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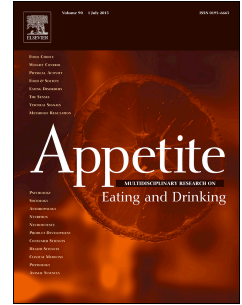
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Are food-related perceptions associated with meal portion size decisions? A cross-sectional study

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1 **Abstract**

2 The purpose of this study was to test a comprehensive model of meal portion size
3 determinants consisting of sociodemographic, psychological and food-related
4 variables, whilst controlling for hunger and thirst.

5 Using cross-sectional nationally representative data collected in 2075 participants
6 from the Island of Ireland (IoI) and Denmark (DK), eight separate hierarchical
7 multiple regression analyses were conducted to examine the association between
8 food-related variables and meal portion size (i.e. pizza, vegetable soup, chicken salad
9 and a pork meal) within each country. Stepwise regressions were run with
10 physiological control measures (hunger and thirst) entered in the first step,
11 sociodemographic variables (sex, age, body mass index (BMI)) in the second step;
12 psychological variables (cognitive restraint, uncontrolled eating, emotional eating,
13 general health interest (GHI)) in the third step and food-related variables (expected
14 fullness, liking, expected healthfulness, food familiarity) in the fourth step.

15 Sociodemographic variables accounted for 2-19% of the variance in meal portion
16 sizes; psychological variables explained an additional 3-8%; and food-related
17 variables explained an additional 2-12%. When all four variable groups were included
18 in the regression models, liking and sometimes expected healthfulness was positively
19 associated with meal portion size. The strongest association was for liking, which was
20 statistically significant in both countries for all meal types. Whilst expected
21 healthfulness was not associated with pizza portion size in either country, it was
22 positively associated with meals that have a healthier image (vegetable soup; chicken
23 salad and in IoI, the pork meal).

24 In conclusion, after considering sociodemographic and psychological variables, and
25 the food-related variables of liking and expected healthfulness, there may be little
26 merit in manipulating the satiating power, at least of these type of meals, to maintain
27 or promote weight loss.

28 **Keywords:** Meal portion size; psychological variables; expected fullness; expected
29 healthfulness; food liking; food familiarity.

30 **Introduction**

31 Excess energy intake and weight gain have been attributed to an increase in food
32 portion sizes (for a recent critical review, see Benton, 2015). Numerous experimental
33 studies in both laboratory and natural social settings (e.g. restaurants) have
34 demonstrated that increasing the portion size served leads to increased energy intake
35 at single meals (Rolls, Morris, & Roe, 2002) and over the course of several days
36 (Jeffery et al., 2007; Rolls, Roe, & Meengs, 2006; Rolls, Roe, & Meengs, 2007). This
37 'portion size effect' has been observed across a variety of food types, among diverse
38 study populations, and in different social contexts (for a recent meta-analysis of the
39 literature, see Zlatevska, Dubelaar, & Holden, 2014). Accordingly, it has been
40 suggested (Birch, McPhee, Shoba, Steinberg, & Krehbiel, 1987) that there is a
41 tendency for people to 'plate clean' when eating larger portions.

42 Interestingly, recent studies in free-living eating scenarios additionally demonstrate
43 that the majority of self-selected meals tend to be consumed in their entirety, with the
44 amount eaten often planned and anticipated in advance of eating (Fay et al., 2011;
45 Hinton et al., 2013). Evidence for meal planning also comes from a detailed

GHI: General Health Interest; BMI: Body Mass Index; IoI: Island of Ireland; DK,
Denmark.

46 qualitative analysis of the discourse of attitudes expressed by focus group
47 participants' towards point-of-purchase interventions aimed at portion size (Vermeer,
48 Steenhuis, & Seidell, 2010) and more recently, from measuring pre-meal intended
49 consumption in males served standard or larger portion sizes (i.e. a 'pre-consumption
50 portion size effect') (Robinson, Te Raa, & Hardman, 2015). Therefore, rather than
51 solely focusing on within meal processes (e.g. satiation, distraction, atmospherics, and
52 socialising etc.) which influence portion size consumption (Hellstrom et al. 2004;
53 Wansink, 2004), meal size could also be governed by a period of cognitive activity
54 (planning) that occurs before a meal begins (Wilkinson et al., 2012).

55 Studies reveal that self-selected or typical portion sizes of various foods are
56 affected by a number of sociodemographic (i.e. body mass index (BMI) (Burger, Kern
57 & Coleman, 2007; Lewis et al., 2015), sex (Burger et al., 2007; Lewis et al., 2015;
58 Brunstrom, Rogers, Pothos, Calitri, & Tapper, 2008)), and psychological (i.e.
59 cognitive restraint, uncontrolled eating, emotional eating (Brunstrom et al., 2008a;
60 Lemmens et al., 2010; Lewis et al., 2015; Spence et al., 2013; Wilkinson et al., 2012;)
61 variables. Food-related variables are also found to be important; for example,
62 expected satiety (for a recent review see Forde, Almiron-Roig, & Brunstrom, 2015),
63 liking (Brunstrom & Shakeshaft, 2009b; Lewis et al., 2015), food familiarity
64 (Brogden & Almiron-Roig, 2010; Brunstrom, Shakeshaft, & Scott-Samuel, 2008b),
65 and expected healthfulness (Faulkner et al., 2014; Spence et al., 2013; Wansink &
66 Chandon, 2006). However, to date, there is limited and mixed evidence for the
67 majority of these effects and the role of each variable relative to one another in meal
68 portion size decisions remains largely unknown. Indeed, a recent review (English,
69 Lasschuijt, & Keller, 2015) of the mechanisms underlying the portion size effect
70 concludes that we need larger studies in more representative samples which 'integrate

71 measures of individual subject-level differences with assessment of food-related
72 characteristics’.

