



Factors that influence the reinforcing value of foods and beverages



Jennifer L. Temple*

Departments of Exercise and Nutrition Sciences and Community Health and Health Behavior, School of Public Health and Health Professions, University at Buffalo, 3435 Main Street, 1 Farber Hall, Buffalo, NY 14214, United States

HIGHLIGHTS

- The reinforcing value of food is related to several factors.
- We can alter the reinforcing value of food through repeated administration of snack food.
- Response to repeated administration of snack food predicts future weight gain.
- Response to repeated administration of caffeinated soda predicts energy drink use.

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ABSTRACT

Behavioral economic principles state that as the cost of a product increases, purchasing or consumption of that product will decrease. To understand the impact of behavioral economics on ingestive behavior, our laboratory utilizes an operant behavior paradigm to measure how much work an individual will engage in to get access to foods and beverages. This task provides an objective measure of the reinforcing value. We have shown that consumption of the same high fat snack food every day for two weeks reduces its reinforcing value in lean individuals, but increases its reinforcing value in a subset of obese individuals. This increase in the reinforcing value of food predicts future weight gain. Similarly, we have shown that repeated intake of caffeinated soda increases its reinforcing value in boys, but not in girls. This increase in reinforcing value is not related to usual caffeine consumption, but may be associated with positive, subjective effects of caffeine that are more likely to be reported by boys than by girls. Because food and beverage reinforcement relates to real-world consumption, it is important to determine factors that increase or decrease the reinforcing value and determine the consequences of these responses. We are especially interested in determining ways to shift the behavioral economic curve in order to develop novel strategies to decrease the reinforcing value of less healthy snack foods and beverages, such as soda, potato chips and candy and to increase the reinforcing value of healthier foods and beverages, such as water, fruits, and vegetables.

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1. Introduction

Eating occurs for many reasons that depend on internal state, such as hunger, recent experience with the food, physiological signals such as blood glucose and insulin and external cues, such as sight and smell of food, time of day, and the price of food. The relationship among these factors and how this relationship influences ingestive behavior can be studied using a behavioral economic framework. This framework allows us to manipulate the behavioral cost of food and determine factors that influence the willingness of individuals to work for that food. This is referred to as the reinforcing value of food.

We and others have examined factors that can impact the reinforcing value of food in both children and adults. Previous studies have shown

that hunger and food deprivation can increase the reinforcing value of food [1–3], while fullness and recent experience with a food can reduce the reinforcing value of food [4,5]. In addition, the reinforcing value of food differs as a function of body mass index (BMI) in both children and adults with higher BMI predicting greater reinforcing value of food [6–9]. Our recent work has explored several other factors that influence the reinforcing value of food and beverages and have shown that some of these predict weight change over time. This review will highlight those recent findings and discuss implications for future studies.

2. Reinforcing value of food

A reinforcer is something that increases the probability of a behavior which it follows. For example, a child that is given a chocolate for cleaning his room may be more likely to clean his room than if he

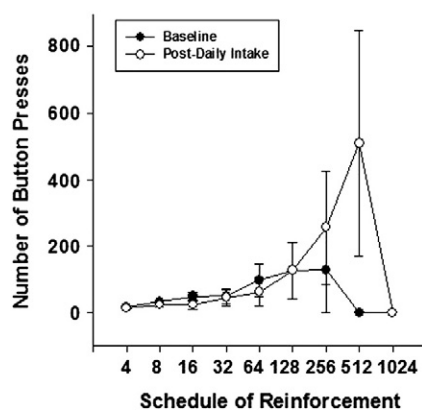
* 3435 Main Street, 1 Farber Hall, Buffalo, NY 14214, United States. Tel.: +1 716 829 5593; fax: +1 716 829 2072.

E-mail address: jtemple@buffalo.edu.

were given no chocolate. The reinforcing value of food is defined as the amount of behavior that a given food will support. There are a number of ways to assess the reinforcing value of food. For example, in animals, lever pressing behavior can be measured. In this case, an animal presses on a lever and, after a certain number of lever presses, a food pellet is given [10]. This is a standard technique used to examine, not only the reinforcing value of food, but the reinforcing value of a variety of stimuli, such as drugs, alcohol, or intracranial self-stimulation. In humans, there are different methods that are used to determine the reinforcing value of food. One method involves asking people to make a choice between a portion of a specified food and an alternative reinforcer, such as money. The point at which the person switches from choosing food to choosing money is an index of the reinforcing value of food. There are more objective ways to measure the reinforcing value of food that are analogous to the lever pressing tasks used in animals. Briefly, participants make responses on a computer mouse for access to food only or for access to either food or an alternative reinforcer, such as sedentary activity, or in some situations, two different types of food [11,12]. Another important component of this task is that after a reinforcer is earned, it becomes harder to earn the next one. The reinforcing value of food is assessed by evaluating the number of responses made for food or alternatives on these progressive ratio schedules of reinforcement [11,12].

