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Out of proportion? The role of leftovers in eating-related affect and behavior[☆]

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ABSTRACT

It is well known that growing portion sizes increase consumption, but grossly enlarged portions also cause consumers to face more and more food leftovers. Despite the relevance of food leftovers, downstream effects of having more food leftovers on consumers' affect and behavior are unknown. In five studies, the authors test the idea that consumers may judge their actual consumption by looking at their leftovers. As such, larger leftovers may reduce perceived consumption and also impact other eating-related behaviors. Using both real and imagined food consumption and leftovers, the authors find that, holding the absolute amount of food consumption equal, larger (vs. smaller) food leftovers lead to reduced perceived consumption. This difference in perceived consumption has consequences for people's motivation to compensate for their eating. Larger (vs. smaller) food leftovers cause them to eat more in a subsequent unrelated food consumption task, and also to exercise less in an explicit calorie compensation task. The psychological drivers of this phenomenon are twofold: larger leftovers reduce perceived consumption, which leads people to feel better about themselves; and feeling better about themselves, in turn, reduces people's motivation to compensate. This research reveals a previously unknown negative consequence of grossly enlarged portion sizes and informs research on perceived consumption.

1. Introduction

A slice of pizza, half a pastry, a chunk of chocolate—food leftovers are commonplace, and have become more so. Average portion and package sizes have increased over time (Smiciklas-Wright, Mitchell, Mickle, Goldman, & Cook, 2003). For instance, between 1977 and 1996, the average portion size of a cheeseburger grew by 23% (from 5.5 oz to 6.8 oz) and that of French fries by 35% (from 2.3 oz to 3.1 oz). Soft drink servings increased by 45% (from 10.8 oz to 15.7 oz) and salty snack portions by 63% (from .8 oz to 1.3 oz; Nielsen & Popkin, 2003). While these increased portion sizes lead to increased consumption (for a review see Herman, Polivy, Pliner, & Vartanian, 2015), the increase in consumption is smaller than the increase in portion size: a recent meta-analysis found that when portion sizes are expanded by 100%, people eat only about 35% more (Zlatevska, Dubelaar, & Holden, 2014). As such, consumers today tend to have greater proportions of their food left over. This paper investigates the impact of food leftovers on consumers.

While people leave a lot of food behind (20 pounds per person per month; Buzby & Hyman, 2012), they also gain weight. As of 2015, 63.5% of Americans are either obese or overweight (Ogden, Carroll, Fryar, & Flegal, 2015). Accordingly, much research has investigated whether and how increased portion sizes may increase consumption and cause weight gain (e.g., Chandon & Ordabayeva, 2009; Dallas, Liu, & Ubel, 2015; Geier, Rozin, & Doros, 2006; Herman et al., 2015; Marchiori, Papias, & Klein, 2014; Rolls, Roe, Kral, Meengs, & Wall, 2004). But is it possible that having more food *leftovers* also shapes people's health- and weight-related behavior? As mentioned before, when portion size increases, consumption increases to a smaller degree, effectively leading to more food leftovers. We examine whether merely having a larger amount of food leftovers changes consumers' perception of how much they ate, and subsequently impacts their eating and exercising behavior. To our knowledge, the influence of food leftovers on later consumption and compensatory behaviors has not yet been studied.

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We address several questions. First, we investigate whether leftover food affects people's perception of how much they have eaten, independent of how much they have actually eaten. Our focus is to examine the effect of leftover size on perceived consumption and subsequent behavior. Prior work has shown that larger portions lead to greater consumption (see Herman et al., 2015; Zlatevska et al., 2014). In contrast, we hold actual consumption equal and only manipulate the amount leftover. Second, we test whether the resulting consumption perceptions influence people's affective reactions to their own eating. Third, we measure the motivational impact of these perceptions and affective experiences on subsequent eating and exercising.

This research adds to the social and health psychology literature that examines micro-contextual influences on food and health judgments and decisions. In studying food *leftovers* we specifically contribute to work on the social cognitive cues in the immediate environment that skew assessments of portion size and appropriateness (e.g., size labels, unit size) by adding a neglected element: a contextual influence that is itself generated in the process of consumption. Further, food leftovers are often a result of oversized portions. We extend beyond the known negative effects of portion distortion (i.e., greater intake from said portion) by revealing an additional layer of problematic outcomes of enlarged portions, namely their detrimental effect on *subsequent* behavior.

We examine our questions in five studies, three of which involve actual food consumption and real leftovers, with two of those further measuring behavioral outcomes, including eating behavior and exercising effort. If larger amounts of leftovers pose an additional mechanism for how growing portion sizes contribute to unhealthy behaviors, this has important implications for the potential success of portion control interventions such as “Just Eat Half” diets. Our results also demonstrate that relativity of absolute judgments also applies to interoceptive perceptions: even though consumption or fullness is, in principle, a concrete bodily sensation, people's perceptions of how much they have eaten are affected by relative amounts (amount eaten vs. amount left).

Note that throughout this paper, we use the term “leftovers” to refer to any uneaten remnants of food that a person could have eaten. “Leftovers” might more often be used for remnants of full meals (e.g., dinner) rather than snacks (e.g., a dessert), but our predictions do not distinguish between meal types. Thus, for ease of reading, we use the same familiar term to describe any food that was left over after an eating occasion.

2. Hypothesis development: the dynamic interplay of portion perceptions and consumption

Much research has studied how visual biases cause people to underestimate the size of growing portions (Krider, Raghuram, & Krishna, 2001; Ordabayeva & Chandon, 2013; Raghuram & Krishna, 1999), how inferences about norms lead them to judge growing portions as “normal” (Aydinoglu & Krishna, 2011; Diliberti, Bordini, Conklin, Roe, & Rolls, 2004; Geier et al., 2006; Kerameas, Vartanian, Herman, & Polivy, 2015; Robinson et al., 2016), and how both of these factors cause people to eat more from larger portions (for a review, see Herman et al., 2015; Zlatevska et al., 2014).

What has been unstudied is the frequent outcome of growing food portions and eating, namely, food leftovers. In the process of consuming food, naturally, the more a person eats from the original portion, the less is leftover. Is it possible that both how much a person has consumed and how much she has leftover impact her perception of her food consumption and downstream behaviors? As noted before, portion sizes keep growing (Nielsen & Popkin, 2003; Smiciklas-Wright et al., 2003). Although people eat more from larger portions, the fact that portion-size-induced increases in consumption are just a fraction of the portion-size-increases themselves (Zlatevska et al., 2014) means that people are often confronted with food leftovers.

We acknowledge that small increases in portion size may often just lead to more consumption and not to (more) leftovers, as people are likely to finish up portions that are only marginally larger than normal (e.g., Geier

et al., 2006). However, in many food categories, portion size increases have been drastic (e.g., mean bagel sizes at bakery chains are more than double the FDA-recommended serving size [4.4 oz. vs. 2 oz.], and mean steaks served are more than triple the USDA food pyramid suggestion [8.1 oz vs. 2.5 oz], see Young & Nestle, 2003). Additionally, many people actively try to restrict their food consumption and attempt to eat less than the portions they are offered (Nielsen, 2015). This research specifically focuses on situations where people are confronted with leftovers—be it because of oversized portions or because of restriction—and isolates the effect of having larger (vs. smaller) leftovers. We focus on scenarios such as the following: If a diner presented with a two-scoop ice cream sundae eats one scoop, she has half of the dessert left. In contrast, if another diner, presented with a three-scoop sundae, eats one scoop, she has two thirds left. Might the two diners feel differently? And if they do, how will it impact their subsequent eating-related decisions?

2.1. Relativity of “absolute” judgments

One of the core tenets of psychology is that judgments are relative—evaluations are made in comparison with a salient reference point. This has been shown for concrete sensory perception (loudness: Garner, 1953; Holland & Lockhead, 1968; pitch: Truman & Wever, 1928; weights: Wever & Zener, 1928; see also von Helmholtz, 1866; Stewart, Brown, & Chater, 2005), and for more abstract cognitive evaluations (e.g., gains and losses: Kahneman & Tversky, 1979; Tversky & Kahneman, 1991; product attributes: Hsee, 1996; goal progress: Fishbach & Dhar, 2005; Kivetz, Urminsky, & Zheng, 2006). Given that judgments are so inherently relative, it is also likely that even feelings of fullness (i.e., interoceptive perceptions) are relative, and that people judge their food consumption in relative terms (see Bem's (1972) self-perception theory for examples of hard-to-judge “inner states”). Related research has shown that several non-physiological factors can impact satiety, such as attention paid to eating (Brunstrom & Mitchell, 2006), recall of recent eating episodes (Higgs, 2008), or framing of foods as (un)healthy (Finkelstein & Fishbach, 2010; Vadiveloo, Morwitz, & Chandon, 2013), hinting at the malleability and subjective nature of satiety.

One salient dimension that might act as a relative measure to assess perceived consumption may be the whole portion that one starts with. That is, people may evaluate their actual consumption in terms of the proportion of the original portion. The leftover amount, then, may cue how much has been consumed from the original portion. Thus, people may perceive the same amount of actual consumption as being smaller when they face a larger (vs. smaller) amount of food leftovers. As such, we predict that, holding absolute consumption constant, a larger (vs. smaller) amount of food leftovers will lead to lower perceived consumption (H1).