73 Accordingly, the present study tested a comprehensive model of meal portion size
74 determinants consisting of sociodemographic, psychological and food-related
75 variables, whilst controlling for hunger and thirst, in a cross-sectional, nationally
76 representative sample of adults living in the Island of Ireland (IoI) and Denmark
77 (DK). Given the wide age range of participants being recruited for the present study
78 and the documented potential of this sociodemographic to impact dietary intake and
79 eating habits (Wakimoto & Block, 2001), we also considered age as a
80 sociodemographic variable of interest. Likewise, given previous positive associations
81 of the General Health Interest (GHI) scale with healthful food choices (Roininen,
82 Lahtenmaki, & Tuorila, 1999) and portion control strategy use (Spence et al., 2015),
83 GHI was included as another psychological variable of interest.

84 **Material and Methods**

85 **Survey and sample description**

86 The data reported here were collected as part of an analytical cross-sectional survey
87 investigating various psychological, social and behavioral factors related to portion
88 control in a quota-controlled nationally representative sample of adults living in the
89 IoI and DK. The measures used in these analyses were common in both countries. The
90 IoI and DK surveys had been piloted on a sample of n=30 and n=200 participants,
91 respectively, and, underwent minor changes before large scale data collection.

92 Data collection for the IoI survey has been described in detail previously (Spence
93 et al., 2015). In brief, interviews were conducted face-to-face in-home, on 31st July to
94 7th September 2012, by marketing company researchers using computer-assisted
95 personal interviewing. The sample (n=1012) was quota-controlled in terms of sex,

96 age, social class and area of residence to match the known demographics of the
97 population. On average interviews lasted approximately 40 minutes and participants
98 received £5/€6.50 remuneration for completing the interview.

99 Data for the DK study were collected between 9th to 31st July 2012 using an online
100 survey designed in the *Qualtrics* (<http://www.qualtrics.com/>) software program. In
101 collaboration with YouGov (a market research agency), 3303 individuals were
102 recruited from an established online panel consisting of consumers with diverse
103 demographic characteristics. Of the 1109 participants that completed the survey
104 (response rate = 34%), 1063 pertained to the target group and formed the final sample.
105 The sample was quota-controlled in terms of sex, age and region to match the known
106 demographics of the population, with each participant claiming to be responsible to
107 some extent for preparing and cooking their household's food. Participants received
108 points which could be redeemed in the YouGov panel store as remuneration for their
109 participation.

110 Demographic characteristics of the IoI and DK participants are described in Table
111 1. All participants provided informed consent verbally (IoI survey) or by agreeing to
112 take part in the survey as members of an online panel (DK survey). The IoI study was
113 conducted according to the guidelines laid down in the Declaration of Helsinki and
114 approved by Queens University Belfast Ethical Committee. The Danish data
115 collection was carried out according to ESOMAR guidelines.

116 **Questionnaire outline for common part of survey**

117 In order to control for current physiological state, we obtained a measure of how
118 hungry or thirsty each participant was by using a seven-point semantic differential
119 scale. End points were labelled “not hungry/thirsty at all” and “extremely
120 hungry/thirsty”. Participants then rated four types of meals (described below in the

121 stimuli section) for expected fullness, liking, expected healthfulness, and food
122 familiarity before selecting a meal portion size, and, completing several psychological
123 measures i.e. GHI, cognitive restraint, uncontrolled eating, and emotional eating.
124 Finally, sex, age, and self-reported height and weight were recorded. The latter two
125 measures were also used to compute BMI (weight in kilograms divided by square of
126 height in meters).

127 **Stimuli**

128 We selected four meals (three single component meals and one multi-component
129 meal) that are commonly eaten in both the IoI and DK and which would potentially
130 differ markedly in their healthfulness ratings; (1) pizza, (2) vegetable soup, (3)
131 chicken salad, and (4) a 'pork meal' consisting of pork fillet, potatoes, mixed
132 vegetables and optional salad. Test foods were digitally photographed in colour on a
133 white 23cm bowl for soup and 24cm plate for all other meals (placed on a white table)
134 next to reference objects that would provide a realistic idea of portion size (a fork,
135 knife or spoon and napkin). The pizza, vegetable soup, chicken salad and components
136 of the pork meal (pork fillet, potatoes, mixed vegetables, and salad) were each
137 photographed six times in increasing portion size; picture number one represented the
138 smallest portion size while picture six represented the largest portion size. Particular
139 care was taken to ensure that each photograph had been taken from the same angle
140 and distance above the plate, whilst maintaining a constant lighting condition. Pictures
141 of the largest meal portion sizes are shown in Figure 1.

