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Influence of BMI and dietary restraint on self-selected portions of prepared meals in US women

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ABSTRACT

The rise of obesity prevalence has been attributed in part to an increase in food and beverage portion sizes selected and consumed among overweight and obese consumers. Nevertheless, evidence from observations of adults is mixed and contradictory findings might reflect the use of small or unrepresentative samples. The objective of this study was i) to determine the extent to which BMI and dietary restraint predict self-selected portion sizes for a range of commercially available prepared savoury meals and ii) to consider the importance of these variables relative to two previously established predictors of portion selection, expected satiation and expected liking. A representative sample of female consumers ($N = 300$, range 18–55 years) evaluated 15 frozen savoury prepared meals. For each meal, participants rated their expected satiation and expected liking, and selected their ideal portion using a previously validated computer-based task. Dietary restraint was quantified using the Dutch Eating Behaviour Questionnaire (DEBQ-R). Hierarchical multiple regression was performed on self-selected portions with age, hunger level, and meal familiarity entered as control variables in the first step of the model, expected satiation and expected liking as predictor variables in the second step, and DEBQ-R and BMI as exploratory predictor variables in the third step. The second and third steps significantly explained variance in portion size selection (18% and 4%, respectively). Larger portion selections were significantly associated with lower dietary restraint and with lower expected satiation. There was a positive relationship between BMI and portion size selection ($p = 0.06$) and between expected liking and portion size selection ($p = 0.06$). Our discussion considers future research directions, the limited variance explained by our model, and the potential for portion size underreporting by overweight participants.

1. Introduction

Results from National Health and Nutrition Examination Survey (NHANES) indicate that the prevalence of obesity among US adults rose from 23% to 35% between 1988 and 2012 (Ogden, Carroll, Kit, & Flegal, 2014). Portion size is widely regarded as an important driver of overconsumption, in part, because people tend to consume all of the food portion they select; *i.e.*, they 'plate clean' (Wansink & Johnson, 2015). This view is supported by an association between trends in obesity and corresponding changes in food portion sizes in the US (Duffey & Popkin, 2011). Nevertheless, it remains unclear whether (and to what extent) BMI and/or adiposity is associated with the selection of larger portions.

Previously, a positive relationship between BMI and self-selected portion sizes has been identified in a secondary analysis of national dietary surveys, both in an adult Swedish population (Berg et al., 2009) and in children in the US (Herman, Polivy, Pliner, & Vartanian, 2015; Huang, Howarth, Lin, Roberts, & McCrory, 2004; McConahy, Smiciklas-Wright, Birch, Mitchell, & Picciano, 2002), and in two acute studies performed among US children (Fisher, Liu, Birch, & Rolls, 2007; Mooreville et al., 2015). In another study students with a higher BMI were found to select larger portions (Burger, Kern, & Coleman, 2007), however other studies in adults

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report a weak or no association (Brunstrom, Rogers, Pothos, Calitri, & Tapper, 2008; Diliberti, Bordi, Conklin, Roe, & Rolls, 2004; Ferriday & Brunstrom, 2011; Rolls, Roe, Meengs, & Wall, 2004; Rolls, Morris, & Roe, 2002; Rolls, Roe, Kral, Meengs, & Wall, 2004). These inconsistencies may reflect the use of small sample sizes (range: 51–104, Mean = 74.6, *SD* = 24.7 across the studies cited) or otherwise a tendency to recruit participants with a relatively narrow range of BMIs or from particular populations (e.g., university students). To address these concerns we sought to determine the relationship between BMI and portion selection in a larger sample, recruited to provide a broader representation of adult females in the US and with a typical wide range of variation in BMI. In addition to body weight, dietary restraint may also influence selected portion sizes. However, again, the evidence for this association has been mixed, some studies suggest that dietary restraint promotes the selection of smaller portions (Brunstrom et al., 2008; Gorman & Allison, 1995) and others do not (Rolls, Roe, & Meengs, 2006; Rolls et al., 2004; Wilkinson et al., 2012).