However, there is reason to believe that the impact of having a larger (vs. smaller) amount of food leftovers goes far beyond this cognitive evaluation of how much one has consumed. Rather, perceiving that they ate a smaller amount may also influence consumers' affective reaction to their consumption and, as a result, their later motivational behavior.

2.2. Affective and motivational consequences of eating

Most people hold healthy eating goals (Bublitz, Peracchio, & Block, 2010), and many people feel guilty for unhealthy eating (Ramanathan & Williams, 2007; Rozin, Bauer, & Catanese, 2003). Indeed, people seek out a variety of excuses to justify their indulgent consumption in order to feel less guilty for this behavior (Hagen, Krishna, & McFerran, 2017; Khan & Dhar, 2006; Kivetz & Zheng, 2006; Mukhopadhyay & Johar, 2009; Okada, 2005). Notably, focusing on downward counterfactuals and considering how much worse things could have been boosts people's positive feelings about themselves (Efron, Monin, & Miller, 2013; White & Lehman, 2005). Accordingly, if larger leftovers lead to lower perceived consumption, and given that people often feel bad for (over)eating indulgent foods, we predict that a larger (vs. smaller) amount of (unhealthy) food leftovers will lead to more positive self-evaluative feelings (H2). Note this hypothesis assumes absolute consumption is held constant.

Larger (vs. Smaller) Leftovers Reduce Motivation to Compensate through Lowering Perceived Consumption and Bolstering Self-Evaluative Feelings

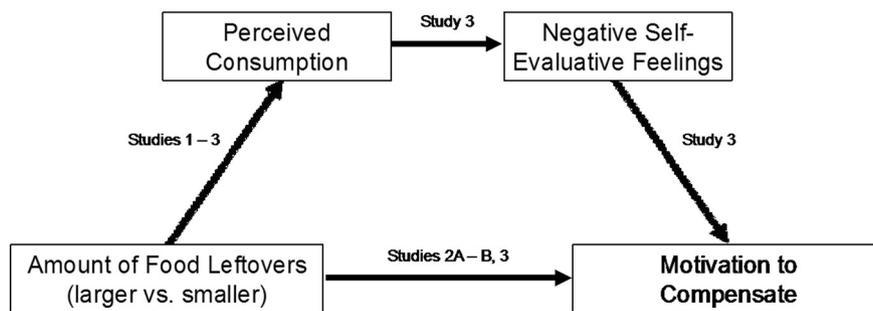


Fig. 1. Conceptual framework of the effects of food leftovers, and studies testing each part.

While more positive self-evaluative feelings may be desirable in the short-term, they can cause people to slack off on beneficial behaviors later on, which may hurt them in the long-term.

Specifically, feeling good about one's current progress or standing in a given domain may lead to “coasting”—feeling that everything is going well and thus reducing effort towards the goal (Bandura & Cervone, 1983; Carver, 2003; Fröber & Dreisbach, 2014; Mizruchi, 1991; Tobin, Greenaway, McCulloch, & Crittall, 2015). Conversely, feeling bad about not meeting a goal can spur motivation. Guilt, specifically, drives motivation to repair one's shortcoming (Amodio, Devine, & Harmon-Jones, 2007; Flynn & Schaumberg, 2012; Ketelaar & Au, 2003; Lickel, Kushlev, Savalei, Matta, & Schmader, 2014).² Therefore, we expect that the sense of achievement stemming from lower perceived consumption and the resulting positive self-evaluative feelings will decrease motivation to engage in compensatory healthy behavior. We predict that, holding absolute consumption constant, a larger (vs. smaller) amount of food leftovers reduces people's motivation to compensate, as reflected in subsequent compensation behavior (i.e., restraining one's eating, intensifying one's exercising) and self-report (H3). Again, this hypothesis assumes absolute consumption is held constant. Finally, we predict that reduced perceived consumption and increased positive self-evaluative feelings will mediate the effect of larger (vs. smaller) leftovers on motivation to compensate (H4).

Five experiments provide evidence supporting our predictions. Studies 1A and 1B tests the basic premise that larger (vs. smaller) amounts of food leftovers cause people to feel they ate less, despite equal actual consumption (H1). Studies 2A and 2B again test this effect of larger (vs. smaller) leftovers on perceived consumption (H1) and also test if larger (vs. smaller) leftovers impact people's motivation to compensate (H3), that is, whether they lead to lower eating restraint later on (study 2A) and less exercise effort in a subsequent task (study 2B). Lastly, study 3 tests if larger (vs. smaller) leftovers also result in enhanced self-evaluative feelings (H2), and whether the negative effect of larger (vs. smaller) leftovers on people's motivation to compensate (H3) is mediated by a sequence of lower perceived consumption and heightened self-evaluative feelings (H4). Fig. 1 summarizes our hypotheses, and the studies testing them. We report all measures, conditions, and data exclusions, and describe sample size determination for each study. Data was analyzed only after data collection had concluded. Further, in the supplementary materials associated with the article, we describe a

² Although the motivating impact of *negative* feedback seems to prevail in the literature, other studies have found that positive feelings during goal progress, such as enjoyment (Woolley & Fishbach, 2016) or self-efficacy (Bandura, 1986), can increase goal commitment. Research trying to reconcile the divergent findings suggests that positive affect *increases* motivation when no other competing goal is salient but *reduces* motivation when a competing goal is present (Fishbach & Dhar, 2005; Orehek, Bessarabova, Chen, & Kruglanski, 2011). Given that hedonic goals compete with health goals in the context of eating, we predict that feeling good will reduce, but feeling bad will boost, motivation.

replication study for study 1A; provide access to the video animation used in study 1B; describe a post-test on size perceptions for the stimuli used in studies 2A and 2B; and share more detailed data on the distribution of the count dependent variables collected in studies 2A and 2B.

Note that our research focuses on leftovers from an individual's portion. That is, we are not studying food leftovers from communal serving bowls, because individuals may not think of those as “their” leftovers. We are also not studying large multi-portion packages, because consumers may not conceptualize uneaten food remaining in the box or package as a “leftover” of their food that they could have eaten, but merely as additional supply.

3. Study 1A: chocolate leftovers and perceived consumption

An initial study tested whether having a larger (vs. smaller) amount of food leftovers leads people to feel they ate less (H1). In this study, we use real consumption and real leftovers.

3.1. Method and procedure

A research assistant approached community members on the campus of a large Midwestern university to participate in a study. Forty-six people volunteered to participate in the study (47.3% women, $M_{\text{age}} = 20.65$, range_{age}: 18 to 30 years). This sample size was determined by how many volunteers the research assistant could recruit in one week at the end of the semester (many students had exams or had already left campus). Participants were randomly assigned to a one-factor 2-cell (amount of leftovers: smaller vs. larger) between-subjects design.

3.1.1. Stimulus design

We used Chocolve bars (see Fig. 2), which come in a mini size (8 squares) and a regular size (18 squares). The size of each square in the two chocolate bars is equal. Participants in both conditions (large and small leftovers) ate the same amount of chocolate: six squares of the chocolate. As a result, people had more chocolate leftover in the larger leftovers condition (12 squares) than in the smaller leftovers condition (2 squares).

3.1.2. Instructions

Under the guise of a study on health and energy, participants were presented with a bar of chocolate and told that they would “have a chance to taste some of this chocolate and rate a few questions about [their] consumption experience.” A whole chocolate bar was presented to them on top of its foil wrapper; the paper cover was removed beforehand so that the chocolate's brand name was not visible and there was no impact of prior experiences or associations with the brand. Once an individual agreed to participate in the study, the research assistant cut off a part of the whole chocolate bar and instructed the participant to eat this amount of chocolate for the tasting.

Then, all participants were asked to eat six (6) squares of chocolate. The remainder of the chocolate bar was left in front of each participant as they



Fig. 2. Chocolove brand chocolate bars used in study 1A. In the smaller leftovers condition (left), a mini size (8 squares) was used. In the larger leftovers condition (right), a regular size bar (18 squares) was used. All participants ate 6 squares of chocolate.

ate the designated six squares of chocolate. Participants indicated their perceived absolute consumption by rating on a 1–9 scale “How much chocolate do you feel you consumed? Please rate the absolute amount you feel you consumed” (1 = *very little* to 9 = *very much*). Finally, they indicated their age and gender.

3.2. Results and discussion

A univariate ANOVA on our dependent variable, perceived consumption, with amount left as the independent variable, revealed a significant effect of the amount of leftovers on perceived consumption ($F(1, 44) = 5.63, p = .022, \eta_p = 0.133$). People felt they had eaten less when they ate six squares but had a larger amount leftover ($M = 5.83, SD = 1.00$) than when they ate six squares but had a smaller amount leftover ($M = 6.77, SD = 1.63$). This result supports the idea that a larger (vs. smaller) amount of food leftovers causes people to feel they ate less (H1). A higher powered online experiment with pictures of the chocolate bars replicated the results (see supplementary materials).

Given that the convenience sample we were able to obtain for this real consumption study was relatively small, we next conducted a much higher powered (100 subjects per cell) online experiment in which we employ a similar design, but use images of a heartier food, and also remedy potential concerns that the effect may be driven by scale usage effects.

4. Study 1B: replication in an online experiment

A follow-up study conceptually replicated the effect from study 1A, but with greater power, heartier food, several measures of perceived consumption, and ensuring comparable scale use across groups through initial calibration.