142 **Measures**

143 *Expected fullness*: Participants rated how filling they expected each type of test
144 meal to be on a 7-point Likert scale ranging from 1 = "Not at all filling" to 7 =

145 “Extremely filling”. We defined expected fillingness as “how long each type of meal
146 will keep you feeling full”.

147 *Liking*: IoI participants rated their liking for each test meal on a 7-point Likert scale
148 ranging from 1 = “I strongly dislike this type of food” to 7 = “I strongly like this type
149 of food”. In DK, liking was rated on a 7-point scale that can be directly translated as 1
150 = “I do not like at all” to 7 = “I strongly like this type of food”, as Danish expression
151 for liking is expressed in a unipolar scale. This difference has implications for the
152 means of the ratings (Tuorila et al., 2008), but as the country data were analysed
153 separately, this should have no implications for the association between liking and
154 meal portion size. Participants were advised to use a separate response option if they
155 had never tasted the type of meal in question.

156 *Expected healthfulness*: Expected healthfulness of each type of test meal was
157 measured on a 7-point Likert scale ranging from 1 = “Not healthy at all” to
158 “Extremely healthy”.

159 *Food familiarity*: To confirm familiarity with the test meals, participants selected one
160 of the following options in response to the question “How frequently have you eaten
161 pizza/ vegetable soup/ chicken salad/ pork meal during the past year?”: once a day, 5-
162 6 times a week, 2-4 times a week, once a week, 1-3 times a month, less than once a
163 month, or never. Responses were coded 1–7, so that high scores reflected high
164 consumption frequency.

165 *Meal portion size*: Participants were asked to think of a typical type of pizza/
166 vegetable soup/ chicken salad/ pork meal which they could eat at home, and, were
167 given the following instruction: “Imagine you’re only having <pizza/ vegetable soup/
168 chicken salad/ pork fillet with potatoes and mixed vegetables (salad optional) > for
169 your dinner. How much would you eat?”. Participants were asked to choose a

170 photograph which most closely represented the amount that they would consume for
171 their dinner at home. In the IoI study, participants viewed six (or seven if salad was
172 chosen) A4 sheets with six portion size photographs (size: 8.0 x 5.3 cm) before
173 making their selection known to the interviewer. The portion size photographs were
174 presented in the same order to participants (pizza; vegetable soup; chicken salad; pork
175 fillet; potatoes; mixed vegetables and salad). In the online DK survey, participants
176 used the online arrow buttons (up and down) to increase or decrease the portion size.
177 The test meals (pizza/vegetable soup/chicken salad/pork meal) were presented in a
178 random order to participants while the meal components within the the pork meal
179 (pork fillet; mixed vegetables; potatoes; and salad) were presented together on one
180 plate and respondents could change the amount of each component; each component
181 was presented on a constant position on the plate. For each meal, the initial portion
182 size displayed on the screen to the participants was a random portion size of the test
183 meal; for the pork meal the initial portion was a combination of random sizes of each
184 one of the components.

185 *General Health Interest:* The importance of health in relation to food choice was
186 measured using the GHI subscale of the Health and Taste Attitude Scales (Roininen,
187 et al., 2001), with the modification that one item with the lowest factor loading was
188 removed; “I do not avoid foods, even if they raise my cholesterol”. All responses were
189 coded on a 7-point Likert scale (ranging from 1 = “strongly disagree” to 7 = “strongly
190 agree”) and a mean score of the items was calculated, so that a higher scale score was
191 indicative of greater GHI.

192 *Cognitive restraint, emotional eating, and uncontrolled eating:* Three aspects of
193 current eating behavior were assessed by the Three-Factor Eating Questionnaire
194 Revised 18 item version (TFEQ-R18; de Lauzon et al., 2004); cognitive restraint (6

195 items), emotional eating (3 items) and uncontrolled eating (9 items). For the present
196 study, we reformulated the response option for one item to match that used in a
197 previous questionnaire (The Nutritional Epidemiology Group, Centre for
198 Epidemiology and Biostatistics, University of Leeds, n.d.) to enable participants to
199 more easily indicate the overall extent of their cognitive restraint. All responses were
200 coded on a 4-point scale (1-4) and a summary scale score was calculated as a mean of
201 the component items, so that higher scale scores were indicative of greater cognitive
202 restraint, emotional eating, or uncontrolled eating. The response alternatives
203 measured, e.g., how true, likely or frequent certain food control behaviors were, e.g.,
204 “I do not eat some foods because they make me fat”.

205 **Data analysis**

206 In the first instance, portion size pictures of each meal or meal component were
207 converted to their respective energy contents based upon back-of-pack nutritional
208 labelling. For the multi-component pork meal, all of the component energy values
209 were summed.