3. Liking vs. reinforcing value

Many of the foods and beverages that we find reinforcing are also ones that are highly liked. So, naturally, we associate liking and reinforcing value. However, food liking is a subjective measurement of self-reported hedonic responses for a food or beverage and the reinforcing value of food can be measured objectively by determining how hard an individual will work for food, so it is possible to dissociate liking and wanting empirically. This is important because there are factors which may alter liking, but not reinforcing value and factors that may alter reinforcing value, but not liking. We and others have shown that liking may change in the absence of a change in reinforcing value or vice versa (Fig. 1) [6,13]. This may be because there are different factors that influence liking and wanting or that liking and wanting are controlled by different regions in the brain [14]. It also may be important to dissociate liking and wanting for a food because some foods that would be desirable for people to want to eat, such as vegetables, may not be highly liked, so determining how to increase motivation to eat foods that are less liked could improve diet quality. It is not clear what the dissociation between liking and wanting tells us about a person's eating behavior outside of the laboratory or risk for obesity. More work needs to be done to understand the potential importance of liking and wanting for real-world eating behavior.



4. Monotony and sensory specific satiety

Repeated exposure to the same food causes a decrease in hedonic ratings for that food while hedonic ratings for uneaten foods remain the same. This is commonly observed when people eat meals and report a decrease in desire to eat their meal food, but have room for dessert. This decrease in hedonic ratings over a single meal is referred to as sensory specific satiety and has been studied and described in detail by Barbara Rolls et al. [15–17]. A decrease in hedonic ratings for foods eaten over days and weeks is referred to as monotony [18,19]. While hedonic ratings for most foods decrease within a single eating occasion, there are categories of food that are resistant to monotony, sometimes referred to as staple foods [18]. As mentioned above, the relationship between hedonics and food reinforcement is not always straightforward. It is important to understand how eating patterns that alter food hedonics change the reinforcing value of food. Our previous research suggests that repeated administration of the same snack food results in a decrease in the reinforcing value of food in non-obese individuals, but it increased the reinforcing value of food in a subset of obese individuals [6,8,20].

5. Factors that influence the reinforcing value of food

5.1. Hunger/fullness

The reinforcing value of food is increased when individuals are hungry and decreased when individuals are full [21]. Although this is well-established in both human and animal models, the broader implications of this for eating patterns and behaviors have not been explored in detail. For example, when introducing new foods to children, it may be beneficial to present them at the beginning of a meal, when children are hungry and, thus find food more reinforcing in order to get them to at least try the new foods. In addition, to my knowledge, no studies have examined interactions among hunger, the reinforcing value of food, and energy density (kcal/g). It is possible that fullness may preferentially decrease the reinforcing value of healthier food, such as fruits and vegetables while the reinforcing value of less healthy, high fat snack foods, such as potato chips and candy, may be maintained [22]. This is consistent with the literature on eating in the absence of hunger, which is a paradigm in which individuals will eat snack foods that are typically high in fat and/or sugar after reporting that they are full from eating a meal [23].

5.2. Energy density/palatability

The majority of the research on the reinforcing value of food has focused on high fat and/or high sugar snack foods that are high in

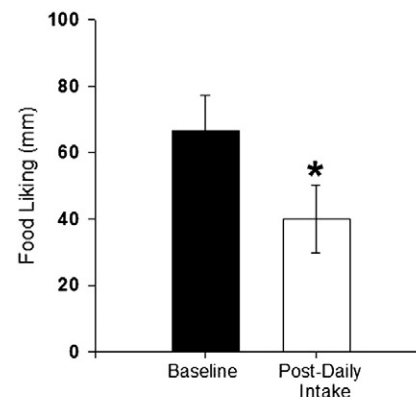


Fig. 1. The number of responses for snack food across different schedules of reinforcement in obese participants who consumed 300 kcal portions (left) and self-reported liking of the snack food at baseline (black bar) and again after two weeks of consumption of 300 kcal portions (white bar) in the same participants. The obese participants who consumed the 300 kcal portions showed an increase in food reinforcement after the two weeks ($p < 0.0001$) despite the fact that they rated the food significantly less liked ($p < 0.05$).

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