4.1. Method and procedure

Two hundred and three U.S.-based participants were recruited through Amazon’s Mechanical Turk platform (39.9% women, $M_{\text{age}} = 35.67$, range: 18 to 85 years) for a nominal payment. Sample size was determined by following current standards for online research, where larger cell sizes are easily achievable, and cells of 100 subjects are common. Participants completed the study on their personal computer (no mobile device users attempted to take the study) and were randomly assigned to a one-factor 2-cell (amount of leftovers: smaller vs. larger) between-subjects design. While the design was similar to study 1A, we incorporated several key differences described below.

First, to mitigate concerns that any perceived consumption differences found could be a scale usage effect—attributable to people in the two conditions using the scale differently as a function of the manipulation—we first calibrated all participants to the scale. Specifically, all participants provided an amount rating for another food (the same across conditions) using the same type of scale they would later use for the key dependent variables.

Second, participants saw an image of either a small portion (one cup) or large portion (two cups) of macaroni and cheese on a plate, with

a fork placed to the right of the plate for scale. They were instructed to imagine this was their plate of macaroni and cheese and they were about to eat. Then they watched a short animation (a “gif”) showing seven images of the plate where each successive plate had two forkfuls less macaroni and cheese on them, creating the illusion of the food being eaten from the plate (see Fig. 3 for still images, or the supplementary materials for a link to the animation).

After seeing the animation, they were instructed to imagine that this was their plate of macaroni and cheese, and that they had just eaten the part that was missing. They were asked to imagine how they would feel, having eaten this food. Then they completed the measures described below the calibration question.

4.2. Measures

4.2.1. Calibration question

Before the manipulation, all participants saw the image of a “regular Snickers bar (i.e., 4 inches)” and rated on a 1–9 scale “In your opinion, how would you rate the amount of candy that is a regular Snickers bar? Please rate the absolute amount of candy.” (1 = *very little* to 9 = *very much*).

Study 1 used one item to measure perceived consumption. In this study, we use several different measures of perceived consumption, to ensure other means of assessment are consistent with the one-item measure that we used in study 1.

4.2.2. Perceived consumption scale

Participants rated their perceived consumption on four items that each addressed perceived consumption from a different angle: “How much would you feel you consumed? Please rate the absolute amount you’d feel you consumed.” (1 = *very little* to 9 = *very much*); “How full would you feel at this point?” (1 = *not at all full* to 9 = *very full*); “How hungry would you still feel at this point?” (1 = *not at all hungry* to 9 = *very hungry*); and “How long would it take until you’d feel hungry again after eating this much from your macaroni and cheese?” (1 = *a very short time* to 9 = *a very long time*). The item pertaining to hunger was reverse-coded and all four items were combined into a “Perceived Consumption Index” ($\alpha = 0.85$).

4.2.3. Perceived satiety equivalency measure

Participants also indicated how much of a reference food—banana—they would have to eat to achieve satiety equal to that from the macaroni and cheese. They chose from images depicting different amounts of banana (akin to Brunstrom, Shakeshaft, & Scott-Samuel, 2008) in response to “How much banana would you have to eat to feel equally full as you would after eating the amount of macaroni and cheese that you ate from the plate?” (1/8, 1/4, 1/2, 3/4, 1, 1 1/8, 1 1/4, 1 1/2, 1 3/4, or 2 bananas).

4.2.4. Perceived calories

Finally, participants estimated their calorie intake on a slider scale ranging from 0 to 600: “How many calories were in the amount of macaroni and cheese you ate?” (Note that the true calorie content of the amount “eaten” was ca. 170 cal.)

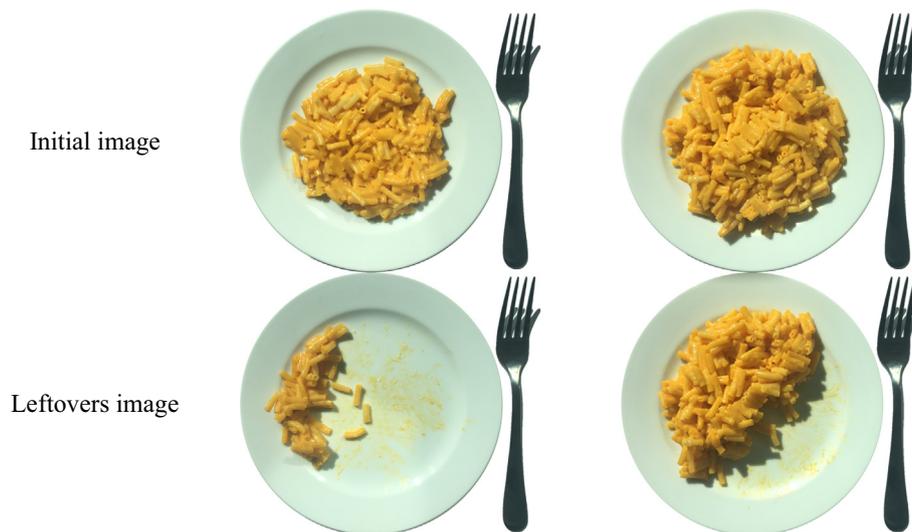


Fig. 3. Still images of the macaroni and cheese plates shown in the animations used in study 1B. In the smaller leftovers condition (left), 5 forkfuls are leftover. In the larger leftover condition (right), 24 forkfuls are leftover. All participants saw 14 forkfuls of macaroni and cheese being “eaten” from the initial portion.

4.2.5. Ease of imagination (equality check)

Participants also rated how easy it was to imagine the scenario (1 = *very easy* to 9 = *very difficult*).

Besides age and gender, participants reported if any dietary restrictions would prevent them from eating macaroni and cheese in real life. Dietary restrictions preventing macaroni and cheese consumption (e.g., lactose intolerance, veganism) were only reported by 3.0% of participants and all subsequent analyses include these individuals.

4.3. Results and discussion

Data were analyzed via univariate ANOVA, with amount left as the independent variable.

4.3.1. Ease of imagination (equality check)

The analysis showed no effect of the amount of leftovers on ease of imagination ($F(1, 201) = 0.07, p = .792, \eta_p = 0.000$). Thus, it was not the case that one scenario (having more or having less leftovers) was easier to imagine than the other.

4.3.2. Dependent variables

4.3.2.1. Perceived consumption scale. The analysis revealed a significant effect of the amount of leftovers on the perceived consumption scale ($F(1, 201) = 29.06, p < .001, \eta_p = 0.126$). People thought they had consumed less when they had a larger amount leftover ($M = 5.04, SD = 1.59$) than when they had a smaller amount leftover ($M = 6.24, SD = 1.60$). (Note that the results also hold for each of the four individual items, $ps \leq .003$).

4.3.2.2. Perceived satiety equivalency measure. The analysis revealed a significant effect of the amount of leftovers on perceived satiety achieved by a comparison food ($F(1, 201) = 25.67, p < .001, \eta_p = 0.113$). People felt that less banana was sufficient to achieve an equivalent level of fullness when they had a larger amount leftover ($M = 1.30$ bananas, $SD = 0.49$) than when they had a smaller amount leftover ($M = 1.61$ bananas, $SD = 0.38$).

4.3.2.3. Perceived calorie content. The analysis revealed a significant effect of the amount of leftovers on perceived calorie content ($F(1, 201) = 19.03, p < .001, \eta_p = 0.086$). People thought they had consumed fewer calories when they had a larger amount leftover ($M = 284.85, SD = 121.98$) than when they had a smaller amount leftover ($M = 354.38, SD = 104.67$).

4.3.3. Calibration

Further, all effects hold when controlling for people's initial size estimation for the Snickers bar ($F(1, 201) \geq 18.76, ps < .001, \eta_p \geq 0.086$). This finding indicates that the effect is not driven by scale usage effects: the initial calibration does not turn off the effect, and statistically controlling for any slight individual differences in terms of general size judgments does not diminish the effect of the manipulation.

The results in study 1B replicate study 1A, which had used real consumption but a smaller sample size. They again support the idea that a larger (vs. smaller) amount of food leftovers causes people to feel they ate less (H1), as measured in a variety of ways, including more objective responses like perceived calorie content and equivalency of a comparison food. In the following studies, we return to the more parsimonious one-item measure for perceived consumption.

The rectangular shape of the chocolate bar used in study 1A is perceptually simple. What is more, the individual chocolate squares (study 1A) and the macaroni and cheese bites (1B) are countable and thus fairly unambiguous, so the fact that we found an effect of leftovers on perceived consumption, even though people could have tracked their consumption quite easily, gives us confidence in our effect. However, food comes in more complex shapes, and food amounts are often not countable but rather ambiguous. For that reason, in the next studies we extend our stimuli to circular shapes and non-countable amounts. Further, we measure behavioral downstream effects, which should also avoid scale usage effects.

5. Experiments 2A and 2B: cookie leftovers and compensatory behavior

Studies 2A and 2B again test whether having a larger (vs. smaller) amount of food leftovers leads people to feel they ate less (H1), and also tests whether a larger (vs. smaller) amount of leftovers reduces motivation to compensate, as reflected in compensation behaviors: lower restraint on subsequent food consumption and lower effort on subsequent exercising (H3).

