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Sugar, perceived healthfulness, and satiety: When does a sugary preload lead people to eat more?

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ABSTRACT

In this research, we examine the interplay between physiological and psychological factors that determine whether the sugar level of a preload increases or decreases consumption on a subsequent snack-eating task. In study 1, participants who drank a high-sugar protein shake (which they believed to be healthy) consumed more subsequent snacks than participants who drank a low-sugar protein shake. Study 2 replicated these findings, but only when the shake was labeled as "healthy." When the shake was labeled as "indulgent," the effect was mitigated.

1. Introduction

There is growing concern that people around the world consume too much sugar. The average per capita consumption of sugar has increased from 5 kg to 70 kg per year since 1800 (Kendig, 2014). Many breakfast foods that are considered "healthy" (such as yogurt, muffins, cereal, or granola bars) contain more than the recommended daily allowance of sugar (Belluz, 2016). How does excessive sugar consumption, particularly in a food that people view as "healthy," affect subsequent consumption throughout the day? We take a preliminary step to reconcile previously mixed results in the literature regarding whether a sugar-laden preload increases or decreases consumption by exploring a new moderator: the perceived healthfulness of the preload. In other words, this research examines the interactive effects of sensory cues (i.e., satiety) and normative cues (i.e., intentional monitoring of what one should eat based on the perceived healthfulness of a preload) on subsequent food intake (Wansink & Chandon, 2014). In two studies, we show that individuals eat more snacks following consumption of a high-sugar preload versus a low-sugar preload, but only when they perceive that preload to be healthy.

Nutrition researchers have noted a dearth of knowledge regarding how different macronutrients affect satiety (e.g., Remick, Polivy, & Pliner, 2009). By focusing on the macronutrient composition of the preload, we attempt to address this call for research. While limited, there is some evidence that the macronutrient composition of equicaloric preloads can influence subsequent consumption. For example, individuals felt more hunger and less fullness after consuming a high-sugar preload than after consuming a high-protein or high-starch preload (Rolls, Hetherington, & Burley, 1988). Moreover, participants felt less hunger (Douglas, Ortinau, Hoertel, & Leidy, 2013) and consumed less of an *ad libitum* meal (Bertenshaw, Lluch, & Yeomans, 2007; 2009) after consuming a high-protein (vs. low- or moderate-protein) preload. However, many of the high-protein preloads in these studies also contained a lower amount of sugar than the other preloads, so it is possible that the sugar content might explain these prior results rather than the protein content. To address this potential confound, in our studies we hold the protein and calories constant (thus varying both the sugar and fat content) in order to further investigate this question.[1] Thus, a contribution of our work is that we specifically examine the effect of a preload's sugar

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[1] It is impossible to vary the sugar content while simultaneously controlling for calories, fat, and protein. Therefore, we made the design decision to vary the fat content, in order to allow us to control for both calories and protein levels.

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content on the subsequent consumption in a snack eating task.

Additionally, by examining how a preload's perceived healthfulness moderates the effect of its sugar content, we contribute to the literature on health labeling. In particular, whereas some studies have found that health labels have no effect on how consumers perceive a product (Carrillo, Varela, & Fiszman, 2012; Kral, Roe, & Rolls, 2002; Norton, Fryer, & Parkinson, 2013; Roberto et al., 2012), others have demonstrated that health labels do impact product perceptions (Brunstrom, Shakeshaft, & Scott-Samuel, 2008; Lotz, Christandl, & Fetchenhauer, 2013; Yeomans, Chambers, Blumenthal, & Blake, 2008). Despite these mixed findings, several studies suggest that health labels affect perceived satiety (e.g. Fay, Hinton, Rogers, & Brunstrom, 2011; Shide & Rolls, 1995; Wooley, 1972). We build on and contribute to these latter studies by showing that labeling a sugary preload as healthy (vs. unhealthy) may interact with the physiological effects of sugar to determine the subsequent amount of food eaten.

1.1. Theoretical background

The term "satiation" refers to the process that causes people to stop eating, whereas the term "satiety" refers to the feeling of fullness after eating that inhibits people from initiating subsequent eating (Benelam, 2009). In this research, we are interested in how the sugar content and healthfulness perceptions of a preload interact to determine satiety, as measured on a subsequent snack-eating task. In other words, we examine how the macronutrient contents of a preload influence the amount eaten in a test meal 20 min later. [2]

The prior literature suggests two possibilities. One stream of literature suggests that consuming sugar or carbohydrates (vs. fat) can result in satiety, thereby lowering subsequent consumption. For example, several studies have provided evidence that high-carbohydrate foods or beverages can be more satiating than high-fat foods or beverages among both rats (Lucas & Sclafani, 1999a, 1999b; Revelle & Warwick, 2009; Warwick, Bowen, & Synowski, 1997) and humans (Blundell, Burley, Cotton, & Lawton, 1993). Furthermore, in some cases people exhibit "good compensation" by lowering their subsequent caloric intake in order to balance out a high calorie snack such as chocolate (e.g., Appleton, McKeown, & Woodside, 2015). Also consistent with this notion, Gailliot et al. (2007) provided preliminary evidence that consuming sugar can enhance self-control on a non-food related task (for critiques of this perspective, see Beedie & Lane, 2012; Hagger & Chatzisarantis, 2016; Kurzban, Duckworth, Kable, & Myers, 2013; Vadillo, Gold, & Osman, 2016). In fact, even the sensation of sugar in the mouth may activate higher levels of self-control (Molden et al., 2012).