210 In analysing the data, a descriptive analysis was first performed to describe the
211 variables (Table 2). Four-step hierarchical multiple regressions were then conducted
212 to examine the association between food-related variables and meal portion sizes,
213 using the energy content for each meal as the dependent variables. The independent
214 variables were entered as groups; in step one the current perceived physiological state
215 of hunger and thirst were entered to control for their possible impact on portion-size
216 decisions, followed by sociodemographic variables (sex, age, and BMI) in step 2;
217 psychological variables (cognitive restraint, uncontrolled eating, emotional eating, and
218 GHI) in step 3; and finally, food-related variables (expected fullness, liking,
219 expected healthfulness, and food familiarity) in step 4. The reason for this order was

220 to start with factors that are likely to influence meal portion size decisions, but which
221 cannot be changed (sociodemographic variables), then have the relatively stable
222 psychological eating styles and in the final step add the stimuli-dependent variables
223 that reflect an individuals' perception of specific types of foods.

224 As a slightly different pattern in explanatory variables was seen for IoI and DK
225 separately, results are presented as cross-country regressions for each meal. For each
226 regression, participants were excluded based upon two exclusion criteria. First,
227 participants with a BMI ≤ 15 ($n = 4$) and BMI ≥ 45 ($n = 14$) were excluded. Second,
228 the Mahalanobis distance procedure was used to identify and exclude multivariate
229 outliers in each regression (Mahalanobis distance $\chi^2(13) = > 34$, $p < .001$). As
230 recommended by Field (Field, 2009), Pearson correlation coefficients and tolerance
231 statistics were used to check for possible multicollinearity between predictor
232 variables. Both collinearity diagnostics indicated that multicollinearity was not a
233 concern (i.e. all correlation coefficients were less than 0.80, all tolerance statistics
234 were above 0.2). Furthermore, regression assumptions regarding normality, linearity
235 and homoscedasticity were met. For each of the eight models in Table 3, we report the
236 explained variance (R^2) for the first regression step and the change of explained
237 variance (ΔR^2) after the addition of steps two, three and four. For the final four-step
238 models in Table 4, we report the standardised regression coefficients for each variable
239 (β) and the adjusted variance explained for the final models (R^2_{adj}). All analyses were
240 conducted using IBM SPSS Statistics for Windows version 21.0 (IBM Corporation,
241 Armonk, NY, USA), with a p-value $p \leq 0.05$ considered to be significant.

242 Results

243 Descriptive statistics

244 Mean (SD) response, possible mean range, and internal reliability values for
245 independent variables by country are presented in Table 2. Participants in the DK
246 sample were slightly older and had a higher BMI than participants in the IoI sample.
247 In relation to both the pizza and pork meal, findings showed that DK (compared to
248 IoI) scored (a) significantly higher for meal portion size, liking, and food familiarity;
249 and (b) significantly lower on expected healthfulness. In contrast, the portion size of
250 the chicken salad in DK was significantly lower than the IoI, and the following food-
251 related variables were scored significantly higher: expected fillingness; liking; and
252 food familiarity. The vegetable soup portion size was comparable between countries,
253 with DK scoring significantly higher on expected healthfulness and food familiarity
254 than IoI, and significantly lower on expected fillingness. In relation to the
255 psychological variables, DK had higher GHI and, lower emotional eating scores than
256 IoI.

257 **Regression Analysis: Predictors of Meal Portion Size**

258 After controlling for current physiological state in step 1, the hierarchical multiple
259 regressions revealed that each additional variable group (step) significantly improved
260 all models (Table 3). Across the models, the sociodemographic variable group
261 accounted for 2-19% of the variance in meal portion size and adding the
262 psychological variable group to the regression model explained an additional 3-8% of
263 the variation. Finally, the further addition of the food-related variable group explained
264 an additional 2-12% of the variation in meal portion size. Together, the four variable
265 groups accounted for 14-43% of the variance in meal portion size; with the percentage
266 of explained variance being largest for the portion size of the pizza in IoI (Table 4).

267 In the group of sociodemographic variables (final regression models in Table 4),
268 sex was consistently and significantly associated with each meal portion size in both

269 countries, with men scoring higher for meal portion size than women. A younger age
270 and higher BMI were also significantly associated with a larger meal portion size in
271 the DK sample, whereas age was only positively associated with pizza meal portion
272 size in the IoI sample.

273 In the group of psychological variables (final regression models in Table 4),
274 uncontrolled eating was consistently and significantly associated with each meal
275 portion size in both countries, with higher uncontrolled eating scores being associated
276 with greater portion size. A lower cognitive restraint was also significantly associated
277 with a greater portion size of each meal in the DK sample, whereas cognitive restraint
278 was only negatively associated with the IoI vegetable soup portion size. Emotional
279 eating (IoI only) and GHI (IoI and DK) were positively associated with portion size in
280 three out of the eight meal models.

281 Of the food-related variables (final regression models in Table 4), liking and
282 sometimes expected healthfulness were positively associated with meal portion size.
283 The strongest association was for liking, which was statistically significant in both
284 countries for all meal types. Whilst expected healthfulness was not associated with
285 pizza portion size in either country, it was positively associated with meals that have a
286 healthier image (vegetable soup; chicken salad and in IoI, the pork meal). Expected
287 fillingness and food familiarity, on the other hand, were only significantly associated
288 with IoI pizza portion size.