6. 2A: cookie leftovers and subsequent eating

6.1. Method and procedure

One hundred and six participants were recruited from the paid subject pool at a large Midwestern university (69.8% women, $M_{age} = 25.9$, range_{age}: 18 to 47 years) for payment of \$4. Sample size was determined by



Fig. 4. Images of the real cookies used in studies 2A and 2B. In the smaller leftovers condition (left), participants ate 3/4 of a smaller cookie and left a 1/4. In the larger leftovers condition (right), participants ate a 1/4 of a larger cookie and left 3/4.

aiming for at least 50 participants per cell, which, in this design, yields about 80% power to detect a moderate effect. Participants completed the study in computer cubicles and were randomly assigned to a one-factor 2-cell (amount of leftovers: smaller vs. larger) between-subjects design. Again, we use real consumption and leftovers.

Under the guise of a taste test, all participants were presented with a chocolate chip cookie and asked to eat a designated section of this cookie that was cut out and marked by an arrow. The cookie was presented on a white paper plate that had been placed in each participant's cubicle before the beginning of the session and covered with another paper plate as a lid. Packaging was removed beforehand to disguise the cookie's brand name and prevent any impact of prior experiences or associations with the brand on the current reaction (see Fig. 4).

6.1.1. Stimulus design

We manipulated cookie size so that the section to be eaten would be nearly perceptually equal across groups, but the amount leftover was different between groups. We designed our stimuli with three important aspects in mind: (i) keeping shapes and angles equal across conditions, (ii) adjusting for underestimation of larger sizes, and (iii) avoiding language that draws attention to sizes.

To achieve the difference in leftovers, we used two differently sized cookies: a smaller cookie for the smaller leftovers condition and a larger cookie for the larger leftovers condition. Critically, the two cookie sizes were matched in such a way that asking people to eat 3/4 of the smaller cookie and 1/4 of the larger cookie for tasting would result in a comparable amount of consumption, but different absolute amounts leftover (see Fig. 4). We selected 1/4 and 3/4 in order to keep the shapes of the wedges and the angles of the cuts identical across conditions.

To adjust for the underestimation of larger sizes (Stevens, 1986) discussed previously, we selected the cookie diameters in an attempt to create visual equality of the 3/4 and 1/4 wedges to be eaten. We corrected for the bias using the widely established rule that Perceived Size = Actual Size ^{ϵ} , with ϵ being 0.8 (for a discussion see Krider et al., 2001). That is, the actual size of the larger cookie was somewhat increased in order to make up for the fact that the human eye perceives increases in size at a slightly smaller-than-actual rate. This adjustment was designed to approximate visual equality of the wedges, but causes the actual area consumed to be slightly larger in the larger leftovers condition (area eaten: 3.98 in²) compared to the smaller leftover condition (area eaten: 2.99 in²)—which works *against* our prediction. (Recall that we predict that people in the larger leftovers condition will perceive *less* consumption and therefore eat *more* at a subsequent occasion, so this adjustment makes for a more conservative hypothesis test. A post-test of the perceived amount of the wedges in isolation supports this notion, see supplementary materials).

The cookies were placed on equally sized plates, because prior research suggests that container or tableware size may introduce additional effects independent of food size (Marchiori, Corneille, & Klein,

2012). One side effect of this decision is, of course, that the area of the larger (smaller) cookie may look even larger (smaller), but again, this works *against* our prediction.

Lastly, to avoid drawing attention to size, the cookie part to be eaten was marked with an arrow drawn on the plate, rather than using terms like “the smaller part” or “one quarter.”

6.1.2. Instructions

Participants were told they were receiving the whole cookie to accurately judge its appearance, but that they should only eat the designated part marked with an arrow. They were instructed to take enough time to experience the taste, scent, and texture while eating the cookie. The instructions highlighted that they would have to leave the remaining food in the laboratory after the session and could not take any part of the cookie with them. After that, they proceeded to the product evaluation questions.

6.2. Measures

6.2.1. Perceived consumption

After eating the designated section of the cookie, participants completed questions on taste to adhere to the cover story. Embedded in these questions was the first variable of interest: perceived consumption. Participants rated their perceived consumption on the 1–9 scale (1 = *very little* to 9 = *very much*) as in Study 1A. At the end of this set of questions, people learned that the first study had concluded; but if they wanted, they could participate in another short (optional) cookie eating and evaluation study. This second study allowed us to measure the second variable of interest: consumption at the next eating occasion.

6.2.2. Subsequent consumption

In the optional second study, people were instructed to open a wax paper bag filled with mini cookies and asked to sample as many or as few cookies as they liked, and to rate them on various dimensions. All bags initially contained 10 cookies and we derived subsequent consumption from the number of cookies remaining in each bag afterwards.

6.3. Results and discussion

Sixteen participants did not follow instructions in the initial part of the study and ate more or less than the marked section of the cookie. One person with a disability participated with the help of an aide, and one person did not receive the instructions regarding the optional second study. These individuals were dropped from the analysis, leaving 88 participants.

6.3.1. Perceived consumption

The analysis revealed a significant effect of the amount of leftovers on perceived consumption ($F(1, 86) = 5.28, p = .024, \eta_p = 0.058$). People rated their consumption amount as lower when they had larger leftovers ($M = 4.00, SD = 1.89$) than when they had smaller leftovers ($M = 5.00, SD = 2.17$). Again, this supports H1.

6.3.2. Subsequent consumption

People who chose not to participate in the additional cookie eating study were coded as having eaten zero (0) cookies. A Kolmogorov-Smirnov test for normality indicated that the distribution of cookies eaten in the second task was highly right-skewed in both conditions ($D_{\text{large}} = 0.16, p < .01; D_{\text{small}} = 0.20, p < .001$), violating the assumptions of standard parametric tests (see supplementary materials for the distribution).

Thus, we conducted a log-linear (or Poisson) regression, the standard analytical approach (Greene, 2011) for count data, which cannot be expected to be normally distributed, and especially for data with a high proportion of zeros, such as ours. Our manipulated condition of smaller leftovers was coded as 0, and larger leftovers as 1. We regressed number of subsequently eaten cookies on amount of leftovers. The

amount of leftovers had a significant effect on the number of cookies eaten during the second study ($b = 0.36$, $SE = 0.12$, $Wald-\chi^2 = 8.64$, $p = .003$)—people ate more cookies during the second study if they had larger leftovers earlier ($M = 3.74$, $SD = 3.06$) than if they had smaller leftovers ($M = 2.62$, $SD = 2.75$). This result supports H3.

Study 2A shows that having a larger (vs. smaller) amount of food leftovers causes people to feel they consumed less food (despite having eaten a slightly larger objective amount) and also leads them to exert less restraint at a subsequent eating opportunity. In other words, larger (vs. smaller) leftovers reduce people's motivation to compensate for their eating (by constraining their eating later). The fact that the leftovers manipulation has a downstream effect on subsequent eating behavior further suggests that the effect is not attributable to idiosyncratic scale usage effects. Note that controlling for the product evaluation questions for the cover story does not impact the effect ($b = 0.39$, $p = .004$). Nonetheless, the cookies were from different manufacturers, so it is possible that differences in the first type of cookie (chocolate chip) may have contributed to people's level of consumption of the second type of cookie (trail mix), even though they were of a different kind. Study 2B uses a different behavioral measure to guard against this potential issue.

7. 2B: cookie leftovers and subsequent exercise

Study 2B replicates study 2A but focuses on a different type of compensatory behavior. Instead of focusing on how much eating restraint people exert eat after leaving different amounts of leftovers, we focus on how much effort they put into exercising.

7.1. Method and procedure

One hundred and thirty-three participants were recruited from the subject pool at a large Midwestern university (58.6% women, $M_{age} = 20.4$, $range_{age}$: 19 to 31 years) and participated in exchange for partial course credit. Sample size was determined by the number of subjects allocated to us from the student pool shared among the department. Participants completed the study individually in a private room and were randomly assigned to a one-factor 2-cell (amount of leftovers: smaller vs. larger). For the initial part of the study, we used exactly the same leftovers manipulation, stimuli, and instructions as in study 2A. However, in 2B, the procedure that followed the initial “cookie taste test” was different and involved exercising on a stepper.

7.2. Measures

7.2.1. Perceived consumption

As in study 2A, participants completed questions on taste to adhere to the cover story, which once again included the question on perceived consumption (1 = *very little* to 9 = *very much*).

After having responded to the taste questions, participants learned that we were also “interested how people evaluate certain nutritional aspects of what they ate” after the fact, and that they would now be asked to engage in some light exercise on a stepper.

7.2.2. Subsequent exercise

As mentioned before, the study was conducted one participant at a time. This helped us eliminate any audience effects on effort (e.g., social facilitation [Markus, 1978]) and also hold audience size (zero) completely equal for all participants. It also allowed us to hold constant the amount of time that passed in between the initial “cookie taste test” and the exercise task, which would not have been possible had we conducted the study in a busy gym.

As soon as each participant was done with the initial part of the study, a research assistant set up a mini stepper in the participant's private study room and familiarized each participant with the stepper equipment. After the research assistant demonstrated how to safely step on and off the

stepper, she left the room. Then people read the specific instructions for the exercise task and completed the exercise task on their own.