Although the impact of individual characteristics (BMI and dietary restraint) on self-selected portion size remains unclear, evidence supporting a role for expectations generated by foods has been more consistent. Indeed, expected liking appears to play a role (Brogden & Almiron-Roig, 2010; Brunstrom & Shakeshaft, 2009; Labbe, Rytz, Godinot, Ferrage, & Martin, 2017; Spence et al., 2016) and, in particular, expected satiation (anticipated fullness from a food) has also been identified as an important determinant of portion selection. The relationship between expected satiation and self-selected portion size has been demonstrated in several studies combining diverse meals, snacks (Brunstrom & Rogers, 2009; Brunstrom & Shakeshaft, 2009) and calorie-containing beverages (Brogden & Almiron-Roig, 2011). Indeed, repeated exposure modifies the satiation that is expected from a food (Irvine, Brunstrom, Gee, & Rogers, 2013; Wilkinson & Brunstrom, 2009) which in turn impacts future portion size selection (McCrickerd & Forde, 2016).

The objective of the current study was to determine whether dietary restraint and/or BMI of a large cohort of adult females is associated with self-selected portions across a wide range of commercially available single-serve frozen lunchtime meals. The current trial focused on female participants, as they were the most regular users of the frozen pre-prepared meal category. They were recruited to ensure that the sample represented a wide variation in age (18–55 years) and comprised participants who were highly familiar with frozen prepared meal category. We hypothesized that beyond the predictive role of expected satiation and expected liking, both BMI and dietary restraint would further explain variance in portion selection. Specifically, we reasoned that relatively large portions would be selected by participants with a higher BMI and by participants with low dietary restraint.

Expected satiation and measures of 'ideal portion size' were obtained using screen-based psychophysical tools. These tools, which have been validated previously in a study showing that estimated portion size for pasta sauce predicted actual self-selected portion and food intake (Wilkinson et al., 2012), enable participants to assess a large number of foods in a single test session, without the need for meal preparation. For reviews of this approach see Forde, Almiron-Roig, and Brunstrom (2015, 2014).

2. Materials and methods

2.1. Participants

A sample of 300 females from the Chicago metropolitan area were recruited to complete a series of computer tasks at a central location. Participants were excluded if they had an eating disorder or if they were not a regular frozen prepared meal consumer (frequency consumption below once a week). Participants were not pregnant, did not report any specific intolerances, aversions or dietary restrictions (i.e. vegetarians, pork aversion), were not currently dieting, and had been weight stable for the previous 12 months (<5 kg change in body weight). Participants were recruited to have an equal distribution across a wide range or ages with four groups of (n = 75) between 18 and 25, 26–35, 36–45 and 46–55 years (age *M* = 36.8 y, *SD* = 11.2). Each participant consented before participating in the study and received an incentive for their time after completing the study. The study was assessed and approved internally as having met the ethical criteria considered appropriate for consumer and sensory studies of this nature.

2.2. Test meal images

Fifteen commercially available single-serving frozen test meals were selected for the study including: lasagne with meat sauce, macaroni and cheese, parmesan crusted fish, four cheese pizza, pepperoni pizza, spaghetti and meat sauce, Salisbury steak with macaroni and cheese, Santa Fe Mexican rice and beans, shrimp Alfredo, steak tips portabella, salmon and basil pasta, baked chicken, butternut squash ravioli, chicken enchilada suiza and sesame chicken. Meals were selected to represent a diverse set of different meal component combinations, cultural styles, familiarity and energy densities (Range: 75.2–211.6 Kcal/100 g, Mean = 114.4 Kcal/100 g, *SD* = 40.3 Kcal/100 g).

Test meals were photographed in line with the protocol for stimuli preparation outlined in Brunstrom, Rogers, et al. (2008) and Brunstrom, Shakeshaft, et al. (2008). Each meal was presented on a standard 255-mm white plate and images were taken in 51 different portion sizes. In each case, picture 25 corresponded to the commercially available pre-packaged portion size and pictures 1 and 51 represented 33% and 300% of the calorie content of picture 25. Across this range the portion size increased in equally-spaced logarithmic steps. Logarithmic spacing enabled a broad range of portion sizes to be taken with a roughly equal discriminable distance between adjacent images.