289 **Discussion**

290 To our knowledge this is the first study to examine a comprehensive framework of
291 contributors to meal portion size in a large representative sample of adults.

292 Specifically, we studied the relative effects of both individual-level variables (i.e.
293 sociodemographic and psychological) and food-related variables on meal portion size

294 in a cross-sectional study of 2075 participants living in two countries with different
295 cultures but similar dishes. Our models showed that, apart from uncontrolled eating,
296 psychological contributors to meal portion size are somewhat different between the
297 IoI and DK. Furthermore, not all food-related variables which appeared important for
298 portion size in previous studies were significantly associated with meal portion size.

299 Sex was the strongest sociodemographic contributor to meal portion size, which is
300 not surprising given the higher energy needs of men, and supports the external
301 validity of the chosen method to study portion size decisions. These observed
302 differences in portion size between men and women have been found in previous
303 studies for some, but not for all food types (Brustrom et al., 2008a; Burger et al.,
304 2007). For example, using real food items, male students served themselves larger
305 portions of high-energy, high-fat and high-carbohydrate foods than female students
306 (and comparable portions in the corresponding lower categories) (Burger et al., 2007),
307 and a study assessing usual portion size using a computer programme found males
308 reported consuming larger portions in half of their test foods (three main meals and
309 three side dishes), compared to females (Brunstrom et al., 2008a). Similarly, in
310 another computer based study, Lewis et al. (2015) found that males had larger
311 personal norms for portion size when compared to females. These findings are
312 consistent with the notion that males have higher energy requirements which can be
313 fulfilled through consumption of larger portion sizes.

314 An interesting finding from this study is the absence of a positive relationship
315 between BMI and all meal portion sizes in the IoI sample and the presence of this
316 positive relationship in the DK sample. While relationships between BMI and portion
317 size are generally not observed in dietary surveys, experimental studies which have
318 explored the relationship between BMI and typical self-selected portion size have

319 reported equivocal results (e.g. a positive relationship (Burger et al., 2007; Lewis et
320 al., 2015) vs no relationship (Brunstrom et al., 2008a; Wilkinson et al., 2012).
321 Previous research has shown that there may be bias in self-report data on food intake,
322 with a greater magnitude of under-reporting of energy intake in obese individuals
323 (Prentice et al., 1986). It is possible that the same underreporting may account for the
324 lack of a relationship between BMI and meal portion size in our IoI sample, however,
325 evidence for this effect remains to be shown. The mode of survey administration (i.e.
326 interviewer-administered in IoI vs computer-administered in DK) may have made
327 participants more reluctant to answer truthfully in the IoI due to greater concerns
328 about the negative impression that their response may give.

329 Overall, uncontrolled eating (IoI and DK) was the strongest psychological
330 contributor to meal portion size, followed by cognitive restraint in DK and emotional
331 eating in IoI. Even though it would seem intuitive that higher levels of uncontrolled
332 eating and lower levels of cognitive restraint would be associated with larger portion
333 sizes, most previous studies have not shown clear effects of these types of variables
334 on food portion size (Brunstrom et al., 2008a; Lewis et al., 2015; Wilkinson et al.,
335 2012). Consistent with previous reports (Brunstrom et al., 2008a; Lewis et al., 2015),
336 we did find that lower cognitive restraint scores were significantly associated with
337 larger portion size, but likewise, we note that we cannot fully exclude the possibility
338 of reporting biases. Furthermore, emotional eating on the IoI was related to a larger
339 portion size of pizza which is typical of high-energy dense foods (Gibson, 2012), but
340 surprisingly, it was also associated with vegetable soup and chicken salad which are
341 low-energy dense foods that were considered as healthy meal options in this study,
342 and thereby could not be considered as typical targets in emotional eating
343 (Raaijmakers, Gevers, Teuscher, Kremers, & van Assema, 2014). In the IoI sample

344 the high responsiveness to emotional eating seemed to be linked to an increased
345 portion size across a wide range of foods, whereas in the DK sample the link was not
346 found with these foods. In general the Danish respondents scored low on the emotional
347 eating scale, which may partly be a result of how food is used in response to
348 emotional stress, and also which kinds of foods are used (e.g. snack vs meals).

349 Perhaps unsurprisingly and in accord with previous studies (Brunstrom et al.,
350 2009b) is the observation that liking was a strong positive food-related contributor to
351 meal portion size. Expected healthfulness, consistent with previous studies (Faulkner
352 et al., 2014; Wansink & Chandon, 2006), was positively associated with meal portion
353 size. Interestingly, this association was only present in meals with a healthier image
354 (vegetable soup; chicken salad and in IoI, the pork meal) and no association was
355 found with pizza portion size. Furthermore, GHI was linked to higher portion sizes,
356 but only in these “healthy” foods. For those respondents who found health as an
357 important factor in their food choices, the healthy image seems to work as a licence to
358 eat more (Poelman, Vermeer, Vyth, & Steenhuis, 2013). Alternatively, those who are
359 more health conscious may have a better understanding of the energy contribution of
360 each meal: even the largest portion size is well below those derived from larger
361 portions of pizza or even the multi-component meal. In future it would be interesting
362 to repeat the study with products that differ in their health image, but have the same
363 energy density; however, this is not the case in most real world foods.