In the task description, participants were told to step on the stepper and to “walk on it as long as [they] think is necessary to balance out the amount of cookie that [they] ate.” (That is, the task was explicitly about compensation—this extends study 2A, where compensation occurred spontaneously, to situations where compensation is a salient goal and consciously pursued). The display mounted between the pedals helped keep track of the number of steps they had taken. Participants exercised privately; the speed of exercise and time spent was at their discretion. We measured steps taken and calories burned with a small onboard computer attached to the stepper.

7.3. Results and discussion

Twenty-four participants either ate more or ate less than the marked section of the cookie, or skipped entire sections of the study. Two participants could not eat the cookie due to allergies. Six participants' step counts were outliers ($> 2SD$ above the mean, the standard cut-off for skewed data, such as reaction time etc., see Cowles & Davis, 1982). These individuals were dropped from the analysis, leaving 101 participants.

7.3.1. Perceived consumption

The analysis revealed a significant effect of amount of food leftovers on perceived consumption ($F(1, 99) = 13.50$, $p < .001$, $\eta_p = 0.12$). People rated their consumption amount as lower when they had larger leftovers ($M = 3.65$, $SD = 1.59$) than when they had smaller leftovers ($M = 5.04$, $SD = 2.14$). Once more, this result corroborates H1.

7.3.2. Subsequent exercise

Again, a Kolmogorov-Smirnov test for normality indicated that the distribution of steps taken in the second task was highly right-skewed, though more strongly in the small leftovers condition ($D_{large} = 0.11$, $p = .16$; $D_{small} = 0.16$, $p < .01$; see supplementary materials for the distribution).

Thus, we conducted a log-linear (or Poisson) regression. Smaller leftovers were coded as 0 and larger leftovers as 1. The amount of leftovers had a significant effect on the number of steps taken during the second task ($b = -0.378$, $Wald-\chi^2 = 568.96$, $p < .001$)—people walked fewer steps to balance out their cookie eating when they had larger leftovers ($M = 133.76$, $SD = 89.27$) than when they had smaller leftovers ($M = 195.19$, $SD = 143.08$). Again, this result supports H3.

Overall, study 2B conceptually replicates study 2A. It further substantiates the hypothesis that a larger (vs. smaller) amount of leftovers reduces perceived consumption (even after having eaten a slightly larger objective amount) and diminishes subsequent exercise effort to compensate for consumption. Once more, larger (vs. smaller) leftovers reduced people's motivation to compensate for their eating (by working off calories), and the downstream effect on behavior underscores that the effect is not an artifact of scale usage. Importantly, larger (vs. smaller) leftovers impacted people's behavior regardless of whether the task was allegedly unrelated to the first (another taste test) or explicitly tied to it (balancing out calories).

These results are likely not explained by magnitude priming (Oppenheimer, Leboeuf, & Brewer, 2008): such a process should have impacted the perceived consumption estimates as well, and we should see larger leftovers leading to larger (not smaller) estimates of consumption. Further, while it is possible that in study 2A, those with small cookie leftovers may have felt more satiated on sweetness (Redden & Galak, 2013) and that contributed to their lower subsequent cookie consumption, in study 2B, satiation is not a viable alternative explanation for the change in exercise behavior.

While studies 2A and 2B uncovered important downstream effects on real behavior, the nature of these behavioral measures (highly skewed, large variance) compared to the nature of the self-reported proposed mediator variable (small variance and normally distributed)



Fig. 5. Chocolate images used in study 3. In the smallest leftover condition (leftmost), 3 squares were leftover. In the largest leftover condition (rightmost), 24 squares were leftover. All participants imagined having eaten 6 squares of chocolate.

does not lend itself to testing for mediation. To better test our mediation hypothesis (H4), study 3 employs a multi-item self-report measure of behavioral intentions to quantify motivation to compensate. Study 3 also introduces the construct of negative self-evaluative feelings, which we hypothesize as the critical link between perceived consumption and subsequent motivation. This allows for a comprehensive, serial mediation test of our proposed model (see Fig. 1).

8. 3: Chocolate leftovers, negative self-evaluative feelings, and motivation to compensate

Study 3 tests all hypotheses together, that is, that having a larger (vs. smaller) amount of food leftovers leads people to feel that they ate less (H1), makes them feel better about themselves (H2), lowers their motivation to compensate, as measured by self-reported intentions to eat less and exercise more (H3), and, finally, that perceived consumption and feeling better mediate the effect of larger (vs. smaller) leftovers on motivation to compensate (H4).

8.1. Method and procedure

Four hundred and three U.S.-based participants were recruited through Amazon's Mechanical Turk (52.9% women [one person did not report gender], $M_{\text{age}} = 37.41$, $\text{range}_{\text{age}} = 19$ to 71 years) for a nominal payment. The sample size was determined by current standards for online research, where large cell sizes are easily achievable and cells of 100 subjects are common. Participants completed the study on their personal computer (14 mobile phone users were screened out right at the start of the survey) and were randomly assigned to a one-factor 4-cell (number of chocolate squares leftover: 3 vs. 6 vs. 14 vs. 22) between-subjects design.

Participants saw the remainder of a chocolate bar resting on its wrapper. To prevent brand associations from impacting participants' inferences, no chocolate brand name was shown. From the image, it was evident that six (6) squares had been eaten from the whole bar. Critically, we manipulated the amount of leftovers by manipulating the size of the whole chocolate bar. People saw either a 9-square bar with three squares left, a 12-square bar with six squares left, a 20-square bar with 14 squares left, or a 28-square bar with 22 squares left (see Fig. 5).

Along with the image, participants were instructed to imagine this was their chocolate bar, and that they had just eaten the part that was missing. They were asked to imagine how they would feel, having eaten this chocolate. Then they completed the measures described below, which were presented in random order.

8.2. Measures

8.2.1. Negative self-evaluative feelings

Participants rated four items on 1–9 scales: “To what extent would you feel the following: good/guilty/regretful/shameful?” (1 = *not at all* to 9 = *very much*). Good was reverse-coded, and the items were combined into a “Negative Self-Evaluative Feelings Index” ($\alpha = 0.91$).

8.2.2. Perceived consumption

Participants rated two items on 1–9 scales: “How much would you feel you consumed? Please rate the absolute amount you'd feel you consumed.” (1 = *very little* to 9 = *very much*) and “How full do you think you would feel after eating this amount of chocolate?”

(1 = *not at all full* to 9 = *very full*; combined into a “Perceived Consumption Index,” $r = .59$, $p < .001$).

8.2.3. Motivation to compensate

Participants rated their motivation to compensate for their chocolate eating on four items on 1–9 scales: “Based on the amount that you just ate out of the entire chocolate bar, ... how healthy would your next food choice have to be to “make up” for it?” (1 = *would not need to be that healthy* to “make up” the amount I'd just eaten) to 9 = *would have to be extremely healthy* to “make up” the amount I'd just eaten), “... how small would your portion have to be to “make up” for it?” (1 = *would not need to be that small* to “make up” for the amount I'd eaten to 9 = *would need to be extremely small* to “make up” for the amount I'd eaten), and “... how hard would you need to work out to “make up” for it?” (1 = *would not need to work out that hard* to “make up” for the amount I'd eaten to 9 = *would need to work out very hard* to “make up” for the amount I'd eaten), and “... how long would you need to work out to “make up” for it?” (1 = *would not need to work out very long* to “make up” for the amount I'd eaten to 9 = *would need to work out very long* to “make up” for the amount I'd eaten; combined into a “Motivation to Compensate Index,” $\alpha = 0.89$).

8.2.4. Manipulation and equality checks

To ensure that the amount leftover was actually perceived as different between groups, participants also rated the amount of chocolate leftover on 1–9 scales: “How much would you feel you left?” (1 = *very little* to 9 = *very much*) and “How filling would this leftover amount of chocolate be?” (1 = *not at all filling* to 9 = *very filling*, combined into a “Perceived Leftovers Index,” $r = .51$, $p < .001$). To ensure equality on other related dimensions between the four conditions, participants rated how easy it was to imagine the scenario (1 = *very difficult* to imagine to 9 = *very easy* to imagine) and the perceived size of one individual chocolate square presented in isolation (1 = *very small* to 9 = *very large*).

8.2.5. Potential moderators and demographics

Although we had no specific hypotheses regarding their impact, we also measured how much people liked chocolate in general (1 = *dislike very much* to 9 = *like very much*) and their dieting tendency (“How often do you... watch calories/moderate sugar intake/cut back on snacks and treats/watch the amount of fat you consume?” 0 = *never* to 5 = *all the time*; $\alpha = 0.87$; Mohr, Lichtenstein, & Janiszewski, 2012). Liking did not interact with the effect of the leftover manipulation on any of the three dependent variables (p s > .103), so it will not be discussed further. Dieting did not interact with the effect of the leftover manipulation on perceived consumption or motivation (p s > .431), but it did with negative self-evaluative feelings ($p = .006$); this interaction is discussed later.

Finally, given the hypothetical nature of the study, besides age and gender as in the other studies, participants also reported if any dietary restrictions would prevent them from eating chocolate in real life. Dietary restrictions preventing chocolate consumption (e.g., lactose intolerance, diabetes, veganism) were only reported by 4.0% of participants and all subsequent analyses include these individuals.

8.3. Results and discussion

We conducted linear regressions, with the number of squares leftover as the predictor variable and the manipulation checks as well as

the indices for perceived consumption, negative self-evaluative feelings, and motivation to compensate as dependent variables.