To assess expected satiation (methods outlined below) images of the 15 test meals were compared against images of four highly familiar 'comparison' meals; chicken fried rice, steak fries, meat loaf and potatoes and spaghetti bolognaise. In all images, the name of the meal was included. To maintain consistency, all images were taken with the same lighting, viewing angle, and camera settings.

2.3. Test measures

At the beginning of the test session, participants rated their hunger. They then completed the expected satiation task and provided measures of expected liking, self-selected portion sizes, familiarity. Within each measure, the presentation order of the test meals was randomized, both within and across participants. At the end of the test session participants completed the DEBQ-R and the test supervisors recorded the height and weight of each participant.

2.4. Hunger

Since estimates of portion size were likely to co-vary according to the level of hunger (Brogden & Almiron-Roig, 2010), each participant rated their hunger using a 100-mm visual-analogue scale, anchored from "not all hungry" to "extremely hungry".

2.5. Expected satiation

Expected satiation was quantified using a 'Matched Fullness'

task, based on a technique previously developed by Brunstrom & Rogers, 2009. In each trial a comparison meal was presented on the right-hand side of a 15.4″ monitor. On the left-hand side the test meal was displayed. Participants were instructed to "match the fullness you would expect from the picture of the left by changing the amount of the meal on the right so that both foods would leave you feeling equally full." Participants used the arrow keys on the keyboard to adjust the size of the comparison meal. Each test meal matched fullness comparison was replicated across the four control meals (fried rice, fries, meat loaf and potatoes and spaghetti bolognaise) producing a total of 60 comparisons (15 × 4) and all presentations were randomized. Accordingly, participants completed 60 trials (15 test foods x 4 comparison foods) in total. For each test food and each participant, a single expected satiation score was calculated by averaging the energy content of the four comparison foods selected.

2.6. Expected liking and meal familiarity

Participants rated their expected liking for the 15 test meals and the four comparison meals. In each trial, the test meal was shown in the same portion as sold and presented in the centre of the monitor. A 154-mm visual-analogue rating scale was presented below this image. The rating was headed "How much do you expect to like this food?" with end anchor points 'not at all' and 'extremely like.' In an otherwise identical task participants responded to the question "How familiar are you with this food?" with end anchor points 'not at all familiar' and 'very familiar'.

2.7. Self-selected portion size

Based on the approach described in Brunstrom and Shakeshaft (2009), each test meal was presented in the centre of the monitor and participants were asked to "select the portion that would satisfy you for lunch today". As in the assessment of expected satiation, participants used the arrow keys to adjust the amount of food presented on the plate, moving between images in animated manner to select their ideal portion size. The portion estimates were recorded as kcals and the kcal value for the ideal portion was averaged across all 15 meals *per* participant for the regression model.

2.8. Dietary restraint

Participants completed the restraint subscale (DEBQ-R) of the Dutch Eating Behaviour Questionnaire (van Strien, Frijters, Bergers, & Defares, 1986). This subscale assesses successful dietary restriction, it has high internal consistency, and it provides a reliable measure in normal-weight and obese individuals (Bohrer, Forbush, & Hunt, 2015; Lowe & Thomas, 2009, pp. 170).

2.9. Data analysis

Among the 300 participants, seven declined to be weighted and were removed from the final dataset. For each participant, self-selected ideal portion size, expected satiation, expected liking measures were averaged across the 15 meals and entered in a three-step hierarchical multiple regression with self-selected portion size as a dependent variable. The first block of the model considered control variables (participant age, hunger score and test meal familiarity), in the second block we introduced expected satiation and expected liking, and in the third block we included our exploratory predictor variables, BMI and DEBQ-R score. Pearson correlation coefficients and collinearity statistics (variance inflation factor and tolerance) were computed to identify potential multicollinearity between variables. In all analyses a 5% confidence level was assumed and calculations were performed using IBM® SPSS® software version 21.0 (IBM Corporation, Armonk, NY, USA).

