



## Research report

Food reward. What it is and how to measure it <sup>☆</sup>Peter J. Rogers <sup>a,\*</sup>, Charlotte A. Hardman <sup>b</sup><sup>a</sup> School of Experimental Psychology, University of Bristol, Bristol BS8 1TU, UK<sup>b</sup> Department of Psychological Sciences, University of Liverpool, Liverpool L69 7ZA, UK

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## ABSTRACT

We investigated the contribution of hunger and food liking to food reward, and the relationship between food reward and food intake. We defined liking as the pleasantness of taste of food in the mouth, and food reward as the momentary value of a food to the individual at the time of ingestion. Liking and food reward were measured, respectively, by ratings of the pleasantness of the taste of a mouthful, and ratings of desire to eat a portion, of the food in question. Hunger, which we view as primarily the absence of fullness, was rated without food being present. Study 1 provided evidence that hunger and liking contribute independently to food reward, with little effect of hunger on liking. Food intake reduced liking and reward value more for the eaten food than uneaten foods. The results were ambiguous as to whether this food-specific decline in reward value ('sensory-specific satiety') involved a decrease in 'wanting' in addition to the decrease in liking. Studies 2 and 3 compared desire to eat ratings with work-for-food and pay-for-food measures of food reward, and found desire to eat to be equal or superior in respect of effects of hunger and liking, and superior in predicting ad libitum food intake. A further general observation was that in making ratings of food liking participants may confuse the pleasantness of the taste of food with the pleasantness of eating it. The latter, which some call 'palatability,' decreases more with eating because it is significantly affected by hunger/fullness. Together, our results demonstrate the validity of ratings of desire to eat a portion of a tasted food as a measure of food reward and as a predictor of food intake.

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## Introduction

This paper describes an approach to measuring food reward in humans using participant ratings of 'desire to eat.' At first sight this might appear naïve when compared with, for example, intake, choice, work-for-food and reaction time tests or measurement of brain activity; however our studies demonstrate the utility and validity of desire to eat as a measure of food reward. In particular they show that desire to eat a portion of a tasted food is: (1) influenced independently by hunger and food liking, and (2) performs better than work-for-food and pay-for-food measures in predicting food intake.

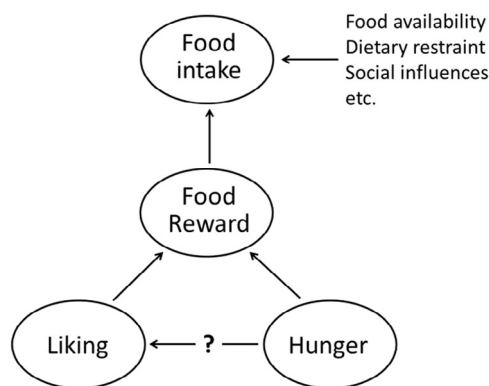
## Definitions of hunger, liking, food reward and food intake, and their interrelationships

The original starting point for the studies described in this paper was the question "Does food taste better when one is hungry compared with when one is full?" (We assume that taste here is understood in the general sense, and so also includes, flavour, texture, etc.) When we ask this question in English to English-speaking people – friends, strangers, classes of psychology undergraduate students, and colleagues – almost everyone answers yes (it does). But we also find that it is easy to turn this ready agreement about an everyday 'fact' of eating into disagreement with the following example: "When you have eaten a really large meal, for example Christmas (or Thanksgiving) dinner, does the food now not taste good, or rather is it that you are simply too full to eat more? Indeed, perhaps it is somewhat frustrating that there is plenty of nice-tasting food left to eat, but you are too full to eat it." The change of mind occurs because the example clarifies the meaning of 'taste better' by making a distinction between how pleasant food tastes in the mouth (our meaning, and also what we define here as liking) and how pleasant it is to eat that food (Mela & Rogers, 1998; Rogers, 1990; Rogers & Blundell, 1990; cf. Mook, 1987), which we suggest is influenced both by liking and hunger/fullness.

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**Fig. 1.** A model of the relationships between food liking, hunger, food reward and food intake. The present studies tested these relationships, including the hypothesis that hunger does not much or at all affect liking, hence the question mark. (Note that the way in which we have conceptualised hunger – as the absence of fullness, and affected by the size of the previous meal, time since last eating, etc. – means that liking cannot be expected to affect hunger.)