On the other hand, a second stream of literature suggests that consuming sugar (or carbohydrates) can increase subsequent consumption. For example, Herman and colleagues found that dieters ate more ice cream after a milkshake preload compared to a no-preload condition (Herman & Mack, 1975; Herman, Polivy, & Esses, 1987; Polivy, Heatherton, & Herman, 1988). Furthermore, individuals who drank small amounts of "high-incentive" (sugar-laden) beverages experienced a "whetted appetite," causing them to consume more of a second product (Wadhwa, Shiv, & Nowlis, 2007). Relatedly, sugar consumption can increase impatience in terms of deciding when to receive monetary rewards (Luo, Monterosso, Sarpelleh, & Page, 2015; Wang & Dvorak, 2010). Indeed, recent fMRI research corroborates the idea that sugar-laden foods activate appetitive responses and reward regions of the brain (Luo et al., 2015; Stice, Burger, & Yokum, 2013), thereby increasing the expectation of receiving an immediate reward, such as additional food, money, or even impulsive purchases (Li, 2008).

The findings in this second stream are consistent with evidence of how glucose works at the physiological level. In particular, increases in glucose in the bloodstream signal the pancreas to secrete insulin. This process moves the sugar from the bloodstream so it can be used as energy, thereby increasing subsequent overall hunger and decreasing satiety levels (Ludwig, 2002; Page et al., 2011; Pittas et al., 2005). Indeed, high-glycemic foods, such as sugar-laden beverages, are absorbed rapidly in the gastrointestinal tract, leading to a sharp increase in glucose (Benelam, 2009; Chew, Brand, Thorburn, & Truswell, 1988; Granfeldt, Björck, & Hagander, 1991). Several studies have shown that foods with a high (vs. low) glycemic index increase hunger and subsequent consumption throughout the day (Ball et al., 2003; Lennerz et al., 2013; Ludwig et al., 1999). Further supporting this notion, high-carbohydrate preloads can increase appetite and subsequent eating behavior relative to high-fat preloads (Cecil, Francis, & Read, 1999; Latner & Schwartz, 1999). By definition, sugar (glucose) has the highest glycemic index of any food (100), whereas fat has a glycemic index of zero. Therefore, a high-sugar beverage is likely to have a much stronger positive effect on hunger than a low-sugar beverage.

There are two potential differences between these two streams of research that might explain their divergent results. First, in some studies, all of the preloads contained varying levels of protein, carbohydrates and fats, making it difficult to isolate the effects of one macronutrient over the other (e.g., Blundell et al., 1993; Cecil et al., 1999). Second, participants in some of the studies may have been aware of the sugar or fat content of the preloads (e.g., Blundell et al., 1993), which may have influenced their responses. Thus, it appears that the previous mixed findings regarding macronutrients and satiety are probably due to a host of cognitive, emotional, and physiological factors (Hammersley, Reid, & Duffy, 2007). In the current research, we attempt to reconcile these previous mixed findings by proposing a factor that might moderate the influence of sugar on subsequent intake: the perceived healthfulness of the sugar-containing preload (e.g., Faulkner et al., 2014).[3]

Previous research with human participants suggests that, at least in some circumstances, individuals feel less satiated and thus eat more when they perceive a food to be healthy versus unhealthy (Crum, Corbin, Brownell, & Salovey, 2011; Scott, Nowlis, Mandel, & Morales, 2008; Vadiveloo, Morwitz, & Chandon, 2013). People believe that foods labeled as "healthy" are less tasty and enjoyable than unhealthy foods (Raghunathan, Naylor, & Hoyer, 2006). As a result, when people perceive a food (such as one that is low in fat but high in sugar) as "healthy" (vs. unhealthy), they tend to underestimate calories and anticipate lower levels of guilt, thereby causing them to mistakenly believe that larger portion sizes are appropriate (Faulkner et al., 2014). These findings suggest that when people perceive a preload to be healthy (such as a protein shake), they are likely to let down their

[2] In this research, we were primarily interested in the effects of different preloads on subsequent snack consumption. Therefore, we did not predict or measure the effects of different preloads on the consumption of the preload itself. Because it takes time for sugar to be absorbed in the bloodstream, it is possible that the immediate effects of sugar may differ from the effects after a 20-min delay (which we investigated in our studies). To control for these potential inconsistencies, we instructed our participants to consume as much of the preload as possible.

[3] In this research, we necessarily limited our focus to human participants, as we used visual food and labeling cues to influence perceptions of healthfulness of the preload. Therefore, in forming our predictions we gave greater weight to the prior literature using human subjects and randomized, controlled trials (rather than rodent studies or observational studies of humans).