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Short Communication

Just a bite: Considerably smaller snack portions satisfy delayed hunger and craving

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ABSTRACT

Could smaller snack portions be similarly effective in decreasing cravings or feelings of hunger as larger portions? To answer this, three common snack foods – chocolate, apple pie, potato chips – were given to 104 participants as either a small portion (x) or a substantially larger portion (5–10x). Results indicate that smaller portions satisfied one's ratings of hunger and craving similar to larger portions, but led to a mean intake that was significantly lower than in the large portion condition (with a difference of 103 calories). This suggests that 15 min after eating a considerably smaller snack, people will have eaten much less but will feel equally satisfied.

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1. Introduction

The proportion of people who are overweight has increased dramatically worldwide, partly due to increasing portion sizes of particularly energy dense foods. Previous research has shown that people's energy intake increases substantially when offered a larger portion or when people eat from larger packages or serving devices and this effect has been shown for a variety of foods, including snacks (Steenhuis & Vermeer, 2009). Snacking is particularly relevant to study as increases in the number of eating occasions and portion sizes have accounted for most of the change in average daily total energy intake (Duffey & Popkin, 2011).

Although several portion size studies have shown that larger portions typically do not lead people to report decreased levels of hunger (Ello-Martin, Ledikwe, & Rolls, 2005; Rolls, Roe, Meengs, & Wall, 2004), it is still unclear how feelings of hunger and food cravings can be satisfied and how much food is necessary to do so. Important to note is that one's hunger is not the same thing as one's craving for a particular food. In this respect, two types of hunger can be distinguished (Lowe & Butryn, 2007). The first, more traditional view of hunger is controlled by physiological signals whereas the more psychological hunger, called 'hedonic hunger' refers to a subjective state driven by external stimuli. The second type of hunger is characterized as a type of desire in that it repre-

sents the pleasure-seeking motives to eat, and it is closely related to the concept of food cravings.

Food cravings are defined as an intense desire for a food that is difficult to resist, such as a craving for chocolate (Pelchat, 2002; Weingarten & Elston, 1990). Food cravings are a very common phenomenon among both males and females (Pelchat, 2002). They are not necessarily compulsive but they are believed to contribute to snacking behavior (Wansink, Cheney, & Chan, 2003), compliance to dietary restrictions and excessive food intake (Gendall, Joyce, & Sullivan, 1997; Pelchat, 2002). Interestingly, hunger is not a pre-condition for wanting to eat or crave a particular food (Hill, 2007). Instead, one's desire for food is believed to be driven by the increasing occasions in which people are confronted with tempting food cues, such as snacks. In this environment, food consumption is strongly driven by pleasure. Within this environment, it is critical to understand how portion size satisfies hunger and craving tendencies both immediately and after a delay.

To explore the largely unexamined impact of portion size on immediate and delayed hunger and craving, we presented participants with either a small portion size of three commonly craved snacks – chocolate, potato chips and apple pie – or substantially larger portions of the same snacks. Although small single packed portion sizes are recommended to reduce intake (Wansink, Payne, & Shimizu, 2011), they might also ignite, rather than satisfy one's appetite. For instance, research on consumers' reward-seeking behaviors found that sampling small amounts of desirable food can also serve as an appetite consumption cue and enhance subsequent reward-seeking behaviors, such as consuming more food or non-food items (Wadhwa, Shiv, & Nowlis, 2008).

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As a result, we expect that hunger and craving tendencies after eating a smaller portion size are increased immediately after eating, similar to the so-called 'appetizer effect' (Yeomans, 1996). That is, when compared to being given a larger portion, a smaller portion size may stimulate one's immediate appetite because of the sensory cues of the food. Yet, 15 min later - when foods are out of sight - we expect people to feel equally satisfied. Specifically, we hypothesize that larger portion sizes will cause people to eat more calories, but will have no measurable impact on one's overall hunger and craving 15 min later. By better understanding how feelings of hunger and craving change with time, we will be better able to educate people on how to develop more effective portion size intervention strategies.

2. Methodology

2.1. Participants

Participants were 104 undergraduate students (51 women, 53 men) who participated in exchange for course credit. One participant was excluded from the data based on unknown gender. The study was approved by the Institutional Review Board and participants provided written consent.

