought of sweetness as the same as calories, it might have been because they believed that the energy in sugar helps to assuage hunger and/or to strengthen energetic feelings.

**Discussion**

This experiment was the very first use of a highly innovative approach. Hence its results were, on one hand, indubitable as demonstrations of new principles while at the same time highly tentative in each specific interpretation, ahead of replication or extension. Four such principles came out of this experiment, plus a particular piece of evidence on each.

*Personal distinctiveness.* First, there was great diversity among individuals in the decision-making processes. We tested 18 of the theoretically possible ways of integrating the sensing of sucrose with the conceptualisation of calories in sugar or an intense sweetener. Every one of these mental interactions was represented at least once among 50 assessors, either in their preferences among the orange drinks or in their attributions of energy to them. There was specific evidence that this was not a random pattern: some aspects of the patterns
of prevalences of different cognitive styles clearly contrasted between conditions. It is therefore most unwise for either product suppliers or health educators to assume that they know how people think or why they act, from counts or averages of answers to field surveys, grouped scores from laboratory questionnaires, or professional reports on narratives in interviews or focus groups.

*Sensory/conceptual interactions.* A second principle demonstrated by this experiment is that sensed material characteristics and conceptualised symbolic communications can both be measured in the same units of discrimination distances from norm. Hence the mental mechanisms of sensory and conceptual interaction can be studied without difficulty. This is of course completely different from the statistical interactions tested in analysis of variance or involved in the mapping of sensory and conceptual data on the same graph. Indeed, the present data were summarised by Freeman et al. (1993) on axes in the disparate units of the two levels of caloric labelling and the concentration of sucrose. Such statistical manoeuvres provide no insight into what mechanisms produce the most popular preferences.

The first step required is to put both the axes on the same scale of mental power for effects of the taste of sugar as for the effects of sight of the caloric symbols. The specific finding of this sort was that most of the choices treated sweetness and calories as distinct influences, whereas most estimation of calories treated them as the same. That makes good sense because caloric judgment focuses on the implications for calories of the sweetness and the labels, whereas choice may allow for other aspects, such as the match of the sweetness to oranges or to other drinks and the perceived relevance of the energy in sugar to weight, hunger and fatigue (Booth, 1987). This illustrates the dangers of attitude surveys: the questions could create the style of thinking being investigated.

*Conceptual-sensory identity.* A third principle is that a common element can be sometimes be perceived between a conceptualised feature and a sensed feature. It is unsurprising if both fats and starch or sugar are thought of as fattening. It is even less of a surprise if sucrose and fructose taste the same. What would be more striking is if the sight of the brand name of a low-calorie sweetener were treated in the same way as a low level of sweetness. Yet just such thinking was seen among the young women who used diet drinks. Perhaps they add or multiply what they believe is the amount of the source of sweetness and the calories in that source; more work is needed on the processes within this single channel.

Users of diet drinks would be expected to have their ideal area at zero calories (or below) and at low sweetness, as was indeed observed (Freeman et al., 1993). They might also show a fear of sweetness as such, not just a fear of calories, in attitudinal questioning or
in personal cognitive modelling of a wider variety of ratings than obtained in this experiment. In a market where this result is replicated, sugar-free drinks should not be formulated on an assumption that their users crave sweetness; rather they may fear it. Those who contrast conceptual and sensory signals (2D interaction), on the other hand, may conceive of the sweetness as fruit-like (Conner & Booth, 1988; Wansink et al., 2006), thereby processing the taste of sucrose and the message about sweetener energy over separate channels.

*Individuality of cognition.* The final principle is a general practical implication. Cognitive interactions among the major sensed and conceptualised influences on expectations and actions need to be measured in each person in a representative sample and then realistic aggregations or identifiable segments constructed from those individuals’ psychological characteristics (Booth, 1988a, 1990; Booth & Freeman, 1999). For example, one particular type of cognitive integration might occur within a popular combination of sweetener calories label and level of sweetness. Then product formulation, pack labelling and advertising straplines could position a brand or subbrand in accord with psychographic segmentation of interactions between influences on each individual user's most likely choice and with messages about healthy uses of such a food or drink (Booth, 1988b, 1989).

The present analyses could not segment users and avoiders of diet drinks within each gender. All the cognitive integrations specified by Booth and Freeman (1993) need to be tested on these data. If the minorities of female avoiders and male users who show interactions between label and sweetness are large enough, habit and gender can be disconfounded and any gender-specific attitude to use of diet drinks identified.

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References


Caption to Figure

Figure 1. Cognitive processes while rating likelihood of choice (upper panels) or judging the number of calories (lower panels) for an orange-flavoured drink by 22 female users of 'diet' drinks (left-hand panels) and 28 male avoiders (right-hand panels).

Setter:

*Please remove the box lines and white space around the body of each histogram – particularly between upper and lower panels.*