364 Of particular note, is our finding that expected fullness is not an important
365 determinant of meal portion size. This finding is at odds with those of previous studies
366 (Forde, Alexander, Thaler, Martin, & Brunstrom, 2011; Brunstrom & Shakeshaft,
367 2009b; Brunstrom & Rodgers 2009a; Wilkinson, 2012;), who have systematically
368 explored computer-based measures of expected satiety relative to liking, to

369 demonstrate that expected satiety is a better predictor of portion size. Although more
370 and less sensitive measures of expected fullness have been used in previous
371 research studies (see Forde, Almiron-Roig, & Brunstrom, 2015 for a recent review),
372 fullness scales, similar to that used in the current study, have been shown to predict
373 energy intake. The current finding suggests that after considering individual level
374 differences, liking and expected healthfulness, there may be little merit in
375 manipulating the satiating power, at least of these type of meals, to maintain or
376 promote weight loss. However, the extent to which this analysis extends to all meal
377 types, especially those eaten outside of the home environment, remains unclear.

378 Apart from the high amount of unexplained variance, which may be improved by
379 adding environmental and context specific factors, there are other limitations to note.
380 Firstly, some of our survey's self-report measures (e.g. about weight, height and
381 portion size) may have been regarded by participants as sensitive and thus prone to
382 social desirability response bias. This bias in portion size report may also have been
383 further compounded by our use of pictures in the measure of meal portion size. This
384 may have resulted in underestimation and/or overestimation of meal portion size,
385 however, it has been recently shown that photographic meal data can be a valid and
386 useful measure of 'real-life' portion size (Hinton et al., 2013). The different modes of
387 survey administration in DK and IoI may also limit comparability of results. Another
388 limitation associated with this type of study was that the composition of our test meals
389 may not be reflective of typical meals. For example, IoI consumers may not typically
390 consume pizza in isolation but may instead choose to add salad or chips for a full
391 meal. Nevertheless, many of these flaws are a result of issues inherent in studying a
392 large sample size and/or exploring contributors to meal portion size.

393 Despite these limitations, a major strength of the current study is that it
394 encompassed a large sample size which was representative of both IoI and DK in
395 terms of age, sex, social class (IoI only) and area of residence. This sample was
396 therefore ideal for assessing the relationship between food-related variables (e.g.
397 expected satiety) and meal portion size, relative to individual-level variables (e.g.
398 BMI, age, cognitive restraint). Future research could examine the relationship
399 between these variables and other meals (e.g. healthy vs less healthy) and snacks in
400 different cultural contexts.

401 **Conclusions**

402 After considering sociodemographic and psychological variables (the latter of which
403 may be culturally specific), and the food-related variables of liking and expected
404 healthfulness, there may be little merit in manipulating the satiating power, at least of
405 these type of meals, to maintain or promote weight loss.

406 **Competing interests**

407 The authors declare that they have no competing interests.

408 **Authors' contributions**

409 All authors participated in the design of the study. VS and MS carried out the
410 statistical analyses and MS and MD drafted the manuscript. All authors contributed to
411 the manuscript by modifying, commenting and reviewing the text, and approving the
412 final manuscript submitted for publication.

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554 **Table 1** Demographic details and characteristics of the study sample

		Sample (%)	
		IoI (n = 1012)	DK (n = 1063)
Sex	Male	48	47
	Female	52	53
Age	18-29 yrs	27	14
	30-49 yrs	38	35
	50-64 yrs	20	33
	65+ yrs	15	17
Body mass index ^a	<18.5 kg/m ²	4	2
	18.5-24.9 kg/m ²	48	44
	25-29.9kg/m ²	29	34
	>29.9 kg/m ²	16	18
	Unknown	3	3
Highest education level	Basic school	27	10
	A-levels (secondary school)	32	32
	Professional training	20	35
	University level	22	24
Occupation status	Employed full-time (>30h per week)	49	57
	Employed part-time (≤29h per week)	12	6
	Full-time homemaker	11	1
	Unemployed	11	7

	Student	6	7
	Retired	12	22

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556 IoI = Island of Ireland, DK = Denmark

557 ^a Based on self-reported height and weight

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579 **Figure 1** (A 1.5 or 2-column fitting image; no additional charge for colour please) Largest portion sizes
580 of (a) pizza, (b) vegetable soup, (c) chicken salad, and (d, e, f, g) the pork meal

(a)

(b)

(c)



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(d)

(e)

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(g)



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Table 2 Mean (SD) response and possible mean range for Island of Ireland and Denmark separately