2.2. Procedure and materials

The first part of the experiment consisted of supposed taste test in which participants were presented with a portion of chocolate, apple pie and potato chips. These foods are reported to belong to the most frequently craved foods (Weingarten & Elston, 1990). To prevent carry-over effects and awareness of the study's objectives among participants, we chose a between subjects design instead of a within subjects design where the participants would have had to return on a later date to participate in the alternative condition. We presented a trio of small portions comprising less food than commonly served and a trio of large portions that most participants would not finish but at the same time would not appear overly large. For example, a regularly displayed serving size at the food package is about 125 g for apple pie and 28 g for potato chips. After pilot testing appropriate portion sizes¹, we created a large portion condition containing 100 g of chocolate chips, 200 g of apple pie and 80 g of potato chips. The small portion condition contained 10 g of chocolate chips, 40 g of apple pie, and 10 g of potato chips. This resulting in a total of 195 calories in the small portion condition and 1370 calories in the large portion condition.

Participants were randomly assigned to one of the two conditions. The procedure followed was exactly the same for both conditions. Participants signed up for the study that was held in the afternoon (one session at 2 pm and one at 3 pm). Four different experimental sessions of 25 to 29 mixed-gender participants were conducted, with two sessions involving a small portion size condition and two sessions involving the large portion size condition. Participants were welcomed and seated at a table in such a way that they could not socialize with other participants or share food. Participants were instructed to eat as much or as little as desired to evaluate the foods on several dimensions (e.g. aftertaste) and take as much time as needed. Water was available to drink with the test.

Measures of overall hunger and craving were assessed just before participants started with the taste test, immediately after finalization of the taste test and at the end of the entire study

(which included filler tasks) which was about 15 min after the taste test. This 15 min period was selected to exclude post-absorptive effects on satiety (Benelam, 2009). The food was in front of participants while they provided ratings before and immediately after tasting. When they were finished, a researcher cleared the leftovers and gave participants another questionnaire. Leftovers were weighted at an electronic food scale (Escali, P115C, 11 lb. digital scale; Minneapolis, USA), out of sight of participants to calculate the amount of food consumed. Grams were converted into calories (1 g of potato chips equals 4.9 calories, 1 g of chocolate equals 5 calories and 1 g of apple pie equals 2.4 calories).

2.3. Measures

Dependent measures were the amount of foods eaten during the 'taste test', overall hunger and craving tendencies for each of the three foods. Using a 7-point category, participants responded to three hunger-related items (Benelam, 2009; Lowe & Butryn, 2007): 'how satisfied are you right now?', 'how much could you eat right now?' and 'how hungry are you right now?' Each scale was marked, respectively: completely empty/cannot eat another bite, nothing at all/a lot, not at all hungry/as hungry as I ever felt. After reverse scoring the first item, these items were combined in a single overall hunger scale given sufficient reliability ($\alpha = 0.78$). Overall craving tendency was measured by two items that comprise the key elements of food cravings (Pelchat, 2002): 'at this moment I have a strong desire for...' and 'the following foods would be difficult to resist...'. Participants rated each of the three provided foods on 7-point scales (anchored at 1 - strongly disagree to 7 - strongly agree). These items were combined into a single overall craving scale given high reliability ($\alpha = 0.87$). Participants also rated the snacks on liking and whether they wanted to eat more, 15 min after consumption (7-point scales). As a manipulation check, we also measured the appeal of the three foods, their familiarity to participants and their expectation on how quickly the food would bore them (7-point scales).

Restrained eating style was measured with a 10-item scale from Polivy, Herman, and Warsh (1978). The reliability of this scale was $\alpha = 0.75$. The restraint scores ranged from 2 to 28 with a mean of 14.44 (SD = 5.3). Furthermore, participants reported the time since they most recently consumed food before the study and self-reported their height and weight, which were used to calculate body mass index (BMI).

2.4. Data analysis

Using analyses of covariance (ANCOVAs) we first checked whether there were differences between conditions (small portion versus larger portion) in the calories consumed, food consumed (total and separate foods in grams), participants' restraint scores and the time since participants had last food. The primary analysis examined the effects of portion size manipulation on hunger and craving ratings at three points in time. We conducted a mixed model ANCOVA with measurement time as within subjects factor (three levels: at baseline before eating, immediately after eating and 15 min after eating) and condition and gender as between subjects factors to assess differences in hunger and craving between conditions and measurement time. To control for influence, BMI (mean-centered) and session time (2 and 3 pm) were included in all models as covariates. Effect sizes (partial η^2) are reported for statistically significant outcome measures and indicate the proportion of variance attributable to the factor considered.

In case no significant difference was observed between the two conditions with inferential tests (mixed model ANCOVA), equivalence testing was conducted using a confidence interval approach (Rogers, Howard, & Vessey, 1993) to test whether mean differences

¹ The pilot testing involved a group discussion with eight individuals of similar demographics as those in the main experiment in which they commented on various portion sizes and what they would consider small and large.