Encouraged by these initial observations, we set out to formally investigate the relationship between hunger and liking and how they in turn relate to food reward. The result is the three studies that we report here. In designing them we had in mind the model depicted in Fig. 1. We were also cognisant of the importance of defining terms unambiguously (Salamone & Correa Mercè, 2013), and we have done that below and in summary in Table 1. The question about whether there is an effect of hunger on liking is depicted in Fig. 1 by the question mark on the line going from the hunger oval to the liking oval. Hunger and liking in turn determine food reward, and food reward influences how much is eaten. To be clear, in relation to this model we define liking as ‘the pleasantness of the taste, flavour, etc.’ of food in the mouth. This is different from, for example, Berridge (1996) who equates liking with palatability, which he defines as “the hedonic component of food reward... (that) results from a central integrative process that can incorporate aspects of not only taste, but of the physiological state and the individual’s associative history” (p. 2). Young (1967), among others, gives a very similar definition of palatability. In this sense, palatability could be said to be experienced as the pleasantness of eating (above), and therefore not what we call liking, which we propose may not be very much affected by hunger, although is modifiable via association between a food’s taste and its post-ingestive consequences (Brunstrom, 2007; Scalfani & Ackroff, 2004; Yeomans, 2012). We suggest that, although liking is usually experienced as part of the pleasantness of eating, it can be evaluated separately, simply by directing attention to ‘tasting’ rather than ‘eating.’ Indeed, as our results indicate (Study 1), at least some participants probably interpret even the question ‘How pleasant is this food?’ as meaning taste pleasantness.

We do not, however, equate pleasantness of eating to food reward because, like Berridge (1996), we can conceive of influences on food reward independent of a ‘hedonic component.’ Perhaps there are effects (via ‘wanting’ in Berridge’s model) of, for example, hunger and the energy density of food on food reward at least partly separate from their effects on the pleasantness of eating. Also there might be significant dissociation between pleasantness of eating and food reward (i.e., ingestion with diminished pleasure) in emotional eating, compulsive eating and binge eating. In the context of our model we define food reward as representing the momentary value of a food to the individual at the time of ingestion. It follows that food reward accumulates over a meal (each mouthful eaten is separately rewarding) so that total food reward will be greater for a large versus small meal of the same food, and also, as described later, greater for a more varied meal.

We view food reward as the final common pathway through which hunger and liking influence food intake. Note, however, that food intake is not the same as food reward (cf. Berridge, 1996), otherwise there would be no need for a food reward component in the model. The model in Fig. 1 seems plausible, at least to us. Eating is more rewarding if one is hungry and it is more rewarding if the food tastes good. Intake, however, is subject to additional influences. For example, dieting or serving a small portion puts a ceiling on the amount eaten – in which case the eater is likely to experience the food as ‘moreish’ because without satiation eating remains rewarding (Rogers & Smit, 2000).

#### *Relationships between hunger, liking, food reward and food intake*

We propose that all four components in the model depicted in Fig. 1 can be measured directly and simply. Specifically, ratings of hunger, food liking, and desire to eat that food, provide measures of, respectively, hunger, food liking and food reward, and intake of that food from an unlimited portion (in practice a portion larger than participants are able to eat) provides the measure of food intake. Two other measures of food reward that have been used are an instrumental response, on for example a progressive-ratio schedule, and asking about the amount that the participant is willing to pay to have access to a fixed portion of the food (e.g., Brunstrom & Rogers, 2009; Epstein, Truesdale, Wojcik, Paluch, & Raynor, 2003; Hardman, Herbert, Brunstrom, Munafò, & Rogers, 2012; Havermans, Janssen, Giesen, Roefs, & Jansen, 2009), and we also included variants of these measures in two of the current experiments.

Of course hunger, etc. ratings have been used routinely in studies of human appetite, and desire to eat ratings have been included in many of those studies dating from research by one of us (Rogers & Blundell, 1979). It appears though that, in the absence of knowing what is on offer to eat, the experience of appetite that a participant communicates via a desire to eat rating differs little or not at all from the experience of appetite that they communicate via a hunger rating. This is supported by the high correlation between

**Table 1**  
Definitions of key terms and how they are operationalised in the three studies.

Term	Definition	How measured?
Hunger <sup>a</sup>	The absence of fullness, as related to, for example, gastrointestinal and post-absorptive signals, and the time since and size of the previous meal.	Rating of hunger (made without food being present).
Liking	The pleasantness of taste of food in the mouth. (Note that this is different from the pleasantness of eating, which has often been called ‘palatability’.)	Rating of food liking. The participant tastes (and swallows) a bite of a portion of the food in question and then rates their liking for the pleasantness of its taste.
Food reward	The momentary value of a food to the individual at the time of ingestion.	Rating of desire to eat. Having completed the liking rating (as above), the participant rates their desire to eat the entire portion of the food.
Food intake	Food intake is not the same as food reward, as it is subject to additional influences such as dieting and food availability.	Intake of the food from a portion much larger than the participant would usually eat.

<sup>a</sup> As described in the General discussion, we view hunger as influencing eating via a ‘wanting’ (Berridge, 1996) component of food reward.

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