Variables (number of items)	Possible mean range (end points)	IoI		DK	
		n	Mean (SD) response or number of participants	n	Mean (SD) response or number of participants
Physiological variables					
Hunger*** (1 item)	1-7 Not hungry at all- extremely hungry	1012	2.9 (1.8)	1063	2.4 (1.6)
Thirst** (1 item)	1-7 Not thirsty at all-extremely thirsty	1012	3.0 (1.8)	1063	3.2 (1.6)
Sociodemographic variables					
Sex (male/female)	-	1012	484/528	1063	499/564
Age***	-	1012	43.2 (16.7)	1063	48.3 (14.7)
Body mass index** (Self-reported height and weight)	-	1012	25.4 (5.2)	1063	26.2 (5.3)
Pizza variables					
Pizza portion size*** (1 item)	1-6 130-792 kcal	1012	1938 (854)	1044	2152 (795)

Expected fullness (1 item)	1-7 Not at all filling-extremely filling	1012	4.5 (1.8)	1063	4.5 (1.6)
Liking*** (1 item)	1-7 Strongly dislike-strongly like	997	4.2 (1.9)	1062	5.0 (1.7)
Expected healthfulness*** (1 item)	1-7 Not healthy at all- extremely healthy	1012	2.9 (1.7)	1063	2.4 (1.2)
Food familiarity*** (1 item)	1-7 Never-once a day	1012	5.1 (1.4)	1063	5.5 (0.8)
Vegetable soup variables					
Vegetable soup portion size (1 item)	1-6 30-180 kcal	1012	527 (159)	1045	531 (192)
Expected fullness*** (1 item)	1-7 Not at all filling-extremely filling	1012	4.7 (1.6)	1063	4.2 (1.6)
Liking (1 item)	1-7 Strongly dislike-strongly like	1007	5.0 (1.5)	1057	5.18 (1.8)
Expected healthfulness* (1 item)	1-7 Not healthy at all- extremely healthy	1012	5.9 (1.2)	1063	6.0 (1.1)
Food familiarity*** (1 item)	1-7 Never-once a day	1012	4.5 (1.3)	1063	5.6 (1.0)
Chicken salad variables					
Chicken salad portion size*** (1 item)	1-6 46-276 kcal	1012	787 (242)	1044	703 (255)
Expected fullness*** (1 item)	1-7 Not at all filling-extremely filling	1012	4.4 (1.6)	1063	5.0 (1.3)
Liking*** (1 item)	1-7 Strongly dislike-strongly like	1008	4.8 (1.6)	1057	6.0 (1.3)
Expected healthfulness (1 item)	1-7 Not healthy at all- extremely healthy	1012	6.0 (1.2)	1063	6.0 (1.1)
Food familiarity*** (1 item)	1-7 Never-once a day	1012	4.5 (1.3)	1063	4.9 (1.1)
Pork meal variables					
Pork meal portion size*** (3-4 items ^a)	1-6 146-408 kcal	1012	1205 (226)	1062	1251 (226)
Expected fullness (1 item)	1-7 Not at all filling-extremely filling	1012	6.0 (1.9)	1063	6.1 (1.0)
Liking** (1 item)	1-7 Strongly dislike-strongly like	1006	5.3 (1.5)	1060	5.5 (1.6)
Expected healthfulness*** (1 item)	1-7 Not healthy at all- extremely healthy	1012	5.4 (1.3)	1063	4.8 (1.3)
Food familiarity*** (1 item)	1-7 Never-once a day	1012	4.3 (1.3)	1063	5.0 (1.2)
Psychological variables					
General Health Interest ^{b***} (7 items)	1-7 Strongly disagree/strongly agree ^c	1012	4.4 (1.2)	1063	4.8 (1.2)
Cognitive restraint ^{de***} (6 items)	1-4 ^f	1012	2.2 (0.7)	1063	2.3 (0.6)

Uncontrolled eating ^{dg**} (9 items)	1-4 ^f	1011	2.1 (0.6)	1063	2.0 (0.6)
Emotional eating ^{dh**} (3 items)	1-4 Definitely false-definitely true ^c	1012	2.1 (0.9)	1063	1.7 (0.8)

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599 Significantly different between studies ($p < 0.05^*$; $< 0.01^{**}$, $< 0.001^{***}$); IoI = Island of Ireland, DK =

600 Denmark

601 ^aThe multi-component pork meal, where meal kilocalories were computed as a summation of its
602 component kilocalories603 ^bFrom the General Health Interest scale (Roininen, Lahteenmaki, & Tuorila, 1999)604 ^cHigher scores indicative of greater levels of the construct605 ^dFrom the Three-Factor Eating Questionnaire Revised 18 item version (de Lauzon et al., 2004)606 ^eReliability (α) = 0.82 and 0.76 for IoI and DK, respectively607 ^fThe response alternatives measured how true, likely or frequent certain food control behaviors were;
608 higher scores indicative of greater levels of the construct609 ^gReliability (α) = 0.87 and 0.85 for IoI and DK, respectively610 ^hReliability (α) = 0.87 and 0.85 for IoI and DK, respectively

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620 **Table 3** The change of explained variance (ΔR^2) for each regression after the addition of each step