Table 1
Small portions lead to lower calorie intake but equal satisfaction as large portions (Mean, SD).

	Small portion (n = 50)	Large portion (n = 54)	P-value
<i>Consumed amount of</i>			
Total calories	134.0 (56.8)	236.9 (149.1)	<0.001
Total food (grams)	42.4 (17.2)	78.9 (52.3)	<0.001
Chocolate (grams)	6.5 (3.9)	8.3 (7.8)	0.08
Apple pie (grams)	29.7 (12.0)	60.2 (45.9)	<0.001
Potato chips (grams)	6.1 (4.0)	10.4 (9.9)	0.001
<i>Post-consumption evaluations^a</i>			
I want to eat more	5.0 (1.6)	5.4 (1.2)	0.22
I liked the food I tasted	5.7 (1.0)	5.7 (1.0)	0.71

^a Measured about 15 min post-consumption. Note: numbers represent mean scores on each of the scales (7-points scale).

between groups are small enough to consider the groups as similar. A series of one-way ANCOVAs were conducted to investigate differences between conditions as well as to calculate $(1-2\alpha)$ 100 percent (90%) confidence intervals (CI) on the pair wise mean differences. Next, equivalence was defined as a 0.9 point scale difference in either direction of ratings on the 7-point rating scale. This equals a 15% range at the 7-point scale. As such, our equivalence criterion is more conservative than the criterion suggested by Rusticus and Lovato (2011) who apply an equivalence criterion of 1.4 scale points for 7-point scales based on general practices within the social sciences. If the confidence interval was entirely included within this 0.9-point scale range, then we keep the null hypothesis that the two conditions are equivalent. If part or the entire confidence interval is outside this equivalence range, there is insufficient evidence to support that there is no difference between the conditions. All analyses were performed using SPSS statistical software (SPSS version 19, SPSS Inc., Chicago, IL, 2010).

3. Results

3.1. Randomization checks

The mean age of the participants was 19.5 years (SD = 3.1) with participants having a mean BMI of 22.6 kg/m² (SD = 2.8, range 17.2–34.8). Of all participants, 14 were overweight (BMI > 25). These participants were distributed evenly across both portion size conditions ($\chi^2(1,104) = 1.70, P = .25$). There were no significant differences in mean restrained score of participants ($F(1,96) = .55, P = .46$) and the time since participant had last food ($F(1,101) = 0.01, P = .91$) across conditions. There were also no differences across conditions in the appeal of the three foods (chocolate ($F(1,101) = 1.25, P = .27$); potato chips ($F(1,101) = 0.30, P = .58$); apple pie ($F(1,101) = 0.94, P = .34$), their familiarity (chocolate ($F(1,101) = 1.35, P = .25$); potato chips ($F(1,101) = 0.16, P = .39$); apple pie ($F(1,101) = 0.67, P = .41$), and expectations on how quickly the food would bore participants (chocolate ($F(1,101) = 0.49, P = .49$); potato chips ($F(1,101) = 0.03, P = .87$); apple pie ($F(1,101) = 0.33, P = .57$). In addition, gender was equally balanced across session times ($\chi^2(1,104) = 0.15, P = .85$).

3.2. Mean (SD) of food consumption across two conditions

When all three foods are considered together, results showed that in the small portion condition, participants ate less food (in grams) than in the large portion condition (Table 1), resulting in a lower overall calories intake ($F(1,98) = 24.97, P < .001$, partial $\eta^2 = 0.20$). In particular, participants being provided with a large portion consumed 76.8% more calories (about 103 calories) relative to participants in the small portion condition. A trend towards a main effect of gender ($F(1,98) = 3.14, P = .08$, partial $\eta^2 = 0.03$) but no interaction effect between portion size and gender on total

calories consumed ($F(1,98) < 0.01, P = .96$) was observed. Session time had a significant influence on total calories consumed ($F(1,98) = 5.93, P = .02$, partial $\eta^2 = 0.06$). Excluding this covariate in the model did not lead to changes the P-value of the experimental condition ($F(1,98) = 22.41, P < .001$, partial $\eta^2 = 0.19$). On average, participants in the large portion size condition consumed about 17% of the energy provided to them compared to participants in the small portion size condition who consumed on average about 69% of the provided energy. While no participants in the large portion size condition ate all the food provided to them, seven participants in the small portion size condition (14% of all participants in that condition) did.