8.3.1. Manipulation and equality checks

8.3.1.1. Perceived leftovers. Regression analysis revealed a significant effect of the amount of leftovers on perceived leftovers ($B = 0.173$, $SE B = 0.010$, $b = 0.648$, $t(402) = 17.043$, $p < .001$): as intended, the more chocolate squares were leftover, the larger people perceived the leftovers.

8.3.1.2. Ease of imagination. Regression analysis showed no effect of the amount of leftovers on ease of imagination ($B = -0.011$, $SE B = 0.011$, $b = -0.052$, $t(402) = -1.044$, $p = .297$).

8.3.1.3. Perceived size of an individual chocolate square. Regression analysis showed no effect of the amount of leftovers on perceived size of an individual chocolate square ($B = 0.006$, $SE B = 0.012$, $b = 0.026$, $t(402) = 0.513$, $p = .608$).

8.3.2. Dependent variables

8.3.2.1. Perceived consumption. Regression analysis revealed a significant effect of the amount of leftovers on perceived consumption ($B = -0.07$, $SE B = 0.012$, $b = -0.278$, $t(402) = -5.79$, $p < .001$): the larger the amount of leftovers, the lower was people's perceived consumption (see Fig. 6 [panel A], and also Table 1).

8.3.2.2. Negative self-evaluative feelings. Regression analysis revealed a significant effect of the amount of leftovers on negative self-evaluative feelings ($B = -0.031$, $SE B = 0.013$, $b = -0.113$, $t(399) = -2.416$, $p = .016$): the larger the amount of leftovers, the lower were people's negative self-evaluative feelings (see Fig. 6 [panel B], and Table 1). This result supports H2. The analysis also revealed a significant effect of dieting (standardized) on negative self-evaluative feelings ($B = 1.054$, $SE B = 0.168$, $b = 0.511$, $t(399) = 6.257$, $p < .001$): the stronger people's dieting tendency, the more negative self-evaluative feelings they reported. Lastly, there was a significant interaction between leftovers and dieting (standardized) on negative self-evaluative feelings ($B = -0.035$, $SE B = 0.013$, $b = -0.226$, $t(399) = -2.761$, $p = .006$): the stronger people's dieting tendency, the greater the effect of leftovers on negative self-evaluative feelings.

8.3.2.3. Motivation to compensate index. The analysis revealed a significant effect of the amount of leftovers on motivation to engage in counteractive behavior ($B = -0.029$, $SE B = 0.013$, $b = -0.11$, t

(399) = -2.212 , $p = .028$): the larger the amount of leftovers, the lower was people's motivation to compensate (see Fig. 6 [panel C], and Table 1). This result again corroborates H3.

8.3.2.4. Test for mediation. To test for statistical mediation, we ran several alternative models. First, we conducted two separate bootstrap analyses (Hayes, 2017) testing each mediator in a simple mediation model by itself (model 4, 10,000 iterations). These two analyses revealed that amount of leftovers exerted a significant indirect effect on motivation to compensate through perceived consumption alone ($B = -0.036$, $SE = 0.007$; 95% CI = -0.052 to -0.023) as well as through negative self-evaluative feelings alone ($B = -0.015$, $SE = 0.007$; 95% CI = -0.031 to -0.001).

Then we tested both mediators jointly in a parallel mediation (model 4, 10,000 iterations). Similar to the two independent simple mediations, the amount of leftovers exerted a significant indirect effect on motivation to compensate via perceived consumption ($B = -0.023$, $SE = 0.006$; 95% CI = -0.036 to -0.013) as well as negative self-evaluative feelings ($B = -0.012$, $SE = 0.006$; 95% CI = -0.024 to -0.002), indicating that each variable contributes uniquely to the explanatory model.

Next, we tested the proposed serial mediation (model 6; see Fig. 1) and found that, as predicted, the amount of leftovers exerted a significant indirect effect on motivation to compensate through the sequence of perceived consumption and negative self-evaluative feelings ($B = -0.013$, $SE = 0.003$; 95% CI = -0.020 to -0.008). Notably, including both perceived consumption and negative self-evaluative feelings (i.e., the full serial model) explained a much greater proportion of the variance ($R^2 = 0.381$) than including only perceived consumption ($R^2 = 0.236$).

Overall, these results are consistent with the idea that larger (vs. smaller) amounts of food leftovers reduce perceived consumption, which causes people to feel better about themselves; and that this feeling better, in turn, reduces their motivation to compensate for their eating (H4).

9. General discussion

The coincidence of the growth in average portion sizes (Nielsen & Popkin, 2003; Smiciklas-Wright et al., 2003) with that of obesity (Ogden et al., 2015) has attracted much study. Indeed, research implicates growing portions as a direct cause of expanding waistlines. To date, work has revolved around the finding that the larger a portion of food, the more people eat from this portion (Herman et al., 2015; Zlatevska et al., 2014). This finding has been attributed either to visuo-perceptual biases that cause people to underestimate larger portions

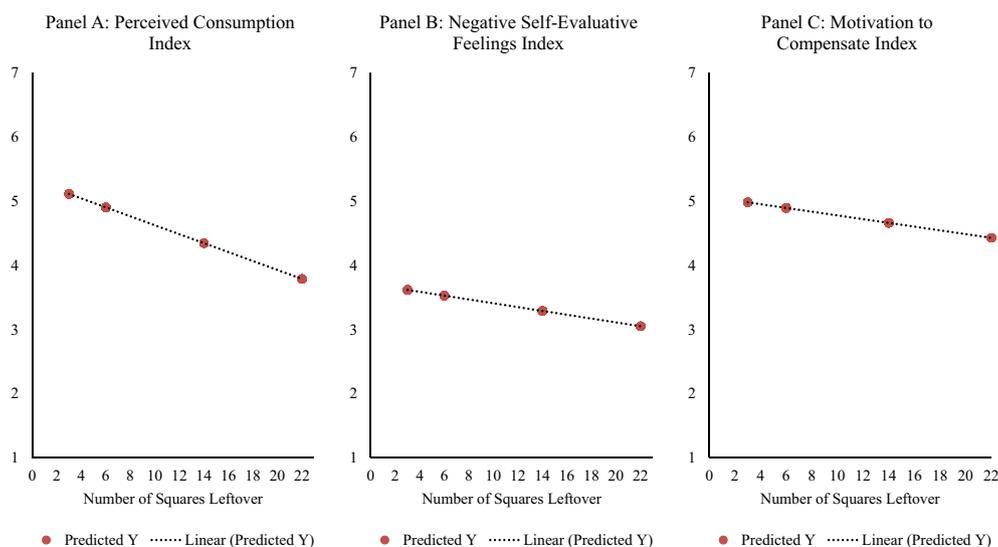


Fig. 6. Perceived consumption (panel A), negative self-evaluative feelings index (panel B), and motivation to compensate index (panel C) as a function of the amount chocolate leftovers in study 3.

Table 1
Summary of means by condition across all studies.

Study (food)	Perceived consumption	Negative self-evaluative feelings	Measure of compensatory behavior
1A (Real Chocolate)			
Large leftovers	5.83 (1.00)	–	–
Small leftovers	6.77 (1.63)		
1B (Imagined Mac & Cheese)	Calories		
Large leftovers	284.85 (121.98)	–	–
Small leftovers	354.38 (104.67)		
2A (Real Cookie)			Cookies eaten
Large leftovers	4.00 (1.89)	–	3.74 (3.06)
Small leftovers	5.00 (2.17)		2.62 (2.75)
2B (Real Cookie)			Steps walked
Large leftovers	3.65 (1.59)	–	133.76 (89.27)
Small leftovers	5.04 (2.14)		195.19 (143.08)
3 (Imagined Chocolate)			4-item Motivation Index
22 squares leftover	3.90 (1.63)	3.01 (1.76)	4.49 (1.96)
14 squares leftover	4.22 (1.89)	3.41 (1.87)	4.57 (1.80)
6 squares leftover	4.71 (1.64)	3.36 (1.99)	4.85 (1.75)
3 squares leftover	5.33 (1.95)	3.71 (2.51)	5.06 (2.22)

Mean (SD) by leftover size condition for each variable in each study (for study 1B, only one of the three measures of perceived consumption is presented).

(Chandon & Ordabayeva, 2009; Krider et al., 2001; Ordabayeva & Chandon, 2013) or to inferences that a presented portion is the appropriate size (Diliberti et al., 2004; Herman et al., 2015).

In this paper, we suggest an additional way in which enlarged portions may lead people to (eventually) overconsume food. We suggest that when people have larger (vs. smaller) food leftovers, they (mistakenly) feel they have eaten less, leading to lower motivation to compensate.