3. Results

3.1. Participants' BMI and DEBQ-R scores

The BMI distribution of our participants did not differ significantly from an estimate of US females (ages 20–59 years) ($\chi^2(4) = 1.1$, $p = 0.89$, see Table 1) provided by the National Health and Nutrition Examination Survey (NHANES, 2011–2012) (Ogden et al., 2014).

The mean DEBQ-R score for our sample was 2.8 ($SD = 0.8$) which is very similar to values reported elsewhere, e.g., 3.1 ($SD = 1.0$) for American college female students (Allison, Kalinsky, & Gorman, 1992) and 2.4 (SD = 0.9) recenlty observed in German women (Nagl, Hilbert, de Zwaan, Braehler, & Kersting, 2016).

3.2. Predictor variables of self-selected portion size

At step 1 the regression model narrowly failed as a significant predictor of portion size selection ($R^2 = 0.02$, $F(3,289) = 2.34$, $p = 0.07$). When expected satiation and expected liking were added (step 2) the model was significantly improved ($R^2 = 0.20$, $F(5,287) = 14.89$, $p < 0.001$). Adding BMI and DEBQ-R scores at Step 3 produced a very small yet significant improvement to the model ($R^2 = 0.24$, $F(7,285) = 13.02$, $p < 0.001$). Inter-correlations (Pearson) between all variables are shown in Table 2. All coefficients were below 0.70, and all variance inflation factors were below 4 and tolerance above 0.1 (Table 3), suggesting a sufficient lack of multicollinearity between variables (Marquardt, 1970; Tabachnick, Fidell, & Osterlind, 2001).

Expected satiation and DEQB-R score were the main predictors of portion size variance and expected liking and BMI were marginally significant (Table 3). Consistent with previous observations DEBQ-R score was positively correlated with BMI across the 293 participants (Table 2). For a review see Lowe and Thomas (2009, pp. 173).

4. Discussion

The objective of the current study was to determine whether variation in dietary restraint or BMI across a large cohort of adult females is associated with self-selected portions of commercial frozen prepared meals. Whereas dietary restraint and BMI were positively correlated, as widely observed in past research (Cebolla, Barrada, van Strien, Oliver, & Baños, 2014; Nagl et al., 2016), only dietary restraint explained a significant proportion of variance in portion-size selection. Specifically, and consistent with previous observations (Lowe and Thomas (2009, pp. 173–174) for a review), women with low dietary restraint tended to select larger meals. One possibility is that the selection of smaller portions by

Table 1
Distribution of BMIs in (a) a large US female sample (adapted from Ogden et al. (2014)) and (b) in participants recruited into the present study.

	a) % US female population (20–59 y)	b) Female participants (18-55y)
BMI<25	34.9	34.8
25 ≤ BMI<30	29.4	24.2
30 ≤ BMI<35	18.4	18.4
35 ≤ BMI<40	8.5	11.9
BMI≥40	8.8	10.6

Table 2
Intercorrelations (Pearson r) between variables (N = 293). *p < 0.05, **p < 0.01.

	Expected satiation	Expected liking	Familiarity	DEBQ-R score	BMI	Hunger	Age
Expected satiation	–	0.11	0.04	-0.08	-0.01	0.14*	-0.01
Expected liking		–	0.66**	0.01	-0.05	0.17**	0.05
Familiarity			–	0.02	-0.11	0.17**	-0.06
DEBQ-R score				–	0.16**	-0.12*	-0.01
BMI					–	-0.04	-0.13*
Hunger						–	0.13*
Age							–

Table 3
Standardized coefficient (β), *t* values, *p*-values, tolerance and variance inflation factors (VIF) for the final regression model (step 3).