3.3. Hunger and cravings reduction does not depend on condition

The mixed model ANCOVA demonstrated a significant main effect of time of measurement ($F(2,92) = 14.92, P < .001$, partial $\eta^2 = 0.14$), but no main effect of portion size condition ($F(1,92) = 0.19, P = .66$), gender ($F(1,92) = 2.17, P = .14$) or interaction between portion size condition and time of measurement ($F(1,92) = 1.26, P = .29$) on hunger ratings. There was also no interaction between portion size and gender ($F(2,92) = 0.04, P = .85$). Tests of within-subject contrasts showed a significant difference between hunger ratings after 15 min and baseline hunger ratings (before tasting) ($F(1,92) = 21.70, P < .001$, partial $\eta^2 = 0.19$). No difference in hunger ratings occurred between immediately post-test and at about 15 min post-test ($F(1,92) = 1.17, P = .28$), which indicates that feelings of hunger and fullness were similar at these two points in time (Fig. 1).

There was no evidence for an experimental condition by time interaction for hunger ratings. Therefore, we assessed equivalence on the change from hunger ratings over the time course. Equivalence testing showed that the criterion for equivalence was met across all time periods. That is, for the hunger ratings before tasting, the 90% CI of the mean difference of 0.14 (SE = 0.22) was -0.23 to 0.51 . For the hunger ratings just after tasting, the 90% CI of the mean difference of 0.03 (SE = 0.20) was -0.31 to 0.36 . For hunger ratings 15 min after tasting, the 90% CI of the mean difference of 0.22 (SE = 0.26) was -0.21 to 0.64 . As our predefined acceptable variation (15% of scale or 0.9 scale points) is greater than the absolute values of the higher and lower bounds of the mean difference CI, the analyses suggest that the hunger scores in the small portion size condition are equivalent to the hunger scores in the large portion size condition.

A similar analysis was done for the overall craving tendency of participants (three levels: pre-test, immediately post-test and after 15 min). No main effect of portion size condition was observed ($F(2,92) = 1.37, P = .24$). Gender also demonstrated no main ($F(2,92) = 0.17, P = .68$) or interactive effects ($F(2,92) = 0.08, P = .78$). A significant main effect of time was observed on these cravings ratings ($F(2,92) = 13.05, P < .001$, partial $\eta^2 = 0.12$). Tests

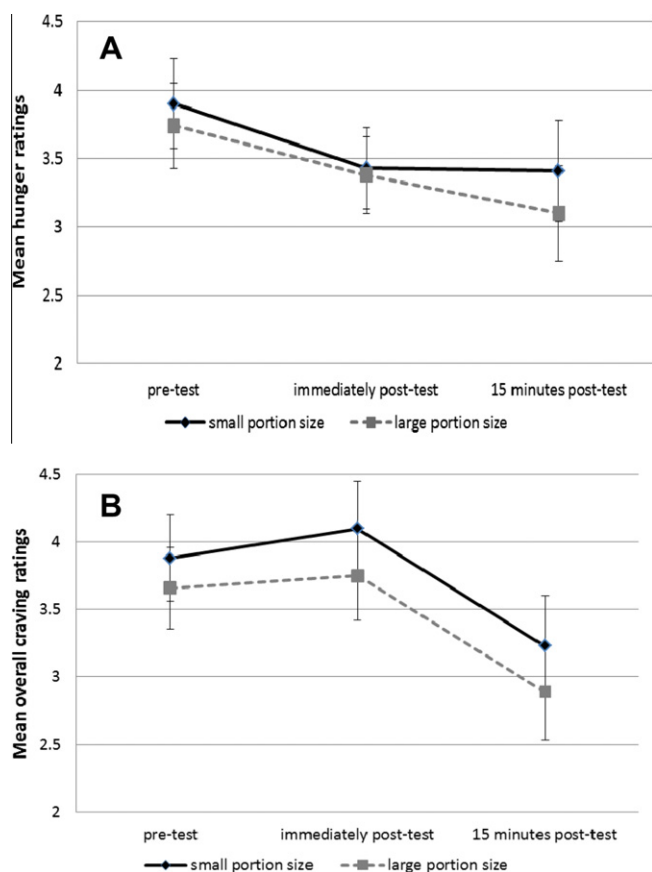


Fig. 1. Small portions satisfy hunger and cravings equivalent to large portions (all P s < .05); mean ratings of (A) hunger (B), overall craving across portion size conditions at three measurement times (pre-test, immediately post-test and 15 min post-test).