Five studies provide evidence for this framework. In study 1A, after eating exactly the same amount of chocolate, people with a larger (vs. smaller) amount of chocolate leftovers perceived they had eaten less. In study 1B, after envisioning eating the same amount of macaroni and cheese based on an online video animation, people with larger (vs. smaller) mac and cheese leftovers further estimated not only that their consumption would leave them hungrier, make them less full, and keep them so for less time, but also believed they had consumed fewer calories and a smaller amount of a comparison food would be equal to their consumption. In studies 2A and 2B, after eating the same amount of a cookie, people with a larger (vs. smaller) amount of cookie leftovers not only felt that they had eaten less, but also exhibited less compensatory behavior in a subsequent task. In study 2A, people with larger (vs. smaller) cookie leftovers failed to curb their subsequent calorie intake and ate more additional cookies later on. In study 2B, people with a larger (vs. smaller) amount of cookie leftovers failed to increase their calorie output and walked fewer steps on a stepper. Lastly, in study 3, after imagining eating the same amount of chocolate, people who saw a larger (vs. smaller) amount of chocolate leftovers perceived they ate less, felt less negatively about their chocolate consumption, and were less motivated to compensate for their chocolate eating (e.g., by eating less at the next meal or working out more later on). The negative effect of larger (vs. smaller) amounts of leftovers on motivation to compensate was mediated by reduced perceived consumption and ameliorated negative self-evaluative feelings.

Our research reveals that unconsumed food can exert meaningful influence on people's perceptions, affect, motivation, and important health-related behavior. Our findings contribute to the food consumption literature, and particularly the body of work that has been devoted to portion size effects. The results showcase a previously unknown mechanism through which growing portion sizes may contribute to obesity. Thus far, research has focused only on the fact that larger portion sizes increase people's consumption *from these portions*. Our work, however, demonstrates that even *leftovers stemming from these enlarged portions* can impact consumption *subsequently*, expanding the scope of portion size research and highlighting the complex ways in which enlarged portions can influence consumption behaviors.

9.1. Constraints on generality and other limitations

Naturally, there are limitations to the generalizability of this research. We found the effects in samples of college students at public and private universities and adults on Amazon Turk in the United States and thus expect the results to generalize to other college students and online panel participants. However, persons with eating disorders, on extreme diets, or otherwise practicing habits that lead them to monitor their consumption unusually closely may not exhibit these effects. Similarly, we found the effects with real and hypothetical, sweet and savory, and small and large food portions. However, our real consumption studies involved a relatively short time between eating and rating perceived fullness. While there is no reason to assume the length of time would affect the calorie estimate, it is possible that a longer period between consumption and judgment reduces the effect of leftovers on perceived fullness, specifically, as more biological satiety signals take effect over time that may provide a counterpoint to external cues.

We further recognize that the assumption that larger portion sizes lead to larger leftovers (Zlatevska et al., 2014) applies chiefly to the high end of the portion size spectrum, or segments of consumers who actively try to restrict their consumption; whereas small increases in portion size may often just lead to more consumption without leftovers. Thus, the effect we document may be restricted to the former contexts.

Relatedly, outside of the laboratory, where actual consumption is not held constant, we must expect that people facing enlarged portion sizes will not only experience the “leftovers effect” that decreases compensatory motivation (described in this work), but also the portion size effect that increases consumption (found in prior work, see Herman et al., 2015). This could potentially increase compensatory motivation—if people are aware of their overconsumption. Under what conditions the possible motivational impact of increased consumption offsets that of increased leftovers is not clear. Another question that is outside of the scope of this research is how the amount of remaining food *during* the ongoing eating episode impacts ongoing perceived consumption and, in turn, influences when people stop eating and thereby influences the size of the leftovers.

9.2. Implications for practice and future research

First and foremost, these insights should serve to further urge policy makers and government agencies to work towards curbing portion oversizing. Dietary recommendations as well as requirements on portion sizes within nutritional programs are domains where smaller portions may contribute to healthier eating in two distinct ways: by

reducing immediate over-consumption (as shown in prior research) and also by reducing the leftovers that would otherwise lead people to underestimate their eating and reduce their motivation to compensate for it (as shown in this research).

Moreover, our findings have important implications for consumers' personal health behaviors. One commonly used strategy to reduce calorie intake is portion control. "Eat only half of whatever portion the restaurant serves!," many dieting columns implore, and, following this advice, many diet-conscious restaurant goers diligently set aside part of their meal to take home for a future meal. At first glance, this may sound like a good idea—half a pizza definitely contains less fat, sodium, and calories than a whole pizza. Yet, our results suggest that to the extent that a person feels she ate less because she has leftovers, she may make up a good amount of the "saved" calories later on, by eating more at the next opportunity and exercising less. Whether "saving half" results in higher overall calorie consumption or not remains to be tested.

In this regard, future research may examine effective interventions to mitigate the subversive impact of leftovers. For instance, researchers may test whether removing food leftovers from sight attenuates the underestimation of one's consumption. If so, consumers who plan to eat only part of their portion may benefit from asking for a to-go box right away and packing up the additional food immediately. If this action changes the framing of this food from "leftovers" to "the additional meal that was served to me that should be kept for tomorrow's lunch," the present effect may be thwarted. Moreover, the presentation of factual size descriptors of food portion, such as weight or volume, could possibly counteract the impact of leftovers (but see [Aydinoğlu & Krishna, 2011](#); [Dallas et al., 2015](#)). Future research may want to identify the circumstances under which such information can help consumers judge their consumption more accurately, despite leftovers.

Finally, a limitation of the present research is that we only examined people's reactions to leftovers of unhealthy food, but not healthy food. Prior research has shown an asymmetry in people's propensity to mentally minimize their consumption for healthy and unhealthy food, finding that people seek to avoid feeling guilty for unhealthy eating ([Hagen et al., 2017](#); [Van Koningsbruggen, Stroebe, & Aarts, 2011](#)). As such, people's motivations and behaviors are more impacted by their perception of how much unhealthy food they ate compared to how much healthy food they ate. That said, consumption of unhealthy foods is particularly important to study from a health and weight-management standpoint. Nonetheless, it may be worthwhile to test how leftovers of healthy foods affect post-consumption behavior. An intriguing question could be whether larger leftovers of healthy foods causes consumers to feel bad, and thus to be more motivated to engage in healthy behaviors later.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jesp.2018.08.005>.

References

Amodio, D. M., Devine, P. G., & Harmon-Jones, E. (2007). A dynamic model of guilt: Implications for motivation and self-regulation in the context of prejudice. *Psychological Science, 18*(6), 524–530.

Aydinoğlu, N. Z., & Krishna, A. (2011). Guiltless gluttony: The asymmetric effect of size labels on size perceptions and consumption. *Journal of Consumer Research, 37*(6), 1095–1112.

Bandura, A. (1986). The explanatory and predictive scope of self-efficacy theory. *Journal of Social and Clinical Psychology, 4*(3), 359–373.

Bandura, A., & Cervone, D. (1983). Self-evaluative and self-efficacy mechanisms governing the motivational effects of goal systems. *Journal of Personality and Social Psychology, 45*(5), 1017–1028.

Bem, D. J. (1972). Self-perception theory. *Advances in experimental social psychology, vol. 6. Advances in experimental social psychology* (pp. 1–62). Academic Press.

Brunstrom, J. M., & Mitchell, G. L. (2006). Effects of distraction on the development of satiety. *The British Journal of Nutrition, 96*(4), 761–769.

Brunstrom, J. M., Shakeshaft, N. G., & Scott-Samuel, N. E. (2008). Measuring 'expected satiety' in a range of common foods using a method of constant stimuli. *Appetite, 51*(3), 604–614.

Bublitz, M. G., Peracchio, L. A., & Block, L. G. (2010). Why did I eat that? Perspectives on food decision making and dietary restraint. *Journal of Consumer Psychology, 20*(3), 239–258.

Buzby, J. C., & Hyman, J. (2012). Total and per capita value of food loss in the United States. *Food Policy, 37*(5), 561–570.

Carver, C. S. (2003). Pleasure as a sign you can attend to something else: Placing positive feelings within a general model of affect. *Cognition and Emotion, 17*(2), 241–261.

Chandon, P., & Ordabayeva, N. (2009). Supersize in one dimension, downside in three dimensions: Effects of spatial dimensionality on size perceptions and preferences. *Journal of Marketing Research, 46*(6), 739–753.

Cowles, M., & Davis, C. (1982). On the origins of the 0.05 level of statistical significance. *American Psychologist, 37*(5), 553–558.

Dallas, S. K., Liu, P. J., & Ubel, P. A. (2015). Potential problems with increasing serving sizes on the nutrition facts label. *Appetite, 95*, 577–584.

Diliberti, N., Bordi, P. L., Conklin, M. T., Roe, L. S., & Rolls, B. J. (2004). Increased portion size leads to increased energy intake in a restaurant meal. *Obesity Research, 12*(3), 562–568.

Effron, D. A., Monin, B., & Miller, D. T. (2013). The unhealthy road not taken: Licensing indulgence by exaggerating counterfactual sins. *Journal of Experimental Social Psychology, 49*(3), 573–578.

Finkelstein, S. A., & Fishbach, A. (2010). When healthy food makes you hungry. *Journal of Consumer Research, 37*(3), 357–367.

Fishbach, A., & Dhar, R. (2005). Goals as excuses or guides: The liberating effect of perceived goal progress on choice. *Journal of Consumer Research, 32*(3), 370–377.

Flynn, F. J., & Schaumberg, R. L. (2012). When feeling bad leads to feeling good: Guilt-proneness and affective organizational commitment. *Journal of Applied Psychology, 97*(1), 124–133.

Fröber, K., & Dreisbach, G. (2014). The differential influences of positive affect, random reward, and performance-contingent reward on cognitive control. *Cognitive, Affective, & Behavioral Neuroscience, 14*(2), 530–547.