Independent variable group	Pizza portion size (kcal)		Vegetable soup portion size (kcal)		Chicken salad portion size (kcal)		Pork meal portion size (kcal) ^a	
	IoI (n=946)	DK (n=988)	IoI (n=953)	DK (n=984)	IoI (n=958)	DK (n=980)	IoI (n=954)	DK (n=1008)
<i>Step 1: Physiological^b</i>								
R ²	.046	.012	.015	.008	.004	.014	.004	.013
ΔF	22.54***	5.79**	7.37**	3.79*	2.12	7.03**	1.72	6.73**
df	2,943	2,985	2,950	2,981	2,955	2,977	2,951	2,1005
<i>Step 2: Sociodemographic^c</i>								
ΔR^2	.191	.190	.085	.016	.043	.088	.127	.178
ΔF	78.23***	78.11***	29.64***	5.21**	14.16***	31.88***	46.00***	73.36***
df	3,940	3,982	3,947	3,978	3,952	3,974	3,948	3,1002
<i>Step 3: Psychological^d</i>								
ΔR^2	.080	.028	.033	.040	.036	.050	.067	.062
ΔF	27.55***	8.73***	8.88***	10.38***	9.37***	14.42***	19.78***	20.56***
df	4,936	4,978	4,943	4,974	4,948	4,970	4,944	4,998
<i>Step 4: Food-related^e</i>								
ΔR^2	.123	.065	.093	.104	.063	.018	.095	.026
ΔF	50.92***	22.40***	28.06***	30.22***	17.50***	5.30***	31.61***	9.07***

df	4,932	4,974	4,939	4,970	4,944	4,966	4,940	4,994
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622	* ** $p < 0.01$, *** $p < 0.001$; IoI = Island of Ireland, DK = Denmark							
623	^a The multi-component pork meal, where meal kilocalories were computed as a summation of its							
624	component kilocalories							
625	^b Including hunger and thirst							
626	^c Including sex, age and body mass index							
627	^d Including cognitive restraint, uncontrolled eating, emotional eating and General Health Interest							
628	^e Including expected fillingness, expected healthfulness, liking and food familiarity							
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643	Table 4 Standardized coefficients (β) for the final regression models (per country)							

Independent variables	Pizza portion size (kcal)		Vegetable soup portion size (kcal)		Chicken salad portion size (kcal)		Pork meal portion size (kcal) ^a	
	IoI (n=946)	DK (n=988)	IoI (n=953)	DK (n=984)	IoI (n=958)	DK (n=980)	IoI (n=954)	DK (n=1008)
<i>Step 1: Physiological</i>								
Hunger ^b	.13***	-.01	.09*	.06	.05	.04	-.01	.01
Thirst ^b	-.10**	-.03	-.09*	-.04	-.08	-.02	-.05	-.02
<i>Step 2: Sociodemographic</i>								
Sex ^c	-.28***	-.22***	-.29***	-.12***	-.25***	-.25***	-.28***	-.31***
Age	-.07*	-.21***	.01	-.07*	-.02	-.10**	-.04	-.13***
Body mass index ^d	-.02	.07*	-.01	.11**	-.00	.11***	.04	.08**
<i>Step 3: Psychological</i>								
Cognitive restraint ^e	-.06	-.11**	-.08*	-.14***	-.07	-.13***	-.05	-.17***
Uncontrolled eating ^e	.11**	.13***	.17***	.14***	.15***	.24***	.31***	.18***
Emotional eating ^e	.15***	-.02	.09*	-.05	.12**	-.02	.00	-.03
General health interest ^f	-.05	.04	.04	.08*	.11**	.08*	.05	-.04
<i>Step 4: Food-related</i>								
Expected fillingness ^b	.06*	.04	-.05	-.06	.02	-.03	.00	.01
Expected healthfulness ^b	-.01	-.05	.12***	.10**	.09**	.08*	.24***	.06

Liking ^b	.28***	.25***	.27***	.29***	.23***	.10*	.15***	.14***
Food familiarity ^b	.15***	.05	.01	.06	-.02	.02	-.05	-.02
<i>Final model (R²_{adj})</i>	.43	.29	.21	.16	.14	.16	.28	.27
<i>Model F</i>	56.17***	31.27***	20.99***	14.96***	12.46***	15.32***	29.91***	29.57***
<i>df</i>	13,932	13,974	13,939	13,970	13,944	13,966	13,940	13,994

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645 * $p \leq 0.05$; ** $p < 0.01$, *** $p < 0.001$; bold text highlights significance; IoI = Island of Ireland, DK =

646 Denmark

647 ^a The multi-component pork meal, where meal kilocalories were computed as a summation of its
648 component kilocalories649 ^b One item measured on a 7-point Likert scale; higher scores indicative of greater levels of the construct650 ^c 0 = males, 1 = female651 ^d Based on self-reported height and weight652 ^e A mean of 6 items (cognitive restraint), 9 items (uncontrolled eating) and 3 items (emotional eating)
653 measured on a 4-point Likert scale taken from the Three-Factor Eating Questionnaire Revised 18 item
654 version (de Lauzon et al., 2004); higher scores indicative of greater levels of the construct655 ^f A mean of 7 items measured on a 7-point Likert scale taken from the General Health Interest scale

656 (Roininen, Lahteenmaki, & Tuorila, 1999) ; higher scores indicative of greater levels of the construct