of within contrasts showed that immediately post-test craving tendencies were not significantly different from pre-test ($F(1,92) = 1.60, P = .21$). After 15 min post-test there was a decrease in cravings ($F(1,92) = 12.08, P = .001$, partial $\eta^2 = 0.12$) compared to pre-test craving ratings (Fig. 1). Thus, craving ratings were reduced 15 min after consumption. More importantly, there are no interaction effects of the craving ratings of any of the three foods to diminish in a particular condition ($F(1,92) = 0.38, P = .69$). This indicates that portion size provided did not impact craving ratings throughout time. For all three craving measures, equivalence test results showed that the upper and lower CIs fall within the specified equivalence range of 0.9 scale point. That is, for the craving ratings before tasting, the 90% CI of the mean difference of 0.22 (SE = 0.22) was -0.15 to 0.58 . For the craving ratings just after tasting, the 90% CI of the mean difference of 0.35 (SE = 0.24) was -0.06 to 0.75 . For craving ratings 15 min after tasting, the 90% CI of the mean difference of 0.35 (SE = 0.26) was -0.09 to 0.78 . Hence, this indicates that the craving scores before, after and 15 min after eating were equivalent for the small and large portion size conditions.

An ANCOVA furthermore showed that there were no differences across conditions in responses to the items 'I want to eat more' ($F(1,98) = 1.55, P = .22$) and 'I liked the food I tasted' ($F(1,98) = 0.14, P = .71$), measured 15 min post-consumption (Table 1).

4. Discussion

Could smaller portions be similarly effective in decreasing cravings or feelings of hunger as larger portions? This study impor-

tantly showed that although providing larger portions increased snack calorie intake by 77% (103 calories), after 15 min, they do not reduce hunger or cravings any more than smaller portions. In contrast to our expectations, no appetite enhancing effects occurred in the small portion size condition. This may be because such an enhancing effect is related to satiety expectations of the total food to come. For example, in some situations people anticipate more foods to come, such as after eating an appetizer before the main course. Expected satiety has been shown to influence experienced satiety (Benelam, 2009).

A typical snack contains about 264 calories (Piernas & Popkin, 2010). Our results show that this amount closely resembles the total calories consumed in the large portion condition (about 237 calories). Nevertheless, although participants in the small portion condition ate considerably less (about 134 calories, which is about 51% of what people typically eat), they were equally tempted by the snacks. This suggests that compared to providing larger portions, smaller portions of commonly craved foods are capable of providing similar fulfillment of desire. As such, it supports the notion of hedonic hunger which is driven by the availability of foods rather than the amount of food already eaten and the time when this occurred.

Whereas some previous studies suggested that ratings of hunger and fullness are not necessarily affected by portion size (Ello-Martin et al., 2005; Rolls et al., 2004), this study included measures of hunger and craving at three points in time (pre-test, immediately post-test and 15 min post-test). Further research is warranted to examine whether people will compensate by eating less or more later the same day. Yet importantly, studies examining a longer time period showed that the increased intake of large portion sizes and packages is not adequately compensated for at a later time (Benelam, 2009).

There are some potential limitations that should be noted about this study. First, the time given to taste the food was not standardized and this could have affected responses about 15 min after eating. A related limitation involves the social norms which influence how much food is seen as 'appropriate' to eat within a particular situation (Herman, Roth, & Polivy, 2003). Because there was no time limit on consumption and participants in the large condition had more food to eat if wanted, social influence could have had more effects in the large portion size condition. An additional control condition without consumption could have helped determine whether feelings of hunger would wane with time.

The snacks were present when participants completed baseline hunger and craving ratings which may have influenced the results. On the one hand, we conservatively believed that exposing participants to food cues (e.g. the sight or smell of the snacks) could have elicited physiological and appetitive responses and been a more stringent test of our theory. Yet on the other hand, simply placing desirable snacks in front of participants does not necessarily provoke food cravings. Nevertheless, although craving tendencies were moderate before eating, they were significantly reduced after 15 min. Still, it is important to determine whether these effects maintain when people are intensely craving a food in ways in which the majority of the population does not. It has to be noted that portion size effects may be different when food packages implicitly communicate 'self-control assistance' as is the case with '100 calorie packs' (Do Vale, Peters, & Zeelenberg, 2008). Furthermore, our sample was restricted to undergraduates with the majority having a normal body weight. Hence, as overweight individuals could be more responsive to portion size cues, future research could include them in a study design.

On balance, the key findings of this research underscore a new dimension about the importance of portion size. Whereas larger portions might increase food intake; smaller portions may make you equally satisfied. The number of separate snacking episodes

has increased significantly throughout the last decades to about five eating occasions per day in the US diet (Piernas & Popkin, 2010). An additional caloric intake of about 100 calories, as found in this study, could lead to substantial increases in intake over an entire day. Small portion sizes can lead to a similar decline in hunger and desire and in this way help people to limit intake. Smaller servings of snacks could support people in controlling their body weight, although more research is needed to unravel the mechanisms behind our findings and gain a better understanding of the implications for overall energy intake.

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