Independent variables	β	T	p-value	Tolerance	VIF
Familiarity	−0.07	-0.98	0.33	0.54	1.86
Hunger	0.07	1.31	0.19	0.92	1.09
Age	0.01	0.27	0.78	0.94	1.06
Expected satiation	−0.40	7.57	0.00	0.97	1.04
Expected liking	0.13	1.90	0.06	0.54	1.84
DEBQ-R score	−0.18	−3.45	0.00	0.95	1.05
BMI	0.10	1.87	0.06	0.94	1.06

restrained eaters reflects a form of 'impression management' or an attempt to avoid the impression that they eat more than others.

The influence of BMI, although marginal, is aligned with results from a previous study showing that students with a higher BMI select larger portions (Burger et al., 2007) and with observations indicating that obese people require more calories to reach fullness compared to normal weight people (Acosta et al., 2015; Delgado-aros et al., 2004; Meyer-Gerspach et al., 2014). By contrast, our findings suggest that the relationship between BMI and portion selection is weak. A previous study has shown an association between calorie selection and intake among overweight people and the consumption of larger meals away from home (e.g. in restaurants) but not in the home (de Castro, King, Duarte-Gardea, Gonzalez-Ayala, & Kooshian, 2012). The authors speculate this association might be explained by high responsiveness of overweight individuals to food-related cues combined with widespread availability of food outside the home. In another study, overweight participants selected less healthy snacks from a buffet compared to normal weight participants, though the difference was not predicted by a food-choice decision model based on neural activity and food photograph choice task outcomes (Medic et al., 2016). The authors suggested that trait impulsivity may have been higher in the overweight participants in the presence of physical foods than with the picture stimuli. Taking together findings from de Castro et al. (2012) and Medic et al. (2016), we hypothesized that using food pictures might not entirely reflect actual food choice behaviour of overweight participants occurring in presence of physical foods.

The current trial took measures of participant's BMI to reduce the likelihood of body weight under-reporting which is often observed in the obese (Visscher, Viet, Kroesbergen, & Seidell, 2006). The weak relationship between BMI and portion selection observed in the present study might then reflect a form of underreporting for self-selected portion size in overweight participants, a tendency that has been documented in other forms of dietary assessment (Lichtman et al., 1992; Scagliusi et al., 2009). In a recent study using food photography, this underreporting bias was highlighted as a potential explanation for a failure to observe a relationship between BMI and portion selection (Spence et al., 2016).

Expected satiation predicted self-selected portions across a range of commercially available prepared meals. The observed negative relationship between expected satiation and self-selected portion size is aligned with previous findings from literature (Brunstrom, Shakeshaft, & Scott-Samuel, 2008; Brogden & Almiron-Roig, 2010; Brunstrom & Rogers, 2009), and Forde et al., 2015 for a recent review. This finding reemphasises the need to understand consumer perceptions of the expected filling properties of foods. Whereas expected liking may predict food choice, expected fullness may be a better predictor of the number of calories that we self-select and then go on to consumed.

Recently, Herman et al. have suggested that the selection of larger portion sizes might not play a causal role in the rise of obesity prevalence, due to the absence of mechanistic studies to support such a claim (Herman, Polivy, Vartanian, & Pliner, 2016). Acknowledging potential bias in self-reporting portion size discussed above, our work suggests that characteristics of the food rather than individuals BMI, are a better predictor of self-selected portion sizes.

5. Limitations and future directions

In summary, dietary restraint and, to a lesser extent, BMI, both predicted self-selected portions of meals that are commonly consumed at lunchtime. Expected satiation, was a much better predictor and yet the final model explained only 24% of the variance portion selection, suggesting that other contributory factors (e.g., socio-economic, psychological, and environmental) remain to be identified. The present study focused on women because they are the primary consumers of the product category that was studied. It remains to be determined whether the same results would be observed in men. Finally, although the use of computer-based portion-selection tasks has been validated previously (Wilkinson et al., 2012), further validation would be helpful in people with a range of BMIs, including those associated with overweight and obesity.

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