Garner, W. R. (1953). An informational analysis of absolute judgments of loudness. *Journal of Experimental Psychology, 46*(5), 373–380.

Geier, A. B., Rozin, P., & Doros, G. (2006). Unit bias: A new heuristic that helps explain the effect of portion size on food intake. *Psychological Science, 17*(6), 521–525.

Greene, W. H. (2011). *Econometric analysis*. Upper Saddle River, NJ: Prentice Hall.

Hagen, L., Krishna, A., & McFerran, B. (2017). Rejecting responsibility: Low physical involvement in obtaining food promotes unhealthy eating. *Journal of Marketing Research, 54*(4), 589–604.

Hayes, A. (2017). *Introduction to mediation, moderation, and conditional process analysis: A regression-based approach*. New York: The Guilford Press.

von Helmholtz, H. (1866). *Handbuch der Physiologischen Optik*. Leipzig: Voss.

Herman, C. P., Polivy, J., Pliner, P., & Vartanian, L. R. (2015). Mechanisms underlying the portion-size effect. *Physiology & Behavior, 144*, 129–136.

Higgs, S. (2008). Cognitive influences on food intake: The effects of manipulating memory for recent eating. *Physiology & Behavior, 94*(5), 734–739.

Holland, M. K., & Lockhead, G. R. (1968). Sequential effects in absolute judgments of loudness. *Perception & Psychophysics, 3*(6), 409–414.

Hsee, C. (1996). The evaluability hypothesis: An explanation for preference reversals between joint and separate evaluations of alternatives. *Organizational Behavior and Human Decision Processes, 67*(3), 247–257.

Kahneman, D., & Tversky, A. (1979). Prospect theory: An analysis of decision under risk. *Econometrica, 74*(2), 263–291.

Kerameas, K., Vartanian, L. R., Herman, C. P., & Polivy, J. (2015). The effect of portion size and unit size on food intake: Unit bias or segmentation effect? *Health Psychology, 34*(6), 670–676.

Ketelaar, T., & Au, W. T. (2003). The effects of feelings of guilt on the behaviour of uncooperative individuals in repeated social bargaining games: An affect-as-information interpretation of the role of emotion in social interaction. *Cognition and Emotion, 17*(3), 429–453.

Khan, U., & Dhar, R. (2006). Licensing effect in consumer choice. *Journal of Marketing Research, 153*, 259–266.

Kivetz, R., & Zheng, Y. (2006). Determinants of justification and self-control. *Journal of Experimental Psychology, General, 135*, 572–587.

Kivetz, R., Urminsky, O., & Zheng, Y. (2006). The goal-gradient hypothesis resurrected: Purchase acceleration, illusory goal progress, and customer retention. *Journal of Marketing Research, 43*(1), 39–58.

Krider, R. E., Raghurir, P., & Krishna, A. (2001). Pizzas: π or square? Psychophysical biases in area comparisons. *Marketing Science, 20*(4), 405–425.

Lickel, B., Kushlev, K., Savalei, V., Matta, S., & Schmader, T. (2014). Shame and the motivation to change the self. *Emotion, 14*(6), 1049–1061.

Marchiori, D., Corneille, O., & Klein, O. (2012). Container size influences snack food intake independently of portion size. *Appetite, 58*(3), 814–817.

Marchiori, D. R., Papias, E. K., & Klein, O. (2014). The portion size effect on food intake. An anchoring and adjustment process? *Appetite, 81*, 108–115.

Markus, H. (1978). The effect of mere presence on social facilitation: An unobtrusive test. *Journal of Experimental Social Psychology, 14*(4), 389–397.

Mizuruchi, M. S. (1991). Urgency, motivation, and group performance: The effect of prior success on current success among professional basketball teams. *Social Psychology Quarterly, 54*(2), 181–189.

Mohr, G. S., Lichtenstein, D. R., & Janiszewski, C. (2012). The effect of marketer-suggested serving size on consumer responses: The unintended consequences of consumer attention to calorie information. *Journal of Marketing, 76*(1), 59–75.

- Mukhopadhyay, A., & Johar, G. V. (2009). Indulgence as self-reward for prior shopping restraint: A justification-based mechanism. *Journal of Consumer Psychology, 19*(3), 334–345.
- Nielsen (2015). We are what we eat. Healthy eating trends around the globe. Retrieved from <http://www.nielsen.com/content/dam/niensenglobal/eu/nielseninsights/pdfs/Nielsen%20Global%20Health%20and%20Wellness%20Report%20-%20January%202015.pdf>.
- Nielsen, S. J., & Popkin, B. M. (2003). Patterns and trends in food portion sizes, 1977–1998. *JAMA: The Journal of the American Medical Association, 289*(4), 450–453.
- Ogden, C. L., Carroll, M. D., Fryar, C. D., & Flegal, K. M. (2015). *Prevalence of obesity among adults and youth: United States, 2011–2014*. Washington, DC: US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Health Statistics 1–8.
- Okada, E. M. (2005). Justification effects on consumer choice of hedonic and utilitarian goods. *Journal of Marketing Research, 42*(1), 43–53.
- Oppenheimer, D. M., Leboeuf, R. A., & Brewer, N. T. (2008). Anchors aweigh: A demonstration of cross-modality anchoring and magnitude priming. *Cognition, 106*(1), 13–26.
- Ordabayeva, N., & Chandon, P. (2013). Predicting and managing consumers' package size impressions. *Journal of Marketing, 77*(5), 123–137.
- Orehek, E., Bessarabova, E., Chen, X., & Kruglanski, A. W. (2011). Positive affect as informational feedback in goal pursuit. *Motivation and Emotion, 35*(1), 44–51.
- Raghubir, P., & Krishna, A. (1999). Vital dimensions in volume perception: Can the eye fool the stomach? *Journal of Marketing Research, 36*(3), 313–326.
- Ramanathan, S., & Williams, P. (2007). Immediate and delayed emotional consequences of indulgence: The moderating influence of personality type on mixed emotions. *Journal of Consumer Research, 34*(2), 212–223.
- Redden, J. P., & Galak, J. (2013). The subjective sense of feeling satiated. *Journal of Experimental Psychology: General, 142*(1), 209–217.
- Robinson, E., Oldham, M., Cuckson, I., Brunstrom, J. M., Rogers, P. J., & Hardman, C. A. (2016). Visual exposure to large and small portion sizes and perceptions of portion size normality: Three experimental studies. *Appetite, 98*, 28–34.
- Rolls, B. J., Roe, L. S., Kral, T. V. E., Meengs, J. S., & Wall, D. E. (2004). Increasing the portion size of a packaged snack increases energy intake in men and women. *Appetite, 42*(1), 63–69.
- Rozin, P., Bauer, R., & Catanese, D. (2003). Food and life, pleasure and worry, among American college students: Gender differences and regional similarities. *Journal of Personality and Social Psychology, 85*(1), 132–141.
- Smiciklas-Wright, H., Mitchell, D. C., Mickle, S. J., Goldman, J. D., & Cook, A. (2003). Foods commonly eaten in the United States, 1989–1991 and 1994–1996: Are portion sizes changing? *Journal of the American Dietetic Association, 103*(1), 41–47.
- Stevens, S. S. (1986). *Psychophysics: Introduction to its perceptual, neural, and social prospects*. Oxford: Transaction Books.
- Stewart, N., Brown, G. D. A., & Chater, N. (2005). Absolute identification by relative judgment. *Psychological Review, 112*(4), 881–911.
- Tobin, S. J., Greenaway, K. H., McCulloch, K. C., & Crittall, M. E. (2015). The role of motivation for rewards in vicarious goal satiation. *Journal of Experimental Social Psychology, 60*, 137–143.
- Truman, S. R., & Wever, E. G. (1928). *The judgment of pitch as a function of the series*. Berkeley, CA: University of California Publications in Psychology.
- Tversky, A., & Kahneman, D. (1991). Loss aversion in riskless choice: A reference-dependent model. *The Quarterly Journal of Economics, 106*(4), 1039–1061.
- Vadiveloo, M., Morwitz, V., & Chandon, P. (2013). The interplay of health claims and taste importance on food consumption and self-reported satiety. *Appetite, 71*, 349–356.
- Van Koningsbruggen, G. M., Stroebe, W., & Aarts, H. (2011). Through the eyes of dieters: Biased size perception of food following tempting food primes. *Journal of Experimental Social Psychology, 47*(2), 293–299.
- Wever, E. G., & Zener, K. E. (1928). The method of absolute judgment in psychophysics. *Psychological Review, 35*(6), 466–493.
- White, K., & Lehman, D. R. (2005). Looking on the bright side: Downward counterfactual thinking in response to negative life events. *Personality and Social Psychology Bulletin, 31*(10), 1413–1424.
- Woolley, K., & Fishbach, A. (2016). For the fun of it: Harnessing immediate rewards to increase persistence in long-term goals. *Journal of Consumer Research, 42*(6), 952–966.
- Young, L. R., & Nestle, M. (2003). Expanding portion sizes in the US marketplace: Implications for nutrition counseling. *Journal of the American Dietetic Association, 103*(2), 231–240.
- Zlatevska, N., Dubelaar, C., & Holden, S. S. (2014). Sizing up the effect of portion size on consumption: A meta-analytic review. *Journal of Marketing, 78*(3), 140–154.